Determinants of Carbon dioxide emissions in low-middle income countries
محددات انبعاثات ثاني أكسيد الكربون في الدول منخفضه الدخل المتوسط

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المستخلص:

حازت العلاقة بين التلوث البيئي وأسبابه أو محدداته مثل النمو الاقتصادي واستهلاك الطاقة على اهتمام الباحثين مؤخراً. وتبحث هذه الدراسة في محددات انبعاثات ثاني أكسيد الكربون في البلدان ذات الدخل المتوسط المنخفض باستخدام طريقة Arellano and Bond المعممة (GMM) باستخدام بيانات بانل الديناميكية خلال الفترة من 1990 إلى 2022. وقد قسمنا البلدان إلى مجموعتين بناء على مستوى انبعاثات ثاني أكسيد الكربون تمثل نموذجين والنموذج الثالث هو النموذج المجمع للدول كلها. كانت النتائج الرئيسية هي أن النمو الاقتصادي والاستثمار الأجنبي المباشر والنمو السكاني السنوي لهم تأثير معنوي إيجابي على انبعاثات ثاني أكسيد الكربون في النماذج الثلاثة. كما أن متغير التحضر له تأثير سلبي على انبعاثات ثاني أكسيد الكربون في النموذج الأول والثالث، وليس له تأثير في النموذج الثاني. أما بالنسبة لمؤشران استخدام الطاقة فأن متوسط استهلاك الفرد من الطاقة الأولية له علاقة إيجابية مع انبعاثات ثاني أكسيد الكربون، في حين أن هناك علاقة عكسية بين استهلاك الطاقة الأولية لكل وحدة من الناتج المحلي الإجمالي مع انبعاثات ثاني أكسيد الكربون لذا أوصت الدراسة بتحسين جودة البيئة وتحقيق النمو المستدام وأن تشجع الحكومة الاستثمار الأجنبي المباشر للاستثمار في مصادر الطاقة المتجددة، كما يجب إدراج الاهتمامات البيئية في خطط التنمية وتطبيق ضريبة الانبعاثات الكربونية للتأثيرات البيئية لتشجيع استخدام مصادر الطاقة المتجددة.

الكلـمات المفتـاحية: انبعاثات ثاني أكسيد الكربون – الدول منخفضه الدخل المتوسط – استهلاك الطاقة – نموذج بانل الديناميكي – النمو الاقتصادي – منحنى كوزنتس.

Abstract:

The relationship between environmental pollution and its causes or determinants such as economic growth and energy consumption Gained the attention of researchers recently. this study examines the determinants of carbon dioxide emissions in low-middle income countries by using the Arellano and Bond generalized method of moments (GMM)/dynamic panel data model in the period from 1990 to 2022. We divided the countries into two groups based on level of carbon dioxide emissions and a global one in three panel data models. The main findings are economic growth, foreign direct investment, population annual growth have a positive significant effect on carbon dioxide emissions in all panels. Urban population has a negative effect on carbon dioxide emissions in the first and the global panel, and insignificant effect in the second one. The two indicators for energy use have different results, while primary energy consumption per capita has a positive relation with carbon dioxide emissions, there is an inverse link between Primary energy consumption per unit of gross domestic product and it. So, the study recommended to improve the environmental quality and attain the sustainable growth that the government should promote foreign direct investment to invest in renewable energy sources, environmental concerns must be included in development plans and implementing carbon emission tax for environmental impacts to encourage using renewable energy sources.

Keywords: carbon dioxide emissions, lower middle-income countries, Energy consumption, panel data model, economic growth, Kuznets curve.

1. Introduction

The extensive usage of fossil fuels and other polluting energy sources in recent years has resulted in climate change. Both the natural world and human situation were impacted by this shift. All aspects of the climate system will see long-term alterations and additional warming if greenhouse gas (GHG) emissions keep rising. The pace of increase in carbon dioxide (CO2) emissions has a negative impact on both the environment's quality and public health. (Kahia et al., 2019)

The increased use of natural or non-renewable resources results in increased pollution, which lowers and diminishes the quality of the environment. Generally, achieving economic expansion necessitates using more labor, capital, and other resources. This leads to an increase in waste being produced in the environment, including the emission of fumes and gases that are harmful to everyone's health (Usenata, 2018).

Growing income led to a greater need for energy which ted to increase environmental concerns and the knowledge that carbon emissions are the primary cause of climate change (world development report 2024). Low- and middle-income countries face several common challenges in having to bring millions out of poverty, expand strategic industries, urbanize and deal with the political challenges of a transition away from fossil fuel use. (Program de las Naciones Unidas para el Medio Ambiente, 2023)

Global GHG emissions increased by 1.2% from 2021 to 2022 to reach a new record of 57.4 gigatons of CO2 equivalent. CO2 emissions from fossil fuel combustion and industrial processes were the main contributors to the overall increase, accounting for about two thirds of current GHG emissions. (Programa de las Naciones Unidas para el Medio Ambiente, 2023)

According to the Carbon Dioxide Information Analysis Center, Contribution of Carbon Dioxide in greenhouse gases in 1990 was 60.6% increased to 66.2% in 2017(CDIAC 2024). In 2022 greenhouse gas GHG emissions intensity (as ab share of GDP) is higher 3.5 times in middle income than high income countries, also energy intensity (as a share of GDP) is higher 2.5 times in

middle income than high income countries. In contrast solar and wind electricity generation (as a share of total electricity generation) in middle income countries is lower 40%,42% than high income countries. the share of global carbon dioxide co2 emissions in lower middle-income countries 15.7% from the world verses 48.6% in upper middle (world development report 2024).

Whether warming can be contained to 1.5°C or 2°C, it will mostly depend on the amount of greenhouse gas emission reductions this decade and the cumulative carbon emissions until net-zero CO2 emissions are reached. Without further mitigation, projected CO2 emissions from the current fossil fuel infrastructure will exceed the remaining carbon budget by 1.5°C (IPCC,2023).

the lower middle-income countries have GDP per capita in 2022 lower than 4300$ annually except Iran. They are developing countries in their beginnings for development.

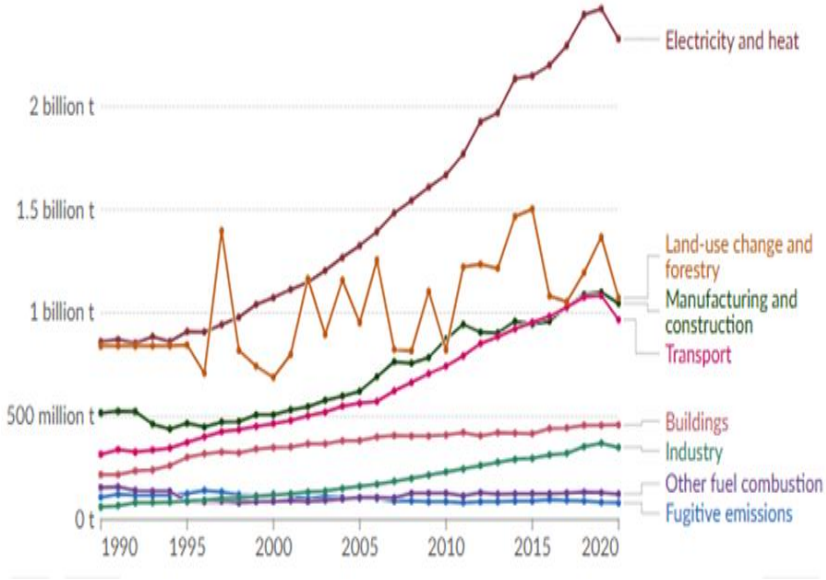
Table (1) co2 emissions in Egypt and Lower middle-income countries (1990 – 2023)

indicator		1990	2000	2010	2023
annual co2 emissions from fossil fuels and industry	Egypt (million tons)	75.22	143.84	203.61	269.01
	Lower middle-income countries (billion tons)	1.11	1.83	2.85	4.88
Annual co2 emissions per capita from fossil fuels and industry (tons)	Egypt	1.288	1.968	2.282	2.348
	Lower middle-income countries	0.646	0.859	1.116	1.584
The share in global co2 emissions from fossil fuels and industry (%)	Egypt	0.33	0.56	0.61	0.71
	Lower middle-income countries	4.87	7.16	8.53	12.92

Source: www.ourworldindata.org

In previous table (1) co2 emissions had been increased from fossil fuels and industry from 1.11 billion tons in 1990 to 1.83 billion tons in 2000 and 4.88 billion tons in 2023, and the annual co2 emissions per capita in metric tons in lower middle-income countries increased continuously from 0.646 in 1990 to 0.859 in 2000 and 1.584 in 2023 except 2020 because of corona pandemic.

Figure (1) Co2 emissions by sectors or activity in lower middle-income countries in (1990-2020)



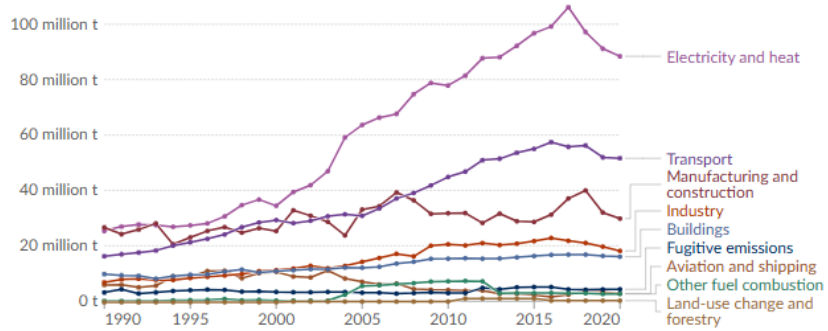
Source: www.ourworldindata.org

As we see in figure (1) the highest sector causing more releasing co2 emissions in lower middle-income countries is electricity and heat during the period (1990-2020). The second sector is land use change and forestry which fluctuates ups and downs across the period (increasing or decreasing). The third is manufacturing and construction then transportation.

Egypt is also suffering from co2 emissions , as we see in previous table (1) annual co2 emissions had been increased from fossil fuels and industry from 75.22 million tons in 1990 to 143.84

million tons in 2000 and 258.98 million tons in 2022, per capita co2 emissions from fossil fuels and industry also increased from 1.3 tons in 1990 to 2.0 tons in 2000 and 2.3 tons in2022 which is more than Lower middle-income countries in all years. The share of Egypt in global co2 emissions from fossil fuels and industry increased more than double from 1990 to 2023 while in Lower middle-income countries it increased triple times.

Figure (2) Co2 emissions by sectors or activity in Egypt in (1990-2020)



Source: www.ourworldindata.org

In figure (2) in Egypt manufacturing and construction, electricity and heat and Transport were the highest sectors release co2 emissions in the period (1990-2020). They exchanged positions in years of the period. In 2020 the electricity and heat sector was the first, then transport, and the third one is manufacturing and construction sector.

Simon Kuznets (kuzenets,1955) presented a study titled Economic Growth and Income Inequality in 1955 in which he concluded that in the early stages of economic development, there is inequality in income distribution, but the contrary, in the later stages, there is more equality. This relationship is expressed by the Kuznets curve, an inverted U letter. The original Kuznets curve was replaced by the environmental Kuznets curve, which has the shape of an inverted U letter in a 1991 (Grossman &

Krueger, 1991) study that examined the relationship between economic development (measured by average per capita income) and environmental degradation (which replaced income inequality).

The goal of the Environmental Kuznets Curve theory is to determine how environmental pollution and economic growth are related.it is proposed that while natural resource use is high to achieve higher levels of development, pollution itself grows quicker as material and productivity output are prioritized (Ronario et al., 2022). Income level and environmental degradation have an inverse U-shaped relationship, according to the EKC model (Jiang et al., 2020).

This study aims to investigate included determinants or factors from the group of determinants addressed by previous studies affect carbon dioxide emissions positively or negatively or do not have an impact on it in low-middle-income countries during the period (1990-2022), where **the study assumes** that the independent factors which included in the study have a significant effect on carbon dioxide emissions in low-middle-income countries. The importance of the study comes from the fact that identifying the most important factors affecting carbon dioxide emissions helps countries in trying to reduce those emissions by reducing their causes to reduce their negative effects on the environment and countries in general. **The study examines** determinants of carbon dioxide emissions in low-middle income countries in the period (1990-2022)

the paper is organized as follows: section 2 presents overview of previous empirical works on the relationship between pollution emissions and potential determinants for carbon dioxide emissions. Section 3 discusses econometric model and data to Examine the linkages between carbon dioxide emissions and related independent variables. Section 4 summarizes our results. Section 5 contains the Conclusion and policy implications as recommendations.

2. literature review

Kuznets (1955) provided the basis for the EKC hypothesis, which investigates the connection between inequality in income and economic growth. (Grossman & Krueger, 1991) presented the first set of empirical EKC studies, examining the impact of the environment on the North American Free Trade Agreement, then (Grossman & Krueger, 1995) discuss the economic growth and environment. environmental Kuznets curve (EKC) hypothesis suggests an inverted U-shaped pattern to explain the relation between environmental quality and economic growth (Ben Cheikh & Ben Zaied, 2021).

Several statistical techniques and econometric methods (such as the two-step generalized method of moments (GMM), fixed effect regression, PVAR, autoregressive distributed lag (ARDL) model, Granger causality, etc.) (2015 ,السـيدعبدالقادر) were applied in earlier empirical research, either for panel data or time series. The results were varying and mostly depend on the methods, time periods, sample sizes, and nations (Narayan & Narayan, 2010)).

Research investigated factors affecting environmental pollution such as:

2.1 Economic growth: the research takes economic growth as a main factor affecting environmental pollution. there is much evidence that economic growth typically causes environmental degradation, particularly in the early phases of development. This can also happen in developing countries that rely on energy-intensive production to increase economic productivity, which could result in a rise in pollutant emissions (Jiang et al., 2020). Kahia et al., 2019 found that economic expansion causes environmental degradation.

The relationship between environmental pollutants and economic growth is strongly tied to determining if the environmental Kuznets curve (EKC) hypothesis is valid (Behera & Dash, 2017). they donated GDP per capita (Sharma, 2011) (Hussain et al., 2012) (Ben Cheikh & Ben Zaied, 2021) (2020 ,عيســى), or GDP per capita growth rate (Kais & Sami, 2016) as a proxy for the economic growth.

Liao & Cao, 2013 used 132 countries investigated the link between economic growth and carbon dioxide emissions. he indicated that per capita carbon dioxide emission first significantly and increase at low-income level and flattens after per capita income reaches at about 22,000 $. Kais & Sami, 2016 found positive relation between GDP per capita growth rate and co2 per capita growth rate as an inverted U-shaped Curve Using a panel data model for fifty-eight nations during the 1990–2012 period.

Based on data of Vietnam in 1990–2019, Tran et al., 2022 shown a causal relationship and an impact between Vietnam's economic growth and CO2 emissions. the same result was by Sharma, 2011. Coondoo & Dinda, 2002 found three different types of causality relationship between per capita income and per capita CO2 emission data holding for different country groups based on a Granger causality test to cross-country panel data. Applied to MENA countries Ben Cheikh & Ben Zaied, 2021 investigated the dynamic relationship between carbon dioxide (CO2) emissions and income growth by a nonlinear panel threshold regression framework. They found threshold effect in CO2 emissions.

In contrast Ronario et al., 2022 found economic development is not significantly correlated with carbon dioxide emissions by using (OLS) estimation regression in Philippines from 1976 to 2014. 2020 ,عيســـى also showed by using panel data models in Arab countries from 1980 to 2017, that the economic growth has an effect on co2 emissions in Arab countries in spite of the different results between oil and non-oil countries because of their economic structure.

Abdou & Atya, 2013 indicated that there is a negative relationship between GDP per capita and carbon dioxide emissions in Egypt during the period 1961–2008 because some polices as energy prices which play an important role in the CO2 emissions and so far in Egypt energy products have been subsidized.

a number of environmental pollution or degradation variables had been used including: the annual decrease in forest areas, the concentration of sulfur dioxide in the atmosphere, the per capita

share of carbon dioxide emissions, etc. (2020 ,عيســى), but many studies deal with co2 emissions per capita from fossil fuels and industry in metric tons as a proxy to environmental pollution as a dependent variable (Hussain et al., 2012). because it is one of the most polluting gases to the environment as well as it represents the largest proportion of greenhouse gases that cause global warming (2015 ,السيدعبدالقادر).

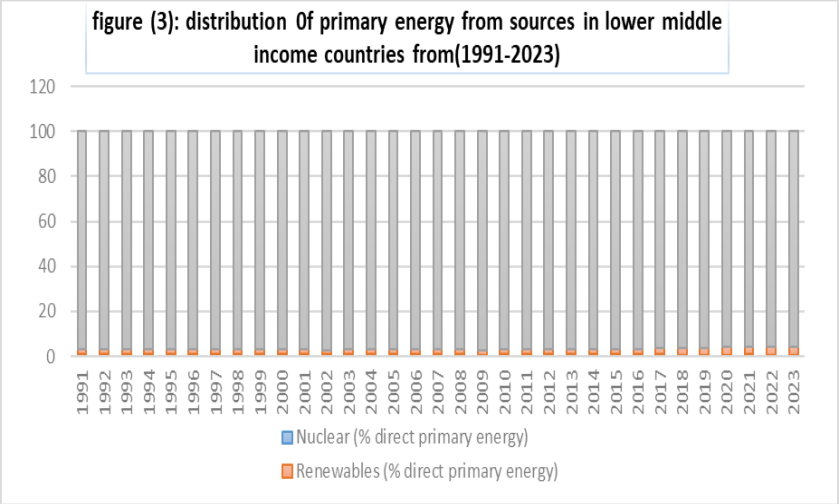
Jiang et al., 2020 analyzes the interaction between regional economic growth and air pollution in China and Korea using sulfur dioxide emission as a proxy of industrial emission and found an inverted U-shaped pattern was found in metropolitan areas while a U-shaped pattern of non-metropolitan areas.

including two indicators for pollutant emissions (sulfur dioxide (SO2) and carbon dioxide (CO2)) Fodha & Zaghdoud, 2010 examined the relationship of economic growth and pollutant emissions in Tunisia from 1961 to 2004 and found that the per capita GDP and the per capita emissions of two pollutants have a long-term co-integrating connection. The link between GDP and SO2 emissions has been determined to be an inverted U. For CO2 emissions, a steady relationship with GDP is acceptable. In contrast 2021,ســمير used environmental pressure on agricultural areas (expressed as total agricultural areas) as an indicator for environment pollution in Algeria between 1980 and 2019 using ARDL model. It was significant to GDP.

2.2 energy consumption: researchers investigated the effect of consuming nonrenewable energy, renewable energy or both with economic growth as the most important determinants of environmental pollution.

energy utilization has a positive impact on carbon dioxide emissions. As global warming and other environmental issues become increasingly serious, there has been a greater focus on the effects of economic expansion on the environment (Kais & Sami, 2016). A nation's ability to develop economically is greatly influenced by its energy usage. Development in the economy necessitates higher rates of production, which raises energy consumption and CO2 emissions (2015 ,السيد عبدالقادر).

The following figure (3) shows the distribution of primary energy from sources in lower middle-income countries as a percentage of the total primary energy where the fossil fuels have the largest percentage around 96% to 97%, renewables energy from 1.8% to 3.6% and nuclear energy less than 1%. So, all countries are still dependent completely on fossil fuels.



Source: : www.ourworldindata.org

A growing number of econometric research based on the EKC hypothesis investigated the link between CO2 emissions, a common proxy for pollution emissions or the environmental degradation, and economic growth in addition to other related factors in developed and developing countries (Liu et al., 2017).

Energy consumption has a great deal of interest as a variable influencing carbon dioxide emissions in recent years, More than one indicator used as a proxy to energy consumption for example Sharma, 2011,used Primary energy consumption per capita and per capita electric power consumption, Hussain et al., 2012 and Liao & Cao, 2013 used Primary energy consumption per capita , Behera & Dash, 2017 used Primary energy consumption per unit

of GDP and Kais & Sami, 2016 used Primary energy consumption per capita growth rate.

To examine the relationship among per capital carbon dioxide (CO2) emission, GDP per capita and energy consumption per capita, Hussain et al., 2012 used time series data from 1971 to 2006 in Pakistan found that there is a long term positive relationship between co2 emissions and energy consumption per capita, Khan et al., 2022 selected South Asian countries from 1972 to 2017 found causality between GDP growth and carbon emission and bidirectional causality between economic growth and energy use and Kais & Sami, 2016 Used also a panel data model, examined the relation of energy consumption on carbon emissions (CO2 emissions) ,it was positive. Mohammadi et al., 2020 using panel data of MENA countries from 2000 to 2015, Mahmood et al., 2020 in five North African nations between 1990 and 2014 and Ronario et al., 2022 using (OLS) estimation regression in Philippines from 1976 to 2014 found that energy consumption has a considerable positive impact on carbon dioxide emissions. The same relation has been found by Liao & Cao, 2013.

Both of Behera & Dash, 2017 for 17 countries in the period 1980–2012 and Sharma, 2011 for 69 countries using a dynamic panel data model the period 1985–2005 used two indicators as a proxy for energy consumption: per capita electric power consumption and per capita total primary energy consumption. They found positive relation with CO2 emission but in the global panel in Sharma, 2011 model the relation was negative between one of the two indicators (per capita electric power consumption) and co2 emissions.

Harrathi & Almohaimeed, 2022 used 3 variables as a proxy for energy consumption in model for 18 MENA countries during the period 1980-2018 and found All determinants are statistically significant for all panels.

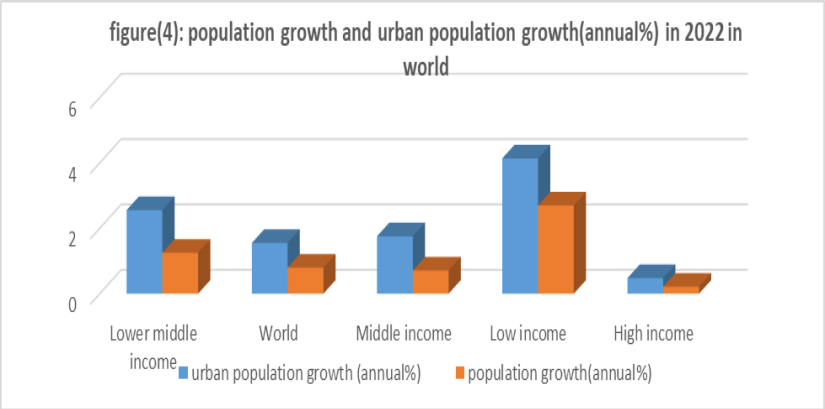
Jebli et al., 2016 used renewable energy use beside non-renewable energy use over a panel of 25 OECD nations in examining the causative links between per capita CO2 emissions

and energy. He demonstrated how rising non-renewable energy leads to rising CO2 emissions, and using more renewable energy reduces CO2 emissions. Bidirectional causality exists between renewable and non-renewable energy consumption.

also, Kahia et al., 2019 investigates the effects of the usage of renewable energy use and other variables on carbon dioxide emissions for a panel of 12 MINA countries for the period 1980–2012. The results demonstrate that while increases in renewable energy, carbon dioxide emissions will decrease.

More explanatory variables or Pollution determinants have been examined to know their effect on environmental pollution or not, such as : annual growth rate of population(Alam et al., 2016) or population density (Liao & Cao, 2013)as a proxy of population, Percentage of urban population (Sharma, 2011) (Liao & Cao, 2013) (Behera & Dash, 2017) (Zhang et al., 2017), trade openness (Sharma, 2011) (Liao & Cao, 2013), foreign direct investment net inflow as percentage of GDP (Ben Cheikh & Ben Zaied, 2021).

2.3 Population: Greenhouse gas emissions, especially carbon dioxide emissions, are increasing due to the rise in population and rapid urbanization (Ronario et al., 2022).



Source: www.worldbankdatabaseindicators.org

from figure (4) lower middle-income countries have the second highest annual growth rate of urban population 1.25% after low-

income countries 2.70%. it is also higher than world average 0.793%. while the high-income countries average 0.21%. for the study countries urbanization annual growth rate is between 3.09% in Angola and 0.11% in Sri Lanka except Lebanon -1.86% and Ukraine -14.32% in 2022.

Yeh & Liao, 2017 and Ronario et al., 2022 found a correlation relation between carbon dioxide emissions and population growth by using (OLS) estimation regression in Philippines from 1976 to 2014, Alam et al., 2016 also examined the impacts of population growth rate for the period 1970–2012 for four countries separately. he found that population growth was statistically significant for India and Brazil only and not significant in other two countries in both the short run and long run.

But Liao & Cao, 2013 used population density to measure population with other indicators and it was significant positive relation.

2.4 Urbanization: Urbanization is a social phenomenon of population migration from rural to urban areas. Urbanization affects energy consumption rates and thus pollution rates (السيدعبدالقادر, 2015).

the implications of urbanization on environment summarize into three theories: ecological modernization, urban environmental transition and compact city theories. Study (Shahbaz et al., 2016) used these three theories to briefly show, at the city level, how environmental aspects were correlated with urban development. The content of these theories shows that the impact of urbanization on carbon dioxide emissions may be negative, positive, or neutral for various reasons mentioned in the theories. It showed the effect of urbanization on energy consumption, which could further influence emissions of carbon dioxide. that effect differed between developing and developed countries. (Zhang et al., 2017)

From the previous graph (4) lower middle-income countries have also the second highest annual growth rate of urban population 2.56% after low-income countries 4.14%. it is also higher than world average 1.56%. while the high-income countries average

0.48% (the lowest average) because these countries passed the stage of industrialization which accompany with high urbanization. for the study countries urbanization annual growth rate is between maximum rate 4.97% in Tanzania and minimum rate 0.989% in Sri Lanka except Lebanon -1.67% and Ukraine -14.08% in 2022.

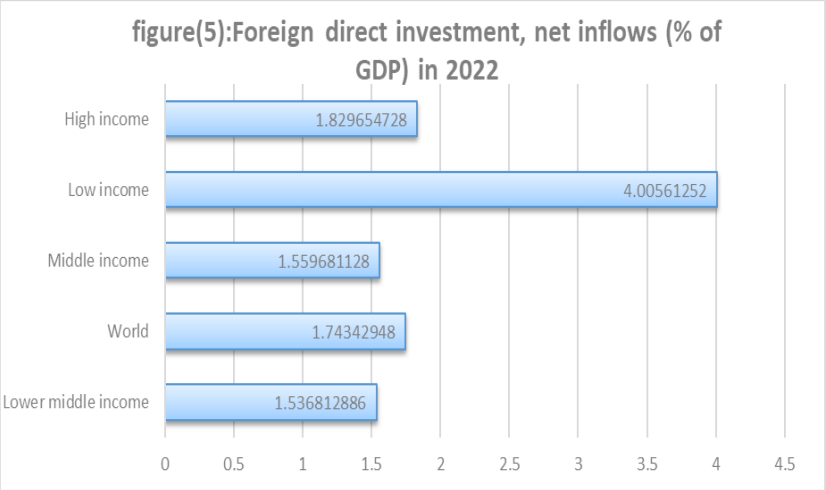
Zhang et al., 2017analyzes the impact of urbanization on carbon dioxide emissions empirically By Using a panel data of 141 countries over the period of 1961–2011. its results show that there is an inverted U-shaped relationship between urbanization and carbon emissions and the turn point is around 73.80%. But excessive urban concentration can claim the benefits of high-level urbanization.

Liao & Cao, 2013 ,Behera & Dash, 2017 , Mohammadi et al., 2020 and Harrathi & Almohaimeed, 2022 said that there is positive relation between urbanization and the absolute level of carbon dioxide emission .But Sharma, 2011 found that Urbanization have a negative impact on CO2 emissions in high, middle and low income panels for 69 countries in the period 1985–2005.Kais & Sami, 2016 also found a negative relation between them.

2.5 Foreign direct investment: Two possible outcomes from FDI might happen as an impact on the environment. First trend is more FDI inflows may result in more emissions on the environment or negative impact (direct relationship) because foreign capital investments, particularly in developing countries, may be accompanied with polluting industry (Pollution Haven Hypothesis (PHH)) (Sapkota & Bastola, 2017). this is supported by two primary arguments. First, corporations in developed countries may be encouraged to relocate their pollution-intensive production to developing countries because of the fierce competition among developing nations to attract foreign direct investment (FDI) and an easing of environmental regulations for foreign firms. Second, pollution-intensive activities become more expensive in developed nations due to the rising costs of reducing

pollution in some sectors of the economy (Demena & Afesorgbor, 2020).

On the other hand, the second trend, foreign direct investment (FDI) may have a positive impact on the environment if it leads to a reduction in emissions (indirect relationship). Theoretically, foreign-owned businesses use greener production methods and are more energy-efficient than domestic businesses. Foreign direct investment (FDI) is likely to utilize cleaner technology than local enterprises in developing nations, even if it does not always use the most advanced technology (Cole et al., 2011). Furthermore, it is possible that international companies will transfer their environmentally friendly technologies to domestic companies through technological spillovers, which would result in a decrease in emissions overall (Eskeland & Harrison, 2003).



Source: www.worldbank database indicators.org

figure (5) shows that lower middle-income countries have the lowest rate of foreign direct investment inflows (%of GDP) in the world 1.54%.it is less than low-income countries 4%. the most attractive country in lower middle-income countries is magnolia 14.61%, Mauritania 14.38% and Cambodia 12.13%.the lowest one is Angola -6.32%.

Kahia et al., 2019 investigates the effects of inflows of foreign direct investment on carbon dioxide emissions for a panel of 12 MINA countries for the period 1980–2012 ,Sapkota & Bastola, 2017 using time series data from 1980 to 2010 for 14 Latin American countries and Mahmood et al., 2020 in five North African nations between 1990 and 2014 .The results demonstrate that while increases in foreign direct investment contribute to reductions in carbon dioxide emissions (negative relation) related to (PHH).

In contrast Behera & Dash, 2017, Tran et al., 2022, Cole et al., 2011and Harrathi & Almohaimeed, 2022 found causal direct relationship between carbon dioxide emissions and foreign direct investment.

3. model, variables and data specification

3.1 the model:

The objective of the study is to investigate the relationship between economic growth and environmental degradation (CO2 emissions) through including other determinants into the carbon dioxide emission function, as per the empirical literature in energy economics.so, the form of proposed model is:

$CO2 = f (GDP, E, URB, FDI, POP)$ (1)

Eq. (1) states that: carbon dioxide emissions(co2), urbanization (URB), GDP (GDP), population (POP), foreign direct investment (FDI) and energy consumption (E).

our suggested model (with a time series specification) takes the following from:

$CO2it = \alpha0 + \alpha1\ GDPt + \alpha2CPCt + \alpha3\ CPGt + \alpha4\ URBt + \alpha5\ FDIt + \alpha6\ POPt + \epsilon t$ (2)

Since our study is a panel data study, Eq. (2) can be written in panel data form as follows:

$CO2it = \alpha0 + \alpha1\ GDPit + \alpha2CPCit + \alpha3\ CPGit + \alpha4\ URBit + \alpha5\ FDIit + \alpha6\ POPit + \epsilon it$ (3)

in Eq. (3): i = 1, 2... N for each country in the panel. t =1,2, …. T refers to the time period, CO2 , it is the dependent variable ,the carbon dioxide emissions (measured in metric tons per capita), and the independent variables are the determines of CO2

emissions which are: (URB) urban population, (POP) annual growth of population,(FDI) foreign direct investment, (GDP) annual growth of GDP per capita, energy consumption E (as explained earlier, we use 2 proxies for energy): (CPG)Primary energy consumption per unit of GDP and (CPC)Primary energy consumption per capita. and εit is the error term.

3.2 Econometric methodology:

Because this is a panel data analysis, we employ a dynamic panel specification in which lagged carbon dioxide emissions emission levels (which has a dynamic panel specification) are considered using the Arellano and Bond (AB, GMM) generalized method of moments estimator in our study (Sharma, 2011). The form of the model we recommend is as follows:

$CO2it = a0\ CO2it\text{-}1 + \beta\ Xit + \psi\ Eit + \mu it + \epsilon it$ (4)

$i = 1, 2... N, \quad t = 1,2, \ldots T$

where CO2it represents per capita CO2 emissions of country i at time t, a0 is the parameter that needs to be evaluated; To model CO2 emissions, a vector of basic explanatory factors (foreign direct investment, population, GDP per capita, and urbanization) is called X; country-specific effects are denoted by μ; and the error term is denoted by ϵ. Furthermore, the effect of energy type variables is captured by ψ, which includes per capita total primary energy consumption and Primary energy consumption per unit of GDP.

Using the panel ordinary least squares (OLS) estimator (with fixed and random effects) poses complications since the correlated lagged dependent variable is linked to the error term. Because the Arellano and Bond methodology first differs the regression model, it can be used to solve this problem. Thus, effects peculiar to a country are eliminated: $E(\epsilon it - \epsilon it\text{-}1) = 0$ but $(co2it\text{-}1 - co2it\text{-}2)$ is not independent of $(\epsilon it - \epsilon it\text{-}1)$

This issue is resolved by the AB approach when two or more lags of the first difference in CO2 emissions are used. The basic assumption is that the energy and the control values are predetermined with considering (Sharma, 2011). The instrument

variables in the model are endogenous variables, they are lag values of independent variables.

3.3 Variables and data source:

From the previous studies to the relation between environmental quality and economic growth, the study used the Annual data for these variables:

• CO2 emissions per capita from fossil fuels and industry in metric tons as the dependent variable extracted from database of our world in data organization.

• The independent variables are urban population as a share of total population, Foreign direct investment net inflows (% of GDP), annual growth rate of population and annual growth rate of GDP per capita. These are downloaded from the World Development Indicators in world bank database.

• Two independent variables are taken to proxy energy intensity, these are: Primary energy consumption per unit of GDP in kilowatt hours per dollar and Primary energy consumption per capita in kilowatt hours. these are extracted from database of our world in data organization.

• All variables are measured in percentage form except CO2 emissions and the two variables for energy consumption. These are values in units.

The study searches the determinants of carbon dioxide emissions during the period (1990-2022) in low-middle-income countries. included 40 countries of lower middle-income countries according to classification of the world bank in 2023.we chosen this group of countries because it includes Egypt as a low middle income country, so the results and recommendations will be suitable for it.

The countries are classifying into two classes of panels according to the average carbon dioxide emissions during ten years from 2011 to 2019. we classify countries to investigate if the two types of countries (high and low carbon emissions) have the same determinants of co2 emissions or not.

The first class is constructed according to co2 emissions more than 1 metric tons. it is consisting of 18 countries (Algeria,

Bolivia, Congo, Egypt, Honduras, India, Iran, Jordon, Kyrgyz, Lebanon, Lesotho, Mongolia, Morocco, Philippine, Tunisia, Ukraine, Uzbekistan, Vietnam). It will be the first panel. the second class is constructed according to co2 emissions less than 1 metric tons. It is consisting of 22 countries (Angola, Bangladesh, Benin, Cabo Verde, Cambodia, Cameroon, Comoros, Ghana, cote devoir, guinea, Haiti, Kenya, Mauritania, Nepal, Nicaragua, Pakistan, Senegal, Sri Lanka, Tajikistan, Tanzania, Zambia, Zimbabwe). It will be the second panel. The third panel is the global panel including all lower middle-income countries in the previous two classes. Our time frame for all variables is for the period (1990 –2022). The countries selected for the study and the timeframe was dictated by data availability and the balanced panel needed.

Table (2): summery descriptive statistics of the variables

	First: Countries with co2 +1				Second: Countries with co2 -1				Third: the global			
	mean	Maximum	Minimum	Std. dev.	mean	Maximum	Minimum	Std. dev.	mean	Maximum	Minimum	Std. dev.
CO2	2.74	15.28	0.31	2.31	0.46	2.21	0.02	0.30	1.48	15.28	0.02	1.93
CPC	11313.90	61924.9	471.96	9237.95	2499.78	14639.24	205.51	2075.97	6489.43	61924.96	205.51	7759.68
CPG	1.83	13.82	0.26	1.67	1.04	7.543	0.14	0.94	1.39	13.82	0.14	1.38
GDP	1.88	46.47	22.52	5.04	1.59	19.94	-37.22	4.84	1.72	46.47	-37.22	4.93
FDI	3.21	43.91	-37.17	4.43	2.56	40.17	-11.19	3.96	2.85	43.91	-37.17	4.18
POP	1.63	11.79	-14.26	1.42	2.22	5.26	0.11	0.81	1.96	11.79	-14.26	1.16
URB	53.32	91.83	13.97	18.38	36.78	68.08	8.854	13.25	44.22	91.82	8.85	17.78

Table (2) for descriptive statistics for co2 emissions and its relative determinants used in this study for three panels. the first panel for low middle income countries which has co2 emission more than 1 metric tons, second one is for low middle income countries which has co2 emission less than 1 metric tons, and the last one is the global panel for all countries together. It shows that

the standard deviation is high in almost all variables, it means they do not have normal distribution. We see it in Jarque Bera test which investigate whether the variables have normal distribution or not, the Null hypothesis is the variables have normal distribution. For the first and third model all variables have probability less than 1% (significant) which means acceptance for Alternative hypothesis that all the variables do not have a normal distribution. the second panel: all variables are the probability less than 1% (significant) except population have a prob. 0.237001 (More than 10%) which means accept null hypothesis that they have normal distribution.

Table (3): Empirical correlations between CO2 emissions and dependent variables

		CPC	CPG	GDP	FDI	POP	URB
First: Countries with co_2 +1	correlation	0.87	0.42	-0.07	0.15	-0.19	0.52
	probability	0.0000	0.0000	0.0968	0.0003	0.0000	0.0000
Second: Countries with co_2 -1	correlation	0.58	0.24	-0.07	0.23	-0.21	0.38
	probability	0.0000	0.0000	0.0756	0.0000	0.0000	0.0000
Third: the global	correlation	0.90	0.45	-0.02	0.15	-0.28	0.59
	probability	0.0000	0.0000	0.5071	0.0000	0.0000	0.0000

Table (3) presents the empirical correlations between carbon dioxide emissions and all variables for the two panels. The correlation coefficients give preliminary insights on the relationship between co2 emissions and the related determinants. for the three panels the related determinants have a correlation with CO2 emissions as the following:

• positively strong correlation to Primary energy consumption per capita (more than 70%) in panel 1&3, but moderate (from 50% to 70%) in panel 2

• positive weak correlation with Primary energy consumption per unit of GDP and foreign direct investment in all panels.
• Negative weak correlation to GDP per capita growth rate in panels 1&2 and not significant in panel 3.
• positive moderate in panel 1&3, weak in panel 2 with urban population
• negative weak correlation (less than 50%) with annual growth of population, in all panels.

3.4 Empirical findings and discussion

Stationary test (panel unit root test): The objective is to decide which variables should enter the model in their level form and which is not. The test is applied for each variable separately to the levels of variables, includes the Levin. Lin &chut (LLC) (levin lin and chu,2002) , the Fisher augmented Dickey-Fuller (ADF) (Dickey and Fuller, 1979), and the Fisher Phillips-Perron (PP) tests (Phillips and Perron, 1988). For all these tests, the null hypothesis is un-stationary with a unit root, while the alternative hypothesis suggests stationary with no unit root.

Table (4) unit root test for the first panel

	level	Levin, in &chut	ADF-fisher chi square	PP- fisher chi square
CO_2	Intercept& trend	-2.61369 0.0045	43.3804 0.1857	52.8798 0.0345
CPC	1st difference	-8.03894 0.0000	189.559 0.0000	354.913 0.0000
CPG	intercept	-5.13496 0.0000	58.6213 0.0100	61.4759 0.0051
GDP	Intercept	-9.13575 0.0012	173.287 0.0000	231.586 0.0000
FDI	intercept	-2.70796 0.0034	65.1711 0.0021	122.426 0.0000
URB	intercept	-4.82275 0.0000	57.8944 0.0118	138.894 0.0000
POP	Intercept& trend	-3.63704 0.0001	91.4324 0.0000	28.9686 0.7909

Table (5) unit root test for the second panel

	level	Levin,lin &chu t	ADF-fisher chi square	PP- fisher chi square
CO_2	1st difference	-10.0375 0.0000	218.262 0.0000	426.525 0.0000
CPC	1st difference	-10.9579 0.0000	240.702 0.6905	425.043 0.8668
CPG	none	-3.90019 0.0000	71.8106 0.0051	117.530 0.0000
GDP	Intercept	-6.67859 0.0000	159.067 0.0000	260.791 0.0000
FDI	intercept	-3.35161 0.0004	109.138 0.0000	160.801 0.0000
URB	intercept	-7.2464 0.0000	65.5198 0.0193	101.432 0.0000
POP	Intercept	-5.10307 0.0000	120.576 0.0000	62.3718 0.0354

Table (6) unit root test for the third global panel

	level	Levin,lin &chu t	ADF-fisher chi square	PP- fisher chi square
CO_2	Intercept& trend	-3.17050 0.0008	89.8973 0.2105	113.022 0.0089
CPC	1st difference	-14.0342 0.0000	428.183 0.0000	764.110 0.0000
CPG	intercept	-5.54806 0.0000	97.9019 0.0848	115.582 0.0057
GDP	Intercept	-11.1628 0.0000	332.353 0.0000	492.378 0.0000
FDI	intercept	-4.31039 0.0000	174.309 0.0000	283.227 0.0000
URB	intercept	-7.45036 0.0000	1233.414 0.0013	240.327 0.0000
POP	Intercept	-3.78789 0.0001	217.108 0.0000	107.984 0.0203

3/5 Estimating the model using the panel method

The following table (7) illustrates the coefficients and probabilities of independent variables in the three models in addition to J-statistic with its probability.

Table (7) the coefficients and probabilities of variables in the models

	The first panel group with co2 more than 1	The second panel group with co2 less than 1	The global panel
$CO_2(-1)$	0.816492 0.0000	0.908038 0.0000	0.808572 0.0000
CPC	6.09e-05 0.0000	9.01e-06 0.0040	6.59e-05 0.0000
CPG	-0.129948 0.0000	-0.019732 0.0000	-0.128528 0.0000
GDP	0.020506 0.0000	0.004153 0.0000	0.015240 0.0000
FDI	0.033865 0.0000	0.001882 0.0063	0.030321 0.0000
POP	0.016643 0.0478	0.010190 0.0076	0.011749 0.0000
URB	-0.016646 0.0610	-0.000613 0.3171	-0.006029 0.0000
J- statistic	11.65661	18.47083	33.78884
Prob.	0.473637	0.359737	0.429223

From the previous table (7):

- for all panels J-statistic is close to zero and the probability is far from zero which Means that all models are good models to estimate the changes in co2 emissions and its determinants.
- lag of co2 emissions (co2(-1)) (as independent variable in the model), Primary energy consumption per capita (CPC), GDP per capita (GDP), foreign direct investment (FDI): have a positive

significant effect on co2 emissions at a moral level of 1% in all panels.

- Primary energy consumption per unit of GDP (CPG): has a negative significant effect on co2 emissions at a moral level of 1% in all panels.
- annual growth of population (POP): has a positive significant relation with co2 at a moral level 5% in the first panel and at a moral level 1% in the second and global panel.
- urban population (URB): has a negative effect on co2 emissions at a moral level of 10% in the first panel, at a moral level of 1% in the global panel, and insignificant effect in the second one.

4. results

- According to statistical results of the econometric models for the three groups of countries, all independent variables had the same relationship with co2 emission in the three models except urban population growth rate (URB). Which answers one of the questions of the study) for which countries were divided into two models other than the global model (which is whether the determinants of carbon dioxide differ in countries with a low level of carbon dioxide from countries with a high level of it. We find that there is no difference between countries and that they all have the same determinants despite the different levels of carbon dioxide in them.
- The rates of co2 emission in the environment are directly correlated with each of these variables: lag of co2 emissions (co2(-1)), GDP per capita (GDP), foreign direct investment (FDI), which can be explain as follows:

• Since the cumulative rates rises gradually in the presence of earlier increases, the percentage of pollution in the environment at earlier times has an impact on the current pollution rates which is consistent with (CDIAC 2024)

• Environmental pollution rises with an increase in the average per capita energy consumption, particularly when (as we previously noted) most of the energy (around 97%) derives from fossil fuels and non-renewable energy sources.

• People can raise their rates of consumption in general and energy especially, due to increasing the average per capita income.

• there is a direct correlation between foreign direct investment and environmental pollution.as FDI increases the environmental pollution increases. This result is consistent with the first trend of interpreting the impact of FDI as negative on emissions. this is because of two reasons, First, corporations in developed countries may be encouraged to relocate their pollution-intensive production to developing countries because of the fierce competition among developing nations to attract foreign direct investment (FDI) and an easing of environmental regulations for foreign firms. Second, pollution-intensive activities become more expensive in developed nations due to the rising costs of reducing pollution in some sectors of the economy (Demena & Afesorgbor, 2020). This result is corresponding to the result of Behera & Dash, 2017, Tran et al., 2022, Cole et al., 2011and Harrathi & Almohaimeed, 2022

• The demand for energy consumption rises in parallel with the pace of population growth, leading to an increase in environmental pollution, which is adapted with the economic theory. The similar result was found by Yeh & Liao, 2017 and Ronario et al., 2022.

• The two indicators for energy use have different results, while primary energy consumption per capita (CPC) has a positive relation with co2 emissions which compatible with the results of previous research, there is an inverse link between primary energy consumption per unit of GDP (CPG) and it in all panels. It indicates that as GDP and energy use for it rises the amount of pollution in the environment decreases.

This can be explained by looking at the production structure of the study countries during the study period, where we find that the study countries tended to decrease the participation rate of the agricultural sector from 25.40% to 15.84% for the years 1990 and 2022, as well as the manufacturing sector from 17.75% to 14.77% for the same two years, in exchange for increasing services from

41.40% to 49.56%.in graph 2 from the high levels in energy consumption is land use and manufacturing.

• there is an inverse relationship between urban population (URB) and co2 emissions, as Environmental pollution rates decrease as the proportion of people living in urban areas rises. Where studies have stated, as we explained earlier, that the relationship between urbanization and may be negative, positive, or neutral for many reasons as: people's awareness and attitude and clean energy sources availability. The found negative relation is The similar result was found by Liu et al., 2017, Kais & Sami, 2016b and contrast with Liao & Cao, 2013, Behera & Dash, 2017, Mohammadi et al., 2020 and Harrathi & Almohaimeed, 2022.

5. Conclusion and policy implications

this study examines the determinants of carbon dioxide emissions in low-middle income countries by using the Arellano and Bond generalized method of moments/dynamic panel data model in the period (1990-2022) inclusive. We divided the countries into two groups based on level of carbon dioxide emissions and a global one in three panel data models. The main findings are economic growth, foreign direct investment, population annual growth have a positive significant effect on carbon dioxide emissions. urban population has a negative effect on co2 emissions in the first and the global panel, and insignificant effect in the second one. The two indicators for energy use have different results, while primary energy consumption per capita (CPC) has a positive relation with co2 emissions which compatible with the results of previous research, there is an inverse link between Primary energy consumption per unit of GDP (CPG) and it.

it can be explained by looking at the production structure of the study countries during the study period, where the participation rate of the agricultural sector and the manufacturing sector decreased, services sector participation rate increased.it can be indicated using less energy.

we cannot prevent environmental pollution, as it is linked to economic activities, which are growing in all countries, so Policy

implications in this study to improve the environmental quality and attain the sustainable growth can be summarized as follows: first: environmental concerns must be included in development plans to increase clean energy consumption. Second: Institutions are crucial to making progress toward establishing laws and regulations that effectively reduce industrial pollution and optimize energy usage. third: Making energy fuel mix to mitigate co2 and other emissions and encourage the consumer to use clean energy by pricing policies. Fourth: Green technology developments ought to be supported by governments. the government should encourage foreign direct investment to invest in renewable energy sources like solar and wind energy or low carbon energy. It might also present chances to utilize less energy from fossil sources. Fifth: Encouraging residents to move to new urban constructed areas by giving them advantages and facilities in those areas to increase urbanization rates in those countries. Sixth: implementing carbon emission tax for environmental impacts to encourage using renewable energy sources.

This suggests that countries (including Egypt) could be able to prevent themselves from being vulnerable to climate change and having their energy infrastructure enclosed in carbon-intensive development patterns. The Differences between countries must also be considered. In terms of their nature, their resources, size and type of pollutants.

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