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Income inequality and environmental degradation in Egypt: Evidence from dynamic ARDL approach

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Abstract

This study aims to explore the effect of income inequality on CO_2 emissions in Egypt during the period 1975-2017. " The analysis investigates the validity of the political economy approach compared to the Keynesian approach regarding the inequality-environment nexus. The study applies the novel dynamic autoregressive distributed lags approach (DARDL) to overcome the complications associated with the structure of the ARDL model. The findings showed that the relationship between inequality and CO_2 emissions is not a trade-off relationship. Rather, inequality leads to environmental deterioration in the long term, which supports the political economy approach in explaining the inequality-environment nexus. Hence, the economic development policies adopted in Egypt during the past four decades have led to a negative impact on the environment.

Keywords: CO_2 emissions, cointegration, dynamic ARDL, income inequality, political economy approach.

Introduction

Debates on the relationship between income inequality and environmental degradation have increased in recent years, especially in light of the increasing trends in both carbon dioxide emissions and income inequality in many countries. According to the United Nation Development Program (UNDP, 2019) income inequality has increased in both developed and developing countries during the last four decades. Available statistics on the global environment indicators also indicate that emissions of carbon dioxide have increased worldwide with an annual average of 2.25% during the period 2000-2017 (Ritchie & Roser, 2017). These increasing trends in both environmental degradation and income inequality raise several questions about the nexus between them.

Despite a large number of recent studies examining the relationship between environmental degradation and income inequality based on different panel data techniques (e.g., Baloch et al., 2020; Chen et al., 2020b; Liu et al., 2019; Uddin et al., 2020a), the studies related to analyzing the effect of inequality on environmental degradation on individual countries are not as numerous as required. Although the results of panel data studies are important in understanding the relationship between these two variables, they failed in reaching a specific global view on the nature of the effect of income inequality on environmental degradation (Hailemariam et al., 2020). The reason for this failure is the great discrepancy in the different panel data results about whether the effect of inequality on environmental degradation is negative or positive. This contradiction in panel data results makes it appropriate in this paper to study the environmental effects of income inequality using the new methods available in the time series econometrics, instead of analyzing a large scale of countries using panel data techniques, so that the results and policy implications drawn from the study will be more specific and clearer.

In this context, there are two main approaches, the first is called the political economy approach (Boyce, 1994, 2007; Magnani, 2000; Torras & Boyce, 1998), which considers that income inequality deteriorates environmental indicators, so more inequality will be reflected in more environmental degradation. Accordingly, income inequality leads to the existence of corruption that passes and accommodates foreign and local investments in many projects that are harmful to the environment. High inequality supports the economic power of this class that opposes any policies to improve environment indicators, this is because inequality reduces the ability for collective action to reduce environmental degradation. This wealthy class with political influence will not allow laws that limit environmental pollution. Therefore, environmental considerations will not be taken into account in light of the prevalence of an unfair distribution of income and wealth.

As for the second approach, it is based on the interpretation of determining the environmental effects of inequality on the Keynesian approach (Heerink et al., 2001; Ravallion et al., 2000), which is concerned with the critical role that aggregate demand exerts on economic activity. This approach believes that inequality in income distribution leads to a transfer of income from the poor to the rich, and thus the demand for environmentally friendly goods and services will increase by the rich, and thus more inequality leads to an improvement in environmental indicators. In explaining this trade-off between inequality and the environment, this approach relies on a high level of the marginal propensity to emit among the poor. If the degree of inequality in income distribution decreases and some income is transferred from the rich to the poor, then an increase in the total consumption of the poor will occur, and this increase will be directed to the consumption of more goods that do not take into account environmental considerations, which puts pressure on resources and ultimately leads to an increase in carbon dioxide emissions. Hence inequality supports the environment according to this approach. Consequently, this study aims to determine which of these two approaches is more capable of explaining the environmental impacts of income inequality in Egypt during the period 1975-2017.

The Egyptian economy is a suitable case to study the environmental impacts of income inequality for many reasons. First, Egypt is a developing economy seeking to achieve economic development which affects both environment and the structure of income distribution, and if there is a trade-off between these two variables, then the Egyptian economy will face a difficult choice in its development path. Available statistics on the pattern of income distribution in Egypt indicate that the Gini coefficient, which measures the degree of disparity in income distribution, has increased during the previous decades from an average of 0.37 in the 1970s to 0.39 during the 1980s, then to 0.41 during the 1990s, and finally increased to 0.42 during the period 2000-2017 (Solt, 2019). This means that the pattern of economic development that Egypt followed during the previous decades was biased towards the rich.

This study seeks to achieve several objectives. First, it aims to identify the appropriate approach to understand the impact of income inequality on environmental degradation in Egypt as an emerging economy. The study employs the dynamic autoregressive distributed lags (DARDL) recently developed by Jordan & Philips (2018) to capture the long and short un relationships between income inequality and environmental degradation in Egypt and avoid the difficulty in explaining the results of the widely known ARDL of (Pesaran et al., 2001) which suffers from a complex structure in the estimation equation that usually includes lags, differences, and difference lags in both short and long terms.

Second, the study covers an important period in the path of economic development in Egypt that has begun in 1975, which is the year after the Egyptian government announced a fundamental structural change in its economic orientations from an economy depending on government intervention to an economy facilitated by supply and demand mechanisms and integrated with the world economy (Farzanegan et al., 2020). This new economic orientation has resulted in a change in the pattern of income distribution in the Egyptian economy during the four decades following this year. In this context, it is necessary to determine the effect of the new pattern of income distribution on environmental degradation in Egypt during this relatively long period.

Thirdly, in Egypt, not only a deterioration in income distribution has occurred, but an environmental deterioration has also occurred during the past four decades. Carbon dioxide emissions have increased at an annual average of 2.13% during the period 1975-2017 (BP, 2020). Many of the explanations tried to find the main drivers of carbon dioxide emissions in many developed and developing countries, but there is a severe dearth of empirical works on the environmental effects of inequality that have been conducted for the Egyptian economy.

The remainder of the study is structured as follows. the second section reviews the literature related to the impact of inequality on the environment, while the third section describes the data and exposes the methodology of the dynamic ARDL model versus the ARDL model, whereas the fourth section discusses the estimation results. Section 5 concludes

2. literature review

Over the past decades, academic attention began to study the determinants of environmental degradation. Empirical works are devoted, in the early stage of research, to estimate the effects of economic growth on the environment, and many studies conducted on developed and developing countries provided evidence on the existence of the inverted U-curve hypothesis in describing the relationship between economic growth and environmental degradation (Grossman & Krueger, 1995). Indeed, the Environmental Kuznets Curve (EKC) implies a nonlinear relationship between the two variables in which the environment begins to deteriorate in the early stages of economic growth and then improves after reaching a specific real income threshold.

Despite the importance to investigate the effects of income growth to understand environmental degradation, researchers realized the necessity to monitor the impact of the structure of income distribution by considering the environmental effect of income inequality indicators. In this respect, several approaches have been used to determine the effect of income inequality on environmental degradation. One of them is to capture its effects indirectly by estimating the effects that inequality will have on factors that positively or negatively affect environmental degradation. (Uzar, 2020) presented his analysis of the impact of inequality on one of the main factors that reduce environmental deterioration, renewable energy consumption, in 43 developed and developing countries during the period 2000-2015. He concluded that reducing income inequality will increase the consumption of renewable energy. This result can give us evidence that inequality harms the environment because of its negative effect on renewable energy consumption.

Researchers tried to estimate the environmental impacts of income inequality directly by adding one of its indicators into the estimation model. As usual, there are many contradictory results about this effect. Some believe that inequality improves the environment, others believe that inequality deepens environmental degradation. In this context, one can distinguish between two main trends that explain the impact of income inequality on the environment. The first trend is called the Keynesian approach (Ravallion et al., 2000) and the second is called the political economy approach (Boyce, 1994, 2007; Torras & Boyce, 1998). According to the Keynesian approach, more inequality enhances the environment. Differences in marginal propensity to consume between poor and rich lead the rich to consume more in friendly environmental goods and services if their incomes increase at the expense of the poor, so inequality improves the environment. On the other hand, if redistribution policies transfer incomes from the rich to the poor to reduce income inequality, the poor will increase their demand by consuming more unfriendly environmental goods and services and thus inducing environmental degradation. This trade-off relationship between income inequality and the environment has been supported by many empirical studies in developed and developing countries. (Hailemariam et al., 2020) supported this hypothesis by estimating the effects of income inequality on carbon dioxide emissions in OECD countries using the common correlated effects mean group CCEMG to consider the problem of cross-section dependency, they found that an increase in income inequality measured by the Gini coefficient reduced the CO2 emissions. Other methodologies are employed to support the Keynesian or trade-off hypothesis, for example (Hübler, 2017) employed the quantile regression technique instead of the mean regression techniques to estimate the effects of income inequality on different quantiles of carbon emissions. He found that increasing inequality could reduce CO_2 emissions.

The second main trend in studying the effects of income inequality on the environment is what is called the political economy approach. According to (Boyce, 2007) high wealth inequalities harm the environment. This view explains the effect of inequality on the environment through the political dimension of inequality which results in the concentration of wealth. More income inequality creates a small class that can deepen its political positions based on its economic power and becomes effective in the decision-making process. Therefore, the concerns of this group, will not concern with projects that support the environment as much as it will focus on influencing investment towards environmentally unfriendly investments. According to (Boyce, 2007), if the parties benefiting from environmental pollution have the economic power backed by political influence, then the parties affected by the negative environmental impacts will not be able to bring about legislative changes that protect the environment. Then the effect of inequality harms the environment as long as this wealthy class exists and influences investment decisions. So, as noted in recent research, more equality in income distribution could reduce CO_2 emissions (Zhang & Zhao, 2014). The political economy explanation of inequality-emissions nexus has been supported also by (Knight et al., 2017), they found that increasing the wealth share of the top 10% had a positive effect on the per capita CO_2 emissions. According to this study, the concentration of wealth leads to political influence and economic power preventing any positive actions to protect the environment. The same results are driven by (Uzar & Eyuboglu, 2019) by employing the ARDL methodology to investigate the environmental effects of income inequality in Turkey during 1984-2014. Their results show that inequality harms the environment which makes it one of the main factors affecting the environment policy design that aims to reduce emissions.

3. Data and methodology

3.1. Data

The present study examines the effect of income inequality on environmental degradation using carbon dioxide emissions (co_2) as a proxy for the state of the environment in Egypt during the period (1975-2017). Despite the availability of data for many independent variables in this study after 2017, the time range of the study stopped in 2017 due to the absence of published data on both co_2 emissions and Gini coefficient after that year.

The independent variables include the Gini index (gini) to measure income inequality as used by many studies, real gross domestic product per capita (gdppc) to measure economic growth, people living in urban areas as a share of total population (urb) to capture the urbanization effect, the sum of exports and imports of goods and services measured as a share of gross domestic product to express trade openness, and primary energy consumption per capita (gigajoule per capita) to track energy consumption effect on co_2. All variables will be used in logarithms to overcome the heteroscedasticity problem (Khan, et al., 2019). Tables (1) and (2), and Figure (1) describe the variables used in the study and trace the time path evolution for the series during the period (1975-2017).

Table 1. variables definition and data sources

Variables	description	source
co_2	Carbon dioxide emissions (kg per capita)	(British Petroleum, 2020)
gini	The Gini index of disposable income inequality, its value ranges from 0 to 1, with 0 means perfect equality and 1 refers to a perfect inequality	(Solt, 2020)
gdppc	Gross domestic product divided by midyear population. Data are in constant 2010 U.S. dollars.	(World Bank, 2020)
urb	Urban population: people living in urban areas as a share of the total population.	(World Bank, 2020)
trade	Trade openness is the sum of exports and imports of goods and services measured as a share of gross domestic product.	(World Bank,2020)
ecpc	Energy consumption per capita (Gigajoule per capita)	(British Petroleum, 2020)

There are many statistical properties of the data presented in Table 2. Perhaps the most noticeable is the coefficient of variance, which measures the ratio of the standard deviation to the mean. Real GDP per capita has achieved the highest percentage of variation compared to the rest of the variables, reaching (32.5%), which means that there is a large variation or dispersion in incomes among individuals, and this is supported by the rise in the mean of Gini coefficient (0.4). On the other hand, the dependent variable in this study, co2, also showed a great variation that reached 24.8% during the study period. This variation in carbon dioxide emissions and the rest of the variables may justify the need to study the relationship between these variables in the short run and long run.

Table 2. Descriptive Statistics

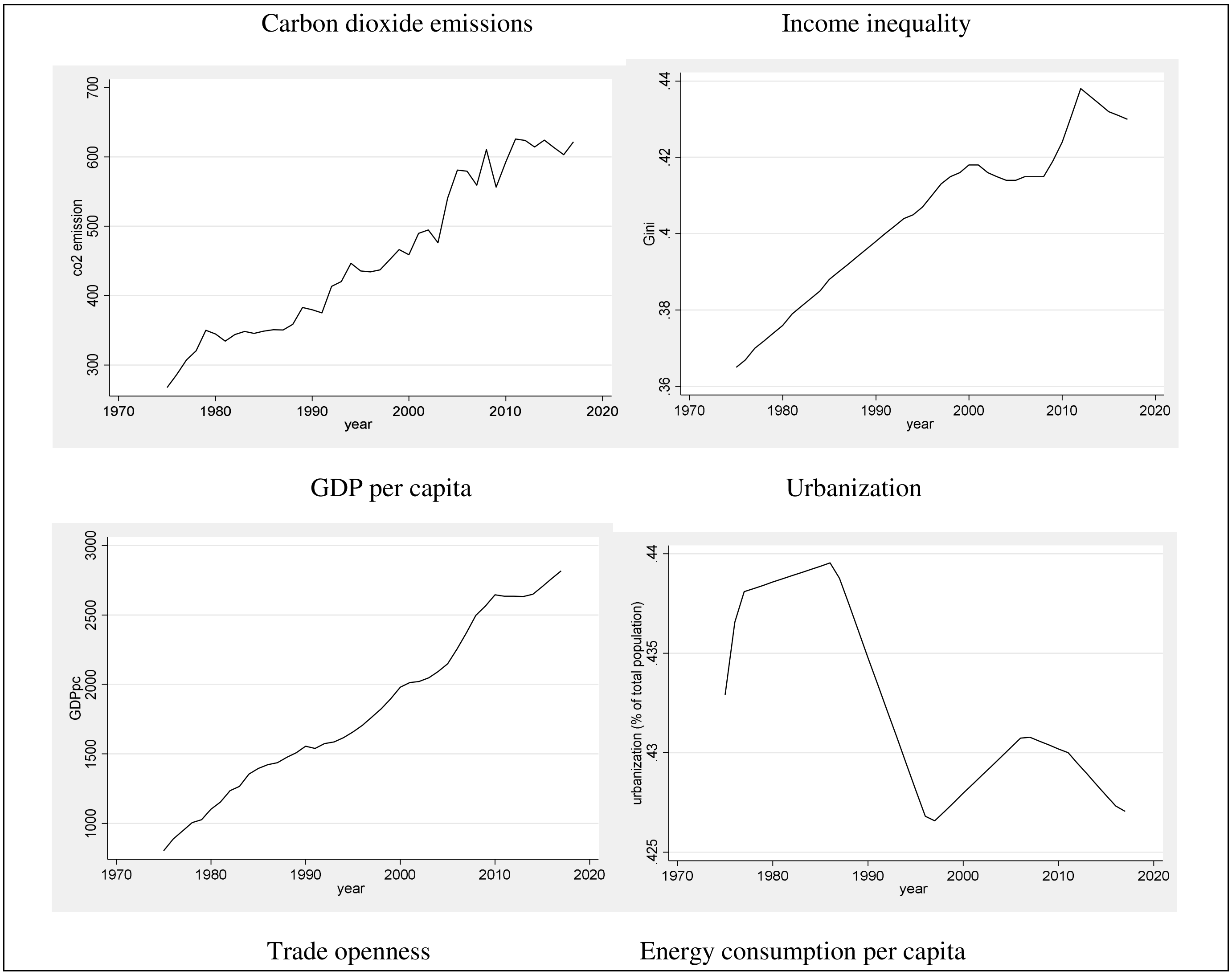
Variables [a]	Obs.	Mean	Std. Dev.	Std. Dev./mean (%)	Min	Max	Skew.	Kurt.
co_2	43	455.084	112.832	24.793	267.192	625.962	.213	1.667
gini	43	.405	.021	5.185	.365	.438	-.3	2.063
gdppc	43	1819.222	591.436	32.51	802.749	2817.32	.153	1.871
urb	43	.432	.005	1.157	.427	.44	.426	1.577
trade	43	.508	.112	22.04	.302	.745	.354	2.376
ecpc	43	27.957	8.256	29.53	11.493	40.541	-.074	2.093

[a] Statistics are calculated using numbers before taking logarithms.

Table 3. Matrix of correlations

Variables	lco2	lgini	lgdppc	lurb	ltrade	lecpc
lco2	1.000					
lgini	0.932	0.932				
lgdppc	0.978	0.978	0.978			
lurb	-0.744	-0.744	-0.744	-0.744		
ltrade	-0.259	-0.259	-0.259	-0.259	-0.259	
lecpc	0.961	0.961	0.961	0.961	0.961	0.961

Table (3) indicates that there is a strong correlation between all the independent variables and the dependent variable except for trade openness, where these coefficients are more than 90% in all variables, and more than 74% for urbanization. So, it is necessary to place these independent variables in the estimation model of the study. It is noted from Figure (1) that there is an upward trend in carbon dioxide emissions, economic growth, and energy consumption, while the openness index is characterized by volatility and the urbanization index took a downward trend with a relative fluctuation in Egypt during the period from 1975 until 2017**.**



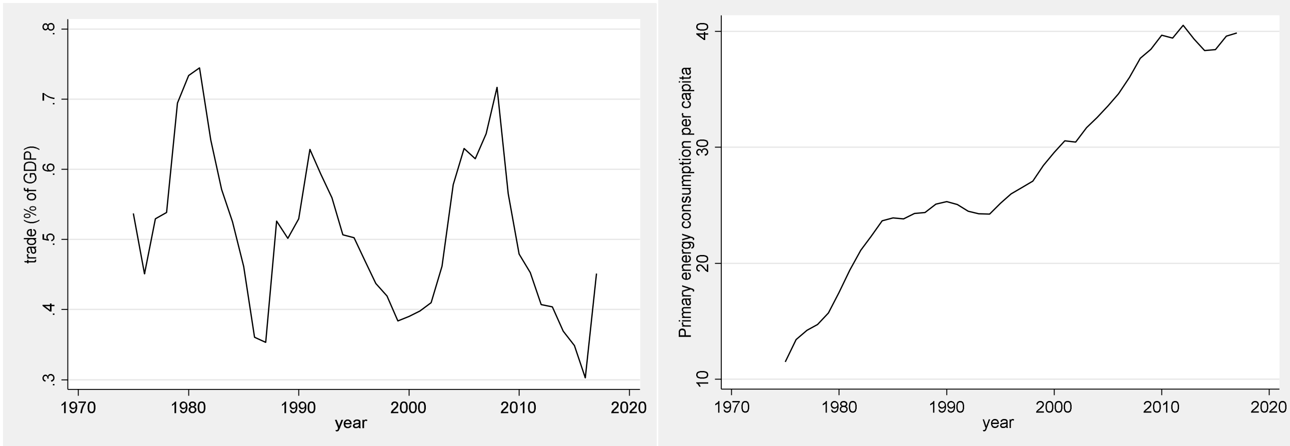


Fig. 1. Time path evolution of the series.

3.2. Model specification: Dynamic ARDL versus ARDL

The main objective of the study is to find out the effect of income inequality on the environmental pollution in Egypt proxied by co_2 emission, and then the Gini coefficient represents the main independent variable in the study. To avoid model specification bias, the study adds control variables depending on the results of many studies in the relevant literature concerning co_2 drivers. In this context, economic growth is often considered an important variable that affects carbon dioxide emissions (e.g., Munir et al., 2020). Its effect is usually studied within the environmental Kuznets curve hypothesis, which indicates that economic growth deteriorates the environment in the early stages of development and then turns into enhancing the environment in the advanced levels of economic development.

The study also includes urbanization index as a control variable as it is recently noted in the literature of co2 drivers. Several new studies have begun to be concerned with the impact of urbanization on the environment as one of the main sources affecting carbon dioxide emissions (Dong et al., 2019). This concern of the environmental effect of urbanization in the empirical literature prompted us to include it as an independent variable in the study, especially since many of the results captured a significant effect of urbanization on carbon dioxide emissions (Ali et al., 2019). On the other hand, urbanization is an important indicator to know the development that is taking place at the level of structural change, especially in a developing country seeking to achieve economic development like Egypt.

Because the Egyptian economy applied many economic policies during the study period (1975-2017), which are consistent with the nature of economic policy programs of both the International Monetary Fund and the World Bank, and which were aimed largely at liberalizing foreign trade, it was appropriate to study the impact of these policies on carbon dioxide emissions by adding an index of trade openness, which measures the ratio of total exports and imports to GDP, to analyze the environmental effect of trade openness in Egypt. Tracking the impact of trade openness on the environment is a common practice in much empirical research such as (Leal & Marques, 202).

Despite the importance of energy consumption in influencing economic growth, the effect of primary energy use on carbon dioxide emissions is difficult to ignore when formulating the econometric model in this study, especially in a developing economy such as the Egyptian economy. Accordingly, the econometric model can be formulated in a logarithmic form as follows:

$$lco_{2t} = \beta_0 + \beta_1 lgini_t + \beta_2\, lgdppc_t + \beta_3\, lurb_t + \beta_4\, ltrade_t + \beta_5\, lecpc_t + e_t \quad (1)$$

in which $\beta_1, \beta_2, \beta_3, \beta_4$, and β_5 account for the elasticity of carbon dioxide emissions lco_2 in response to a 1% change in income inequality ($lgini$), GDP per capita ($lgdppc$), urbanization ($lurb$), trade openness ($ltrade$), and energy consumption per capita ($lecpc$) respectively. β_0, and e_t denote constant and the error term respectively, *t* refers to the year and *l* means logarithm. All variables are defined in Table 1.

The main feature of the ARDL methodology according to (Pesaran et al., 2001) is the possibility of testing cointegration among time series that differ in the degree of integration so that it does not exceed I(1) and provided that the dependent variable is integrated after taking the first difference I(1). Thus, as long as there is no time series is integrated in the second-order I(2), it is possible to test the relationship between the variables not only in the long run but rather to monitor the behavior of these variables in the short run and to capture the adjustment process by estimating the error correction term.

The ARDL model can be formulated as follows:

$$\begin{aligned}\Delta lco_{2t} = a_0 &+ \sum_{i=1}^{p} a_{1i}\Delta lco_{2t-i} + \sum_{i=0}^{q1} a_{2i}\Delta lgini_{t-i} + \sum_{i=0}^{q3} a_{3i}\Delta lgdppc_{t-i} + \sum_{i=0}^{q4} a_{4i}\Delta lurb_{t-i} \\ &+ \sum_{i=0}^{q5} a_{5i}\Delta ltrade_{t-i} + \sum_{i=0}^{q6} a_{6i}\Delta lecpc_{t-i} + b_1 lnco_{2t-1} + b_2 lgini_{t-1} + b_3 lgdppc_{t-1} \\ &+ b_4 lurb_{t-1} + b_5 ltrade_{t-1} + b_6 lecpc_{t-1} + \in_t \quad (2)\end{aligned}$$

where Δ refers to the first difference, p and qi denote the lag length determined by Akaike information criterion (AIC), and $\in_t$ represents the error term. The long-run relationships will be captured by b, whereas the short-run relationships will be explored by a. Long-run equilibrium relationship among variables is testing using F-statistic based on the null hypothesis of no cointegration H_0: $a_1 = a_2 = a_3 = a_4 = a_5 = a_6 = 0$ and against the alternative hypothesis of the existence of cointegration of H_1: $a_1 \neq a_2 \neq a_3 \neq a_4 \neq a_5 \neq a_6 \neq 0$. According to (Pesaran et al., 2001), if the value of the F-statistic is greater than the upper bound of the critical values, then there is a long-run equilibrium relationship among the variables, and if the calculated value of the F-statistic is less than the lower bound then there is a long-run equilibrium relationship among the variables. This study depends on the critical bounds values provided by (Kripfganz & Schneider, 2019)

The error correction model can be estimated according to Eq. (3) whereas ECT_{t-1} represent a one lagged error correction term and δ is the adjustment coefficient that must be statistically significant and negative to guarantee the convergence towards the equilibrium path in the long run.

$$\Delta lco_{2t} = a_0 + \sum_{i=1}^{p} a_{1i}\Delta lco_{2t-i} + \sum_{i=0}^{q1} a_{2i}\Delta lgini_{t-i} + \sum_{i=0}^{q3} a_{3i}\Delta lgdppc_{t-i} + \sum_{i=0}^{q4} a_{4i}\Delta lurb_{t-i} + \sum_{i=0}^{q5} a_{5i}\Delta ltrade_{t-i} + \sum_{i=0}^{q6} a_{6i}\Delta lecpc_{t-i} + \delta ECT_{t-1} + \epsilon_t \quad (3)$$

Despite the simple implementation and the wide use of ARDL models in studying the relationship between variables in the short and long runs, there are many complications in understanding and interpreting the results of these models as they usually contain multiple lags or difference lags. The complex structure of ARDL models leads to difficulty in quantifying the short and long-run effects of the independent variables on the dependent variable which may lead to a lack of clarity for the decision-maker to apply the appropriate economic policy. In addition to the importance of knowing the extent of a relationship between the variables, as well as the direction of this relationship, the policy-maker also needs a clear answer to the following question: What is the effect of an increase or decrease in one of the independent variables in the ARDL model on the response variable while the other variables remain constant? To overcome these difficulties, (Jordan & Philips, 2018) presented a Dynamic Autoregressive Distributed Lags model using simulation to predict the effect of a positive or negative change in one of the regressors on the dependent variable while keeping the rest of the variables constant (Khan, Teng, Khan, et al., 2019).

According to (Danish & Ulucak, 2020; Jordan & Philips, 2018) the error correction term estimated by dynamic ARDL can be calculated according to Eq. (4):

$$\Delta lco_{2t} = a_0 + \omega_0 lco_{2t-1} + \varphi_1 \Delta lgini_t + \omega_1 lgini_{t-1} + \varphi_2 \Delta lgdppc_t + \omega_2 lgdppc_{t-1} + \varphi_3 \Delta lurb_t + \omega_3 lurb_{t-1} + \varphi_4 \Delta ltrade_t + \omega_4 ltrade_{t-1} + \varphi_5 \Delta lecpc_t + \omega_5 lecpc_{t-1} + \epsilon_t \quad (4)$$

By generating 5000 simulations, the dynamic ARDL not only can estimate coefficients in the short and long runs but also predict, using graphs, the response of carbon dioxide emissions to positive and negative shocks in every independent variable while other regressors are constant (Khan et al., 2020).

4. Results and discussion

4.1. Unit root tests

Many criticisms have been directed to the results of unit root tests when ignoring the presence of structural breaks (Perron, 1989). During the study period 1975-2017, fundamental changes have been occurred in macroeconomic policies based on different IMF programs implemented in the Egyptian economy. These programs included many structural adjustment policies like privatization and exchange rate liberalization. So, it is necessary to test the stationarity of time series considering the presence of structural breaks. The study applies Clemente–Montañés–Reyes unit root test with two endogenous structural breaks (Clemente et al., 1998) to capture the sudden changes in means of the series which called the additive outliers model (AO), along with exploring the gradual changes which called innovative outliers (IO). According to the results of the Clemente–Montañés–Reyes unit root test listed in Table (4) all series are integrated of order one I(1), meaning that the dynamic ARDL cointegration test could be performed.

Table 4. Clemente–Montañés–Reyes unit root test with two structural breaks

Variables	Additive outlier model (AO)			Innovative outlier model (IO)		
	t- statistic	Break 1	Break 2	t-statistic	Break 1	Break 2
level						
Lco2	-4.993	1989	2001	-5.218	1990	2002
lgini	-2.651	1992	2013	-2.342	2007	2010
lgdppc	-3.225	1985	2001	-3.147	1994	2004
lurb	-3.433	1998	2015	-5.467	1985	2011
ltrade	-3.659	1987	2013	-3.485	1988	2010
lecpc	-3.737	1983	2002	-4.570	1977	1997
First difference						
d.lco2	-6.918**	2003	2007	-8.808**	2002	2006
d.lgini	-5.618**	2009	2014	-6.107**	1999	2000
d.lgdppc	-5.977**	1982	2006	-5.574**	1984	1993
d.lurb	-5.564**	1989	1999	-6.698**	1985	1995
d.ltrade	-5.500**	2002	2006	-5.516**	1985	2007
d.ecpc	-5.759**	1982	2010	-6.010**	1983	1993

Notes: The critical value at 5% significance level is − 5.490

4.2. Bounds cointegration test

According to the results of unit root tests tabulated in Table (4), the bounds test for cointegration is performed to explore the eventual existence of long run relationships among variables. Table (5) includes F-statistic and T-statistic values compared with critical values of (Kripfganz & Schneider, 2019) and approximate p-values. The results indicate that the null hypothesis of no cointegration can be rejected as both F and T calculated values are greater than the critical values of the upper bounds I(1) at 10% and 5% levels of significance respectively. This result confirms the existence of a long-run equilibrium relationship between CO2, income inequality, economic growth, urbanization, trade openness, and primary energy consumption in Egypt during the period (1975-2017).

Table 5. Bounds test for cointegration

Calculated values		Kripfganz and Schneider (2019) critical values and approximate p-values							
		10%		5%		1%		p-value	
		I(0)	**I(1)**	**I(0)**	**I(1)**	**I(0)**	**I(1)**	**I(0)**	**I(1)**
F- statistic	4.082*	2.451	3.760	2.957	4.440	4.167	6.052	0.011	0.072
T- statistic	-4.554**	-2.504	-3.812	-2.864	-4.240	-3.597	-5.110	0.001	0.029

Notes: *** p<0.01, ** p<0.05, and * p<0.1

4.3. Estimation results

Table (6) displays the estimation results of both dynamic simulated ARDL model estimation and the ARDL model used as a robustness check model, whereas Figures (2-6) depict the effects of 1 % decrease and 1% increase in predicted income inequality, economic growth, urbanization, trade openness, and energy consumption on CO2 emissions in Egypt respectively. Results indicate that the value of the error correction term ECT_{t-1} is negative and statistically significant. This means that, in the short run, the model corrects its deviation (error) and converges to the long-run equilibrium path at a speed of 75% annually.

Table 6. Dynamic ARDL and ARDL results

VARIABLES	Dynamic ARDL	ARDL
ECT_{t-1}	-0.750***	-0.663***
	(0.165)	(0.140)
$\Delta lgini$	0.526	
	(1.487)	
$lgini_{t-1}$	2.285*	3.102**
	(1.216)	(1.442)
$\Delta lgdppc$	0.538	
	(0.469)	
$\Delta lurb$	11.61**	8.300*
	(4.358)	(4.207)
$\Delta ltrade$	0.139***	
	(0.0487)	
$\Delta lecpc$	-0.536*	
	(0.309)	
$lgdppc_{t-1}$	1.039***	1.347***
	(0.293)	(0.342)
$lurb_{t-1}$	3.990*	4.902*
	(2.144)	(2.716)
$ltrade_{t-1}$	0.188***	0.232***
	(0.0513)	(0.0572)
$lecpe_{t-1}$	-0.761***	-0.987***
	(0.229)	(0.339)
Constant	4.893	4.239
	(3.250)	(2.660)
R^2	0.527	0.454
Simulations	5000	
Diagnostic Tests [b]		
Jarque-Bera	.3392[0.844]	1.414 [0.493]
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity	0.06[0.807]	0.02[0.90]
Breusch-Godfrey LM test for autocorrelation	2.052[0.321]	0.218[0.6405]
Ramsey RESET test	0.24[0.8671]	1.79[0.1698]
Cumulative sum test for parameter stability [a]	0.567	0.518
Durbin-Watson d-statistic	2.298	2.073

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, and * p<0.1. [a] Critical value are: 1.143, 0.9479, and 0.850 for 1%,5%, and 10% levels of significance respectively. [b] Square brackets include p-value.

Several diagnostic tests are performed to confirm the power and reliability of the dynamic ARDL and ARDL assessment results. According to the Jarque-Bera test residuals are normally distributed, and the models don't suffer from the serial correlation according to the Breusch-Godfrey LM test for autocorrelation, and also there is no problem of heteroskedasticity as indicated by the results of the Breusch-Pagan /Cook-Weisberg test for heteroskedasticity. On the other hand, the diagnostic tests indicate that models are stable and don't suffer from specification bias according to the cumulative sum test for parameter stability and Ramsey RESET tests respectively.

Results indicate that in the short run there is no significant relationship between income inequality and carbon dioxide emissions, whereas, there is a statistically significant and positive relationship between them in the long term, as a 1% rise in income inequality increases carbon dioxide emissions in the long run by 2.285%. This effect of income inequality in Egypt in long run is consistent with other results in recent works like (Baloch et al., 2020; Wolde-Rufael & Idowu, 2017) and contradicts with others (Grunewald et al., 2017).

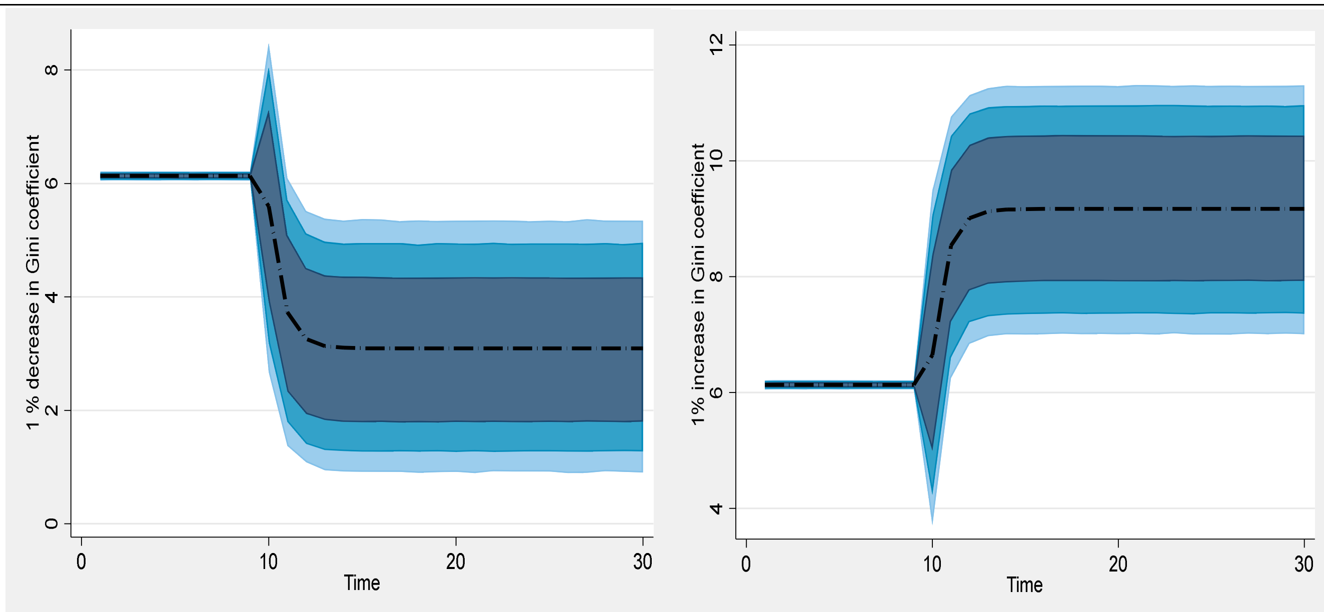


Fig. 2. Effects of 1 % decrease and a 1% increase in predicted Gini coefficient on co_2 in Egypt. The average predicted values are indicated by the dashed line. The shaded area shows (from darkest to lightest) 75%, 90%, and 95% confidence intervals.

This finding is inconsistent with the inequality-environment trade-off approach which depends on the high marginal propensity to emit for the poor. Despite the high ratio of private consumption to GDP in Egypt that reached 88% in 2017, which means that the marginal propensity to consume in Egypt is very high and accordingly the expected effect of income inequality will enhance the environment, results suggest that more inequality increases CO_2 emission in Egypt. The harmful effect of income inequality on the environment in the long term means that the political economy approach to understanding the effect of inequality on environmental pollution is valid in the Egyptian economy, and deepening inequality through transferring incomes to the rich at the expense of the poor in Egypt will not lead to an increase in the rich's demand for environmentally friendly goods, but it will lead to an increase in the demand of the poor to purchase less environmentally friendly and cheaper goods, which harms the environment. On the other hand, the continued concentration of income and wealth in the hands of the few people or rich class as a result of the continuing increase in income inequality, as what happened in the increase of the Gini coefficient in Egypt during the past four decades. In the long term, this class would create political centers based on its economic power that would enable them to block any laws taking environmental considerations into account, whether at the level of domestic production or imports from abroad. Although economic growth doesn't affect environmental pollution in the short term, its effect, in the long run, is positive and significant. Results show that an increase in the real per capita GDP by 1% will lead to an increase in carbon dioxide emission rates in Egypt by 1.04% in the long run. This can be explained by relying on the fact that the real GDP per capita in Egypt is still low ranging from 802.7 to 2817.3 according to Table (2) during the study period (1975-2017), so any increase in real income will be directed to more consumption at the expense of environmental degradation. Results refer to a very harmful environmental effect of urbanization in the short and long terms in Egypt as supported by recent works on urbanization-emissions nexus (Das Neves Lopes et al., 2020; Ullah et al., 2020).

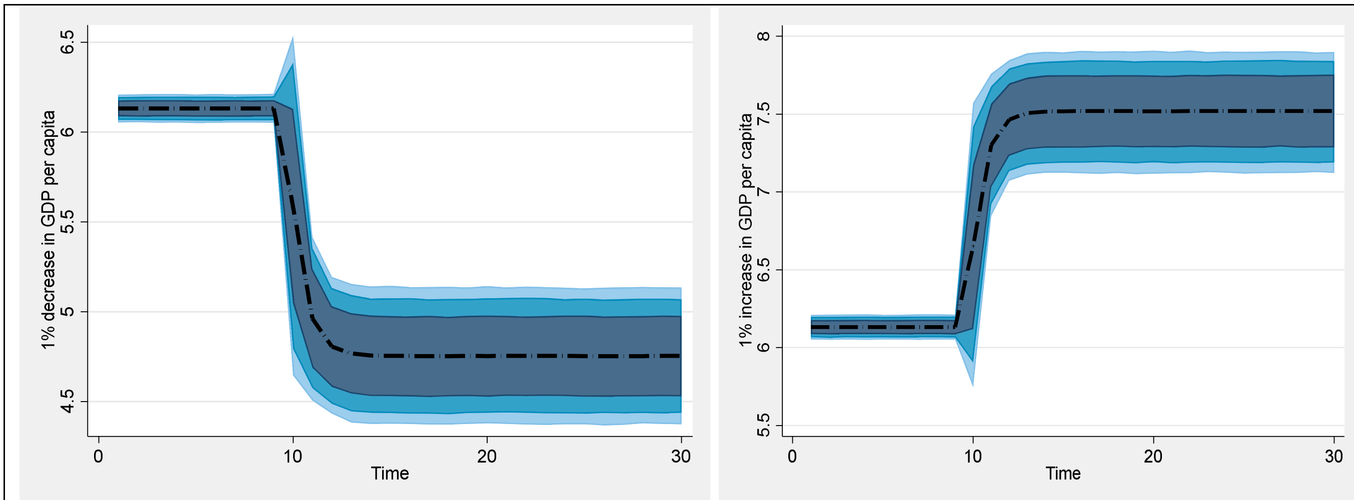


Fig. 3. Effects of 1 % decrease and a 1% increase in predicted GDP per capita on co_2 in Egypt. The average predicted values are indicated by the dashed line. The shaded area shows (from darkest to lightest) the 75%, 90%, and 95% confidence intervals.

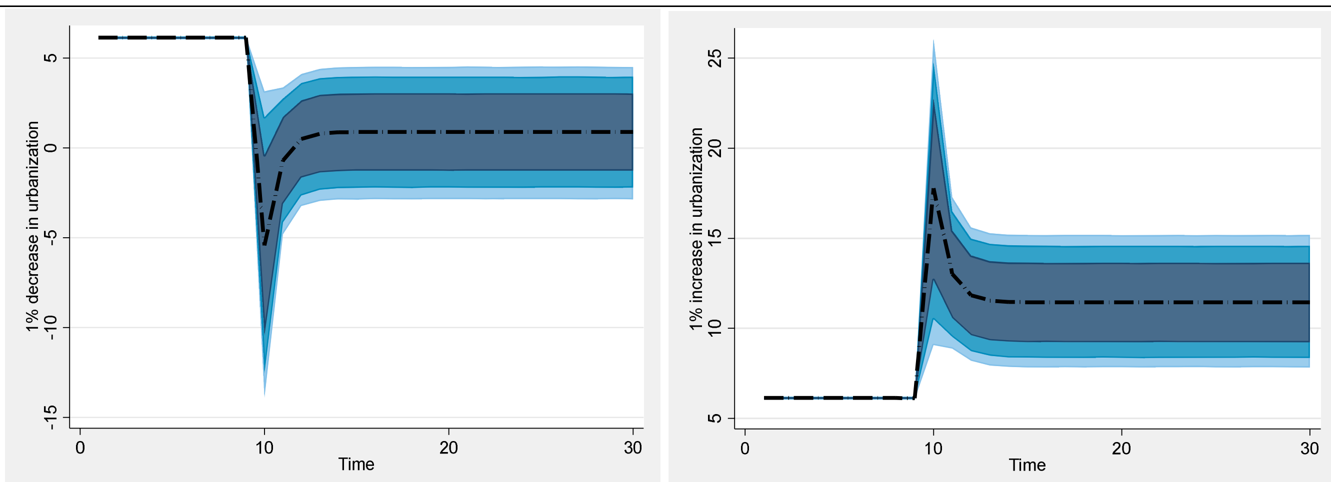


Fig. 4. Effects of 1 % decrease and a 1% increase in predicted urbanization on co_2 in Egypt. The average predicted values are indicated by the dashed line. The shaded area shows (from darkest to lightest) the 75%, 90%, and 95% confidence intervals.

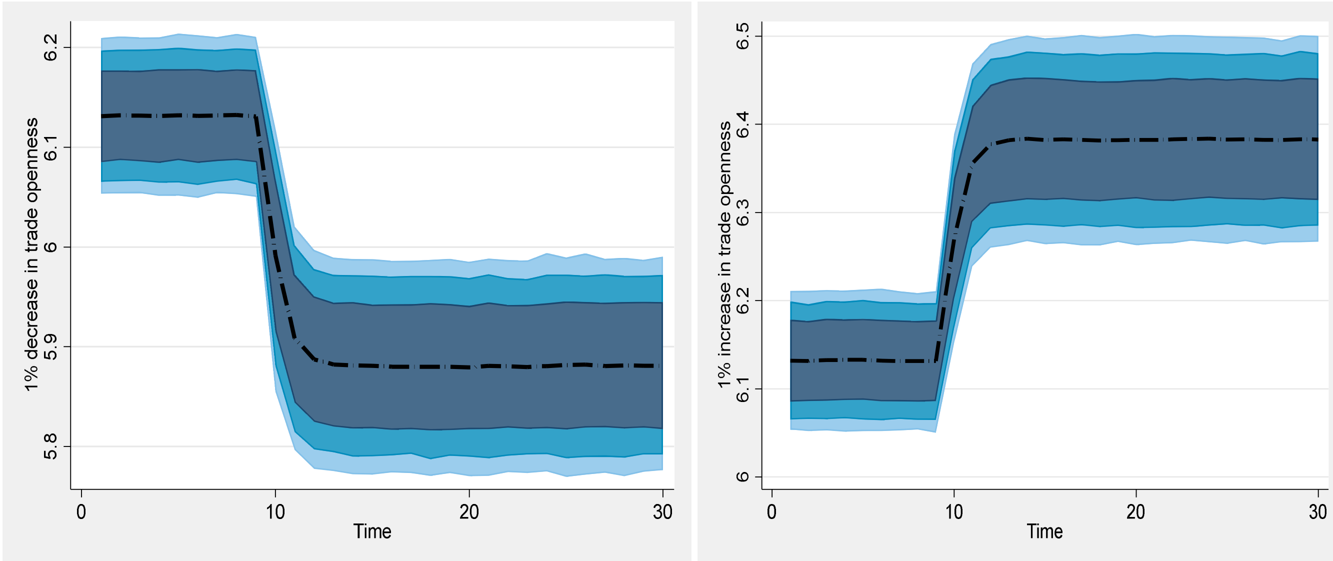


Fig. 5. Effects of 1 % decrease and a 1% increase in predicted trade openness on co_2 in Egypt. The average predicted values are indicated by the dashed line. The shaded area shows (from darkest to lightest) the 75%, 90%, and 95% confidence intervals.

As for the impact of trade openness on the environment in Egypt, results show a harmful effect environment, which contradicts with (Shahbaz et al., 2013) and recently (Zubair et al., 2020), but consistent with other works (Asongu, 2018; Sannassee & Seetanah, 2016). A 1% increase in trade openness results in an increase in carbon dioxide emissions by 0.14% and 0.19% in the short and long terms respectively. This result supports the political economy approach in explaining the harmful effect of inequality on the environment. In many developing economies, trade openness and capital account liberalization led to an increase in imports of goods and encouraged foreign direct investments that work in anti-environment and many dirty industries which faced many environmental restrictions in developed countries since the early 1970s (Al-Ayouty et al., 2017). Results also indicate significant and negative effects of energy consumption on CO_2 emission in both short and long terms. This result contrasts with the positive effect captured in many recent empirical works in developing countries and needs further investigation.

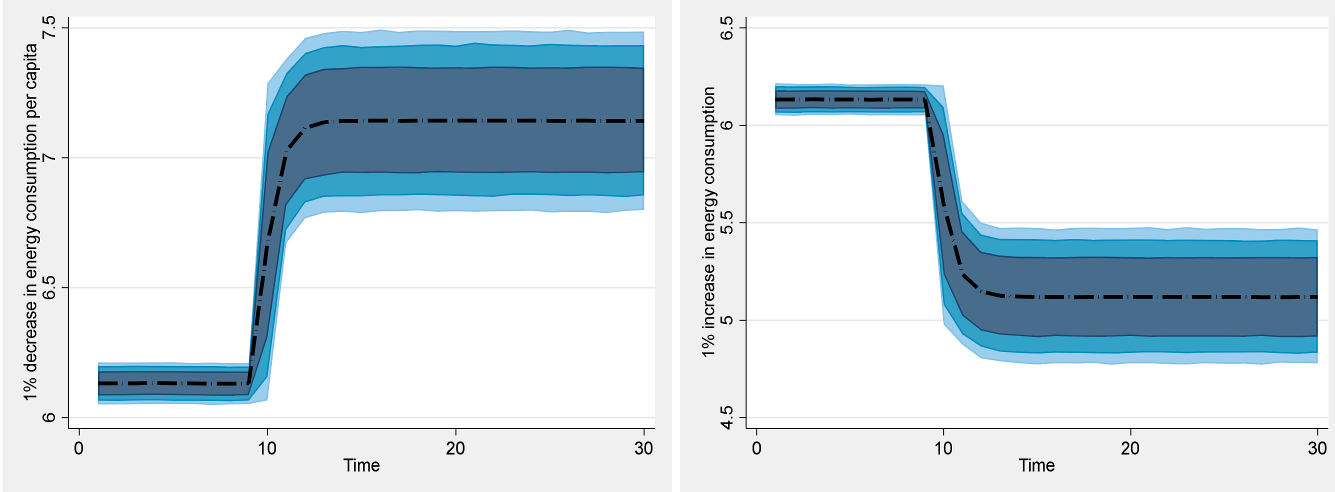


Fig. 6. Effects of 1 % decrease and a 1% increase in predicted primary energy consumption per capita on co_2 in Egypt. The average predicted values are indicated by the dashed line. The shaded area shows (from darkest to lightest) the 75%, 90%, and 95% confidence intervals.

5. Conclusion and policy implications

The previous analysis is an extension of the empirical studies assessing the relationship between income inequality and environmental degradation in developing economies. The study aimed to examine the extent to which economic policy-makers in Egypt could rely on the political economy approach in determining the effect of income inequality on environmental degradation during the period (1975-2017). To this end, the study employed the dynamic ARDL methodology initiated by (Jordan & Philips, 2018) to estimate the environmental impacts of Gini effects during the short-run and long run. The main finding of the study is that income inequality harms the environment in Egypt in the long run despite the absence of a significant relationship between them in the short run. This is consistent with the political economy approach which believes that income inequality harms the environment. The study also employed the ARDL model for robustness check and its results are compatible with the Dynamic ARDL results.

There are several implications for both economic policy and environmental policy. Firstly, the pattern of economic development in Egypt was not only biased towards the rich at the expense of the poor, but rather led to a negative impact on the environment reflected by an increase in carbon dioxide emissions. This is a complex problem the Egyptian economy suffers, and it can be mitigated by adopting economic policies that redistribute income in favor of the poor and improve the environmental indicators in Egypt. Secondly, when studying the factors affecting environmental pollution, it is necessary not to be satisfied with the real income growth index as a measure of economic activity, but it is also important to consider the effect of the income distribution structure accompanying the growth process in the estimation model, especially in developing economies that seek to achieve economic development and the requirements of sustainable development.

Thirdly, it is noticeable according to the previous analysis that it is wrong to continue pursuing the biased economic growth policies for the rich at the expense of the poor in Egypt claiming that inequality improves the environment. The analysis showed that more inequality deteriorated the environment despite the rise in private consumption in Egypt to rates that reached more than 80% of the GDP, which means that the increase in the incomes of the poor will go to more consumption and then more pressures on the environment. This result means that the Keynesian approach in explaining the relationship between inequality and the environment is not valid in the Egyptian economy.

Finally, the previous analysis illustrated that there is no trade-off relationship between income inequality and environmental degradation, and therefore economic policy in Egypt will not be subject to choosing one of them and sacrificing the other. Rather, an improvement in income distribution in Egypt will lead to an improvement in the environment and the achievement of some sustainable development goals.

Declarations:

1- **Ethics approval and consent to participate**: Not applicable.

2- **Consent to Publish**: “Not applicable” for this paper.

3- **Availability of data and materials**: The datasets are available in the World Development Indicators data of the World Bank, British Petroleum Statistics (2020), and (Solt, 2020)

4- **Competing interests**: The author declares that he has no competing interests.

5- **Funding**: There is no funding for this study.

6- **Author Contributions:** The author contributed to all parts of this article.

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Figures

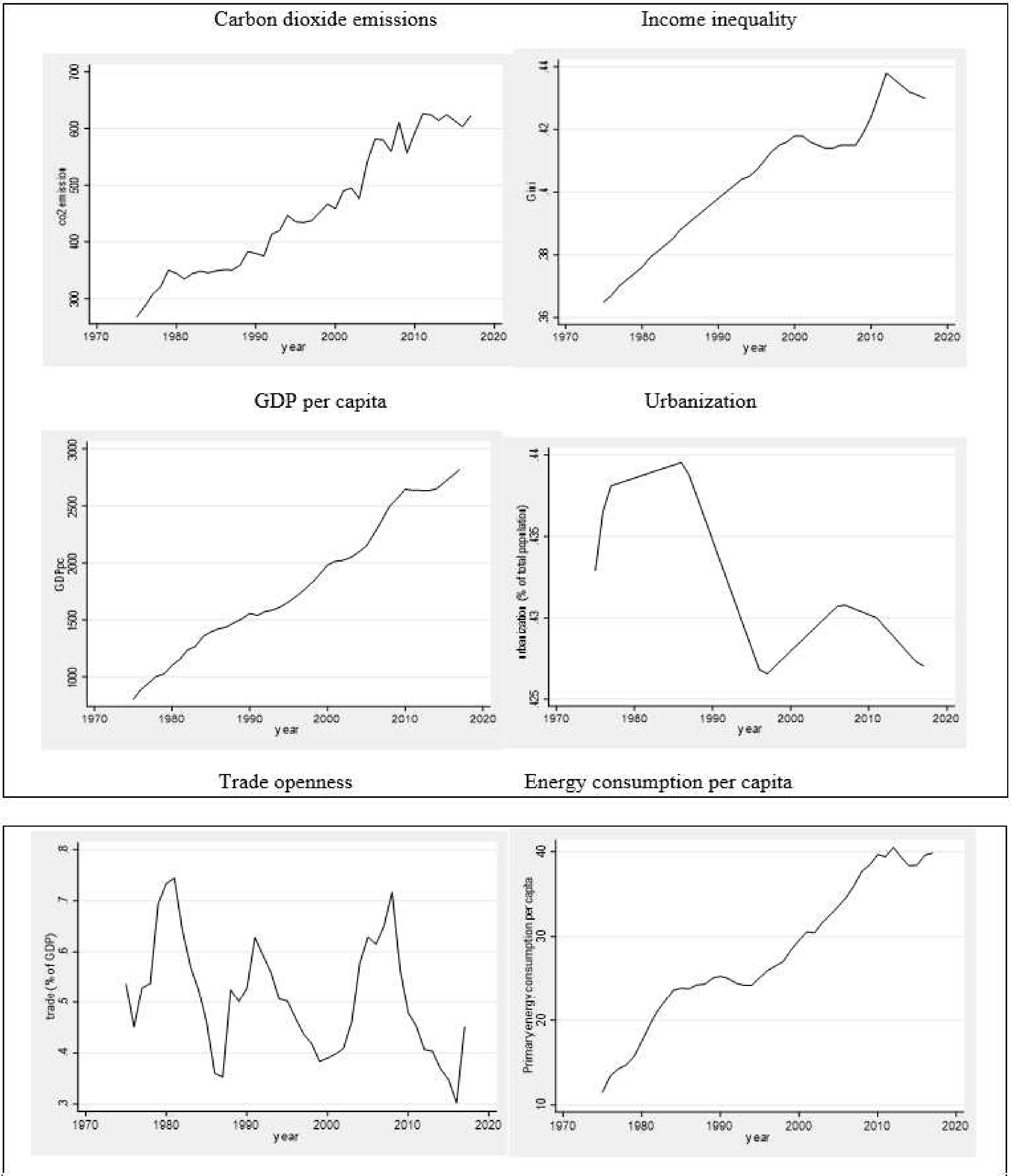

Figure 1

Time path evolution of the series.

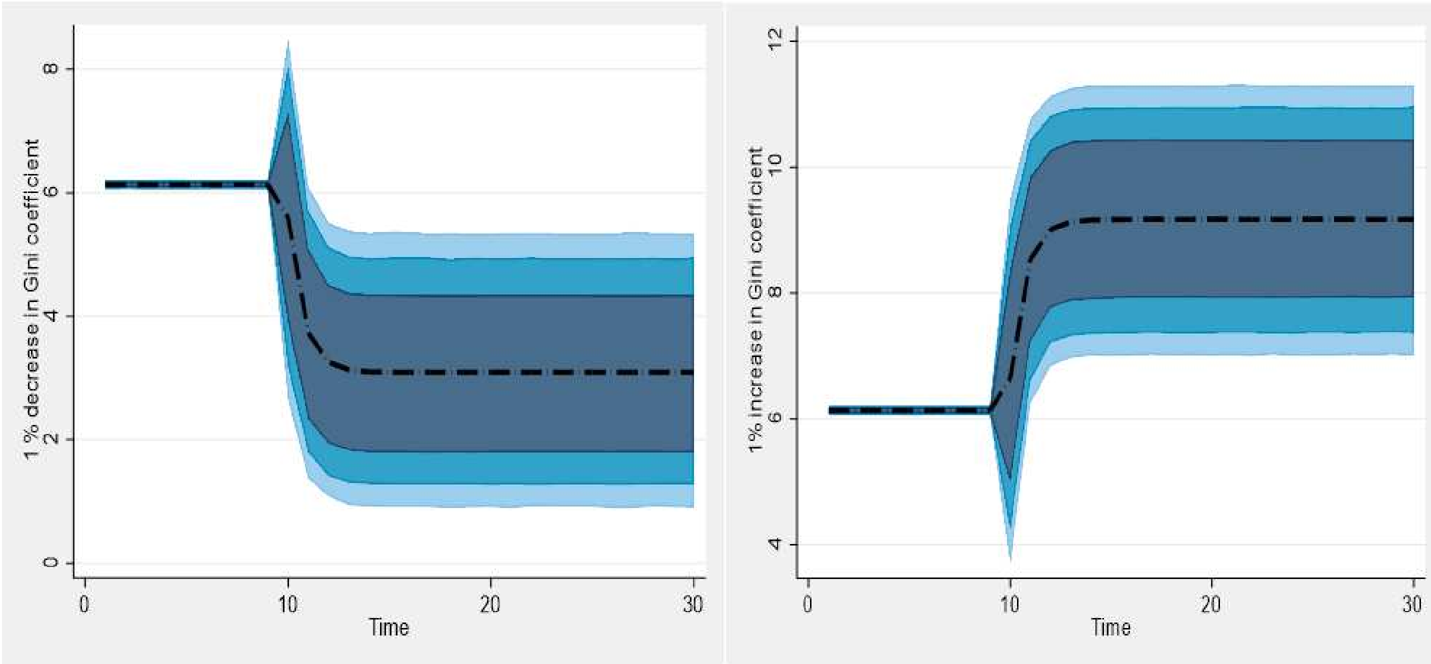

Figure 2

Effects of 1 % decrease and a 1% increase in predicted Gini coefficient on co2 in Egypt. The average predicted values are indicated by the dashed line. The shaded area shows (from darkest to lightest) 75%, 90%, and 95% confidence intervals.

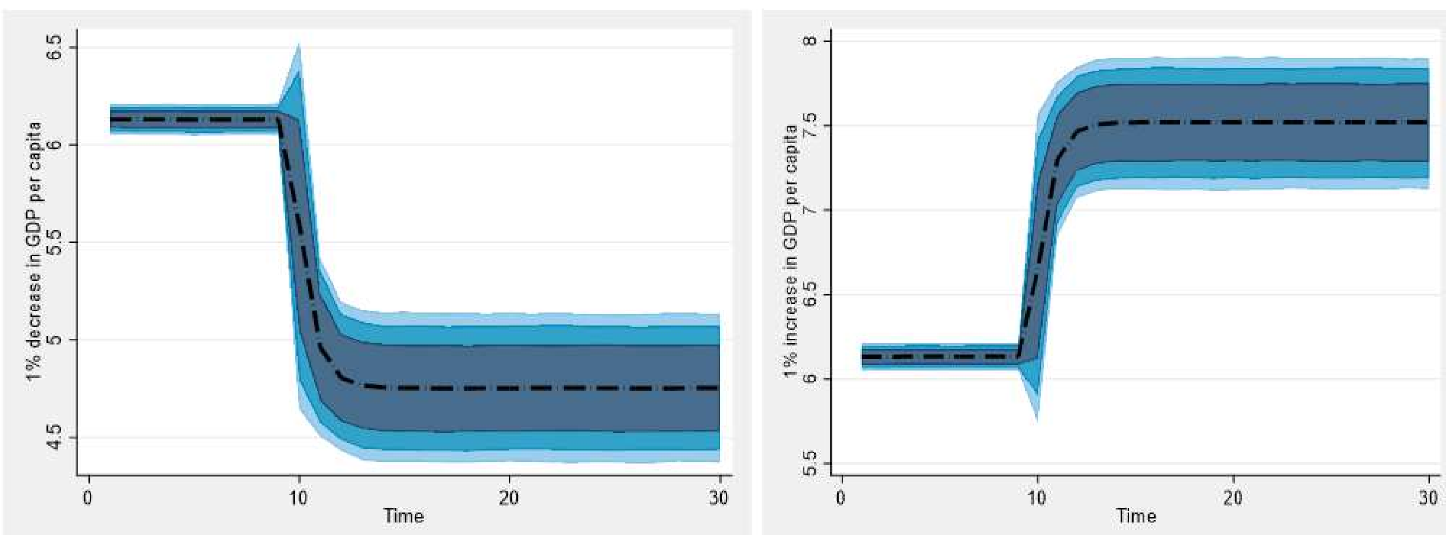

Figure 3

Effects of 1 % decrease and a 1% increase in predicted GDP per capita on co2 in Egypt. The average predicted values are indicated by the dashed line. The shaded area shows (from darkest to lightest) the 75%, 90%, and 95% confidence intervals.

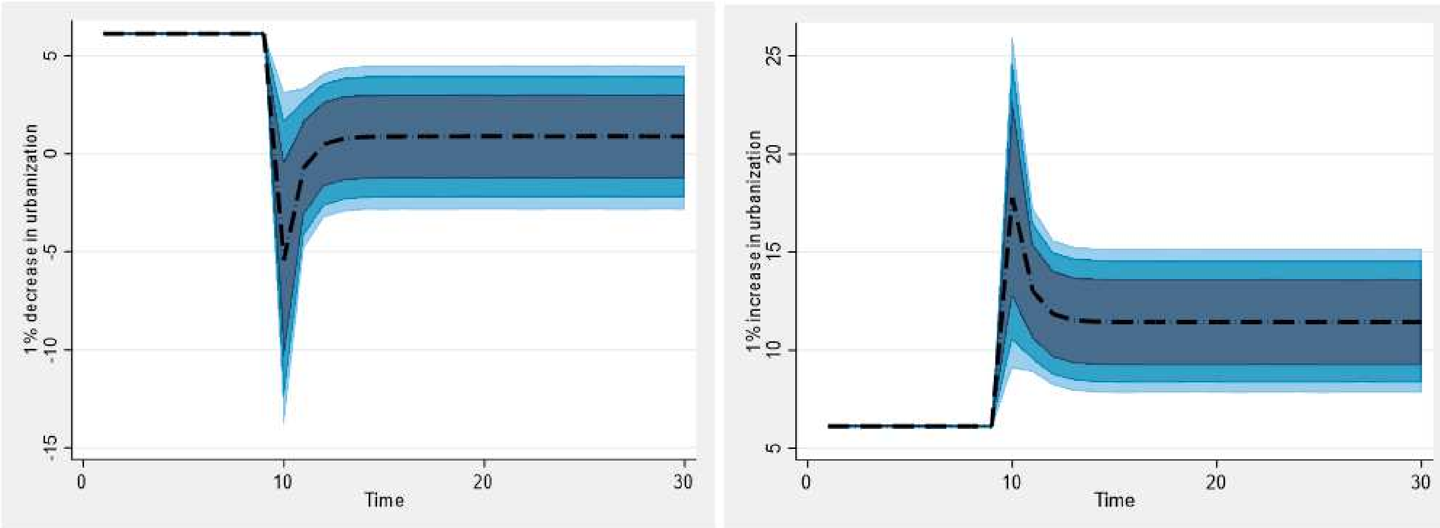

Figure 4

Effects of 1 % decrease and a 1% increase in predicted urbanization on co2 in Egypt. The average predicted values are indicated by the dashed line. The shaded area shows (from darkest to lightest) the 75%, 90%, and 95% confidence intervals.

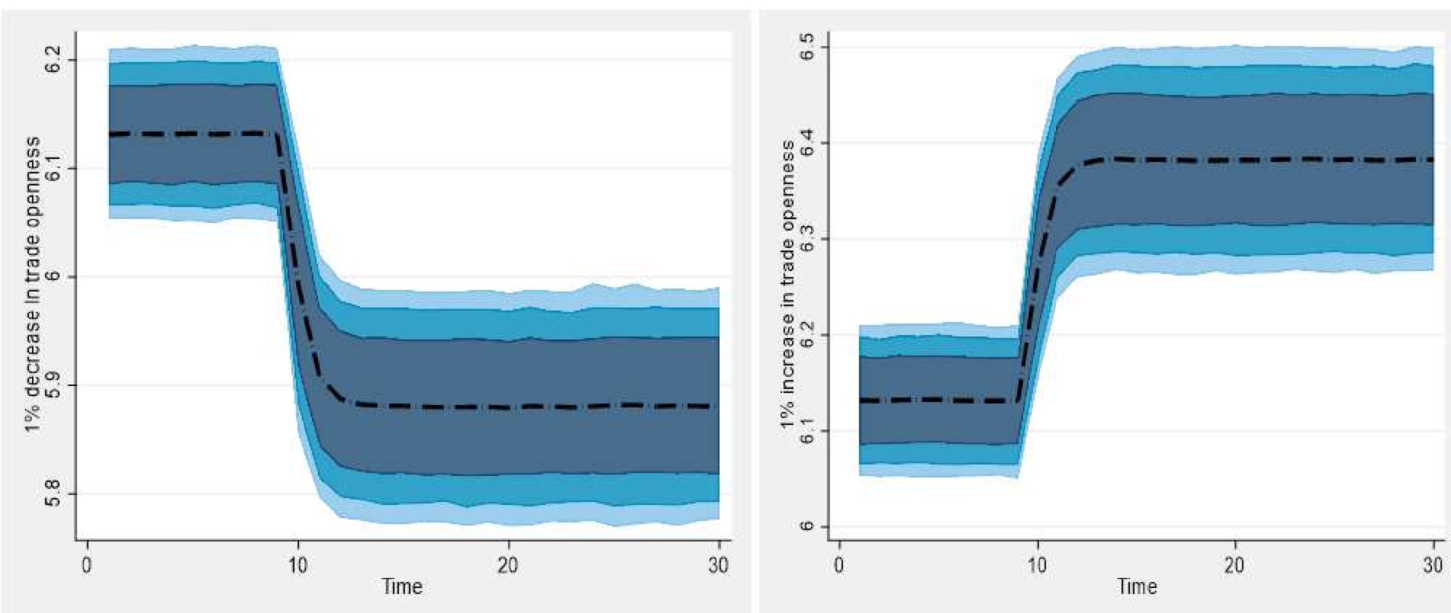

Figure 5

Effects of 1 % decrease and a 1% increase in predicted trade openness on co2 in Egypt. The average predicted values are indicated by the dashed line. The shaded area shows (from darkest to lightest) the 75%, 90%, and 95% confidence intervals.

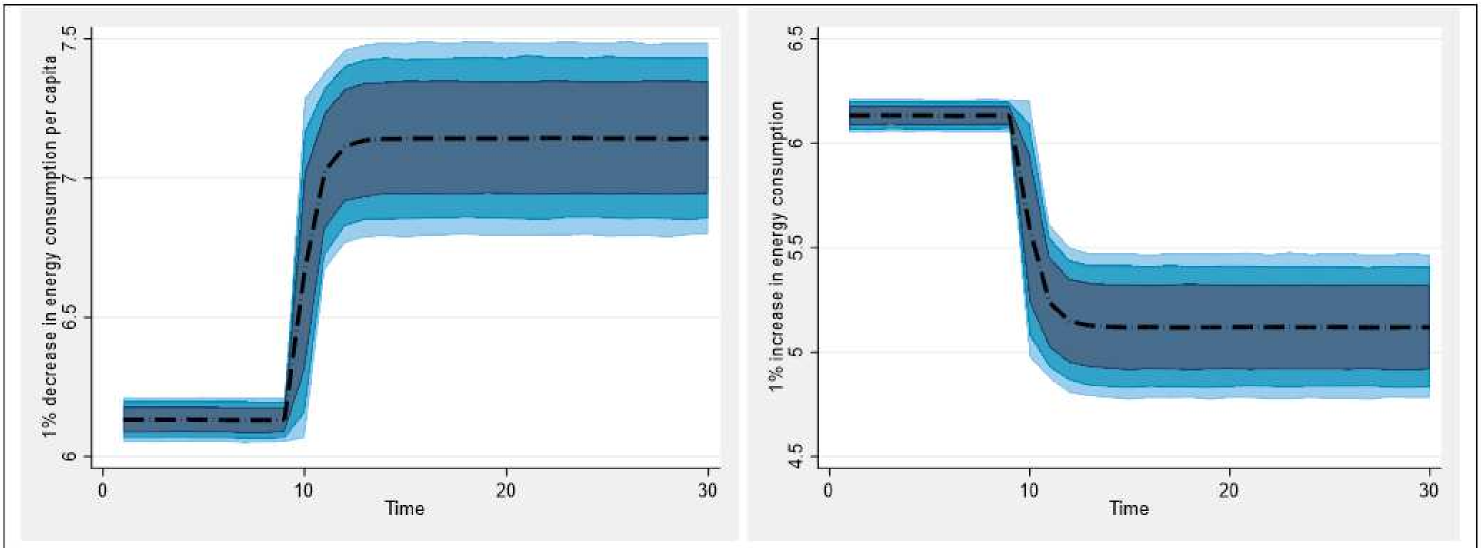

Figure 6

Effects of 1 % decrease and a 1% increase in predicted primary energy consumption per capita on co2 in Egypt. The average predicted values are indicated by the dashed line. The shaded area shows (from darkest to lightest) the 75%, 90%, and 95% confidence intervals.