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Explore the factors influencing CO2 emissions in Tunisia in the short and long term

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Abstract:
The main objective of this paper is to examine the linkage between CO2 emissions, total factor productivity, energy consumption, financial development, trade, and foreign direct investment in Tunisia. The vector error correction model (VECM) with the breakpoint method is performed to achieve this goal. The results provide evidence for a relatively robust long-run relationship between these variables for the period 1970 to 2019. The findings show that the long-term total factor productivity parameter has a larger value than the short-term one. Additionally, our result shows that all variables affect negatively the environmental quality. As a result, Tunisian policymakers should enhance the total factor productivity, further develop the financial sector oriented to green projects, enhance the share of renewable energy consumption, and reduce the energy consumption resulting in import and export goods. These goals will be achieved by improving Tunisia's innovation capacity and creating renewable energy projects.
Keywords: CO2 emission; VECM; Tunisia.

INTRODUCTION:

Human activities have significantly impacted climate change since the Industrial Revolution by increasing the atmospheric concentrations of CO2 and other gases. Global carbon dioxide (CO2) emissions are rising, which is posing a threat to our planet. It seriously harms human health, global food security, and economic growth. Problems of CO2 emissions affect almost all the world's countries.

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One of the nations affected by this issue in Tunisia. Fig 1 shows that Tunisia's CO2 emissions have increased over the past three decades, rising from 1.8 metric tons in 1990 to 2,726 in 2000 and to 2,557 in 2019. Therefore, the issue is just getting worse.

CO2 emissions are shifting, as we've already witnessed. As a result, there is a significant issue with this nation's ecology, economy, health, etc., despite, having implemented a number of regulations.

Also, Tunisia has adopted a proactive approach to combating climate change since the UNFCCC was ratified in 1992, according to the country's first biennial report (2014). In addition to fulfilling its obligations under the UNFCCC by ratifying the Climate Change Convention and the Kyoto Protocol and submitting its first and second national communications, it is also aware of the issues relating to adaptation and mitigation (the process of preparing the INDC and the third national communication has been underway since November 2014).

Besides, we can see that during this time period, there has been an upward tendency in economic growth (Fig 2), energy consumption (Fig 3), FDI (Fig 4), trade (Fig 5), and financial development (Fig 6).

According to Tunisia's first biennial report (2014), GDP per capita increased from 1,491,119 in 1990 to 4,543,992 in 2014 and then 3,571,945 in 2019.

The 1990s and 2000s saw Tunisia's economy diversify with a focus on the growth of activities in sectors with high added value, particularly the services and light industries.

The Tunisian economy has been impacted by a very low GDP growth since the collapse of the ruling regime on January 14, 2011, and the proliferation of social movements. The year 2011 witnessed a negative growth of -1.9% compared to 2010. The political change, fiscal pressures, and inflationary pressure continued in 2013, which resulted in a relatively low economic growth of 2.3%. The economic recovery started in 2012 with GDP growth reaching 3.9% from 1990 to 2014.

Energy consumption increased from 600,173 kWh in 1990 to 752,539 kWh in 2000 and 950,491 kWh in 2014. Chebil (2017) has shown that the demand for energy has experienced strong growth over the past 20 years following the socioeconomic development of the country and an economic and social policy of subsidies for all forms of energy. Per capita consumption of primary energy is globally constantly increasing over the period 1990-2014. We note a cyclical decline between 2010 and 2011, followed by a recovery between

2011 and 2014. The evolution over the entire period was at an average annual rate of 1.8%. On the other hand, between 1990 and 2007, oil demand grew at an average yearly rate of 1.9%, while gas demand recorded an average annual growth of 6.4%. According to the five-year report (2021), gross inland consumption recorded a positive trend, rising from 10.3 Mtoe in 2010 to 11.3 Mtoe in 2019. During this period, the consumption trend underwent a marked decline, in 2011, when consumption fell by 5% compared to the previous year. This decline is due to the political and social context of 2011, marked by the advent of the revolution. This drop was only compensated for over two years, thanks to a relative recovery in 2012 and a somewhat attenuated growth since 2013, thus recording a modest increase of 1% annually.

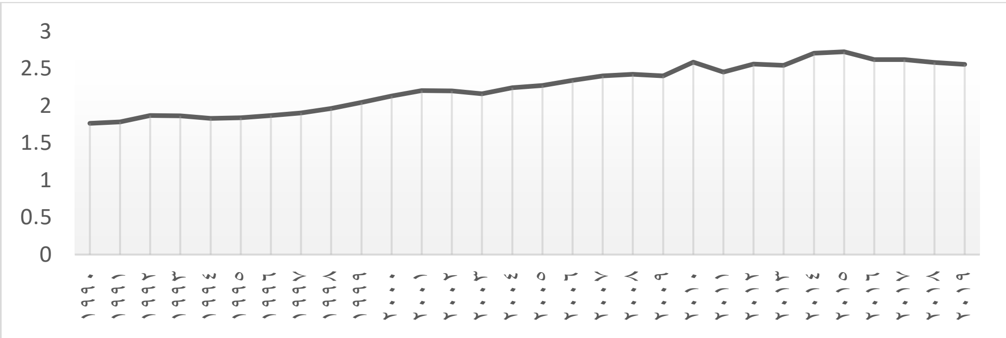
From 77419354,838 in 1990 to 3239909092,616 in 2006, FDI inflows decreased to 810173457,680 in 2019. Indeed, Tunisia has made unquestionable attempts to draw in international investment ever since the passage of the law of April (1972), which established significant benefits for the export industry. Since 1990, Tunisia has mostly drawn foreign direct investment (FDI) to the energy industry. The industrial and service sectors come in second. The industry profited from privatization efforts in the 1990s and continues to be primarily focused on the textile and apparel sector. Additionally, the share of services in total FDI increased noticeably, from 9.4% in the years 1990-2000 to 25% in the years 2001-2014, displacing energy from the transport sector. The operations of privatization (in telecommunications, banking, etc.) are mostly to blame for this increase in weight. The stock of inward FDI in Tunisia at the end of 2018 was estimated by the OECD (2020) to be 27 billion USD, up from 17 billion USD in 2005, or 64% of GDP. In the MENA area, according to the stock of inward FDI, Tunisia was ranked fifth at the end of 2018.

The trade climbed from 73,544 in 1990 to 97,987 in 2008, then to 87,370 in 2019. According to a research in 2013 by the African Development Bank, the governments of Tunisia, and the United States, Tunisia joined the World Trade Organization (WTO) in 1995 after joining the General Agreement on Tariffs and Trade (GATT) in 1990. The Association Agreement with the European Union (EU) was put into effect in the same year, which led to the gradual implementation of free trade agreements for industrial goods between 1996 and 2008. Tunisia’s exports grew by 5.1% annually in the 1990s, increasing from 30.2% of GDP in 1986 to 55.6% in 2008 before falling to less than 50% as a result of the European recession. The primary export market for Tunisia has historically been Europe. In 2010, 73% of Tunisia's exports were consumed by the European Union (EU). Seven of Tunisia's top 10 export markets were in Europe, with France and Italy alone taking in more than half of the country's total exports. Libya, Algeria, and the United States are three more non-EU destinations that make the top 10. But in recent years, Tunisia has made a minor effort to diversify its export markets.

Then, financial development increased from 66,170 in 1992 to 72,819 in 2011 and 81,712 in 2017. El hourani (2020), after the creation of the central bank in 1958, the banking sector faced several transformations due to changing regulations. In 1987, the system experienced the liberalization of the banking sector which was accompanied by the establishment of prudential regulations and the introduction of equity and liquidity regulations. In the early 2000s, the sector experienced a transformation that allowed the creation of universal banks that replaced the traditional form of deposit banks. Since the beginning of 2015, the Tunisian banking system has tended to comply with international banking systems in order to strengthen and modernize its regulations. In 2015, the Tunisian central bank led a project with the Banque de France to modernize Tunisian monetary policy. In October 2015, the World Bank granted a loan of 460 million euros to Tunisia to strengthen the financial sector, and increase the social responsibility of society. Regarding the implementation of Basel II and Basel III regulations, the Tunisian Central Bank has adopted a reform plan for the period up to 2020, with the aim of improving and modernizing banking supervision according to EMNES (2018).

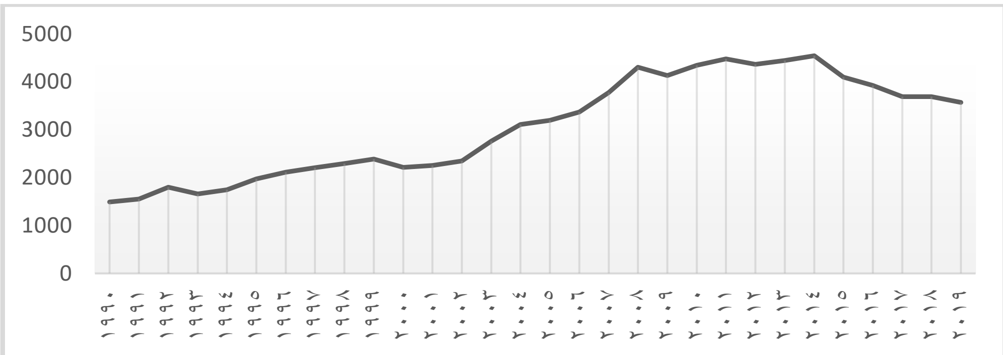
So, this economy faces a significant environmental challenge in cutting CO_2 emissions; this country needs to limit its CO_2 emissions if it wants to prevent the worst effects of those emissions. Therefore, we shall, theoretically and empirically, investigate the variables that may affect CO_2 emissions in Tunisia. Most research has relied heavily on evidence from multiple countries to support their conclusions. By identifying the variables that significantly affect CO_2 emissions, this research aims to assist decision-makers in enhancing the efficacy of environmental legislation. Also, this study tries to demonstrate the short and long-run relationship between air pollution, as measured by carbon dioxide emissions, and a number of influencing factors, including trade, energy consumption, financial development, FDI, and economic growth. This study is divided into the following sections: a literature review, data and methodology, empirical methodology with results, and a discussion of the findings.

Fig 1. CO_2 emissions in Tunisia (metric tons per capita)



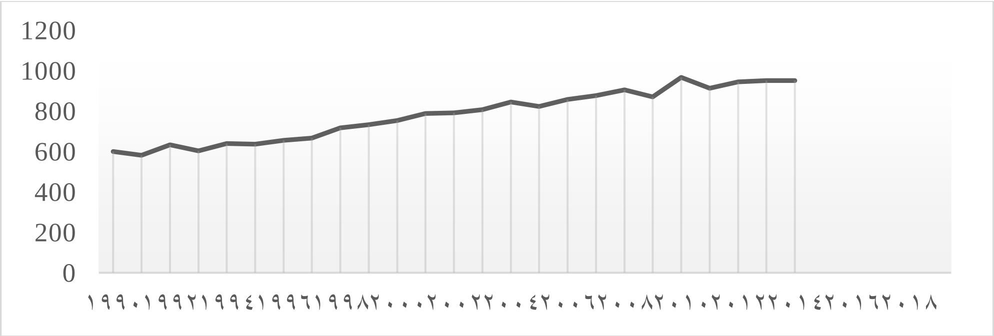
Source : author's by WDI

Fig 2. GDP per capita (current)



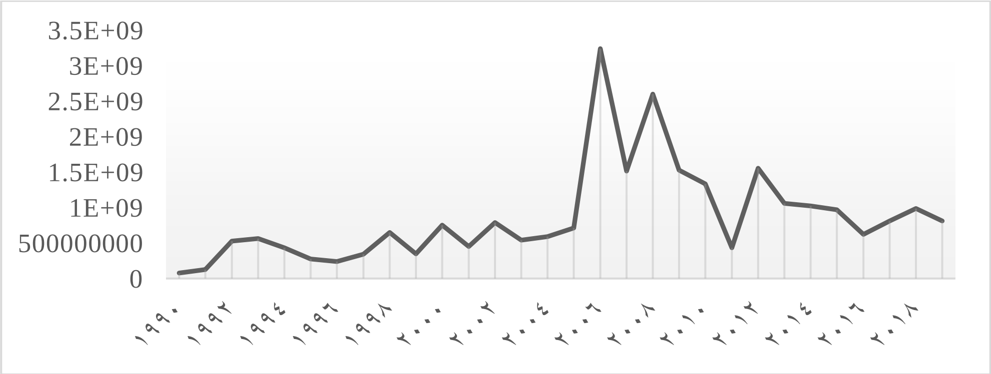
Source : author's by WDI

Fig 3. Energy consumption



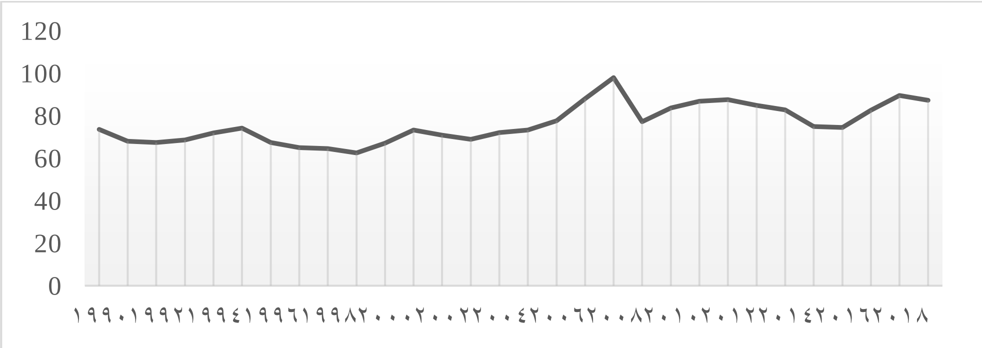
Source : author’s by WDI

Fig 4. FDI



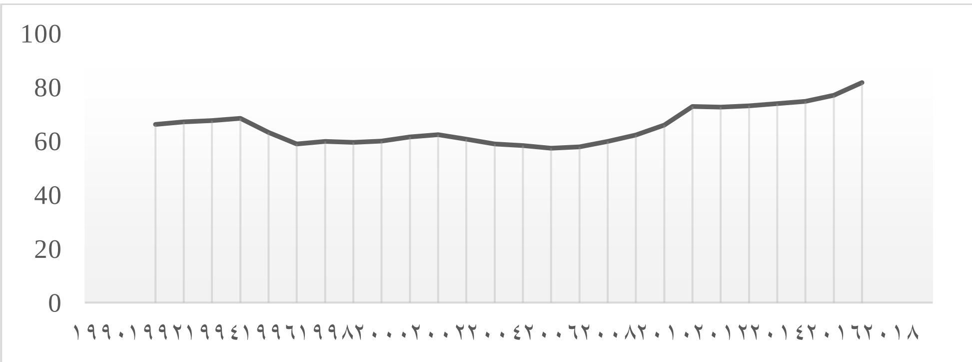
Source : author’s by WDI

Fig 5. Trade



Source : author's by WDI

Fig 6. Financial development



Source : author's by WDI

Chapter I: Literature review

First main title: Economic growth

Shafik (1994), Grossman and Krueger (1995), Apergis and Payne (2009), Onoja, Ajie, and Achike (2014), and Ayobamiji and Kalmaz (2020) pointed out that economic growth is considered a major source of environmental degradation. Besides, Osadume and Edih (2021) showed a positive relation between these two variables. Ahmad and al. (2018), Akalpler and Hove

(2019), Chen and al. (2019), Cosmas and al. (2019), Dong and al. (2018), Gill and al. (2018), Khan and al. (2019), Riti and al. (2017), and Toumi and Toumi (2019) concluded that there is a positive long-term relationship between economic growth and CO2 emissions.

In contrast, Azomahou and al. (2006), Atici (2009), Baek and Pride (2014), Ajmi and al. (2015), Saidi and Hammami (2015), and Zaidi and al. (2017), Salahuddin and al. (2016), Dogan and Aslan (2017), and Rasool and al. (2020) showed a negative effect of CO2 on economic growth. Also, Omar (2019) used the Autoregressive Distributed Lag (ARDL) model and limits test for cointegration to investigate the factors influencing carbon dioxide emissions for the Republic of Djibouti for the years 1990-2017, confirming that per capita income levels decrease CO2 emissions.

Dinda and Coondoo (2006), Lee and Lee (2009), and Narayan and Narayan (2010), all investigated the connection between GDP growth and CO2 emission. A two-way causal relationship between GDP growth and CO2 emission. They are connected in both directions over the short term, according to Ghosh (2010). This finding is in line with Govindaraju and Tang (2013), and Khoshnevis and Dariani (2019). The unidirectional relationship between GDP growth and CO2 emissions has proved by Farahani and al. (2014), Ertugrul and al. (2014), and Wang and al (2016).

Although, Lantz and Feng (2006), Liu and al. (2012), Rahman and al. (2020), and Adebayo (2020) found no correlation between per capita GDP and CO2 emission.

Second main title: Financial development

According to Campiglio (2016), Yuan and Gallagher (2018), and Leimbach and al. (2018) the level of financial development may have a significant effect on the environment. These studies by Heidari and al. (2015), Usman and al. (2017), Wang and al. (2018), Bakirtas and al. (2018), Akadiri and al. (2018), Zakaria and Bibi (2019), Le and al. (2020), Shahbaz and al. (2020), Khan and al. (2021), Anwar and al. (2021), also claim that financial development contributes to environmental damage.

However, Zhang (2011) explored the effect of financial development on carbon emissions. The results indicate firstly, that China's financial development is an important factor in the increase of carbon emissions. Secondly, the influence of financial intermediation on carbon emissions outweighs that of other financial development indices. But, the impact of its effectiveness appears to be much lower, even if it can statistically cause a change in CO_2 emissions. Thirdly, the scale of China's stock market has a relatively greater influence on CO_2 emissions, while the impact of its efficiency is much reduced. Liu and al. (2021) discovered that CO_2 emissions increased by 0.17-0.52% for every 1% of financial development.
Although, Tamazian and al. (2009) found that a high degree of economic and financial development decreased environmental degradation. They claimed that financial development improves the quality of the environment by increasing income and capitalization, exploiting new technologies, and implementing environmental regulations. In addition, according to Shahbaz and al. (2018) and Khan and al. (2019), Szymczyk and al. (2021), and Haldar and Sethi (2022) financial development aid in the reduction of CO_2 emissions.

Third main title: FDI

Mahmood and Chaudhary (2012) found that FDI has three types of effects on the environmental quality of developing countries:

- The first is the scale effect, which is favorable when the economy is expanding and there is a demand for environmental goods, facilitating the resolution of environmental problems. On the other hand, it is detrimental when a nation experiences economic growth without taking environmental management and regulation into consideration.

- The second effect is technological, and it is advantageous when foreign investors adopt green technology and have an impact on domestic investment because of competitiveness.

- The third is a political effect, this effect is positive when the host government makes tight regulations on environmental protection and forces foreign investors to follow the regulations. A negative effect of the policy occurs when competition exists between developing countries to attract FDI and host governments relax their environmental regulations for FDI.

In addition, Zhang (2011) predicts that China's FDI exerts the least influence on the variation in carbon emissions, due to its relatively lower volume compared to income.

Besides, Pao and Tsai (2011), Al-Mulali and Tang (2013), Liu and al. (2017), and Jiang and al. (2017) are a studies that show the benefits of FDI on environmental quality.

In contrast, Ren and al. (2014), Tang and Tan (2015), Shahbaz and al. (2015), Paramati and al. (2016), Abdouli and Hammami (2017), Shahbaz and al. (2018), Nasir and al. (2019), Hanif and al. (2019), and Nawaz and al. (2021) show that FDI flows increase GHG emissions. Also, Elliott and al. (2013) prove that FDI has a detrimental effect on energy intensity. Also, Nguyen and al. (2020) analyze the factors that influence carbon emissions. They discover that FDI has a moderately detrimental effect on carbon emissions.

However, Peng and al (2016) proved that there is a causality relationship between CO2 emission and FDI : bidirectional in Neimenggu and unidirectional from FDI to CO2 emissions in Beijing, Henan, Guizhou, and Shanxi.

A few other investigations by Lee (2013), Kivyiro and Arminen (2014), Baek (2015), Zhu and al. (2016) produce insignificant and inconclusive results.

Forth main title: Trade

Costantini and Monni (2005) observed that a higher level of trade and manufacturing industries generates a higher level of CO2 emissions, isolating the effect of composition and the effect of scale according to an explanation of the offer of the EKC. This explanation has been proven by previous researchers, including Chichinilsky (1994), and Suri and Chapman (1998). They noted that the increase in trade has been associated with an increase in CO2 emissions, especially for developing countries due to the relocation of polluting industries known as the "the pollution heaven effect". Also, Copeland and Taylor (2004), Andersson and al. (2009), Halicioglu (2009),

Jalil and Mahmud (2009), Jalil and Feridun (2011), Nasir and Rehman (2011), Jayanthakumaran and al. (2012), Yasmeen and al. (2018), Dauda and al. (2021), and Bouchoucha (2023) prove that trade contributes to the increase of pollution level.
In contast, Al Muman and al. (2014), Shahbaz and al. (2017), Amri, Ben Zaied, and Ben Lahouel (2019), Salman and al. (2019), Lv and Xu (2019), Adebayo (2020), Essandoh and al. (2020) observed a negative relationship between CO2 and trade.
Although, Akin (2014), Ertugrul and al. (2016) found a one-way association between trade and CO2 emissions.
Naranpanawa (2011) examined the relationship between trade and carbon emissions in Sri Lanka during the period from 1960 to 2006. The results suggest that there is neither a long-term equilibrium relationship nor a long-term causality. However, there is a short-term relationship between these two variables.

Fifth main title: Energy consumption

Ang (2008), Soytas and Sari (2009), Menyah and Wolde-Rufael (2010), Ozturk and Acaravci (2010), Wang and al. (2011), Alshehr and Belloumi (2015), Apergis and Payne (2015), Dogan and Seker (2016), Souza and al. (2018), and Adebayo (2020) investigates the relationships between CO2 and its determinants. The findings show a positive relationship between CO2 emissions and energy consumption. However, Yavuz (2014) and Seker and al. (2015) are two studies that point to the validity of the EKC hypothesis, whereas Halicioglu (2009), Ozturk, and Acaravci (2010), among others, do not. These studies are among those that evaluated the validity of the EKC hypothesis, and the results found are inconsistent even for the same countries and regions. For Brazil, the EKC hypothesis was supported by Souza and al. (2018), unlike the United Kingdom, Italy, and Japan, where no support was found by Ajmi and al. (2015). In turn, little evidence has been found for Arctic countries (Canada, Finland, Denmark (Greenland), Iceland, Norway, Russia, Sweden, and the United States (Alaska)) by Baek (2015). According to the research of Balat (2005) and Shafiei and Salim (2014) proved that the usage of fossil fuel energy sources worsens environmental quality. Bai and al. (2019) consider that large cities and urban agglomeration areas have higher CO2 emissions because of the high energy consumption for residential heating, gas, transportation, and power.

In constrast, Talbi (2017) analyzes the factors influencing the evolution of CO2 emissions from the Tunisian transport sector. It has shown that energy efficiency and fuel efficiency play a predominant role in reducing CO2 emissions.

The ASEAN study by Lean and Smyth (2010) revealed a long-term connection between energy use, economic expansion, and CO2 emissions. Apergis and Payne (2010) discovered a unidirectional relationship between energy use and CO2 emissions. This finding was also supported by Wang and al. (2011). The findings of Salahuddin and Gow (2014) showed a causal relationship between energy use and CO2 emissions in both directions. Contrary to Pao and Tsai's (2010) and Gorus and Aydin's study (2018), findings show a bi-directional relationship between energy use and GDP growth. Then, In the long term, Zhang and Cheng (2009) discovered a unidirectional Granger causation connecting energy use and carbon emissions, but neither factor influenced economic development in their model. On the basis of annual data from 1965 to 2006, Hwang and Yoo (2014) looked into similar relationships in Indonesia and demonstrated that there was a bi-directional causal relationship between energy consumption and CO2 emissions. This implies that an increase in energy consumption directly affects CO2 emissions and that CO2 emissions also stimulate additional energy consumption.

Chapter II: Empirical Analysis

First main title: Data sources

The descriptive data for these series for the Tunisian economy are shown in Table 1. According to the statistics of the Jarque-bera test, it suggests that all series are regularly distributed. Real GDP per capita (US $ current), energy consumption (kg of oil equivalent), financial development measured using domestic credit to the private sector as a share of GDP), trade openness (that is equal to the ratio of export plus import to GDP), and foreign direct investment are all positively correlated with CO2 emissions, according to pairwise correlation research. Energy use, financial development, trade openness, and foreign direct investment all positively correlate with real GDP per capita. Additionally, there is an inverse relationship between energy use and financial development, trade openness, and foreign direct investment. Trade openness and foreign direct investment are also found to be strongly correlated with financial development, according to the correlation analysis. Foreign direct investment and trade openness are proven to be positively correlated.

Table 1. Descriptive statistics (before logarithmic transformation) during the period 1970–2019

	lnCO2	**lnGDP**	**lnEC**	**lnFD**	**ln TRADE**	**lnFDI**
Mean	**0.513719**	**7.705299**	**6.410056**	**4.024164**	**4.396621**	**4.034051**
Median	**0.567077**	**7.647802**	**6.412631**	**4.076651**	**4.440809**	**4.077594**
Max	**0.901422**	**8.244615**	**6.821107**	**4.323705**	**4.751001**	**4.232714**
Min	**−0.211960**	**7.089723**	**5.762051**	**3.517544**	**3.882388**	**3.703004**
Std. dev. [a]	**0.307794**	**0.318388**	**0.300864**	**0.196767**	**0.194854**	**0.151122**
Skewness	**−0.773911**	**0.208149**	**−0.389546**	**−0.954328**	**−0.844335**	**−0.699610**
Kurtosis	**2.736421**	**2.059881**	**2.216499**	**3.420899**	**3.626581**	**2.321130**
J–Bera [b]	**4.314146**	**1.849975**	**2.136501**	**6.685211**	**5.677370**	**4.232696**
Prob	**0.115663**	**0.396536**	**0.343609**	**0.335345**	**0.358503**	**0.120471**

lnCO2	***1***					
lnGDP	***0.940371***	***1***				
lnEC	***0.984275***	***0.975382***	***1***			
lnFD	***0.849419***	***0.719732***	***0.804767***	***1***		
lnTRADE	***0.873503***	***0.809026***	***0.843893***	***0.748140***	***1***	
lnFDI	***0.980108***	***0.930615***	***0.979275***	***0.849509***	***0.848903***	***1***

a. b indicates respectively standard deviation and Jaque–Bera

Second main title: Model specification

In the current study, the long-term relationships between carbon dioxide emissions and their determinants economic growth, energy consumption, trade, and financial development, and foreign direct investment are examined. The study followed the research of Shahbaz (2013), who for the first time discussed the connection between financial development and the level of emissions.

The following model is used to investigate the factors that affect CO2 emissions:

$$CO2_t = A\, GDP_t^{\beta_1}\, EC_t^{\beta_2}\, FD_t^{\beta_3}\, TRADE_t^{\beta_4}\, FDI_t^{\beta_5} \quad (A)$$

The following equation is obtained by taking the natural logarithm (ln) of Equation (A):

$$lnCO2_t = \beta_0 + \beta_1 lnGDP_t + \beta_2\, lnEC_t + \beta_3 lnFD_t + \beta_4 lnTRADE_t + \beta_5 lnFDI_t + \varepsilon_t \quad (B)$$

Where t, β_0, and ε denote, respectively, the time, the fixed country effect, and the stochastic disturbance term. In addition, β1, β2, β3, β4, and β5 are, respectively, the long-run elasticities of GDP, energy consumption, financial development, trade openness, and foreign direct investment. It is anticipated that the coefficients β_1 and β_2 in Eq. (B) will have positive expected signs. Because a considerable rise in energy consumption could spur economic growth and raise CO2 emissions, the sign β_3 is anticipated to be positive (Kohler 2013, Farhani and al. 2014). According to Ozturk and Acaravci (2013), Shahbaz (2013), and Shahbaz and al. (2013) the sign β_4 is predicted to be positive, and it will be covered in more detail in this study. Because it relies on a country's economic growth stage, the projected sign of β_5 is also favorable.

Third main title: Econometrical methodology

In order to determine how the variables are related over the long and short terms, our empirical estimator aims to analyze these relationships. According to these goals, our methodological strategy in this work is organized as follows: The first step is to estimate the degree of integration of the series using the Philips and Perron test. The second step consists in testing the presence or not of a cointegrating relationship that can link the variables. Finally, the third step is to develop the VECM which allows to model the short and long term dynamics.

First subtitle: The unit root tests

The unit root tests Phillips-Perron (PP) of Phillips and Perron (1988) is used to apply the time series properties of the variables in Eq (B). The findings shown in Table 2 demonstrate that all series appear to have a unit root levels but are stationary in its first differences.

The results show that the T-Statistics associated with the Phillips-Perron test of all the variables are lower (in absolute value) than the critical values in the three thresholds 1%, 5%, and 10%. Then, the null hypothesis of non-stationarity rejected and the series is not stationary in level. Whereas, the T-statistics in the first difference of all the variables become higher than the critical values at the 1% level. So, at the 1% level of significance, we get the conclusion that they are integrated in the same order I(1).

Table 2. Phillips-Perron Unit root tests

Vbs	Level		First difference	
	T-stat	**Crit Val**	**T-stat**	**Crit Val**
lnCO2	-3.472	-3.600 *** -2.935** -2.605*	-7.311	-3.605*** -2.936** -2.606*
lnGDP	-2.883	-3.600*** -2.935** -2.605*	-3.955	-3.605*** -2.936** -2.606*
lnEC	-2.805	-3.605*** -2.936** -2.606*	-9.482	-3.610*** -2.938** -2.607*
lnDF	-1.719	-3.600*** -2.935** -2.605*	-5.824	-3.605*** -2.936** -2.606*
lnTRADE	-1.325	-3.600*** -2.935** -2.605*	-5.940	-3.605*** -2.936** -2.606*
lnIDE	-2.993	-3.632*** -2.948** -2.612*	-8.369	-3.639*** -2.951** -2.614*

Note: ***, **and * represent the significance at the 1%, 5% and 10% level

Second subtitle: Cointegration Test

After having detected the order of integration of the variables, we will proceed to the co-integration test. Therefore, we will apply the Johansen test for our country to determine if there is a long-term equilibrium relationship between CO2 emission and its determinants.

The trace test shows that there is a co-integration relationship at a 5% significance level. Check with a reasonable ratio:

H0: there are r co-integration relations;

H1: there is r+1 co-integration relation:

Test statistics: $LRmax(r|r + 1) = -n\ln(1 - \lambda r + 1) = LRtr((r + 1|k) - LRtr(r|k)$

For r = 0, LRmax = 111.15, the 5% critical value equals 95.75, so H1 is accepted.

Table 3. Johansen cointegration tests

Hypothesized no. of CE(s)	r = 0	r ≤1
Trace statistic	111.15	66.60
Critical value*	95.75	69.81
Probability**	0.010	0.572
Hypothesized no. of CE(s)	r = 0	r =1
Maximum eigenvalue statistic	44.54	28.99
Critical value*	40.07	33.87
Probability**	0.002	0.785

* Denotes rejection of the hypothesis at the 5% level.

** Mackinnon-Haug-Michelis (1999) p-values.

Table 3 demonstrates that the null hypothesis is rejected at 5% whether it is (at most) r=0 (for the trace test) or exactly r=0 (for the maximum eigenvalue test). It shows that the values obtained from these two statistics 111.15, the trace statistic, and 44.54, the maximum eigenvalue statistic are bigger than the critical values corresponding to them (respectively 95.75 and 40.07). On the other hand, we accept the hypothesis of at least one co-integration relationship among the variables. The variables ln CO2, lnPIB, lnEC, lnDF, and lnTRADE, and lnFDI are found to be cointegrated. The existence of a cointegration relationship justify the adoption of the error correction model.

Forth main title: The Result of the VECM Model

The results of the long-term relationship and the VECM are:

$lnCO2_{t-1}=-7.38+0,24lnGDP_{t-1} + 1,16lnEC_{t-1} + 0,11lnFD_{t-1} + 0,4lnTRADE_{t-1} + 0,01lnFDI_{t-1}$

and

$dlnCO2_{t} = -5,85-0,79lnCO2_{t-1} + 0,2lnGDP_{t-1} + 0,91lnEC_{t-1} + 0,1\ lnFD_{t-1} + 0,32lnTRADE_{t-1} + 0,008lnFDI_{t-1} + 0,27D(lnCO2_{t-1}) + 0,23D(lnGDP_{t-1}) - 0,008D(lnEC_{t-1}) + 0,11D(lnFD_{t-1}) - 0,22\ D(lnTRADE_{t-1}) + 0,001D(lnFDI_{t-1})$

The error correction term ECT_{t-1} represents the speed of adjustment of CO2 to its long-run equilibrium following a shock. Coefficient of (-0,79) is significant at the 5% level with a negative sign expected, suggesting that a deviation from the long-run equilibrium level of CO2 emissions in 1 year is corrected by 79% over the following year. Moreover, a significant error correction confirms the existence of a stable long-run relationship between the regressors (GDP, EC, FD, TRADE, and FDI) and the dependent variable.

There is a long-run relationship between CO2 emissions and GDP. A 1% increase in GDP will lead to increase CO2 emissions by 0.2% and over the long and the short run. They also concluded that emission reduction policies and more investment in pollution abatement cost will not upset the Tunisian's economic growth.

The equations also indicate that energy consumption has a long-run positive impact on CO2 emissions. The finding results show that a 1% increase in energy consumption will lead to increase CO2 emissions by 1.16% over the long-run. The case is different in the short run when the relation is negative, but not significant. This result indicates that energy consumption in Tunisia creates an environmental degradation. This result is likely since non-renewable energy use, a source of pollution, dominates Tunisia's energy consumption.

Thus, foreign direct investment is positive both in the long and the short run. It seems that this investment results in the establishment of polluting companies. However, we note that the coefficient of the financial sector is positive and significant. This is explained that Tunisian policymakers develop the financial sector in order to finance the non-renewable energy projects.

It is implied that financial organizations don't have any environmentally fri endly policies, which leads to excessive CO2 emissions.

As well, we see that trade openness has a positive impact on CO2 only in the long run. Therefore, in the short run the unit increase of openness would result in a significant negative effect (-0,22) in CO2 emissions.

We can explain the both effect of trade openness on pollution and the environment.

We break down the environmental implications of commerce into three dist inct categories: scale, composition, and technique. First, the scale's effect s hows how increasing economic activity brought on by trade will affect CO2 emissions. The trade opening will increase economic activity and hence energy use. Everything else being equal, this increase in the economic activity scale and energy use will lead to higher levels of CO2 emissions. Second, the composition's effect describes how trade shifts a country's production mix toward those goods where it has a comparative advantage. The impact on greenhouse gas emissions will depend on the industries in which a country has a comparative advantage. The technique's effect it observed in the short run that trade openness can result in increases in energy efficiency. As a result, the production of goods and services can produce fewer greenhouse gas emissions, the availability of more goods, services, and technologies increases energy efficiency, and trade can assist in addressing the problem of global warming.

CONCLUSION

This paper consists of analyzing the dynamic relationships between CO2 emissions, real GDP, energy consumption, financial development, trade, and foreign direct investment in Tunisia. The relationship in which CO2 emissions are the dependent variable is used to test the short-run and long-run elasticities of CO2 emissions with respect to the explanatory variables. The elasticity of CO2 emissions with respect to energy consumption and trade are computed as 1,16 and 0,4 respectively. To this extent, the study suggests that the critical factor affecting CO2 emissions is energy consumption. The findings so imply that this nation is threatened by imported emissions (via international trade). Also, the results suggest that the implementation of energy conservation policies has not inversely affected the long-term economic performance of Tunisia. Therefore, Tunisia must develop a green economy by increasing public knowledge of environmental dangers, gathering and tracking environmental indicators, enacting stronger environmental and energy legislation, and enforcing sanctions against those who violate environmental norms.

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