

Industrial Production and Carbon Emissions: A Comparative Analysis of Selected Arab and European Countries (1990–2023) ¹

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Abstract: The study investigated the impact of industrial production on carbon emissions in selected European countries versus selected Arab countries. Using the econometrics methodology by applying the Granger Causality Test, (OLS) Model, Fixed Variable Panel data VS Random Variable Panel data models. The results showed that industrial production causes carbon emissions and vice versa in the EU countries, as for the case of Arab countries industrial production does not cause carbon emissions, this may reflect the differences between the volume of industrial production in each case, this result is consistent with (Abokyi et al., 2019), in addition there is an impact of industrial production on carbon emissions in both groups of countries, this means that every rise in industrial production leads to a corresponding rise in carbon emissions, which aligns well with the current reality and is supported by (Xiaoqing & Jianlan, 2011). The study recommends targeting sectors like chemicals, cement, and iron and steel petrochemicals, which account for over 70% of total emissions, aligning with the findings of (Brown et al., 2012). Alternatively, it is crucial to measure the emissions generated by industrial operations to comprehend the worldwide carbon balance and create an appropriate climate strategy, as stated by (Liu, 2016). The study also recommends stimulate an industrial investment environment compatible with environmental protection and carbon reduction considerations in Arab countries highlighting the importance of using new and renewable energy and clean technology in manufacturing from all countries of the world so that it can achieve sustainable development.

Keywords: Industry, Industrial production, Carbon Emissions, Arab Countries, European Union Countries.

الإنتاج الصناعي وانبعاثات الكربون: دراسة مقارنة لعدة دول عربية ودول أوروبية (1990-2023) ¹

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المستخلص: هدفت الدراسة إلى استكشاف أثر الإنتاج الصناعي على انبعاثات الكربون في عدة دول أوروبية مقابل عدة دول عربية باستخدام منهجية الاقتصاد القياسي حيث تم تطبيق اختبار جرانجر للسببية، نماذج انحدار خطي متعدد (OLS)، نماذج تحليل لوحة المتغيرات الثابتة، ونماذج (تحليل لوحة المتغيرات العشوائية). أظهرت النتائج أن الإنتاج الصناعي يسبب انبعاثات كربونية والعكس صحيح في حال الدول الأوروبية، أما في حال الدول العربية فإن الإنتاج الصناعي لا يسبب انبعاثات كربونية، وربما يعود ذلك لاختلاف حجم الإنتاج الصناعي في كل حالة، هذه النتيجة تتوافق مع نتائج دراسة (Abokyi et al., 2019). كما أكدت النتائج أن هناك تأثير للإنتاج الصناعي على الانبعاثات الكربونية في كلا المجموعتين من الدول، إلا أن التأثير أكثر وضوحاً في حالة الدول الأوروبية وهذا يعني أن كل ارتفاع في الإنتاج الصناعي يؤدي إلى ارتفاع مماثل في انبعاثات الكربون، ولكن نسبة الارتفاع في حال الدول الأوروبية أعلى منها في حالة الدول العربية، وهو ما يتوافق بشكل جيد مع الواقع الحالي ويدعمه نتائج دراسة (Xiaoqing & Jianlan, 2011). وأوصت الدراسة بضرورة تركيز الجهود نحو تخفيض انبعاثات الكربون من القطاع الصناعي عامة، واستهداف صناعات المواد الكيماوية، الاسمنت، البتروكيماويات والحديد والصلب حيث تمثل وحدها أكثر من 70% من إجمالي انبعاثات الكربون من القطاع الصناعي، ويتوافق ذلك مع دراسة (Brown et al., 2012). وأنه من الضروري قياس الانبعاثات الناتجة عن العمليات الصناعية لفهم توازن الكربون في جميع أنحاء العالم ووضع استراتيجية مناخية مناسبة أكثر عدالة مع وضع سياسات صناعية في الدول العربية تحفز بيئة استثمار صناعي متوافقة مع اعتبارات حماية البيئة وخفض الكربون. وهذا يؤكد أهمية استخدام الطاقة الجديدة والمتجددة والتكنولوجيا النظيفة في التصنيع في جميع دول العالم.

الكلمات المفتاحية: الصناعة، الانتاج الصناعي، انبعاثات الكربون، الدول العربية، دول الاتحاد الأوروبي.

¹ The selected arab countries are: Egypt, Saudi Arabia, Syria, UAE, and Tunisia, the selected European countries are: Germany, France, Sweden, Spain, and the UK.

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1. INTRODUCTION

The 2007 IPCC Fourth Assessment Report states that burning fossil fuels is the primary source of greenhouse gases, accounting for 95.3% of the total CO₂ emissions. Many domestic academics examine the connection between CO₂ emissions energy consumption and economic growth from a qualitative and quantitative research standpoint. However, the connection between industrial restructuring and a low-carbon economy is less well-studied, and most research focuses on qualitative analysis.

In this study, the impact of industrial production on the Co₂ emissions, in selected Arab countries Vs selected European countries are examined. The Arab countries were compared with the European Union countries, these countries were chosen for study as they are classified as among the most industrialized countries in both groups to challenge the idea of equal obligations in climate change negotiations based on the damage caused by carbon emissions, particularly from industrial production.

The US EPA (2016) states that the consumption of fossil fuels is the main cause of CO₂ emissions worldwide, and empirical evidence supports this claim (Kwakwa and Alhassan, 2018); Nnaji et al., 2013).

This study aims to test the hypothesis:

H0: Industrial production is the main cause of carbon emissions in Arab countries compared to European Union countries during the period 1990-2023.

H1: Industrial production is not the main responsible for carbon emissions, applying to the Arab countries compared to the state of the European Union countries during the period 1990-2023.

H2: The volume of industrial production in Arab countries is much less than the volume of industrial production in European countries.

H3: The volume of carbon emissions in Arab countries is much less than the European countries.

The study adopts the methodology of econometrics by applying the Granger Causality Test, and then the (OLS) Model, fixed panel Vs random panel data also applied.

Often used to test the cointegration relationship between two variables, the Engle-Granger test consists of two steps: cointegration regression is the first step, and Granger causality tests are used to confirm the relationship between the CO₂ and the Indus variables in the chosen countries.

The World Bank Data Indicators WDI (2024) version of the annual time series data, which covered the years 1990–2023, was used in the study. Since information on CO₂ emissions in the chosen Arab and EU nations was available, this time frame was used. Value added (as a percentage of GDP), industry (including construction), GDP (constant 2015 US\$) as a control independent variable, and CO₂ emissions (kg per 2021 PPP \$ of GDP) as the dependent variable were among the variables of interest for which data was gathered.

2. LITERATURE REVIEW

From the energy consumption perspective (Wise et al., 2007) present an overview and scenario findings from the long-term energy consumption model in the US industrial sector, which included a module in the ObJECTS-MiniCAM integrated assessment model. With an emphasis on energy technologies and fuel choices spanning a century, this new industrial model enables the assessment of the industrial sector's response to climate policy within a framework of global modeling. The study clarified that one of the significant issues was defining an aggregate level that could reflect the dynamics of industrial energy demand reactions to pricing and regulations while still being manageable over an extended period.

(Alberola et al., 2008) conducted a critical analysis of the effects of industrial output on spot pricing for emissions permits during Phase I for industries covered by the EU Emissions Trading Scheme (EU ETS) from the perspective of industrial production (2005-2007). Initially, sector production indices are used as a proxy to measure economic activity in the industries that are subject to the EU ETS. The ratio of allowance allocation to baseline CO₂ emissions is used to calculate the amount that an installation is restricted by the EU ETS. According to the study, changes in carbon pricing are a result of industrial production in the three industries that are subject to the EU ETS: combustion, paper, and iron. They also show that errors in energy price predictions and extreme weather events also affect carbon prices.

Although the goal of (Xiaoqing & Jianlan, 2011) study was to quantify the relationship between CO₂ emissions and industrial structure adjustment, the study found that there is a long-term stable equilibrium relationship between the two in Shandong Province. Granger causality tests also demonstrate that the industrial structure is the cause of the change in emissions, but the latter is not the cause of the former. Three key findings are obtained by constructing the decomposition model of CO₂ emissions, which measures the contributions of industrial structure, technical efficiency, and economic growth to the growth of CO₂ emissions: (1) The overall economy's shift is the primary driver of emissions; (2) the industrial structure's shift contributes differently to emissions at different phases, from 1994 to 1999 and from 2006 to 2009.

(Brown et al., 2012), found that an ongoing, dedicated effort is needed to reduce industrial emissions and the alternatives for lowering industrial CO₂ are also described in this briefing paper. Focusing on the industries that contribute the most share (>70%) of emissions, including chemicals, cement, and iron and steel petrochemicals. The article provides a summary of industrial mitigation, technologies, including those that relate to specific processes as well as spread over the entire sector. The potential for these to reduce technology, their affordability and adoption challenges, as well as the policies to remove these obstacles are covered. The study concluded that to fully grasp the scope of energy efficiency and emissions abatement options, a concentrated effort to enhance emissions measurements and benchmarking is still required. The implementation of cross-cutting energy efficiency improvements should be hampered by certain obstacles, which should be addressed. These barriers are frequently "social" in nature, such as managerial and organizational structures or ignorance, as opposed to financial. Increases in energy efficiency can save a lot of CO₂ and are frequently inexpensive or even free. It is important to use suitable mechanisms, like a carbon price, subsidies, or regulations, to encourage the use of biomass and waste instead of fuels and raw materials.

In his 2015 study, "National carbon emissions from the industry process: Production of glass, soda ash, ammonia, calcium carbide, and alumina," Zhu Liu attempted to determine the relationship between industrial production and carbon emissions in China, one of the world's most industrialized nations. He did this by estimating the carbon emissions from the manufacturing of five major industrial products and calculating the emissions from five different types of major industry production processes using a bottom-up data source approach. He discovered that quantifying the emissions from industrial processes is essential for comprehending the global carbon budget and creating an appropriate climate policy.

However, in their attempt to examine the same relationship over an extended period in Turkey, (Gokmenoglu et al., 2015) used the Granger causality test and discovered a unidirectional association between financial development and carbon emissions.

According to (Andrew, 2018) quantifying global process emissions from cement production is difficult due to data availability issues and the need for strong assumptions for analysis. It is no longer feasible to use cement production data with constant emission factors since countries all over the world have been producing cement with decreased clinker ratios during the past three decades. Compared to other attempts, the new worldwide cement emissions database given here relies less on conjecture and more on official and trustworthy data sources. The database is meant to be utilized in the global carbon budget and updated yearly with new data and improved methodology. Data will increasingly replace assumptions in the creation of datasets as more nations estimate their emissions and provide detailed

reports to the UNFCCC. Since China and India are the two biggest manufacturers of cement worldwide and official time-series estimates are insufficient, there is still work to be done to improve estimates of cement emissions from both countries.

Focussing on how fossil fuels affect CO₂ emissions is unusual for developing countries like Ghana (Abokyi et al., 2019). The ARDL approach was applied in this investigation. Analyzing the feasibility of applying the Bayer-Hanck joint cointegration method and structural breakdowns The EKC hypothesis highlights the importance of fossil fuel use and economic growth in Ghana's dynamic link between industrial deFeroz Kazivelopment and carbon dioxide emissions (CO₂). Cointegration of the elements is found, and the long- and short-term characteristics both showed indications of industrial growth and a U-shaped link between CO₂ emissions, which was further confirmed. according to Lind and Mehlum's U-test. There is a one-way causal relationship in the short term between CO₂ emissions and the usage of fossil fuels. The study encourages the efficient application of policies. A one-way causal relationship between the usage of fossil fuels and CO₂ emissions was demonstrated via the short-run causality. To achieve policy objectives, the paper advocates for low-carbon emission and efficient technologies.

(Sibanda & Ndlela, 2020) tried also to investigate the relationship between agriculture/ industrial output and carbon emission in South Africa using annual frequency data for the 1960-2017 data set, applied the Autoregressive Distributed Lag (ARDL) technique, they found that industrial output had no effect on carbon emission, but agriculture output negatively influenced by carbon emission and industrial output, then adversely affecting food security.

The focus of (Islam et al., 2017) is on environmental awareness and its connection to economic development. Researchers have long maintained that both should be reduced since sustainable growth and environmental degradation are interdependent. This study looks at how Bangladesh's industrial production index growth, total energy consumption, and economic development relate to environmental degradation (using carbon emissions as a proxy for degradation) between 1998 and 2013. This study uses the Vector Autoregression (VAR) Model and variance decomposition of VAR to investigate the relationship between these factors and carbon emissions. The VAR model's findings show a strong correlation between industrial production, GDP per capita, and carbon emissions. Carbon emissions regularly affect industrial output, according to additional study employing variance decomposition.

According to (Yoro & Daramola, 2020), researchers have worked extremely hard to decrease the amount of anthropogenic CO₂ that is released into the atmosphere. The literature reviewed in this study demonstrates that various methods, including adsorption, absorption, and membrane separation, have been proposed and tested in the literature for CO₂ capture. CO₂ capture is a costly technology in many nations due to the high energy and material requirements of the current methods. In order to lower the high energy and material needs in the previously mentioned CO₂ capture systems, this study proposes that the application of process integration techniques through heat and mass exchanger network synthesis can be expanded. Furthermore, the study's research findings demonstrate that the primary human activities responsible for greenhouse gas emissions and global warming include transportation, cement manufacture, and electricity generating. With the addition of CO₂ collection mechanisms to the current power plants, this study proves that burning fossil fuels (such as coal) to generate electricity is still possible.

According to (Rahman et al., 2022), industrial processes and product use (IPPU) have been steadily increasing in the Kingdom of Saudi Arabia. Emissions from the IPPU have been trending upward. This study looked into cross-sectional and time-series analyses of the IPPU industry. The Kingdom's top source categories are cement, iron and steel, and petrochemicals. The production of titanium dioxide, zinc, and aluminium has expanded in recent years. In 2020, emissions from IPPU (excluding energy use) reached 78 million tons of CO₂ equivalent (CO₂eq), with the cement industry being the largest contributor (35.5%), followed by the petrochemical (32.3%) and iron and steel industries (16.8%). A scenario-based projection estimated that emissions could range between 199 and 426 million tons of CO₂eq by 2050. The Kingdom's efforts primarily focus on climate change adaptation and economic

divergence while achieving mitigation co-benefits. Key mitigation strategies for this sector include (i) energy efficiency, (ii) emissions efficiency, (iii) material efficiency, (iv) product recycling and material reuse, (v) extended product lifespan, and (vi) demand management.

(Zhang et al., 2022) examined the CO₂ emissions inventory and its uncertainty analysis of China's industrial parks. Industrial parks are essential to reaching carbon neutrality and the carbon peak in industrial sectors. The first stage in reaching the carbon peak of industrial parks is creating the inventory of CO₂ emissions. This study created a thorough inventory of CO₂ emissions for industrial parks that included three sections: waste disposal, industrial processes, and energy usage. The study created an uncertainty analysis framework and took scope 1, 2, and 3 emissions into account. By breaking down the emissions into scopes 1, 2, and 3, scope 2 can be found to be the biggest source of emissions. The study also included activity levels, emissions factors, and unspecific factors in its inventory uncertainty analyses. These findings could, in general, encourage the development of greenhouse gas accounting guidelines for industrial parks in China.

(Kurnia et al., 2020) explored four key aspects of firm value: the impact of carbon emission disclosure on firm value, the influence of good corporate governance on firm value, the mediating role of financial performance between carbon emission disclosure and firm value, and the mediating role of financial performance between good corporate governance and firm value. The study analyzed a sample of 43 mining, agricultural, and manufacturing companies listed on the Indonesian Stock Exchange from 2015 to 2017. Carbon emission disclosure was assessed using the Environmental Aspect indicator from the Global Reporting Initiative Series, while corporate governance was evaluated based on factors such as investor disclosure, audit committees, boards of directors, outside directors, shareholder rights, and internal auditors. Financial performance was measured using return on investment as a key indicator.

In an article published before the UN Global Climate Summit in Paris, (Yessekina, 2015) explores current trends in global warming, greenhouse gas pollution, and debates regarding the roles of industrialized and poor nations. The article talks about decarbonization as a national program that involves advanced tools for reducing CO₂ levels, improving energy efficiency, and setting up emissions trading systems. The author emphasizes that because Kazakhstan and Turkmenistan have the greatest potential to emit greenhouse gases (GHGs) in the region, they should be included in the UNFCCC and participate in the global effort to build national decarbonization programs. These policies enable these nations to participate in the global carbon trading market, access foreign financial resources, and substantially lower CO₂ emissions in the area.

(Bezić et al., 2022) Explored the factors causing CO₂ emissions in the EU and the potential for reducing them in the fourth industrial revolution. The study focuses on the 27 EU countries and examines the Panel Generalized Method of Moments (GMM) two-step dynamic estimator from 2012 to 2019. The study found that the EU is focused on sustainable development through its strategies and economic policies. The results also show that creativity economic components that influence a country's growth and prosperity, are all negatively correlated with CO₂ emissions and, therefore, make a substantial impact on the decrease in carbon dioxide emissions. based on the empirical findings, it can be inferred that The EU must increase innovation activity and technological advancements to achieve sustainable development goals.

By evaluating their Circular Carbon Economy Index (CCEI), we examine Saudi Arabia (KSA), atar,the United Arab Emirates (UAE), Kuwait, Algeria, and Iraq on the effects of implementing carbon capture and storage technology in the Kingdom (Baidas, 2024), Saudi Arabia, Qatar, the United Arab Emirates, and Kuwait all scored higher on the CCEI than Algeria and Iraq, according to the study. This indicates that these countries have implemented CCE-transition policies more thoroughly and have increased funding for modernization projects that aim to reduce emissions, change their industrial composition, develop top-notch human resources, and raise the caliber of their governmental bodies.

Hence, all previous studies and literature in the field of studying the relationship between industrial production and carbon dioxide emissions did not agree on the direction of the relationship between the two variables absolutely, and none of them dealt with the study of the causal relationship between the two variables in the group of European Union countries compared to the group of Arab countries. In examining the direction and magnitude of the relationship between industrial production and carbon emissions in two sizable groups of nations—one serving as a model for developed nations and the other as a model for developing nations—the current study should be a useful scientific addition. A variety of research techniques from earlier studies are employed in this one.

3. RESEARCH METHODS AND DATA SOURCES

3.1. DATA

Table (1) below lists the variables that were selected to investigate the relationship between industrial production and carbon emissions in the selected Arab countries and the selected European Union countries between 1990 and 2023. All of the variables that make up the econometric model are defined in Table (1). Every annual statistic used in the model, which covers the years 1990–2023, was taken from World Bank tables. The data analysis was carried out with E-Views 12.

Table (1): The model's economic variables

Name	Code	Data Source	Definition
Industry (including construction), value added (% of GDP)	Indus Arab Indus Eu	World Bank Database	ISIC divisions 05–43 are associated with industry (including construction) and manufacturing (ISIC divisions 10–33). It encompasses value-added in construction, mining, manufacturing (sometimes shown as a separate subdivision), power, gas, and water. A sector's net output after subtracting intermediate inputs and totalling all outputs is known as value added.
CO2 emissions (kg per 2021 PPP \$ of GDP)	Co2Arab Co2Eu	World Bank Database	Emissions of carbon dioxide are produced when fossil fuels are burned and cement is made. Among these are carbon dioxide emissions from gas flaring and the ingestion of solid, liquid, and gas fuels.
GDP (constant 2015 US\$)	GDPArab GDPEU	World Bank Database	Gross Domestic Product (GDP) at buyer's prices represents the total gross value added by all domestic producers to the economy, including product taxes and excluding subsidies that influence product value. The data is presented in US dollars, adjusted to constant 2015 prices.

(Source: World Bank national accounts data, and OECD National Accounts data files, <https://tradingeconomics.com/united-states/co2-emissions-kg-per-ppp-dollar-of-gdp-wb-data.html>)

3.2. METHODOLOGY

The study intends to ascertain the relationship between CO2 emissions (kg per 2021 PPP \$ of GDP) and industry value added (% of GDP), including construction, in the Arab countries group vs the European Union countries group from 1990 to 2023. The direct and unambiguous causal relationship between industrial production and carbon emissions is explained by the Granger Causality Test. The relationship between industrial production and carbon emissions was further investigated using the Ordinary Least Square (OLS) model and the Panel data fixed vs. random model. the main model will take the following formula:

$$Y_{it} = \alpha + \beta_1 X_{1it} + \beta_2 X_{2it} + \varepsilon_{it} \quad (1)$$

Where Y_{it} is the dependent variable, refers to the CO2 emissions (kg per 2021 PPP \$ of GDP)

α is the intercept,

β_1 represents the partial coefficients for the independent variable X_{1it} (which refers to Industry (including construction) value added (% of GDP))

β_2 represents the partial coefficients for the independent variable x_{2it} (which refers to GDP (constant 2015 US\$) as a control independent variable)

In the study, this model will be applied twice. It will be used to examine the effects of industrial value added on Co2 emissions in these selected Arab countries. Then, it will be used to examine the same relationship in the selected European Union countries group.

4. RESULT ANALYSIS AND DISCUSSION

4.1. DESCRIPTIVE AND TESTS FOR MODEL VARIABLES:

Table(2): Descriptive Statistics for the selected Arab countries

	CO2	GDP	Indus
Mean	0.300596	25.45147	3.566417
Median	0.281696	25.87089	3.529392
Max	0.723988	27.38514	4.196139
Min	0.125933	23.18477	2.740281
Std. Dev	0.125933	1.299949	0.339997
Jarque- Bera	42.10700	17.51101	4.494070
Prob	0.000000	0.000158	0.105712
Sum	51.101134	4326.750	606.2908
Sum Sq. Dev	2.553747	285.5876	19.53601
Observations	170	170	170

Source: Calculated by the researcher using E-views 12, and World Bank data

Quantitative insights into the chosen data series are offered by descriptive statistics. Standard deviation and central measurements are shown in Table (3) below and Table (2) above. According to the findings, the mean of every variable chosen during the study period was positive. However, when compared to the other variables in the model, a high standard deviation indicates the highest value (GDP) in Arab countries and an identical outcome for the chosen European countries.

Table (3): Descriptive Statistics for the selected European countries

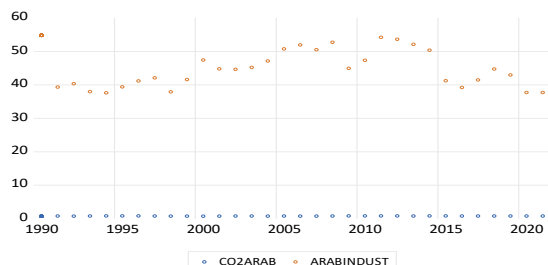
	CO2	GDP	Indus
Mean	0.146994	3.140360	28.02127
Median	0.143069	3.165157	28.32791
Max	0.283526	3.512266	28.92124
Min	0.053992	2.797015	26.36917
Std. Dev	0.052231	0.173807	0.753421
Jarque- Bera	5.517755	9.099720	21.35240
Prob	0.063363	0.010569	0.000023
Sum	24.98906	533.8612	4763.615
Sum Sq. Dev	0.461037	5.105282	95.93175
Observations	170	170	170

Source: Calculated by the researcher using E-views 12, and World Bank data

In general, there are three steps to be followed according to the methodology of studying time series: The unit root test to determine the degree of integration, the co-integration test between this series, and the causality test. In this study, these three standard steps were followed according to Enders (1995) for the following reasons: 1st, to ensure that all variables under study are stationary whether at the levels or at the first differences (unit root test), 2nd, to identify the possibility of complementarity relationships between variables in the long run (cointegration tests), 3rd, to determine the direction of causation, further

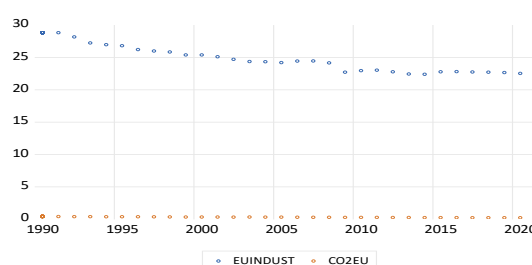
Autoregressive distributed lags (ARDL) model will be applied, because this model uses a general-to-specific modelling framework with enough lags to represent the data generation process.

Figure (1): Trends of CO2 In Arab Countries and Arab Industrial Output



Source: World Bank Data Website

Figure (2): Trends of CO2 In EU Countries and EU Industrial Output



Source: World Bank Data Website

4.2. UNIT ROOT TEST:

The stationarity of the time series and the order of data integration are assessed using a unit root test. The null hypothesis states that $D(\text{ARABCO}_2)$ has a unit root. Based on the unit root test results at the first difference, as shown in Table (3), the null hypothesis can be rejected, indicating that the variables do not have a unit root.

Table (4): Unit Root Test Results Augmented Ducky- Fuller

Variables	Level		1st difference
	Test	Prob	Prob
EUINDUST (For Eu industry)	Fisher ADF	0.000044	0.0005
ARABINDUST(For Arab country's industry)	Fisher ADF	0.000000	0.0000
EUCO2 (For Eu co2 emissions)	Fisher ADF	0.000031	0.0004
ARABCO2 (For Arab countries co2 emissions)	Fisher ADF	0.000015	0.0002

Source: Calculated by the author, using WB data, and applied with E-views

4.3. JOHANSEN COINTEGRATION TEST

4.3.1. FOR ARAB COUNTRIES:

Table(5):Unrestricted Cointegration Rank Test (Trace)

Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	1.000000	1062.576	12.32090	0.0000
At most 1	0.066374	2.060374	4.129906	0.1782

Source: Calculated by the author, using WB data, and applied with E-views

The study accepts alternative hypothesis H1, which states that industrial production in Arab countries was not the primary cause of carbon emissions, and vice versa for European countries. This is because the previous results of the ADF unit root test, which are shown in Table 3, show that the null hypothesis of unit root is rejected for all variables, i.e. integrated of order 0 (I(0)).

4.3.2. FOR EU COUNTRIES:

Table(6): Unrestricted Cointegration Rank Test (Trace)

Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	1.000000	1091.909	20.26184	0.0000
At most 1 *	0.297638	10.59918	9.164546	0.0265

Source: Calculated by the author, using WB data, and applied with E-views

The previous results indicate that the trace statistic is greater than the critical Value (0.05) at the first deference, so we can reject H0 (Where there is just one cointegration between variables), and accept the alternative hypothesis H1, which means that there is more than one cointegration between variables for the European countries group.

4.4. GRANGER CAUSALITY TEST:

The Granger causality test is used to assess whether one time series can help forecast another by examining causal relationships between two variables over time. This method provides a probabilistic approach to causality by analyzing observed data for correlation patterns. A key advantage of time series vector autoregression (VAR) is its ability to test causality in a specific sense. Originally introduced by Granger (1969), this test is commonly referred to as the Granger causality test (Feroz Kazi, 2020). In this study, the Granger causality test will be applied to examine the relationship between CO₂ emissions and the value added by the industry (including construction) as a percentage of GDP in Arab and EU countries.

Table (7): Granger test results

Null Hypothesis:	Obs	F-Statistic
CO2ARAB does not Granger Cause ARABINDUST	30	0.0226
ARABINDUST does not Granger Cause CO2ARAB	0.9373	0.4050
Null Hypothesis:		
CO2EU does not Granger Cause EUINDUST	30	1.8540
EUINDUST does not Granger Cause CO2EU	1.2054	0.3164

Source: Calculated by the author, using WB data, and applied with E-views12

The results above show that :

CO2EU  EUINDUS

As F Statistic is greater than F Probability, then we accept H0 and refuse H1, so there is a causal relationship between variables. This means that there is a positive relationship between industry and Co2 emission in European countries, but also each of the two variables causes the other one.

ARABINDUST  CO2ARAB

But for Arab countries, the result shows that ARABINDUST does not Granger Cause CO2ARAB, this is a logical result as the size of the industrial sector and production in the Arab countries is still below the level that raises carbon emissions, and on the contrary in the case of European countries, where the volume of industrial production increases and carbon emissions rise with it, and the relationship here is mutual. This result is consistent with Ghana Eric Abokyi & others(2019). This result supports the necessity of reconsidering industrial development plans in Arab countries and strategies to support industrial production.

4.5. Ordinary Least Squares (OLS) MODEL:

In its simplest form, OLS regression is used to assume a linear relationship between the x predictor and the y result variable in many scientific domains, including economics. It solves the $y = a + bx + e$ model, where e is the residual error, or the difference between the predicted and actual score for any given value of x , b is a regression coefficient that quantifies how much y varies for every unit change in x , and a is an intercept or value of y at $x = 0$. Since it establishes the degree, direction, and intensity of the relationship between y and x , the regression coefficient b is the most significant (Kleinbaum et al., 1988).

So, in this study, the OLS model was applied as mentioned in the methodology above, and in Table (7) The results show that industrial production in Arab countries affects carbon emissions, as the coefficient has a positive sign and a value of 0.19. Table (8) also shows that for the European countries, industrial production also affects Co2 emissions as the coefficient has a positive sign and a value of 0.21. Hence, the previous results support the scientific fact that industrial production increases carbon emissions, but noting that this effect in European countries is stronger than its counterpart in Arab countries, this is due to the huge volume of industrial production in European countries. This result is consistent with (Xiaoqing & Jianlan, 2011).

Table(8): OLS model for Arab countries

Variable	Coefficient	Std. Error	T - Statistics	Prob.
c	1.748	0.172	10.11	0.0000
INUS	0.196	0.040	4.882	0.0000
GDP	-0.084	0.010	-8.010	0.0000
R^2	0.301			
Adjusted R^2	0.293			
Log Likelihood	146.16			
F- Statistic	36.096	Durbin - Watson	0.054	
Prob(F-Statistic)	0.000000			

Table(9): OLS model for Arab countries

Variable	Coefficient	Std. Error	T - Statistics	Prob.
c	-1.311	0.126	-10.327	.0000
INUS	0.215	0.016	13.313	.0000
GDP	0.027	0.003	7.442	.0000
R^2	0.540			
Adjusted R^2	0.535			
Log Likelihood	327.299			
F- Statistic	98.357	Durbin - Watson	0.059	
Prob(F-Statistic)	0.000000			

Source: Calculated by the author, using WB data, and applied with E-views

4.6. Panel data model:

Data that shows how entities (i) behave across time (t) is called panel data, sometimes referred to as longitudinal or cross-sectional time-series data. (X_{it} , Y_{it}), where $t=1, \dots, T$; $i=1, \dots, n$. Panel data addresses the bias caused by omitted variables due to the diversity of the data. This is achieved by taking into consideration variables that are associated with the predictors but are not observable, accessible, or quantifiable. There are two types: entity fixed effects are variables that don't change over time but vary from one entity to another (cultural factors, differences in business practices between businesses, etc.).

Time-fixed effects are variables that vary over time but do not vary between entities (such as international agreements, federal rules, and national policies).

So, in this study the time fixed and the random models were applied as The entity fixed effects regression model is $Y_{it} = \alpha_i + \beta X_{it} + u_i + e_{it}$, where;

Y_{it} outcome variable (for entity i at time t).

α_i is the unknown intercept for each entity (n entity-specific intercepts).

X_{it} is a vector of predictors (for entity i at time t).

ui within-entity error term ;

eit overall error term.

While the entity and time-fixed effects regression model is $Y_{it} = \alpha_i + \beta X_{it} + \delta t + ui + eit$,
where;

Y_{it} outcome variable (for entity i at time t).

α_i is the unknown intercept for each entity (n entity-specific intercepts).

X_{it} is a vector of predictors (for entity i at time t).

δt is the unknown coefficient for the time regressors (t) ui within-entity error term ;

eit overall error term.

Table(10):
Fixed effects regression results for Arab countries

Variable	Coefficient	Std. Error	T - Statistics	Prob.
c	0.466	0.247	1.888	0.060
INUS	0.039	0.023	1.691	0.092
GDP	-0.012	0.009	-1.226	0.221
R^2	0.872			
Adjusted R^2	0.868			
Log Likelihood	290.928			
F- Statistic	186.480	Durbin-Watson	0.154	
Prob(F-Statistic)	0.000000			

Table (11):
Fixed effects regression results for EU countries

Variable	Coefficient	Std. Error	T - Statistics	Prob.
c	3.811	0.389	9.792	0.000
INUS	0.115	0.018	6.113	0.000
GDP	-0.143	0.012	-11.844	0.000
R^2	0.896			
Adjusted R^2	0.892			
Log Likelihood	453.681			
F- Statistic		Durbin-Watson	0.162	
Prob(F-Statistic)	0.000000			

Source: Calculated by the author, using WB data, and applied with E-views

The above Fixed effects regression results show that Industrial production in both groups, whether Arab or European countries, affects carbon emissions, although the effect is stronger in the case of European countries.

Table (12):
Random effects regression results for Arab countries

Variable	Coefficient	Std. Error	T - Statistics	Prob.
c	0.512	0.247	2.274	0.040
INUS	0.039	0.023	1.685	0.093
GDP	-0.013	0.009	-1.432	0.153
Weighted Statistics				
R^2	0.023			
Adjusted R^2	0.001			
F- Statistic	1.994	Durbin-Watson	0.150	
Prob(F-Statistic)	0.139			
Unweighted Statistics				
R-squared	0.084	Durbin-Watson	0.021	

Table (13):
Random effects regression results for EU countries

Variable	Coefficient	Std. Error	T - Statistics	Prob.
c	1.873	0.314	5.957	0.000
INUS	0.189	0.016	11.439	0.000
GDP	-0.082	0.009	-8.465	0.000
Weighted Statistics				
R^2	0.756			
Adjusted R^2	0.753			
F- Statistic	259.070	Durbin-Watson	0.126	
Prob(F-Statistic)	0.000			
Unweighted Statistics				
R-squared	-1.948	Durbin-Watson	0.006	

Source: Calculated by the author, using WB data, and applied with E-views

The above random effects regression results also show that Industrial production in both groups, whether Arab or European countries, affects carbon emissions, although the effect is stronger in the case of European countries.

The study then applied the Husman Test to test the hypothesis:

H0: Random test is preferred to fixed effect.

H1: fixed test is preferred to Random effect.

Table (14):
Husman test results for Arab countries

Variable	Fixed	Random	Var(Diff.)	Prob.
INUS	0.039	0.039	0.000	0.893
GDP	0.012	-0.013	0.000	0.336
R^2	0.872			
Adjusted R^2	0.868			
F-Statistic	186.48	Durbin-Watson	0.154	
Prob(F-Statistic)	0.0000			

Table (15):
Husman test results for EU countries

Variable	Fixed	Random	Var(Diff.)	Prob.
INUS	0.115	0.189	0.000	0.000
GDP	-0.143	0.082	0.000	0.000
R^2	0.896			
Adjusted R^2	0.892			
F-Statistic	234.539	Durbin-Watson	0.162	
Prob(F-Statistic)	0.0000			

Source: Calculated by the author, using WB data, and applied with E-views

We accept H0, so the random effects results are more accurate and reliable. This means that the results all go in the same direction and support the effect of industrial production on carbon emissions in both groups of countries. They also confirm that this effect is stronger and clearer in European countries compared to Arab countries.

5. CONCLUSIONS AND POLICY RECOMMENDATIONS:

The study found a positive causal relationship between industrial output and Co2 emission in the selected European countries, but each of the two variables also causes the other one. For the selected Arab countries, the result shows that ARABINDUST does not Granger Cause CO2ARAB, this is a logical result as the size of the industrial sector and production in the Arab countries is still below the level that raises carbon emissions, and on the contrary in the case of European countries, where the volume of industrial production increases and carbon emissions rise with it, and the relationship here is mutual, so the volume of industrial production in Arab countries cannot be compared to its counterpart in European countries. This result is consistent with (Abokyi et al., 2019), and (Sibanda & Ndlela, 2020).

The results also confirmed the presence of a clear impact of industrial production on carbon emissions, whether in the selected Arab countries or European countries, emphasizing that the effects in the case of European countries are more clear from a statistical standpoint, and from a practical standpoint also given the large volume of industrial production in them compared to Arab countries. This result is consistent with (Xiaoqing & Jianlan, 2011).

The study recommends that dedicated effort is needed to reduce industrial emissions. focusing on the industries that contribute the most share (>70%) of emissions, including chemicals, cement, and iron and steel petrochemicals, this is consistent with (Brown et al., 2012). On the other hand, quantifying the emissions from industrial processes is critical for understanding the global carbon budget and developing a suitable climate policy, and this is consistent with (Cui et al., 2019) Industry must remain competitive not only inside Europe but also globally to continue to ensure prosperity and economic success. This calls for the kind of business environment that encourages innovation and reducing CO2 that a contemporary industrial policy may establish. Fair competition is crucial in global marketplaces as well. The Arab countries could develop their industrial sectors without significantly increasing carbon emissions this is through the use of new, renewable, and low-carbon energy methods and supporting green economy strategies in developing the industrial sector.

References

- Abokyi, E., Appiah-Konadu, P., Abokyi, F., & Oteng-Abayie, E. F. (2019). Industrial growth and emissions of CO₂ in Ghana: the role of financial development and fossil fuel consumption. *Energy Reports*, 5, 1339-1353.
- Alberola, E., Chevallier, J., & Chèze 1, B. (2008). The EU emissions trading scheme: The effects of industrial production and CO₂ emissions on carbon prices. *Economie internationale*(4), 93-125.
- Andrew, R. M. (2018). Global CO₂ emissions from cement production. *Earth System Science Data*, 10(1), 195-217.
- Baidas, S. (2024). Carbon Capture Technologies in OAPEC Member Countries and the Circular Carbon Economy: A Roadmap to Zero Emissions by 2050. *Open Journal of Energy Efficiency*, 13(2), 25-37.
- Bezić, H., Mance, D., & Balaž, D. (2022). Panel evidence from EU countries on CO₂ emission indicators during the Fourth Industrial Revolution. *Sustainability*, 14(19), 12554.
- Brown, T., Gambhir, A., Florin, N., & Fennell, P. (2012). Reducing CO₂ emissions from heavy industry: a review of technologies and considerations for policy makers. *Grantham Institute for Climate Change Briefing Paper*, 7.
- Cui, D., Deng, Z., & Liu, Z. (2019). China's non-fossil fuel CO₂ emissions from industrial processes. *Applied Energy*, 254, 113537.
- Gokmenoglu, K., Ozatac, N., & Eren, B. M. (2015). Relationship between industrial production, financial development and carbon emissions: The case of Turkey. *Procedia Economics and Finance*, 25, 463-470.
- Islam, M. Z., Ahmed, Z., Saifullah, M. K., Huda, S. N., & Al-Islam, S. M. (2017). CO₂ emission, energy consumption and economic development: a case of Bangladesh. *The Journal of Asian Finance, Economics and Business*, 4(4), 61-66.
- Kurnia, P., Darlis, E., & PUTR, A. A. (2020). Carbon emission disclosure, good corporate governance, financial performance, and firm value. *The Journal of Asian Finance, Economics and Business*, 7(12), 223-231.
- Liu, Z. (2016). National carbon emissions from the industry process: Production of glass, soda ash, ammonia, calcium carbide and alumina. *Applied Energy*, 166, 239-244.
- Nkoro, E., & Uko, A. K. (2016). Autoregressive Distributed Lag (ARDL) cointegration technique: application and interpretation. *Journal of Statistical and Econometric methods*, 5(4), 63-91.
- Olivier, J. (2022). TRENDS IN GLOBAL CO AND TOTAL GREENHOUSE GAS EMISSIONS-2021 Summary Report.
- Olivier, J. G., Schure, K., & Peters, J. (2017). Trends in global CO₂ and total greenhouse gas emissions. *PBL Netherlands Environmental Assessment Agency*, 5, 1-11.
- Rahman, M. M., Rahman, M. S., Chowdhury, S. R., Elhaj, A., Razzak, S. A., Abu Shoaib, S., . . . Rahman, S. M. (2022). Greenhouse gas emissions in the industrial processes and product use sector of Saudi Arabia—An emerging challenge. *Sustainability*, 14(12), 7388.
- Shojaie, A., & Fox, E. B. (2022). Granger causality: A review and recent advances. *Annual Review of Statistics and Its Application*, 9(1), 289-319.
- Sibanda, M., & Ndlela, H. (2020). The link between carbon emissions, agricultural output and industrial output: Evidence from South Africa. *Journal of Business Economics and Management*, 21(2), 301-316.
- Wise, M. A., Sinha, P., Smith, S. J., & Lurz, J. P. (2007). *Long-Term US Industrial Energy Use and CO₂ Emissions*.
- Xiaoqing, Z., & Jianlan, R. (2011). The relationship between carbon dioxide emissions and industrial structure adjustment for Shandong Province. *Energy Procedia*, 5, 1121-1125.
- Yessekina, B. K. (2015). Problems of Decarbonization of the Economy of Kazakhstan. *The Journal of Asian Finance, Economics and Business*, 2(3), 37-39.

- Yoro, K. O., & Daramola, M. O. (2020). CO2 emission sources, greenhouse gases, and the global warming effect. In *Advances in carbon capture* (pp. 3-28). Elsevier.
- Zhang, J., Liu, J., Dong, L., & Qiao, Q. (2022). CO2 emissions inventory and its uncertainty analysis of China's industrial parks: a case study of the Maanshan economic and technological development area. *International Journal of Environmental Research and Public Health*, 19(18), 11684.