The Significance of Economic Freedom in Determining How Economic Growth & Carbon Dioxide Emissions Are Related: Empirical Evidence From Egypt

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Abstract:

Purpose: This paper addresses the relationship between economic growth and emissions without any moderator, then examines the significance of economic freedom in changing this relationship in Egypt during the period (1995 – 2022).

Design/methodology/approach: the researcher uses the Autoregressive Distributed Lag (ARDL) bound testing framework, using the variables of economic growth rate, carbon emissions, and the economic freedom index, which is also examined through three main aspects (government size, market openness, and regulatory efficiency).

Findings: It has been found that economic growth has a direct negative impact on carbon emissions, and that economic freedom has a negative impact on the relationship between economic growth and carbon emissions in Egypt. Moreover, each one of financial freedom, government spending, and the variables of regulatory efficiency has a negative effect on the relationship

between economic growth and carbon emissions, although the tax burden has a positive effect on this relationship.

Originality/value: There are many studies that estimate the relationship between economic growth and carbon dioxide emissions, although few have attempted to find out and determine this relationship with the moderating impact of economic freedom. So, this study concerns this matter with a focus on the Egyptian economy. The study is important as it highlights the effects of promoting economic freedom that still require government attention to create attractive business environment that foster effective environmental protection through decreasing carbon emissions and increasing economic growth.

Keywords: economic freedom – carbon dioxide emissions – economic growth – sustainable development – gross domestic product – business freedom – monetary freedom – financial freedom – investment freedom – tax burden – trade freedom.

Study plan:

The theoretical framework
The methodology/ approach
Results & findings
Policies Implications
References

أهمية الحرية الاقتصادية في تحديد العلاقة بين النمو الاقتصادي وانبعاثات ثاني أكسيد الكربون: دراسة حالة عن مصر

الملخص:

الغرض من الدراسة: تتناول هذه الورقة البحثية العلاقة بين النمو الاقتصادي والانبعاثات الكربونية في مصر ودون أي عامل وسيط يؤثر علي تلك العلاقة، ثم يتم دراسة دور الحرية الاقتصادية في تغيير هذه العلاقة وذلك خلال الفترة من ١٩٩٥ إلى ٢٠٢٢.

التصميم / المنهجية / النهج: يستخدم الباحث إطار عمل اختبار الانحدار الذاتي الموزع (ARDL) باستخدام متغيرات معدل النمو الاقتصادي ، وانبعاثات الكربون ، ومؤشر الحرية الاقتصادية ، والذي يتم فحصه أيضاً من خلال ثلاثة جوانب رئيسية (حجم الحكومة، و إنفتاح السوق، والكفاءة التنظيمية).

النتائج: تم التوصل إلي أن النمو الاقتصادي له تأثير مباشر وإيجابي على الانبعاثات الكربونية، وأن الحرية الاقتصادية لها تأثير سلبي على العلاقة بين النمو الاقتصادي وإنبعاثات الكربون في مصر، علاوة على ذلك فإن الحرية المالية، والإنفاق الحكومي، ومتغيرات الكفاءة التنظيمية لها تأثير سلبي على العلاقة بين النمو الاقتصادي وإنبعاثات الكربون، على الرغم من أن العبء الضريبي له تأثير إيجابي.علي تلك العلاقة

الأصالة / القيمة: هناك العديد من الدراسات التي تقدر العلاقة بين النمو الاقتصادي وانبعاثات ثاني أكسيد الكربون، على الرغم من أن القليل منها حاول معرفة وتحديد شكل هذه العلاقة في وجود تأثير الحرية الاقتصادية، لذا فإن هذه الدراسة تهتم بهذا الأمر مع التركيز على الاقتصاد المصري،وبالتالي فالدراسة مهمة لأنها تسلط الضوء على آثار تعزيز الحرية الاقتصادية والتي لا تزال تتطلب اهتماما حكوميا لخلق بيئة أعمال جذابة تعزز الحماية البيئية الفعالة من خلال خفض انبعاثات الكربون وأيضاً زيادة النمو الاقتصادي.

الكلمات المفتاحية: الحرية الاقتصادية - انبعاثات ثاني أكسيد الكربون - النمو الاقتصادي - التنمية المستدامة - الناتج المحلي الإجمالي - حرية الأعمال - الحرية النقدية - الحرية المالية - حرية الاستثمار - العبء الضريبي - حرية التجارة.

Introduction:

The trend that most of countries around the world tend to follow is to enable their citizens to enjoy their vital right to manage their own property or what is called "economically free individuals". They are free to consume, produce, work, and invest in a way they prefer. And government should let goods, labor, and capital move easily, without compulsion or limitation of liberty beyond the extent essential to keep and protect liberty itself. This trend brings a higher level of prosperity. Since, economic freedom is strongly associated with positive economic growth rate, poverty elimination, cleaner environments, human development, and democracy. And the main important economic effect among all the above is an increasing economic growth rate, which comes with a cleaner environment and other positive effects. But as already known, economic growth is positively associated with carbon dioxide emissions in low- and middle-income countries like Egypt.

This fact is not true for high-income countries. Since, they decreased emissions while achieving economic growth, for example, the UK, Germany, France, Finland, Sweden, Italy, Denmark, Romania, Czechia, and many others. That happened only during the last 20 years because they decreased fossil fuel use and used renewable energy instead. But the positive relationship between emissions and economic growth still works in low- and middle-income countries such as Senegal, Ghana, Gambia,

Nigeria, Togo, and so forth because of the use of more energy, which mainly stems from fossil fuels. In the case of Egypt, as an example of a lower-middle income country, the economic growth rate was increasing from 4.6% in 1995 up to 5.6% in 2019 (before the period of COVID 19), and the carbon dioxide emissions increased from 93.7 kt to 249.3 kt for the same period. With no doubt, the crisis of carbon dioxide emissions is a very big problem, or, without simplifying, a disaster. Approximately more than one billion children will suffer from a severe climate crisis, and poorer countries will bear a bigger load.

So, to make it short, economic freedom increases the economic growth rate, but an increasing of the economic growth rate, increases carbon emissions. And at the same time, there is another claim that says that increasing the level of economic freedom increases the quality of the environment, which means decreasing carbon emissions. So, the main target for the government is to raise the economic growth rate without increasing the level of emissions, which may be achieved through increasing economic freedom. And that will be examined through this paper.

Problem of the study: In Egypt, an increasing in the economic growth rate from 4.6% to 5.5% in the period of the study (1990-2019), comes with an increase in CO_2 emissions from 94,890,390 to 256,140,160 for the same period.

And Egypt increased from 45.7 to 52 in the economic freedom index for the same period. Unsurprisingly, the global average for this indicator is 61.1, which means Egypt is still far below the average, with a ranking of 152 among 177 countries around the world, and the 11th among 14 countries in the Middle East and North Africa region. And the situation became worse since Egypt had fallen from the category of "Mostly unfree" (from 59.9 to 50) to the category of "Repressed" (from 49.1 to 0). Since then, it scored 49.1 in 2022. So, if the government increases economic freedom, will that increase economic growth? Will the increase in growth come with a decrease in CO_2 emissions as a result of economic freedom or not? Hence, from the above data, the researcher can illustrate the problem of the study through the following questions:

Is there a directly positive effect of economic growth on carbon emissions in Egypt? and does this effect become negative with the moderating effect of economic freedom? and from these questions the hypothesis can be formed as follows:

Hypothesis development:

H_1: There is a significant positive influence of economic growth on carbon dioxide emissions in Egypt.

H_2: There is a significant negative influence of economic growth on carbon dioxide emissions through the moderating role of economic freedom.

The theoretical framework

The concept of economic freedom:

Economic freedom, according to Friedrich Hayek, is a governance philosophy that believes in the human right to determine how to manage his life and that he is totally free to obtain and consume economic goods or resources according to his own priorities & philosophies, regardless of what a technocratic elite or even the government wants. When governments intervene in economic decisions, the decisions tend toward compulsion and the constraint of freedom. It cannot consider individual needs as efficiently as a free market and thus encourages resource waste.

The Economic Freedom Index shows persuasive evidence that unimplemented policies do not restrict economic expansion as much as policies that the government puts in place. And the rights the person has end at others' doorsteps. So, activities and decisions that have a possible effect on others are controlled by laws. Hence, economic freedom does not mean the absence of restraint; it means creating and maintaining liberty for all. However, when the government plans beyond the bare minimum, it may infringe on economic liberty.

Economic freedom is not just a favorable business environment: There are lots of benefits the country can get from promoting a higher level of economic freedom, and some of these benefits can be illustrated as follows:

- **Improving health:** EF improves health, and that can be approved through the study of Esposto & Zaleski in 1999 since they found that EF positively influences life expectancy for states that have a life expectancy rate of less than 65 years.
- **Sustainable food production**: The low level of EF causes a slump in productivity, especially in agricultural production and, by extension, food production. This matter can be shown through the contributions of Ding G, *et al* (2021) to examine whether EF could increase food production. Since they pointed out that EF has a positive impact on food production in least-developed countries.
- **Promoting FDI:** A higher level of EF goes with increasing FDI inflows, and that can be illustrated through the contribution of Ansari *et al* in 2022 about the effect of EF on FDI in Southeast Asian countries. And it has discovered that there is a direct relationship between EF & FDI since EF can make an improvement in financial institutions and the quality of human resources.
- **Human Development (HD)**: greater EF promotes human development, and that can be illustrated through many studies such as that of Goldsmith (1997), where he found that there is a direct relationship between HD & EF for 90 developing states. And these results go with the results of Grubel (1998) for 113 nations and pointed out a favorable impact of EF. And recently, Naanwaab (2018) found that the role of EF on HD is

not the same for developing countries. So, nations with a low level of HD have a greater chance of catching up through promoting EF.

The above points show that the EF has direct positive effects on both FDI & HD. And it also has a positive indirect effect on HD through its effect on FDI. And that can be shown through the contributions of Ahiabor *et al* (2020) for 32 African countries. Since they pointed out that FDI, without the effect of EF, has an insignificant impact on HD, but FDI has a significant & positive impact on HD once measures of EF are moderators.

- **Enhancing well-being:** many studies demonstrated the favourable impacts of EF on well-being, such as the contribution of Faria and Montesinos in 2009 for 104 nations. Since they observed that raising the level of EF raised the level of well-being, which is estimated by education, health, and prevention of disease.
- **Enhancing economic growth**: The undeniable role of EF in enhancing prosperity is an example of what people are capable of when given the freedom to follow their wants and interests through the confines of the law. And many studies that examine the effect of EF on growth as well as the environment can be discussed separately below in the following sections.

Assessing economic freedom:

Economic freedom is an interesting concept not only for economists but also for governments and the whole society. So, there is not just one index ranking nations, but recently there have been 2 accepted indices of economic freedom: Economic Freedom of the World Index, which is developed by the Fraser Institute, and the Index of Economic Freedom by the Heritage Foundation includes similar aspects of Fraser's index. However, this index ranks countries through a shorter time span, starting in 1995, compared to 1970 for the Fraser's index. But the Index of Economic Freedom has a comprehensive view of economic freedom. And the aspects are complementary in effect, but an improvement in one aspect promotes an improvement in another. And this index measures economic freedom through four categories:

1- **Rule of Law:** which can be measured through the following subcomponents:

A- Property rights: the capability of accumulating wealth for investors. It is an effective factor for capital accumulation.

B- Judicial Effectiveness: "Judicial effectiveness" refers to well-functioning laws that protect the rights of all. It plays an effective role in promoting economic freedom, particularly in developing countries.

C- Government Integrity: Corruption in one place influences actions in another, destroying the government's integrity:

Since letting some people gain facilities at the expense of others destroys the concept of an economically free society, As well, there is a positive impact of government interference in the economy on the pervasiveness of corruption.

2- **Market openness:** It is measured using the following subcomponents:

A- Trade Freedom: Government restrictions that affect trade freedom negatively not only include export taxes, tariffs, and trade quotas but also standard-setting and licensing that go beyond their current economic impact.

B- Investment Freedom: Restrictions on transporting capital limit both outflows and inflows, thus decreasing opportunities for growth. But if individuals can choose where to invest freely, capital will flow to its best channels for the most needed activities with the highest returns.

C- Financial Freedom: In a process that is based on supply and demand in the financial sector, the market gives information about prices. This process is based on transparency and the honesty of the information. The government should ensure transparency and truthfulness in the disclosure of assets and risks. But if financial regulations go beyond transparency and honesty, they can hinder efficiency and competition.

3- **Government Size:** which can be measured through the following subcomponents:

A- Tax Burden: The greater the tax burden on income or wealth, the lower one's return on economic activity. So, it is a direct restraint on one`s economic freedom.

B- Government Spending: Not all government spending is equally damaging to economic freedom. Some of it is considered an investment. And, even if the economy grows faster due to increased government spending, it will only be temporary because it will distort resource allocation, resulting in lower productivity and an additional burden on future generations.

C- Fiscal Health: A growing public debt and deficits in a public budget damage a government`s fiscal health. As a result, macroeconomic instability, economic uncertainty, and thus economic freedom are created.

4- **Regulatory Efficiency:**

A- Business Freedom: economic activities are free from government intervention. Governmental regulations, such as increasing production costs, are barriers to economic freedom, but those related to licensing are the most onerous. In many countries, such as Singapore, starting a new business required a day and a half, and there was no need for minimum capital.

B- Labor freedom: It refers to the ability to find a job vacancy and work, as well as the ability of businesses to freely hire and fire workers, both of which are important for promoting productivity and overall economic growth. Since voluntary

exchange is the main concept of an economically free labor market, Government intervention includes a minimum wage, restrictions on firing, and other restraints that result in a mismatch between market forces.

C- **Monetary Freedom:** It needs a stable currency and determined prices in the market. Monetary policy also has an impact on currency. But for instance, an inflationary policy decreases wealth, raises the cost of doing business, and distorts prices. And there is not an accepted theory for monetary policy that matches the concept of economic freedom. But almost all theories stand for a low inflation rate and the independence of the central bank.

First: The effect of economic freedom on CO_2 emissions:

According to the work of Carlsson & Lundström in 2002, which is about the effects of economic freedom (EF), they pointed out three main hypotheses about the impact of economic freedom on CO_2 emissions as follows:

1- **The Efficiency Impact:** EF promotes efficiency and creates competitive markets, but resource efficiency does not directly influence CO2 emissions. Because of competition, businesses should adjust to changes to survive. To save money, fewer resources should be used with less waste, which may result in lower output. And lower production means lower utilization of energy. And as is known, energy use influences CO_2 emissions positively. So, cost reduction may reduce gas emissions.

2- **Trade Regulation Impact:** Trade liberalization has two opposite impacts: an efficiency impact and a pollution haven impact. Trade liberalization increases the efficiency of resource allocation because of market competition. But at the same time, trade liberalization supports specialization, and countries with lax laws regarding the environment will attract environmentally unfriendly businesses, which is called the "pollution haven" effect. So, the effect of EF on carbon emissions is uncertain.

3- **The Stability Impact:** Stability in price levels and protection for property rights increase efficient investment. And stability at the macroeconomic level will decrease emissions, especially if there is an expectation that the economy is going to prosper in the future. The relationship between EF and environmental quality became clearer with time, but the volume and scope of the evidence are inadequate. As a result, it is critical to investigate empirically how increased freedom affects CO_2 emissions in the case of Egypt. Since there isn`t a universal agreement about the influence of EF on CO_2 emissions. And that can be shown through the literature review about the effect of EF on CO_2 emissions as follows:

- The study of Nikensari *et al* (2021), which analyses the hypothesis that states with greater EF have a healthier environment for seven ASEAN states, The findings illustrate that increasing EF decreases CO_2 emissions.

- The same results are pointed out in the paper of Abban *et al* (2022), which examines the marginal effect of energy price and EF on Europe's environment. The findings show that the higher the EF and the higher the energy price in a country, the lower the CO_2 emissions in this country. And the results of comparing the direct effects of energy prices and EF to the fixed effect are 12.77% and 23.53% of the direct effects, respectively.
- The previous findings go with the findings of Agyekum *et al* (2022) in some South Asian states, and the results reveal that EF decreases CO2 emissions, suggesting that EF should be integrated into environmental awareness programs with more investment in R&D initiatives to support renewable energy.
- However, the work of Bae and Rishi (2017) comes with opposite findings. They have since studied the factors that influence environmental quality in independent post-Soviet Union states. And surprisingly, one of their findings is that EF and political democracy raise CO_2 emissions in an indirect way through their effect on economic growth.
- Those results agree with the result of Carlsson and Lundström (2001), who concentrated their work on low- and high-income countries. And they found that increasing EF directly increases CO_2 emissions for high-income countries, whereas increasing EF directly decreases CO_2 emissions for low-income countries. And increasing EF indirectly increases CO_2 emissions for all countries.

Second: The effect of economic freedom on economic growth:

Economic theory points out that EF influences productive work, incentives, and the efficient use of resources. And, since Adam Smith, or even before, there has been a call for the right to trade, supply and demand for resources, secure property rights, and competition in markets freely, all of which are essential components of economic growth. So, many recent studies have found that EF is vital for explaining why countries differ in economic growth. And that can be shown through the literature review about the effect of EF on economic growth as follows:

- The work of Mahmood M *et al* (2022) which is about a panel test of 41 Asia-Pacific nations for all income groups. The results suggest that economic growth rates are in a need of economic freedom. The findings highlight the crucial positive role of economic freedom in encouraging economic activities directly and indirectly to diminish energy intensity just to mitigate environmental threats.
- The work of Carlsson F, and Lundström S (2002), which is about the impact of EF on GDP growth using a common measure of EF (including seven various categories), determining the impact of each one on GDP for 74 states through 25 years. The findings pointed out that EF affects growth. But in this study, an increase in EF does not guarantee increased GDP growth since some variables adversely affect growth & and some are insignificant.

In most of the studies mentioned before and others, an aggregate measure of EF is used, but the last one uses a single measure. It should be mentioned that a single measure of economic freedom cannot illustrate the whole economic environment, and the aggregated index cannot enable the researchers to recommend a policy conclusion.

Lately, Heckelman & Stroup in 2000 criticized the aggregate measure because it includes some variables that do not affect growth or affect it negatively; thus, it is better to find different aggregated measures in case there is an adequate weighting measure for the variables. So, they found another aggregation measure that is based upon the significance of each variable for growth through regressions for 49 states for the time span (1980–1990). And they found that half of the gaps in growth between nations can be explained through economic freedoms. And that agrees with the results of Sturm *et al* (2002) which is about economic freedom & growth. They found that the aggregate measure of Heckelman & Stroup is flawed. So, they suggested another indicator. Then they found that their own economic freedom index does not strongly affect economic growth, and that the Heckelman & Stroup index weakly affects economic growth. So, there is no big difference between both. Even if the aggregate measure is used with or without considering the significance of each variable, the results will be similar.

Third: The effect of economic growth on CO_2 emissions:

Economic growth may come with undesirable consequences such as more pollution, misuse of resources, degradation, and climate change. Since economic growth is facilitated by industrialization, which is improved through increasing energy use & technology, and that ends up increasing global warming through increasing CO_2 emissions. Ayoade (2003) pointed out that the industrial revolution leads to an increase in CO_2 emissions. At the start of the industrial revolution, CO_2 emissions were around 280 ppm (parts per million) for almost 700 years. Nevertheless, in 1860, CO_2 emissions were about 0.5% per year. The increase in economic activities increases the level of pollution enormously. It reached 37.12 billion tonnes in 2021.

And this is demonstrated by the following literature review on the debate over whether economic growth has a positive effect on CO_2 emissions:

- Meadows *et al* (1972), and Mardani *et al* (2019) found that economic activities are a main source of pollution. Since then, there have been international initiatives about clean economies like the Kyoto Protocol.
- Al - Mulali et al. (2015) claimed in his work about the impact of urbanization & economic growth on pollution in Europe that urbanization, which stems from economic growth, raises the level of pollution in Europe, which contrasts with the case

of Malaysia. since population has no effect on CO_2 emissions there. More investigation may be necessary to confirm the validity of the Malaysian study in light of opposing findings.

- Although Osadume (2021) found that a 1% unit increase in economic growth increases CO_2 emissions by 3.11121% in six West African nations.

Design/methodology/approach

The data were analyzed using some statistical techniques and tests to study the significance of economic freedom in determining how economic growth & carbon dioxide emissions are related in Egypt during the period from 1995 to 2022. Table (I) gives a description of all the variables used in the analyses as follows:

Table (I): Description of the variables

Variables Type	Variables		Symbol
Independent Variable	Economic Growth		EG
Dependent Variable	Carbon Dioxide Emissions		CDE
Moderator Variables	Economic Freedom Over All Score		EF
	Government Size	Tax Burden	TB
		Government Spending	GS
	Regulatory Efficiency	Business Freedom	BF
		Monetary Freedom	MF
	Market openness	Trade Freedom	TF
		Financial Freedom	FF

Therefore, the statistical analysis will investigate the previous hypotheses. Since the data are annual time series during

the period from 1995 to 2022, this paper adopts the Autoregressive Distributed Lag (ARDL) bound testing framework (Pesaran and Shin 1995, Pesaran and Shin 1999, Pesaran et al. 1996, Pesaran 1997) to estimate the Error Correction Mechanism (ECM). ARDL model is a model that has both lagged values of the dependent variables (autoregressive) and lagged values of the independent variables (distributed lag) as one of the explanatory variables. The ARDL cointegration is used to establish whether there is a long-run equilibrium relationship among the variables under review when the variables are integrated of both order zero I(0) and order one I(1). Following Pesaran et al. (2001), the ARDL approach to cointegration is done as shown in Equation (I).

$$\Delta Y_t = \beta_0 + \beta_1 \Delta X_{1t} + \cdots + \beta_k \Delta X_{kt} + \beta_{k+1} Y_{t-1} + \beta_{k+2} \Delta X_{1t-1} + \cdots + \beta_{k+k} \Delta X_{kt-1} + ECT_{t-1} \quad (1)$$

Where, Y is the dependent variable, X are the dependent variables, k is the number of independent variables, Δ is first difference operator, p is the optimal lag length, ECT_{t-1}, is the error correction term and all other variables remain the same. Wald tests on the coefficients of unrestricted ECT variables are conducted to obtain F-statistics, which are used to test the existence of a long-run relationship. The F-test has a non-standard distribution, which depends on whether the variables included in the model are I(0) or I(1), the number of regressors, and whether the model contains an intercept and/or a time trend. The F-statistics are compared with

Pesaran's critical value at the 5% level of significance. The test involves asymptotic critical value bounds depending on whether the variables are I(0) or I(1) or a mixture of both. Upper and lower bound critical values derive from the I(1) and I(0) series, respectively. When an F-statistic is above the upper bound value, we reject the null hypotheses of no cointegration among the variables and therefore conclude that there is evidence of a long-run relationship among the variables regardless of the order of integration of the variables. If it falls below the lower bound value, we do not reject the null hypotheses of no cointegration, and if it lies between the bounds, the result is inconclusive. When it is established that variables are co-integrated (i.e., there is a long-run or equilibrium relationship between them), in the short-run there may be disequilibrium. Error correction mechanism is used to correct the dis-equilibrium. The short-run dynamics can be derived by estimating the Error Correlation Term (ECT) with the specified lags as shown in Equation (2). $\Delta Y_t = \beta_0 + \sum_{i=1}^{p} \beta_1 \Delta Y_{t-i} + \sum_{i=1}^{p} \beta_2 \Delta X_{1t-i} + \cdots + \sum_{i=1}^{p} \beta_k \Delta X_{kt-i} \; + +\beta_{k+1} ECT_{t-1}$ (2)
Where β_{k+1} represents the speed of adjustment.

1- Descriptive statistics

Table (II) shows descriptive statistics for the variables using minimum value, maximum value, mean and standard deviation.

Table (II): Descriptive Statistics

Variables	Sample Size	Descriptive Statistics			
		Minimum	Maximum	Mean	Std. Dev.
CDE	28	93720	249370	181286.7	54242.95
EG	28	1.76	7.16	4.46	1.50
EF	28	45.70	59.10	54.51	3.02
TB	28	46.00	90.80	76.34	13.71
GS	28	53.70	78.60	68.62	6.68
BF	28	39.80	71.50	58.81	7.37
MF	28	40.90	80.10	68.19	8.34
TF	28	25.00	74.00	60.18	13.56
FF	28	30.00	70.00	43.21	11.24

2- Time Series Stationarity test

To investigate the stationarity of the time series of the variables, unit root tests using Augmented Dicky-Fuller (ADF) and Phillips–Perron (PP), was applied. Table (III) shows the unit root tests for the variables at (the level), and after taking the first difference.

Table (III): Stationarity tests

Variables	Augmented Dicky-Fuller (ADF) test					Phillips–Perron (PP) test				
	Level		1st Diff		co-int	Level		1st Diff		co-int
	Test value	*p*-value	Test value	*p*-value		Test value	*p*-value	Test value	*p*-value	
CDE	-0.133	0.991	-3.808	0.008	I(1)	-0.535	0.975	-3.785	0.008	I(1)
EG	-3.430	0.019	-------	-------	I(0)	-2.522	0.122	-4.900	0.000	I(1)
EF	-3.849	0.007	-------	-------	I(0)	-3.849	0.007	-------	-------	I(0)
TB	-2.249	0.195	-5.477	0.000	I(1)	-2.284	0.184	-5.477	0.000	I(1)
GS	-3.555	0.014	-------	-------	I(0)	-3.588	0.013	-------	-------	I(0)
BF	-1.965	0.300	-4.280	0.000	I(1)	-2.039	0.269	-4.184	0.000	I(1)
MF	-0.174	0.931	-3.523	0.001	I(1)	-0.174	0.931	-3.515	0.001	I(1)
TF	-3.116	0.037	-------	-------	I(0)	-3.116	0.037	-------	-------	I(0)
FF	-2.330	0.170	-4.796	0.000	I(1)	-2.399	0.151	-5.251	0.000	I(1)

From table (III) some variables are non-stationary at level, whereas *p*-value > α = 0.05. So, the first difference for the time series was taken for these variables to get rid of the unit roots. Therefore, it became stationary, whereas the *p*-value < α = 0.05. Since the stationarity test of the variables under consideration is a mixture of I(1) and I(0), the ARDL approach was deemed appropriate for estimation and testing our hypothesis.

3- Correlation Matrix

Table (IV) shows a correlation coefficient matrix between variables using Pearson's correlation coefficient.

Table (IV): Correlation matrix between variables

Variables	Corr.	CDE	EG	EF	TB	GS	BF	MF	TF	FF
CDE	Corr.	1								
	p-value									
EG	Corr.	-0.258	1							
	p-value	0.186								
EF	Corr.	0.172	-0.035	1						
	p-value	0.381	0.861							
TB	Corr.	0.886	-0.199	0.432	1					
	p-value	0.000	0.310	0.022						
GS	Corr.	0.159	0.082	0.468	0.155	1				
	p-value	0.420	0.679	0.012	0.432					
BF	Corr.	0.578	-0.402	0.266	0.517	-0.194	1			
	p-value	0.001	0.034	0.172	0.005	0.322				
MF	Corr.	-0.649	0.261	0.057	-0.595	-0.135	-0.299	1		
	p-value	0.000	0.180	0.773	0.001	0.495	0.122			
TF	Corr.	0.836	-0.282	0.525	0.871	0.258	0.563	-0.390	1	
	p-value	0.000	0.146	0.004	0.000	0.185	0.002	0.040		
FF	Corr.	0.020	0.102	0.135	-0.040	0.128	0.293	-0.368	-0.098	1
	p-value	0.921	0.604	0.494	0.838	0.517	0.131	0.054	0.621	

From table (IV) it is clear that:

1- There is a statistically significant relationship between CDE and TB, BF, MF, TF at 5% significant level of, whereas *p*-value < α = 0.05.
2- There is no statistically significant relationship between CDE and EG, EF, GS, FF at 5% significant level of, whereas *p*-value > α = 0.05.
3- There is a statistically significant relationship between EG and BF at 5% significant level of, whereas *p*-value < α = 0.05.
4- There is no statistically significant relationship between EG and EF, TB, GS, MF, TF, FF at 5% significant level of, whereas *p*-value > α = 0.05.

4- Test of hypothesis

Statistical analysis will be made to test the hypothesis of the study (2 hypothesis) as follows:

4.1- Test of the 1st hypothesis

ARDL model has been applied to test the first hypothesis. Error correction model (ECM) is used as shown in Equation (3), note that the formulation of the quantitative model will be based on the logarithm of all variables.

$$\Delta logCDE_t = \beta_0 + \sum_{i=1}^{p} \beta_1 \Delta logCDE_{t-i} + \sum_{i=1}^{p} \beta_2 \Delta logEG_{t-i} + \beta_3 ECT_{t-1} \quad (3)$$

Thus, the first step is to estimate and conduct a lag length test to estimate the optimum lag length for the variables. The

maximum order of lags was set as three in the ARDL options using Akaike information criterion (AIC) to determine the optimum lag length to be included in the unrestricted ECM. The results suggests that the optimum lag length for CDE is one; and for EG is three (e.g. ARDL(1, 3)). The next step is to estimate and examines the long-run relationships among the variables. Conducting a Wald test on the coefficients of unrestricted ECM variable, we obtain an F-Bounds test for the joint significance of lagged levels of the variables. The calculated F-statistic of the Bounds test (15.618) is higher than the upper bound critical value (4.16) at the 5% level of significance using a restricted constant and no trend. Thus, the null hypothesis (H_0) of no cointegration among the series can be rejected. This implies that there is a long-run relationship among all the variables. In order words, the model variables co-move together in the long run. Now we estimate the ECM short-run model as shown in Table (V).

Table (V): ECM short-run model

Variable	Coefficient	Std. Error	t-Statistic	*p*-value
$\Delta \log EG_t$	-0.018	0.016	-1.083	0.292
$\Delta \log EG_{t-1}$	0.037	0.016	2.279	0.034
$\Delta \log EG_{t-2}$	0.046	0.016	2.813	0.011
ECT_{t-1}	-0.062	0.009	-7.196	0.000
R-squared	0.406	S.E. of regression		0.027
Adjusted R-squared	0.321	ARCH-test (F (*p*-value))		0.047 (0.831)
Jarque-Bera (*p*-value)	1.015 (0.602)	Breusch-Godfrey (F (*p*-value))		0.536 (0.595)

The results of the ECM presented in Table (V) show that:

1- There is statistically significant impact of the EG on CDE at 5% significance level, whereas *p–value* < α = 0.05.
2- Although, the model performs well in terms of goodness of fit: R^2 = 0.406; meaning that the variables forming the model can explain (40.6%) of the changes in CDE.
3- Moreover, the error term (residuals) is normally distributed whereas the probability value of Jarque-Bera test is greater 5% (JB = 1.015, *p–value* = 0.602 > α = 0.05).
4- Also, there is no heteroskedasticity problem whereas the probability value of *ARCH*-test is greater than 5% (F(1,22) = 0.047, *p*-value = 0.831 > 0.05).
5- In addition, there is no serial correlation whereas the probability value of Breusch–Godfrey serial correlation LM test is greater than 5% (F(2,17) = 0.536, *p*-value = 0.595 > 0.05).

4.2- Test of the 2nd hypothesis

ARDL model has been applied to test the second hypothesis. Therefore, Error correction model (ECM) is used using economic freedom overall score as dependent variable as shown in Equation (4), note that the formulation of the quantitative model will be based on the logarithm of all variables:

$$\Delta logCDE_t = \beta_0 + \sum_{i=1}^{p} \beta_1 \Delta logCDE_{t-i} + \sum_{i=1}^{p} \beta_2 \Delta logEG_{t-i} + \sum_{i=1}^{p} \beta_3 \Delta logEF_{t-i} + \sum_{i=1}^{p} \beta_4 \Delta \log(EG * EF)_{t-i} + \beta_5 ECT_{t-1} \quad (4)$$

The optimum lag length for CDE is one; and for EG is two; and for EF is zero; and for EG*EF is three (e.g. ARDL(1, 2, 0, 3)). The calculated F-statistic of the Bounds test (10.667) is higher than the upper bound critical value (3.67) at the 5% level of significance. Thus, the null hypothesis (H_0) of no cointegration among the series can be rejected. This implies that there is a long-run relationship among all the variables. Now we estimate the ECM short-run model as shown in Table (VI).

Table (VI): ECM short-run model

Variable	Coefficient	Std. Error	t-Statistic	*p*-value
$\Delta \log EG_t$	-0.289	0.273	-1.056	0.308
$\Delta \log EG_{t-1}$	0.784	0.288	2.723	0.016
$\Delta(\log EG_t * \log EF_t)$	0.069	0.068	1.012	0.328
$\Delta(\log EG_{t-1} * \log EF_{t-1})$	-0.185	0.072	-2.589	0.021
$\Delta(\log EG_{t-2} * \log EF_{t-2})$	0.010	0.004	2.522	0.024
ECT_{t-1}	-0.060	0.007	-8.219	0.000
R-squared	0.569	S.E. of regression		0.024
Adjusted R-squared	0.455	ARCH-test (F (*p*-value))		0.210 (0.651)
Jarque-Bera (*p*-value)	0.149 (0.928)	Breusch-Godfrey (F (*p*-value))		0.639 (0.544)

The results of the ECM presented in Table (VI) show that:

1- There is statistically significant negative impact of the EF on the relation between EG and CDE at 5% significance level, whereas $\Delta(\log EG_{t-1} * \log EF_{t-1})$ is negative (-0.185) and *p–value* $< \alpha = 0.05$.

2- Although, the model performs well in terms of goodness of fit: $R^2 = 0.569$; meaning that the variables forming the model can explain (56.9%) of the changes in CDE.
3- Moreover, the error term (residuals) is normally distributed whereas the probability value of Jarque-Bera test is greater 5% (JB = 0.149, *p–value* = 0.928 > α = 0.05).
4- Also, there is no heteroskedasticity problem whereas the probability value of *ARCH*-test is greater than 5% (F(1,22) = 0.210, *p*-value = 0.651 > 0.05).
5- In addition, there is no serial correlation whereas the probability value of Breusch–Godfrey serial correlation LM test is greater than 5% (F(2,13) = 0.639, *p*-value = 0.544 > 0.05).

Moreover, ARDL model has been applied again to test the second hypothesis. using government size (tax burden, government spending), regulatory efficiency (business freedom, monetary freedom), market openness (trade freedom, financial freedom) as dependent variables as shown in Equation (5), (6) and (7) respectively, note that the formulation of the quantitative model will be based on the logarithm of all variables:

$$\Delta logCDE_t = \beta_0 + \sum_{i=1}^{p} \beta_1 \Delta logCDE_{t-i} + \sum_{i=1}^{p} \beta_2 \Delta logEG_{t-i} + \sum_{i=1}^{p} \beta_3 \Delta logTB_{t-i} + \sum_{i=1}^{p} \beta_4 \Delta logGS_{t-i} + \sum_{i=1}^{p} \beta_5 \Delta \log(EG * TB)_{t-i} + \sum_{i=1}^{p} \beta_6 \Delta \log(EG * GS)_{t-i} + \beta_7 ECT_{t-1} \quad (5)$$

$$\Delta logCDE_t = \beta_0 + \sum_{i=1}^{p} \beta_1 \Delta logCDE_{t-i} + \sum_{i=1}^{p} \beta_2 \Delta logEG_{t-i} + \sum_{i=1}^{p} \beta_3 \Delta logBF_{t-i} + \sum_{i=1}^{p} \beta_4 \Delta logMF_{t-i} + \sum_{i=1}^{p} \beta_5 \Delta \log(EG * BF)_{t-i} + \sum_{i=1}^{p} \beta_6 \Delta \log(EG * MF)_{t-i} + \beta_7 ECT_{t-1} \quad (6)$$

$$\Delta logCDE_t = \beta_0 + \sum_{i=1}^{p} \beta_1 \Delta logCDE_{t-i} + \sum_{i=1}^{p} \beta_2 \Delta logEG_{t-i} + \sum_{i=1}^{p} \beta_3 \Delta logTF_{t-i} + \sum_{i=1}^{p} \beta_4 \Delta logFF_{t-i} + \sum_{i=1}^{p} \beta_5 \Delta \log(EG * TF)_{t-i} + \sum_{i=1}^{p} \beta_6 \Delta \log(EG * FF)_{t-i} + \beta_7 ECT_{t-1} \quad (7)$$

1- Using government size (tax burden, government spending)

Table (VII) shows the estimated ECM short-run model.

Table (VII): ECM short-run model

Variable	Coefficient	Std. Error	t-Statistic	*p*-value
$\Delta\log CDE_{t-1}$	1.610	0.038	42.562	0.001
$\Delta\log EG_{t}$	-1.235	0.287	-4.300	0.050
$\Delta\log EG_{t-1}$	-1.751	0.288	-6.087	0.026
$\Delta\log EG_{t-2}$	18.040	0.853	21.139	0.002
$\Delta\log TB_{t}$	-0.145	0.080	-1.809	0.212
$\Delta\log TB_{t-1}$	-2.575	0.154	-16.733	0.004
$\Delta\log TB_{t-2}$	6.295	0.300	20.981	0.002
$\Delta\log GS_{t}$	0.055	0.073	0.753	0.530
$\Delta\log GS_{t-1}$	1.189	0.074	16.079	0.004
$\Delta\log GS_{t-2}$	2.624	0.119	22.076	0.002
$\Delta(\log EG_{t} * \log TB_{t})$	1.089	0.047	23.077	0.002
$\Delta(\log EG_{t-1} * \log TB_{t-1})$	0.926	0.065	14.312	0.005
$\Delta(\log EG_{t-2} * \log TB_{t-2})$	-3.447	0.164	-21.008	0.002
$\Delta(\log EG_{t} * \log GS_{t})$	-0.855	0.071	-12.002	0.007
$\Delta(\log EG_{t-1} * \log GS_{t-1})$	-0.570	0.045	-12.616	0.006
$\Delta(\log EG_{t-2} * \log GS_{t-2})$	-0.666	0.044	-15.302	0.004
ECT_{t-1}	-0.103	0.004	-23.102	0.002
R-squared	0.996	S.E. of regression		0.004
Adjusted R-squared	0.988	ARCH-test (F (*p*-value))		0.196 (0.663)
Jarque-Bera (*p*-value)	44.795 (0.000)	Breusch-Godfrey (F (*p*-value))		15.636 (0.158)

The results of the ECM presented in Table (VII) show that:

1- There is statistically significant negative impact of the TB on the relation between EG and CDE at 5% significance level, whereas both $\Delta(\log EG_t * \log TB_t)$ and $\Delta(\log EG_{t-1} * \log TB_{t-1})$ are positive (1.089, 0.926) and $p\text{–}value < \alpha = 0.05$.
2- There is statistically significant negative impact of the GS on the relation between EG and CDE at 5% significance level, whereas all $\Delta(\log EG_t * \log GS_t)$, $\Delta(\log EG_{t-1} * \log GS_{t-1})$ and $\Delta(\log EG_{t-2} * \log GS_{t-2})$ are negative (-0.855, -0.570, 0.-666) and $p\text{–}value < \alpha = 0.05$.
3- Although, the model performs well in terms of goodness of fit: $R^2 = 0.996$; meaning that the variables forming the model can explain (99.6%) of the changes in CDE.
4- Moreover, the error term (residuals) is not normally distributed whereas the probability value of Jarque-Bera test is less 5% (JB = 44.795, $p\text{–}value = 0.000 < \alpha = 0.05$).
5- Also, there is no heteroskedasticity problem whereas the probability value of ARCH-test is greater than 5% (F(1,22) = 0.196, p-value = 0.663 > 0.05).

In addition, there is no serial correlation whereas the probability value of Breusch–Godfrey serial correlation LM test is greater than 5% (F(1,1) = 15.636, p-value = 0.158 > 0.05).

2- Using regulatory efficiency (business freedom, monetary freedom)

Table (VIII) shows the estimated ECM short-run model.

Table (VIII): ECM short-run model

Variable	Coefficient	Std. Error	t-Statistic	*p*-value
$\Delta logCDE_{t-1}$	-2.304	0.022	-105.146	0.006
$\Delta logCDE_{t-2}$	-0.947	0.010	-95.945	0.007
$\Delta logEG_{t}$	11.497	0.113	101.562	0.006
$\Delta logEG_{t-1}$	7.706	0.094	81.677	0.008
$\Delta logEG_{t-2}$	16.862	0.160	105.631	0.006
$\Delta logBF_{t}$	3.245	0.039	83.135	0.008
$\Delta logBF_{t-1}$	1.713	0.027	63.018	0.010
$\Delta logBF_{t-2}$	6.359	0.058	109.560	0.006
$\Delta logMF_{t}$	0.923	0.009	103.732	0.006
$\Delta logMF_{t-1}$	0.815	0.014	57.438	0.011
$\Delta logMF_{t-2}$	0.814	0.015	54.250	0.012
$\Delta(logEG_{t}* logBF_{t})$	-1.681	0.020	-85.141	0.008
$\Delta(logEG_{t-1}* logBF_{t-1})$	-0.931	0.014	-67.259	0.010
$\Delta(logEG_{t-2}* logBF_{t-2})$	-3.322	0.030	-110.412	0.006
$\Delta(logEG_{t}* logMF_{t})$	-1.061	0.009	-118.164	0.005
$\Delta(logEG_{t-1}* logMF_{t-1})$	-0.926	0.011	-83.308	0.008
$\Delta(logEG_{t-2}* logMF_{t-2})$	-0.744	0.011	-65.697	0.010
ECT_{t-1}	-0.194	0.001	-142.432	0.005
R-squared	0.999	S.E. of regression		0.0008
Adjusted R-squared	0.999	ARCH-test (F (*p*-value))		4.135 (0.054)
Jarque-Bera (*p*-value)	0.843 (0.656)	Breusch-Godfrey (F (*p*-value))		1.688 (0.418)

The results of the ECM presented in Table (VIII) show that:

1- There is statistically significant negative impact of the BF on the relation between EG and CDE at 5% significance level, whereas both $\Delta(logEG_{t}* logBF_{t})$, $\Delta(logEG_{t-1}* logBF_{t-1})$ and $\Delta(logEG_{t-2}* logBF_{t-2})$ are negative (-1.681, -0.931, -3.322) and $p\text{–}value < \alpha = 0.05$.

2- There is statistically significant negative impact of the MF on the relation between EG and CDE at 5% significance level, whereas all $\Delta(\log EG_t * \log MF_t)$, $\Delta(\log EG_{t-1} * \log MF_{t-1})$ and $\Delta(\log EG_{t-2} * \log MF_{t-2})$ are negative -1.061, -0.926, -0.744) and *p–value* < α = 0.05.
3- Although, the model performs well in terms of goodness of fit: R^2 = 0.999; meaning that the variables forming the model can explain (99.9%) of the changes in CDE.
4- Moreover, the error term (residuals) is normally distributed whereas the probability value of Jarque-Bera test is greater 5% (JB = 0.843, *p–value* = 0.656 > α = 0.05).
5- Also, there is no heteroskedasticity problem whereas the probability value of ARCH-test is greater than 5% (F(1,22) = 4.135, *p*-value = 0.054 > 0.05).

In addition, there is no serial correlation whereas the probability value of Breusch–Godfrey serial correlation LM test is greater than 5% (F(1,1) = 1.688, *p*-value = 0.418 > 0.05).

3- Using market openness (trade freedom, financial freedom)

Table (IX) shows the estimated ECM short-run model.

Table (IX): ECM short-run model

Variable	Coefficient	Std. Error	t-Statistic	*p*-value
$\Delta\log EG_t$	0.073	0.131	0.556	0.596
$\Delta\log EG_{t-1}$	0.741	0.131	5.667	0.001
$\Delta\log EG_{t-2}$	0.319	0.096	3.318	0.013
$\Delta\log TF_t$	0.084	0.038	2.244	0.060
$\Delta\log TF_{t-1}$	-0.085	0.023	-3.636	0.008

$\Delta logFF_{t}$	-0.155	0.064	-2.405	0.047
$\Delta logFF_{t-1}$	0.380	0.059	6.489	0.000
$\Delta logFF_{t-2}$	0.175	0.046	3.819	0.007
$\Delta(logEG_{t}* logFF_{t})$	0.144	0.038	3.810	0.007
$\Delta(logEG_{t-1}* logFF_{t-1})$	-0.194	0.035	-5.574	0.001
$\Delta(logEG_{t-2}* logFF_{t-2})$	-0.080	0.026	-3.118	0.017
ECT_{t-1}	-0.130	0.008	-16.213	0.000
R-squared	0.947	S.E. of regression		0.010
Adjusted R-squared	0.902	ARCH-test (F (*p*-value))		0.277 (0.604)
Jarque-Bera (*p*-value)	2.918 (0.232)	Breusch-Godfrey (F (*p*-value))		0.863 (0.477)

The results of the ECM presented in Table (IX) show that:

1- There is statistically significant negative impact of the FF on the relation between EG and CDE at 5% significance level, whereas both $\Delta(logEG_{t-1}* logFF_{t-1})$ and $\Delta(logEG_{t-2}* logFF_{t-2})$ are negative (-0.194, -0.080) and $p\text{–}value < \alpha = 0.05$.

2- Although, the model performs well in terms of goodness of fit: $R^2 = 0.947$; meaning that the variables forming the model can explain (94.7%) of the changes in CDE.

3- Moreover, the error term (residuals) is normally distributed whereas the probability value of Jarque-Bera test is greater 5% (JB = 2.918, $p\text{–}value = 0.232 > \alpha = 0.05$).

4- Also, there is no heteroskedasticity problem whereas the probability value of ARCH-test is greater than 5% (F(1,22) = 0.277, *p*-value = 0.604 > 0.05).

In addition, there is no serial correlation whereas the probability value of Breusch–Godfrey serial correlation LM test is greater than 5% (F(2,5) = 0.863, *p*-value = 0.477 > 0.05).

Results and findings:

At the 5% significance level with a p-value of = 0.05, it is found the following results:

1- Economic growth has a statistically significant positive impact on carbon emissions, So the first hypothesis is accepted.
2- Economic growth forming the model can explain 40.6% of the changes in carbon dioxide emissions, and the remaining 59.4% is because of random error or other factors that are not studied in this research.
3- Economic freedom has a statistically significant negative impact on the relationship between economic growth and carbon emissions. Or, in other words, economic growth affects carbon emissions negatively through the effect of economic freedom. So, the second hypothesis is accepted.
4- Economic freedom, economic growth, and their lags can explain 56.9% of the changes in carbon emissions.
5- Furthermore, when delving deeper into the variables that comprise the economic freedom index to determine the impact of each on the relationship between economic growth and carbon emissions, the following results are discovered:
   A- The tax burden has a statistically significant positive impact on the relationship between economic growth and carbon emissions, which means that taxes allow the relationship between economic growth and emissions to be

positive. And the reason behind that may be that taxes take a proportion of the capital allocated to using clean technology or transferring to the green economy. So, the businesses still run the same way and release emissions.

B- Government spending has a statistically significant negative impact on the relationship between economic growth and carbon emissions.

C- Government size (which includes tax burden and government spending) plus economic growth and their lags can explain 99.6% of the changes in carbon emissions.

D- Business freedom has a statistically significant negative impact on the relationship between economic growth and carbon emissions.

E- Monetary freedom has a statistically significant negative impact on the relationship between economic growth and carbon emissions.

F- Financial freedom has a statistically significant negative impact on the relationship between economic growth and carbon emissions.

G- All of the above results mean that government spending, business freedom, monetary freedom, and financial freedom promote economic growth in a way that is environmentally friendly and decreases emissions.

H- Regulatory efficiency (which includes monetary freedom and business freedom) plus economic growth and their lags can explain 99.9% of the changes in carbon emissions.

I- Market openness (which includes trade freedom and financial freedom) plus economic growth and their lags, which form the model, can explain 94.7 % of the changes in carbon emissions.

Policies Implications:

1- The study recommends focusing on promoting economic freedom to reduce carbon dioxide emissions and increase economic growth, particularly through its channels of increased government spending, increased monetary freedom, increased financial freedom, and increased business freedom.

2- The study recommends focusing on decreasing the tax burden on businesses even if it is a source of government revenues because increasing the tax burden decreases the level of economic freedom, which affects economic growth negatively and increases emissions.

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- https://ourworldindata.org/co2-gdp-decoupling.(Our World in Data (OWID) is a scientific online publication that focuses on large global problems. It is a project of the Global Change Data Lab, a registered charity in England and Wales).