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Does External Debt Worsen Environmental Pollution? Evidence from Morocco

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ABSTRACT

Morocco's new development model report published in 2021 offers a renewed vision of the country's economic emergence strategy. It advocates an economic growth model that respects the environment and takes into consideration climate change challenges while promoting external debt, as one of the main economic instruments to achieve this new development pathway. This study investigates the empirical relationship between external debt and carbon dioxide emissions as an indicator of environmental pollution through the environmental Kuznets theory. As Morocco has a growing external debt and relies mainly on fossil fuels, the purpose is to analyze the long-term and short-term effect of external debt on carbon dioxide emissions using an ARDL model over the period 1984-2018. The time series data was collected from World Bank. The core findings of the study confirm the existence of inverted U-shaped Kuznets curve, they also reveal that external debt has a significant negative effect on carbon dioxide emissions in Morocco.

Keywords: External Debt, Environmental Pollution, ARDL
JEL Classifications: O44, O55, Q5

1. INTRODUCTION

Since the industrial revolution, economic growth has been achieved to the detriment of climate stability and ecosystem equilibrium. The impact of the current economic paradigm on the environment is demonstrated through two major concerns: on the one side, an increase in consumption involves a higher demand for fossil fuels, a non-renewable source of energy that will inevitably deplete over time. On the other side, higher fossil fuel consumption is also associated with higher negative externalities, mainly carbon emissions known as the primary cause of climate change. Admittedly, the consequences of economic growth would be the depletion of conventional natural resources upstream and the degradation of the environment downstream (Grossman, 1993). Based on Kuznets' theory linking income to inequality, Grossman and Krueger (1995) adapted this curve to explore the relationship between air pollution indicator and per capita income. The Environmental Kuznets Curve (EKC) has been widely revisited in the literature using the ecological footprint variable to reflect environmental degradation, or CO_2 emissions for environmental pollution (Sarkodie and Strezov, 2019), as the major gas responsible of climate change.

Climate change disproportionately affects regions of the world, and most developing countries show a high vulnerability profile. For instance, and according to the latest Intergovernmental Panel on Climate Change (IPCC) report, the African continent is experiencing an increase in extreme weather events that will be more severe over the next decade (IPCC, 2022). Furthermore, Africa's vulnerable profile, coupled with its high dependence on fossil fuels, makes the overall situation more challenging. Currently, 80 % of electricity generation is based on fossil fuels despite the ambitious plans to develop renewable energies, given the continent's high potential of solar, wind and geothermal resources (IEA, 2021).

In this regard, Morocco, one of the most dynamic African countries in developing renewable energy projects, is still dependent on fossil fuels to meet its growing electricity demand, while the country is strongly impacted by climate change, even though its carbon emissions represent only 0.16% of global greenhouse gases (GHG) (WBG, 2021). Indeed, urban sprawl increases the demand for energy and raises other challenges related to pollution and the pressure exerted on natural resources. The New Development Model published in 2021 addresses these issues and formulates ambitious perspectives for the Moroccan economy. It supports initiatives oriented toward achieving sustainable development and environmental conservation. The New Development Model (NDM) report presents a diagnosis of the country's most salient environmental issues. Accordingly, it states that achieving the Sustainable Development Goals (SDGs) by 2030 as established by the United Nations agenda is compromised by environmental challenges (SCDM, 2021). The report repeatedly emphasizes the need to protect natural capital. Its conservation is indeed required to ensure that future generations needs are effectively considered. Beyond this long-term goal, natural capital preservation also means green economic growth that respects biodiversity and promotes the country's local renewable energy potential. The NDM report provides a series of recommendations to ensure the country's economic development, prioritizing a circular economy through investments and reform proposals and suggests mobilizing external debt as one of the financing sources to be considered.

In response to the Covid-19 induced health and economic crisis, Morocco, like many other developing countries, has relied on external debt to cover public revenues deficit (Elkhishin and Mohieldin, 2021). According to World Bank data, Morocco's external debt went from \$50 billion in 2018 to \$55 billion in 2019 and \$65.6 billion in 2020, reaching an overall increase of 15% (World Bank, 2021b). While the country was in the midst of overcoming the Covid-19 sanitary crisis, the Moroccan economy was hit by a drought season in 2021, which will negatively impact the agricultural season in 2022 (Diaz Cassou et al., 2022). Financial stability in Morocco is indeed closely correlated to climate variability (Ejjiar and Arib, 2022). Morocco is also confronted with the consequences of the war in Ukraine and its implications in terms of energy supply, a situation that weakens the Moroccan economy's budgetary balance and reinforces the need to rely on external debt, coupled with an increasing inflation (Diaz Cassou et al., 2022). It has been argued in the literature that there is a relationship between external debt and economic growth, and the evolution of the latter is closely linked to energy consumption and consequently, to the level of emissions emitted by a country. Therefore, we assume that external debt should have an indirect impact on emissions, and thus, on environmental pollution.

In addition to its dependence on imported fossil fuels, and given the European geopolitical instability that impact its economic equilibrium, Morocco is also challenged by the necessity to meet its commitments under the Paris Agreement to achieve its nationally determined contributions (NDC) through mitigation policies.

This article answers the main question that emerges from the previous points, which is the impact of external debt (ED) on environmental pollution, expressed in terms of carbon emissions (CE). The Environmental Kuznets curve (EKC) will also be tested through this study. The paper will also investigate whether or not Morocco has reached the per capita income that would allow the country to ensure economic growth while reducing CE.

More precisely, the following hypotheses are tested in this paper:

- H1: The EKC is validated for Morocco.
- H2: Morocco has reached the EKC turning point for CE.
- H3: ED increases CE in Morocco.

To the best of our knowledge, no study has explored the impact that external debt may have on environmental pollution in Morocco. Not only does this study fills a gap in the literature, but it can also guide policymakers in making decisions about Morocco's economic regulations to support decarbonization strategies by identifying the main factors that increase carbon emissions, and among these factors, external debt, a key macroeconomic variable.

In the first section of this paper, we will review the findings of existing literature investigating the impact of external debt on the environment, as well as those exploring the relationship between external debt and economic growth. We will also be reviewing EKC and whether or not it has been validated in other countries. The subsequent section following the review of literature will be dedicated to present the data and the methodology adopted to test the three hypotheses formulated above. We will then present the results we obtained using a quantitative analysis software. These results will then be discussed to finally present our conclusion in order to validate or refute the different hypotheses and provide empirical evidence that answers the question raised in this paper.

2. LITERATURE REVIEW

This section will first present some recent findings concerning the impact of economic growth on environmental pollution. Next, we will cite some relevant studies that investigated the effect of external debt on economic growth before considering what has been found regarding the impact of external debt on environmental pollution.

The impact of economic growth on the environment has been largely explored empirically. The pioneering work of Grossman and Krueger (1991) should be mentioned in this respect. They revisited the Kuznets curve hypothesis, initially aimed to study the income-inequality nexus. As a result, they found that there is an inverted U-shaped relationship between GDP and air pollutants. These findings suggest that the initial development of an economy causes environmental degradation. Afterwards, when the income is above a certain level, the economy moves towards green investments and less polluting technologies.

Several studies have found similar results. Among the most recent is Haseeb et al., (2018) who used Fully Modified Ordinary Least Squares panel to test EKC for BRICS countries. In addition to validating the EKC, he also found bidirectional causality between FC, GD and GDS with CE emissions. Two later studies used ARDL model to test the relationship between carbon dioxide emissions and economic growth (Liu et al., 2020; Zhang et al., 2020). EKC is confirmed in both studies, for G7 and 15 developing countries, respectively. For the G7 countries, the study shows that RC consumption has a significant negative effect on CE. Other studies have found the opposite results. In this regard, Ajmi and Inglesi-Lotz, (2021) found a U-shaped relationship between GD and CE for Tunisia using ARDL model, rejecting the EKC hypothesis. Another recent panel study by Shah et al., (2021) didn't validate EKC for 17 countries among Western Asia and North African region.

The relationship between economic growth and external debt has been widely investigated, and the results are mitigated. Using the Autoregressive Distributed Lag model, Kharusi and Ada (2018) found that external debt has a significant negative impact on economic growth in Oman. These results are supported by two recent studies that used the same method to test this relationship in Ghana and Fiji Islands respectively (Duodu and Baidoo, 2022; Makun, 2021). Aboudi and Khanchaoui (2021) studied the impact of inflation and external debt on economic growth in the case of Morocco from 1985 to 2019. Based on ARDL model, inflation would not only have a significant negative effect on economic growth but also induce difficulties for the government to recover its external debt. The results of this study also show that external debt has a significant negative effect on economic growth in Morocco. According to the results interpretations, the authors suggest that the external debt is not devoted to projects that generate added value for the Moroccan economy, but rather to cover the public deficit.

Nath (2020) applied cointegration test, error correction model and Granger causality test to study the relationship among external debt, exports and economic growth for the Indian economy for 1970-2018 period. Results indicate that ED and exports have a significant positive impact on GD. Mazorodze (2020) also noted positive impact of external debt on economic growth based on the Fully Modified Ordinary Least Squares method in Zimbabwe for the period between 1980 and 2016, when ED represents 57% of GD. Beyond this percentage, the effect of ED on GD is reversed.

Beşe et al. (2020) conducted the same investigation for China. They tested EKC and the impact of ED on CE using ARDL and NARDL methods. As a result, while the EKC is not confirmed, the authors found that ED and energy consumption have a positive and significant impact on CE. They also found that there is a symmetric and asymmetric relationship between GD and CE. Another recent Beşe et al. (2021) paper investigates the impact of ED on five different GHGs, including CE, in India. The results show that external debt has a positive and significant impact on EC and three other GHGs. The authors conclude that India finances its emissions through external debt by supporting environmentally harmful projects. Two panel studies were also carried out for 33 Heavily Indebted Poor Countries (HIPC) countries and SANE countries comprising South Africa, Algeria, Nigeria and Egypt in 2021 and 2022 respectively (Akam et al., 2021, 2022). Concerning the HIPC countries, Akam et al. (2021) found that external debt doesn't impact environmental pollution, unlike GD and energy consumption, whose impact is significant. By including the ecological footprint as a dependent variable, another study by Akam et al., (2022) found that ED has a significant and positive impact on environmental degradation in South Africa and Algeria but not in Nigeria and Egypt.

It appears that regardless of the level of external debt, the results diverge, hence the importance of empirically investigating the impact of external debt on the environment in other contexts. Our paper focuses on Morocco to investigate the impact of external debt on carbon emissions. After specifying the model and the selected variables, a set of statistical tests will be performed in order to evaluate the robustness of the model before estimating the short- and long-term relationships between the dependent variable, CE, and the independent variables, GD, ED, RC and FC.

3. DATA AND METHODOLOGY

3.1. Data

In order to investigate the three hypotheses formulated above in the introduction, we have opted for time series that we have retrieved from the World Bank development indicators (World Bank, 2021a), for the period running from 1984 to 2018. The period considered is motivated by data availability. The main objective is to explore the impact of external debt stocks, including long-term and short-term external debt, on CO_2 emissions in Morocco. Non-renewable and renewable energy consumption are included as control variables. The impact of these two variables on CO_2 emissions will therefore be analyzed. Table 1 briefly describes the selected variables.

3.2. Econometric Model

We applied Auto Regressive Distributed Lag (ARDL) model to estimate both long run and short run relation of the variables to explain the CO_2 emission variable. In a dynamic model, a dependent variable (Y_t) can be explained both by its own lagged values (Y_(t-i)) and by current values of the independent variables (X_t) and their time lagged values (X_(t-i)).

In our study, we seek to capture the impact of economic growth, external debt on CO_2 emissions (dependent variable), considering other key control variables that can improve the results, such as energy consumption. Thus, we propose to estimate an ARDL model for the following functional form of linear model:

$$CE_{it}=f\,(GD_{it}, GDS_{it}, ED_{it}, FC_{it}, RC_{it}) \quad (1)$$

Where CE, GD, GDS, ED, FC, RC stand respectively for CO_2 emissions per capita, GDP per capita, square of GDP per capita, external debt stocks, fossil fuel energy consumption, renewable energy consumption. Given that the variables have different measurements units, we convert the data into natural logarithm in order to overcome issues related to heteroscedasticity and distributional properties (Ahmad et al., 2016; Chang, 2010; Ummalla and Samal, 2019). The logarithmic form of the model is as follows:

$$\ln(CE)_t = \alpha_0 + \alpha_1 \ln(GD)_t + \alpha_2 \ln(GDS)_t + \alpha_{3j} \ln(ED)_t + \alpha_{4j} \ln(FC)_t + \alpha_{5j} \ln(RC)_t + \varepsilon_t \quad (2)$$

3.3. Econometric Methodology

The study is carried out following theoretical and empirical aspects based on recent developments in time-series econometrics: ARDL model and bounds cointegration test of Pesaran et al. (2001). The objective is to evaluate the effects of external debt, but also energy consumption, and economic growth on CO_2 emissions in Morocco. Therefore, we will investigate the long and short-run effects through ARDL model estimations.

$$\Delta LnCE_t = \alpha_0 + + \sum_{i=0}^{q1} \alpha_{1i} \Delta LCE_{i-1} + \sum_{i=0}^{q2} \alpha_{2i} \Delta LGD_{i-1} + \sum_{i=0}^{q3} \alpha_{3i} \Delta LGDS_{i-1} + \sum_{i=0}^{q4} \alpha_{4i} \Delta LED_{i-1} + \sum_{i=0}^{q5} \alpha_{5i} \Delta LFC_{i-1} + \sum_{i=0}^{q6} \alpha_{6i} \Delta LRC_{i-1} + \beta_1 LGD_{t-1} + \beta_2 LGDS_{t-1} + \beta_3 LED_{t-1} + \beta_4 LFC_{t-1} + \beta_5 LRC_{t-1} + \varepsilon_t \quad (3)$$

To test the EKC hypothesis in order to define GD-CE correlation, the estimated coefficients for the long term should correspond to one of the following scenarios:
$\beta_1 = \beta_2 = 0$; no GD-CE correlation;
$\beta_1 > 0, \beta_2 = 0$; positive linear relationship between GD and CE.
$\beta_1 < 0, \beta_2 = 0$; negative linear relationship between GD and CE.
$\beta_1 > 0, \beta_2 < 0$; inverted U-shaped relationship between GD and CE.
$\beta_1 = 0, \beta_2 > 0$; U-shaped relationship between GD and CE.

To test our model, we will first analyze the correlation matrix of the series. Then, we have to test the stationarity of the series in order to determine the order of integration of the series and to choose the most appropriate model. We will then perform the cointegration tests in order to avoid issues associated with spurious regression Shrestha and Bhatta (2018). Afterwards, we will test the robustness of the coefficients through diagnostic tests and finally estimate the short term and long-term relationships of the ARDL model.

4. RESULTS AND DISCUSSION

4.1. Correlation Analysis

Table 2 presents the results of bivariate correlation between the selected variables. The coefficients ranging between 0 and 1 indicates to which extent the variables are linearly related. The correlation between CE and GD records a value of 0.975153, which indicates that there is a very high positive correlation between the two variables. The highest coefficient (0.989955) concerns the strong positive correlation between CE and FC, and lowest coefficient (−0.526543) involves CE and RC, which denotes of a low negative correlation between the two variables. Indeed, the higher fossil fuel consumption, the higher carbon emissions. On the contrary, the higher the renewable energy consumption, the lower the carbon emissions. That being said, the low correlation between CE and RC shows that Morocco's rate of renewable energy consumption is probably still relatively modest to reduce CO_2 emissions drastically. We finally point out that there is a positive correlation between CE and ED, and the results of the ARDL model will further enlighten our understanding on the relationship between these two variables in the short and long term.

4.2. Unit Root Test

The first step is to consider the univariate properties of the series and to determine their degree of integration. The ARDL model requires that the dependent variable is I(1). The other independent variables are either I(0) or I(1). Moreover, if a variable is I(2), the estimation of the ARDL F-statistic is no longer applicable. For this purpose, we perform the Augmented Dickey fuller (ADF) unit root test. The ADF test statistics performed for the series are not all stationary at level, as the null hypothesis of unit root test is not always rejected (Table 3). We found that the dependent variable CE is integrated of order 1, denoted I(1) and the other variables are either I(0) or I(1). In fact, apart from the variable FC which is stationary at level, denoted I(0), the first difference results of the other series show that the ADF test statistics performed at 5% or 1% are significant, and thus these series are stationary at first difference, as shown in Table 4. Therefore, the ARDL model is the most suit-able model in our case. Subsequently, the next step is to identify the optimal ARDL model by the Akaike Information Criterion (AIC), afterwards, the short- and long-term relationships are analyzed.

4.3. Cointegration Test

We select the optimal ARDL model that provides statistically significant results. The selection of the lag is very important in the ARDL model. We used Akaike Information Criterion (AIC)

Table 1: Description of analyzed variables

Variables	Acronyms	Measurement unit	Data sources
Carbon dioxide emissions	CE	Metric tons (Mt) per capita	(World Bank, 2021a)
Gross Domestic Product	GD	Current US dollars per capita	(World Bank, 2021a)
External Debt stocks	ED	DOD, current US dollars	(World Bank, 2021a)
Fossil Energy consumption	FC	% of total energy utilization	(World Bank, 2021a)
Renewable Energy consumption	RC	% of total energy utilization	(World Bank, 2021a)

Table 2: Correlation matrix

Variables	CE	GD	GDS	ED	FC	RC
LCE	1.000000					
LGD	0.975153	1.000000				
LGDS	0.973113	0.999903	1.000000			
LED	0.622414	0.733939	0.739164	1.000000		
LFC	0.989955	0.988722	0.987719	0.709867	1.000000	
LRC	−0.526543	−0.626149	−0.634554	−0.713371	−0.579479	1.000000

to select the appropriate lag length that helps capture the dynamic relationships in order to identify the best ARDL estimation model. The lag length results are presented in Figure 1 which indicates that the ARDL (1, 0, 0, 0, 0, 0, 0) model is the one that has been

Table 3: Augmented dickey fuller unit root test

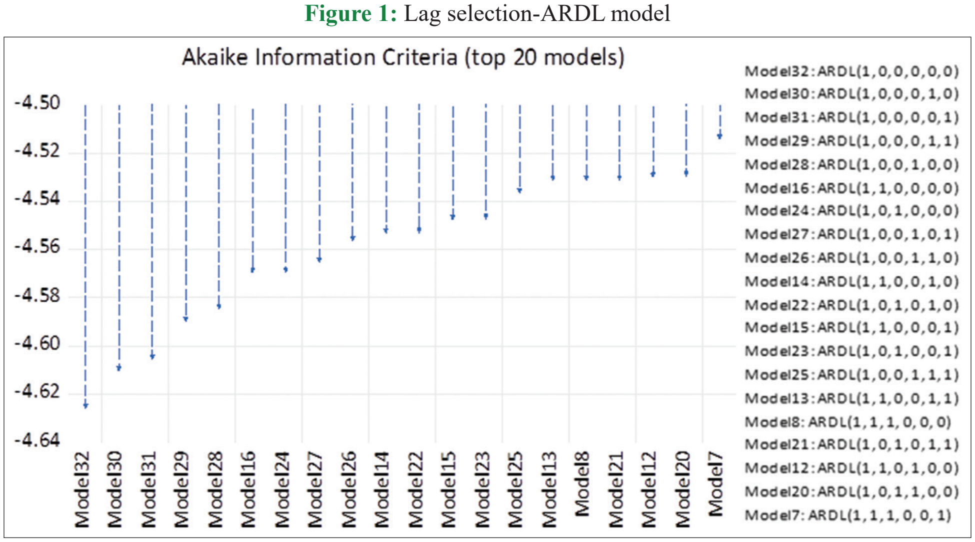
Variables	ADF at level		ADF at first difference		Order of integration
	t-statistic	Critical value 5%	t-statistic	Critical value 5%	
LCE	−1.26 (0.63)	−2.95	−6.37*** (0.00)	−2.95	I(1)
LGD	6.59 (1.00)	−1.95	−2.49** (0.01)	−1.95	I(1)
LGDS	6.66 (1.00)	−1.95	−2.39** (0.02)	−1.95	I(1)
LED	1,22 (0.94)	−1.95	−3.29*** (0.00)	−1.95	I(1)
LFC	−5.99*** (0.00)	−1.95			I(0)
LRC	−0.40 (0.53)	−1.95	−4.88*** (0.00)	−1.95	I(1)

p-values are in brackets, *, ** and *** denotes the level of significance at 10%, 5% and 1%. −1.95: critical values of the Dickey Fuller test at 5% level (no constant). −2.95: critical values of the Dickey Fuller test at 5% level (with constant)

Table 4: Summary of selected literature review

Author(s)	Countries	Period	Methodology	Findings
Environmental pollution-Economic growth nexus				
Haseeb et al. (2018)	BRICS countries	1995-2014	FMOLS	EKC is confirmed.
Liu et al. (2020)	G7 Countries	1970-2015	ARDL, DOLS, FMOLS	EKC is confirmed.
Zhang et al. (2020)	15 developing countries.	1990–2013	ARDL	EKC is confirmed.
Shah et al. (2021)	17 countries	1980-2017	DCCEMG	EKC is not confirmed.
Ajmi and Inglesi-Lotz (2021)	Tunisia	1965-2013	ARDL	EKC is not confirmed.
Economic growth-External debt nexus				
Kharusi and Ada (2018)	Oman	1990-2015	ARDL	ED has a significant negative effect on GD.
Nath (2020)	India	1970-2018	ECM, cointegraiton, Granger causality.	ED has a significant positive effect on GD.
Mazorodze (2020)	Zimbabwe	1980-2016	FMOLS	ED has a significant positive effect on GD.
Makun (2021)	Fiji Islands	1980-2018	ARDL	ED has a significant negative effect on GD.
Aboudi and Khanchaoui (2021)	Morocco	1985-2019	ARDL	ED has a significant negative effect on GD.
Duodu and Baidoo (2022)	Ghana	1984-2018	ARDL	ED has a significant negative effect on GD.
Environmental pollution-External debt nexus				
Beşe et al. (2020)	China	1978-2014	ARDL, NARDL	EKC is not confirmed. ED has a significant positive effect on CE.
Akam et al. (2021)	33 HIPC countries	1990-2015	DCCE-MG, AMG, CCE-MG	ED has a significant positive effect on CE.
Beşe et al. (2021)	India	1971-2012	ARDL	ED has a significant positive effect on CE and three other types of emissions. (5 types of emissions were included in the study)
Akam et al. (2022)	SANE countries	1970-2018	CADF, AMG	ED has a significant positive effect on ecological footprint in South Africa and Algeria.

Figure 1: Lag selection-ARDL model



selected among the 20 others presented, as it offers the lowest value of the Akaike information criteria.

We performed three diagnostic tests to evaluate the stability of the model. The first diagnostic test Breusch-Godfrey shows that there is no serial correlation between the residuals. The second test concerns heteroskedasticity. We performed ARCH test and the results indicates that the variances of the residuals are constant, therefore, homoscedastic. Finally, the errors are normally distributed based on the Jarque-Bera normality test. Accordingly, the null hypothesis is accepted for the three diagnostic tests (Table 5).

Concerning the cointegration bounds test (Pesaran et al., 2001), we will have to compare the Fisher value obtained within the critical values (bounds) simulated at different significance levels (Table 6). The upper bound shows the results for the variables with order of integration I(1) and the lower bound concerns the I(0) series.

The results of the bounds test confirm the existence of a cointegrating relationship between the variables. In fact, F-stat calculated (14.15) is higher than the upper bound values at the 1%, 2.5%, 5% and 10% significance levels. This validates the cointegration between CE, GD, ED, FC and RC in Morocco. As a result, there is a proven relationship between these variables over the period from 1984 to 2018, which allows us to estimate long-term effects. Thus, the cointegration analysis via a long-run relationship using ARDL model is reliable and robust.

4.4. Parameter Stability

In order to check the robustness of the results and test the short- and the long-run parameter stability in the cointegrating equation, we applied the cumulative sum of recursive residuals CUSUM and the CUSUM of squares tests (Figures 2 and 3). The figures demonstrate that the curve is within the critical interval at 5% significance level, which indicates that the ARDL model used in this study is stable and there is no problem of heteroscedasticity.

Table 5: Diagnostic tests for the ARDL model

Diagnostic test	Null hypothesis	Statistic	Probability
Breusch-godfrey serial correlation tsest	No serial correlation	0.63	0.59
ARCH heteroskedasticity test	Homoscedastic	1.34	0.26
Jarque-bera normality test	Normally distributed	0.85	0.65

Table 6: Bounds F-test for cointegration Pesaran et al. (2001)

Dependent variable: LCE
Independent variables: LGD, LGDS, LED, LFC, LRC
F-statistic calculated: 14.15412

Critical value	Lower bound value I(0)	Upper bound value I(1)
10%	1.81	2.93
5%	2.14	3.34
2.5%	2.44	3.71
1%	2.82	4.21

4.5. ARDL Regression Results

First, Table 7 shows that the error correction coefficient (CointEq(-1)) is negative and significant (-0.685250), which confirms the existence of a long causal relationship (cointegration) between the variables. The long-term coefficients reveal a positive correlation between GD and CE with a statistical significance level at 1%. In fact, according to the coefficient estimation, if GD increases by 1%, it will generate 0.905% increase in CE. Meanwhile, ED has a significant and negative effect on CE. Indeed, each 1% point in ED will decrease CE by −0.129% in the long run. This reveals that ED can considerably impacts the energy strategy performance of the Moroccan economy.

We also note that RC does not have a significant effect on CE in Morocco. However, 1% increase in total FC significantly increases CO_2 emissions by 0.681% in the long run. Furthermore, the most important result here is the highly significant and negative effect of GDS on CE emissions at the 1% significance level. In fact, based on the coefficient's estimations of LGD (positive and significant coefficient: 0.905) and LGDS (negative and significant coefficient: −0.053) Table 7, we conclude that the Environmental Kuznets Curve (EKC) hypothesis is valid for Morocco.

Secondly, concerning the short-run results, we recall that the error correction term ECT(t-1) is statistically significant (at 1% significance level) and negative (−0.685), which ensure a mechanism of error correction and return of CE to the equilibrium

Figure 2: CUSUM test

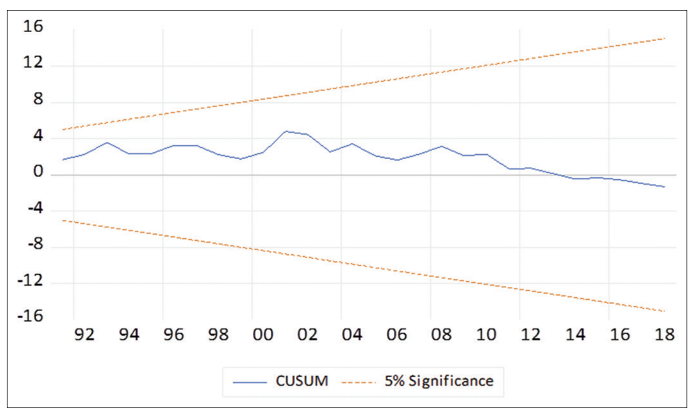


Figure 3: CUSUM of squares test

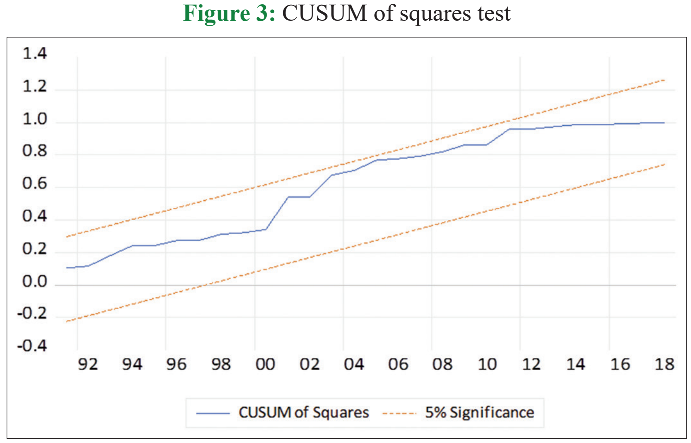


Table 7: Estimated long-run and short-run coefficients of ARDL model

Variable	Coefficient	SE	t-statistic	Prob.
Short-run coefficients				
LGD(-1)	−0.685250	0.128218	−5.344428	0.0000
LGD	0.620371***	0.206884	2.998639	0.0056
LGDS	−0.036476**	0.017646	−2.067079	0.0481
LED	−0.088779***	0.024147	−3.676622	0.0010
LFC	0.466679***	0.104523	4.464839	0.0001
LRC	0.033486	0.036147	0.926375	0.3622
CointEq (−1)=ECT (t-1)	−0.685250	0.068494	−10.00449	0.0000
Long-run coefficients				
LGD	0.905321***	0.252453	3.586105	0.0013
LGDS	−0.053230**	0.023729	−2.243202	0.0330
LED	−0.129557***	0.028934	−4.477656	0.0001
LFC	0.681035***	0.089658	7.595907	0.0000
LRC	0.048867	0.056206	0.869425	0.3920
EC=CE - (0.9053*GD - 0.0532*GDS - 0.1296*ED + 0.6810*FC + 0.0489*RC)				

*,** and ***denotes the level of significance at 10%, 5% and 1%

in the long term. This confirms that 68.5% of CE variations are corrected by short-term deviations towards a global equilibrium path each year. Thus, in our model, the short-term deviations of these emissions can move toward global equilibrium in less than 2 years.

Moreover, and according to the short-term results, CE are positively driven by GD and FC but negatively by ED (at 1% significance level). On the other hand, RC does not significantly cause CE during our study period from 1984 to 2018. This result is similar to the long-term findings presented above.

Based on the long-term coefficients of the quadratic form, we can estimate the EKC turning point, expressed in terms of GDP per capita, at which Morocco will move towards a green economy, where CO_2 emissions will follow a downward trend, while maintaining an upward economic growth.

The estimated turning point is as follows:

$$TP = \exp\left(-\frac{coeff.LGD}{2*coeff.LGDS}\right) = \exp(-\frac{0.905321}{2*\left(-0.05323\right)})$$
$$= 4933.779\,USD$$

According to World Bank Indicators, GDP per capita in Morocco was 3496.8 USD in 2021. Morocco's GDP per capita has averaged 1939.39 USD from 1966 to 2021, reaching the highest value of 3496.8 USD in 2021 and the lowest value of 815.39 USD in 1966 (World Bank, 2021a).

It can be concluded from our estimations that there are still a few years to go before the turning point income is reached. Meanwhile, CO_2 emissions will continue to increase in Morocco until the GDP per capita reaches the estimated value of 4933.779 USD, which will ultimately match the maximum CO_2 emission threshold. From that point on, we can expect to see a decrease in CO_2 emissions per capita in Morocco.

5. CONCLUSION

This paper examines the impact of external debt on environmental pollution in Morocco. The results present empirical evidence of causal effects ranging from economic growth, energy consumption and external debt to CO_2 emissions in Morocco. Furthermore, we find that any increase in GDP and total fossil fuel consumption contributes to the increase in CO_2 emissions. On the other hand, the increase in external debt reduces CO_2 emissions. In particular, our results confirm the existence of a Kuznets relationship in Moroccan. This inverted U-shaped relationship shows that economic growth causes environmental pollution until it reaches a specific level of per capita income, at this point, environmental pollution begins to decrease, while economic growth is sustained.

In the present empirical study, we wanted to evaluate the impact of external debt on environmental pollution in Morocco. The key findings of our study can be summarized as follows:

- H1 is validated. There is an inverted U-shaped relationship between GD and CE. Therefore, the EKC is confirmed for Morocco.
- H2 is rejected. The Moroccan economy has not reached the EKC turning point yet.
- H3 is rejected. ED does not increase CE in Morocco.

The first result indicates that Morocco is still in a phase of economic development where it still relies on fossil fuels, and therefore, the country will continue to emit CO_2, hence the positive correlation between these variables. This trend will be reversed once an optimal per capita income of 4933,779 US dollars is reached. This estimated income level represents the turning point at which Morocco will start to reduce its CO_2 emissions through green investments while maintaining overall high economic growth. Indeed, the more the economy is oriented toward the tertiary sector, the more the energy transition is facilitated. For instance, in 2021, agriculture contributed around 12.65% to the GDP of Morocco, 26.81% came from the industry and 49.14% from the services sector (World Bank, 2021a). This distribution demonstrates that the country is in the process of moving from the primary sector, on which its entire economy was centered, towards the tertiary sector. Therefore, based on the estimation of the quadratic form coefficients, we conclude that the EKC hypothesis is valid for the case of Morocco.

Certainly, economic growth requires higher energy consumption. However, in light of the alarming conclusions drawn in the latest IPCC report (IPCC, 2022), implementing energy saving strategies is necessary, as the overconsumption of nonrenewable resources can negatively affect the environment. Meanwhile, our results suggest that external debt could significantly decrease CO_2 emissions in the medium and long term. This means that Morocco's externally funded energy transition process may contribute to reducing CO_2 emissions over the long term. Morocco has indeed recently embarked on an energy transition process. However, its effectiveness requires considerable financing. For this reason, Morocco would need to rely on external financing to decarbonize the economy and reduce CO_2 emissions successfully.

Morocco is experiencing a noticeable economic dynamic at the continental and regional levels and has a growing potential in the clean energy sector. The latest RECAI 57 ranking, Renewable Energy Country Attractiveness Index released biannually by Ernst and Young, placed the country in the 16th position out of 40 countries, outperforming developed countries like Israel, Portugal and Belgium (EY Global Renewables, 2020). According to this report, investment in green energy could represent a significant competitive advantage for Morocco. The latest geopolitical events are redefining the energy landscape rules in Europe, and this may represent an opportunity for Morocco to position itself as a critical role in the renewable energy sector regarding the current price volatility in fossil fuel markets.

For further research, the impact of external debt on environmental degradation, namely ecological footprint, should be investigated. Future research could also explore the asymmetric relationship between the variables CE, GD, GDS, ED, FC and RC, based on non-linear ARDL.

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