

The Economic Growth, Energy, Trade, FDI, Exchange Rate, And CO₂ Emissions In Turkey. Fresh Evidence From Combined Co-Integration Test

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ABSTRACT

This paper examines the effect of economic growth, energy, trade, and FDI on CO₂ emissions in Turkey. Also, the prime objective of this paper is to provide a new insight by examining the impact of the real exchange rate (EX) on CO₂ emissions by using a new Bayer–Hanck combined co-integration approach. The study covers the period of 1980–2015. The ARDL and FMOLS models are used to test the relationship between the examined variables. The Granger causality test is applied to test the direction of the causality among the examined variables. The findings from FMOLS and ARDL models show that an increase in economic growth, non-renewable energy consumption, and FDI in Turkey led to an increase in Turkey's carbon emissions. Furthermore, the outcomes show that the real exchange rate negatively affects CO₂ emissions in Turkey. Additionally, the outcomes confirm that the real exchange rate negatively affects carbon dioxide (CO₂) emissions through the channels of energy consumption, FDI, and international trade. It is suggested that Turkey's policymakers should play a significant role in supporting trade, FDI, energy investment projects to lower the level of Co₂ emission by employing different economic and monetary policies such as exchange rate policy to reduce environmental degradation.

Keywords: combined co-integration, real exchange rate, CO₂emissions, Turkey

Mathematics Subject Classification: 28-XX

(JEL) Classification Number: D, E, O, R

1. INTRODUCTION

Turkey represents a crucial case for examining the effect of international trade, non-renewable energy consumption, and real exchange rate on carbon dioxide emissions. In this regard, Turkey is a country whose economy and population are proliferating. Accordingly, Turkey has made efforts to enhance and support economic growth, FDI, and international trade. Consequently, the GDP per capita rose from 4,981 US\$ in 1980 to 13,312 US\$ in 2014. Total exports rose from 5 billion US\$ to 256 billion US\$ in 2014. FDI inflows in Turkey reached a total of 127 billion US\$ during the period from 2001 to 2012. Also, the banking sector in Turkey experienced positive development over the period 2002 to

2014; for example, Turkey experienced rapid growth in total assets during this period, credits provided by the banking sector to the private sector reached around 50% of GDP, and the non-renewable energy consumption of Turkey is continually increasing. However, nonrenewable energy resources such as fossil fuels (coal, petroleum, and natural gas) are not unlimited and exhausted after a certain period. Furthermore, using these types of energy sources harms the environment (Samour, 2019). The primary strategy applied in Turkey is to reduce the harmful impact of environmental degradation. Policymakers play a significant role in supporting energy investment projects that offer lower carbon dioxide emission levels. However, policymakers can also enforce different methods to minimize environmental degradation using economic and monetary policies such as the exchange rate.

In this direction, the main aim of the current research is to present a new insight by exploring the impact of the real exchange rate (EX) on CO₂ emissions in Turkey by using a new Bayer–Hanck combined co-integration approach. However, there is no other research that has tested the impact of exchange-rate on CO₂ emissions in Turkey by using a new Bayer–Hanck combined co-integration approach. However, by exploring the impact of the real exchange rate, we examine the impact of monetary policy on environmental degradation, which is considered as one of the main monetary policy channels. The following schematic shows the impact of an expansionary policy accomplished by decreasing the interest rate:

$$R^i \downarrow \rightarrow E \downarrow \rightarrow EX \uparrow \rightarrow Y^a \uparrow$$

When the local currency depreciates, domestic goods and services become more expensive for consumers. Although the local currency depreciation is not suitable for consumers, it is helpful for many export firms because it becomes easier to sell their goods and services. A final group affected by the exchange rate is investors who own foreign assets. Depreciation of the local currency presents more advantages for this group because it increases the assets' value in the foreign currency (Smets and Wouters, 2002).

In contrast, the following schematic shows the impact of a contractionary policy accomplished by increasing the rate of interest:

$$R^i \uparrow \rightarrow E \uparrow \rightarrow EX \downarrow \rightarrow Y^a \downarrow$$

This schematic shows that a contractionary policy leads to an increase in rates of interest ($R^i \uparrow$), which in turn causes the local currency to appreciate ($E \uparrow$). An increase in the value of the local currency causes the local goods to be more expensive than foreign goods, thus leading to a decrease in net exports ($EX \downarrow$), which in turn leads to a decrease in aggregate demand ($Y^a \downarrow$). In this regard, Dornbusch (1980) showed that a contractionary policy increases the real interest rate. Under the contractionary monetary policy, domestic goods' cost in foreign currencies increases, and the net exports decline. This is also accompanied by a decrease in economic growth and price level (Mishkin, 2016).

When the local currency appreciates, domestic goods and services become less expensive for local consumers. Although an appreciation of the local currency is good for local consumers, it hurts many export sectors because it becomes harder to sell their goods and services. A final group affected by the exchange rate is investors who own foreign assets. Appreciation hurts this group because it reduces the assets' value in foreign currency (Mishkin, 2016).

In this article, we suggest that the impact of the exchange rate on carbon dioxide emissions depends on how this rate affects international trade, FDI, economic growth, and non-renewable energy consumption. However, the exchange rate affects multinational corporations' competitiveness in terms of their earnings and stock prices. Furthermore, the depreciation of the local currency generates benefits for exports, while the appreciation of the local currency creates benefits for imports; thus, the real exchange rate may indirectly influence CO₂ emissions through the international trade channel. Moreover, the real exchange rate affects foreign direct investment and economic growth and thus causes a change in carbon emissions.

The rest of this research is as follows: Section(2) presents a literature survey of the current research; Sections (3) and (4) document methodology. Section (5), and 6 provide the empirical findings and conclusion parts.

2. LITERATURE SURVEY

2.1 The linkage amongst economic growth, non-renewable energy consumption, and carbon dioxide emissions.

The first strand of the literature surveyed in this study is related to the linkage between energy consumption, economic growth, and CO₂ emissions. Some of the studies in the literature indicate that there is a positive relationship between energy consumption, economic growth and CO₂ emissions. In this regard, Katircioglu and Katircioglu (2018), Samour et al. (2019), Isiksal et al. (2019), Pata (2018), and Seker et al. (2015) examined the impact of economic growth on carbon dioxide emissions. They found empirical evidence supporting a positive relationship between economic growth and carbon dioxide emissions in Turkey from 1974 to 2010. However, in their studies, Katircioglu and Katircioglu (2018), and Pata (2018) applied the ARDL testing model, and they indicated that economic growth rate is one of the main drivers of non-renewable energy consumption in Turkey; they also recommended that policymakers should promote energy efficiency to boost sustainable growth. Samour et al. (2019) used FMOLS and the CCR model. They found a positive linkage amongst economic growth rate and carbon dioxide emissions in Turkey for the examined period from 1980-2014, whereas Isiksal et al. (2019) used the ARDL testing approach and found that an increase in non-renewable energy consumption led to an increase in the levels of CO₂ emissions in Turkey using data from 1980-2014.

Unlike these studies, Mert and Boluk (2016) used panel data and found no linkage between economic growth rate and carbon dioxide emissions from 1992 to 2010 in 21 Kyoto Annex countries. Akbostanci

et al. (2009) and Ozturk and Acaravci (2010) employed time series models, and both found no evidence of economic growth rate and the level of carbon dioxide emissions.

2.2 The linkage amongst FDI, international trade, and carbon dioxide emissions.

The second strand of the literature surveyed in this study is related to international trade, FDI, and carbon dioxide emissions. In this regard, Sadorsky (2011) applied the FMOLS model and showed a positive linkage between FDI and consumption of energy in Middle East countries for the period 1980-2007. Similarly, Dedeoğlu and Kaya (2013) used the DOLS model and found a positive relationship between trade and non-renewable energy consumption in some OCED countries for the period 1980-2011. Nasreen and Anwar (2014) used the FMOLS and DOLS models and suggested that FDI, international trade has a positive effect on the consumption of energy for 15 Asian countries over the period 1980-2011. Topcu and Payne (2018) used a panel data model and tested the nexus between international trade and non-renewable energy consumption for OCED countries from 1990 to 2015. The outcomes revealed a significant positive impact of international trade on energy consumption.

Using the ARDL model, Apergis and Payne (2014) confirmed that international trade positively impacted Pakistan's non-renewable energy consumption over the period 1973-2013. Shahbaz et al. (2013) found a positive impact of international trade on the consumption of energy in Indonesia for the period 1971-2011. Another study by Raza et al. (2015) used ARDL to show that international trade positively affected non-renewable energy consumption in Pakistan for 1973-2013. In Turkey, Erkan et al. (2010) used the vector error correction model (VECM) and tested the linkage between energy and exports. Their outcomes showed that co-integration existed among exports and non-renewable energy consumption over the period 1970-2010. Another empirical research in Turkey conducted by Halicioglu (2011) indicated a unidirectional causal relationship between exports and non-renewable energy consumption in Turkey using 1968-2008. In contrast, Ghani (2012) used VECM for selected developing countries and found no relation between FDI, international trade, and non-renewable energy consumption over the period 1980-2007. Similar findings were reported for China by Ren et al. (2014), who found a significant relationship between international trade and non-renewable energy consumption over 2000-2010. Ozturk and Acaravci (2013) affirmed a positive linkage between the level of CO₂ emission and trade in Turkey over the period 1960-2007. These studies suggest that governments should promote and support international cooperation on environment protection to decrease Co₂ emissions.

In contrast, Dogan et al. (2017) applied the DOLS approach and showed that international trade led to a decrease in CO₂ emissions in selected OECD countries. Jebli et al. (2016) used the FMOLS model and showed that an increase in international trade in renewable energy sources is an efficient strategy to combat global warming.

2.3 The linkage between exchange rate and carbon dioxide emissions.

The third strand of the literature surveyed in this study is related to exchange rate and carbon dioxide emissions. The exchange rate dimension is one of the main monetary policy channels that can affect

the economy. In this regard, the spillover effect of this channel on carbon dioxide emissions depends on how the exchange rate channel may affect economic growth and other factors such as international trade and how it may affect non-renewable energy consumption and consequently carbon dioxide emissions.

According to the literature, the exchange rate can affect economic performance through several factors such as international trade and FDI. In this regard, Sehrawat and Giri (2017), Almahadin and Tuna (2017), and Balaguer and Cantavella (2002) showed that the linkage between exchange rate and economic performance could vary. This relation can be attributed to various economic structures as well as different exchange rate systems. These studies mainly suggested that the exchange rate channel plays a vital role in improving economic performance; for instance, when the local currency depreciates, domestic goods and services become more expensive for consumers. Although a depreciation of the local currency is not suitable for consumers, it is beneficial for many export firms because it becomes easier to sell their goods and services. A final group affected by the exchange rate is investors who own foreign assets. Depreciation of the local currency presents more advantages for this group because it increases the assets' value in the foreign currency (Smets and Wouters, 2002).

In this vein, if exchange rates have a real influence on economic growth rates. Hence, it will lead to affect the levels of energy consumption. Chari et al. (2002) and Benigno and Thoenissen (2008) argued a high correlation between real exchange rate and energy consumption. Zhang and Zhang (2018) studied the indirect impact of exchange rate on China's CO₂ emissions by using the ARDL bounds testing approach to co-integration over the period 1982 to 2016 and found a decrease in the exchange rate led to an increase in carbon emissions.

3. MODELING AND DATA

This research explores the impact of the real exchange rate (EX) on CO₂ emissions in Turkey. Also, the main aim of this paper is to explore the linkage between economic growth, international trade, and CO₂ emissions. The tested model of the current paper is formulated and presented as follows:

$$LnCO2_t = \beta_0 + Y_1 LnY_t + Y_2 LnENC_t + Y_3 LnITR_t + Y_4 LnREX_t + \varepsilon_{it}(1)$$

where $LnCO2_t$ represents the logarithm of CO₂, LnY is the logarithm of $Y(GDP)$, $LnEnc_t$ symbolizes the logarithm of energy consumption, $LnITR$ is the logarithm of international trade, and REX represents the logarithm of the real exchange rate. This research's data is yearly data from 1980-2015 retrieved from the World Bank (WB) website. Descriptions of the variables used in this paper are summarised in Table 1:

Table 1 :summary of examined variables.

Variables	Description
$\ln CO_2_t$	Carbon emissions in metric kilograms per capita
$\ln Y_t$	GDP (2010= 100) in USD
$\ln ENC_t$	Energy consumption measured as kilotons of oil equivalent
$\ln IT$	International trade is the sum of total exports and imports as a % of GDP
$\ln FI$	Net-inflows (FDI) as (percentage) of G.D.P
$\ln EX$	The real exchange rate is calculated based on weighted averages of bilateral exchange rates; relative consumer price rates adjust the rate

4. EMPIRICAL METHODOLOGY

4.1 co-integration test

The current research uses the following unit roots tests the PV test (Perron-Vogelsang, 1999) and ZA test (Zivot Andrews, 2002), and CMR test (Clemente et al., 1998) to examine the stationary amongst the tested variables. ARDL model is utilized to determine the level of co-integration amongst the tested series (Pesaran et al., 2001). This test's advantage is that it uses different lags to determine the short-run and long-run parameters simultaneously (Moyo et al.,2021). However, this test aims to determine if co-integration exists amongst the tested variables by employing the ARDL approach. In this approach, the hypothesis of no co-integration amongst the tested series will be rejected; if the F -statistics is more than the upper bound $I(1)$ (Alhodiry et al.,2021). It will be accepted if the F -statistics is less than the upper bound $I(1)$ the findings of this test will inconclusive if the F -statistics were between $I(0)$, and $I(1)$.

The ARDL testing model for the examined variables of this research is as follows:

$$\Delta \ln CO_{2t} = \beta_0 + \sum_{i=1}^l \gamma_1 \Delta \ln CO_{2t-j} + \sum_{i=1}^l \gamma_2 \Delta \ln Y_{t-j} + \sum_{i=1}^{nl} \gamma_3 \Delta \ln ENC_{t-j} + \sum_{i=1}^{nl} \gamma_4 \Delta \ln ITR_{t-j} + \sum_{i=1}^l \gamma_5 \Delta \ln EX_{t-j} + \sigma_1 \ln CO_{2t-1} + \sigma_2 \ln Y_{t-1} + \sigma_3 \ln ENC_{t-1} + \sigma_6 \ln ITR_{t-1} + \sigma_7 \ln EX_{t-1} + \varepsilon_{1t} \quad (2)$$

Equation (3) Δ represents the first difference level of the examined variables, $\ln CO_{2t}$ is the dependent variable and $\ln Y_t$, $\ln ENC_t$, $\ln ITR_t$, $\ln EX_t$ are the independent variables, l is the maximum of lags and ε_t is the error-term, (ECM) is estimated as follow:

$$\Delta \ln CO_{2t} = \beta_0 + \sum_{i=1}^l \gamma_1 \Delta \ln CO_{2t-j} + \sum_{i=1}^l \gamma_2 \Delta \ln Y_{t-j} + \sum_{i=1}^l \gamma_3 \Delta \ln ENC_{t-j} + \sum_{i=1}^l \gamma_4 \Delta \ln ITR_{t-j} + \sum_{i=1}^l \gamma_5 \Delta \ln EX_{t-j} + \omega ECT_{t-1} + \varepsilon_{1t} \quad (3)$$

Confirming the ARDL bound test of co-integration, the study uses Bayer and Hanck's (2013) approach (BH 2013). This new approach provides various individual co-integration test results to present more conclusive findings (Abumunshar et al.,2020). The combination of the computed significance level (p_{value} -) of individual co-integration test in this study is in the Fisher's^f formulas as presented in the following Equation:

$$EG_t - JOH_t = -2[IN(P_{EG_t}) + (P_{JOH_t})] \quad (4)$$

$$EG_t - JOH_t - BO_t - BDM_t = -2[IN(P_{EG_t}) + (P_{JO_t}) + (P_{BO_t}) + (P_{BA_t})] \quad (5)$$

In eq(5) p is the value of individual co-integration tests (EG_t, JO_t, BO_t, BA_t). The estimated long-run combined co-integration Fisher F -statistics (FFS) will be compared with critical values (CV) of the BH 2013 test. The combined co-integration hypothesis will not be accepted if the computed FFS values exceed BH 2013 CV.

Supporting the findings of the ARDL model, the study used the (FMOLS) approach, The direction of the causality relation between CO_2 emissions, Y , Y^2 , ENC , T , FI , and EX are examined by applying the Granger causality within VECM. The Granger causality test within VECM determines co-integration among the time series in both the short and long run. Also, the Granger causality test within VECM allows for the addition of an (ECT). The ECT is represented as follows:

$$\Delta \ln CO_{2t} = \beta_0 + \sum_{i=1}^n \gamma_1 \Delta \ln CO_{2t-i} + \sum_{i=1}^l \gamma_2 \Delta \ln Y_{t-i} + \sum_{i=1}^l \gamma_3 \Delta \ln ENC_{t-i} + \sum_{i=1}^l \gamma_4 \Delta \ln T_{t-i} + \sum_{i=1}^n \gamma_5 \Delta \ln FI_{t-i} + \sum_{i=1}^l \gamma_6 \Delta \ln EX_{t-i} + \omega ECT_{t-1} + \varepsilon_t \quad (6)$$

$$\ln Y_t = \beta_0 + \sum_{i=1}^l \gamma_1 \Delta \ln Y_{t-i} + \sum_{i=1}^l \gamma_2 \Delta \ln CO_{2t-i} + \sum_{i=1}^l \gamma_3 \Delta \ln ENC_{t-i} + \sum_{i=1}^l \gamma_4 \Delta \ln ITR_{t-i} + \sum_{i=1}^n \gamma_5 \Delta \ln FI_{t-i} + \sum_{i=1}^n \gamma_6 \Delta \ln EX_{t-i} + \omega ECT_{t-1} + \varepsilon_t \quad (7)$$

$$\Delta \ln ENC_t = \beta_0 + \sum_{i=1}^l \gamma_1 \Delta \ln ENC_{t-i} + \sum_{i=1}^l \gamma_2 \Delta \ln CO_{2t-i} + \sum_{i=1}^l \gamma_3 \Delta \ln Y_{t-i} + \sum_{i=1}^l \gamma_4 \Delta \ln T_{t-i} + \sum_{i=1}^l \gamma_5 \Delta \ln FI_{t-i} + \sum_{i=1}^l \gamma_6 \Delta \ln REX_{t-i} + \omega ECT_{t-1} + \varepsilon_t \quad (8)$$

$$\Delta \ln T_t = \beta_0 + \sum_{i=1}^l \gamma_1 \Delta \ln T_{t-i} + \sum_{i=1}^l \gamma_2 \Delta \ln CO_{2t-i} + \sum_{i=1}^l \gamma_3 \Delta \ln Y_{t-i} + \sum_{i=1}^l \gamma_4 \Delta \ln ENC_{t-i} + \sum_{i=1}^n \gamma_5 \Delta \ln FI_{t-i} + \sum_{i=1}^n \gamma_6 \Delta \ln EX_{t-i} + \omega ECT_{t-1} + \varepsilon_t \quad (9)$$

$$\Delta \ln FI_t = \beta_0 + \sum_{i=1}^l \gamma_1 \Delta \ln FI_{t-i} + \sum_{i=1}^l \gamma_2 \Delta \ln CO_{2t-i} + \sum_{i=1}^l \gamma_3 \Delta \ln Y_{t-i} + \sum_{i=1}^l \gamma_4 \Delta \ln ENC_{t-i} + \sum_{i=1}^n \gamma_5 \Delta \ln T_{t-i} + \sum_{i=1}^n \gamma_6 \Delta \ln EX_{t-i} + \omega ECT_{t-1} + \varepsilon_t \quad (10)$$

$$\Delta \ln EX_t = \beta_0 + \sum_{i=1}^l \gamma_1 \Delta \ln EX_{t-i} + \sum_{i=1}^l \gamma_2 \Delta \ln CO_{2t-i} + \sum_{i=1}^l \gamma_3 \Delta \ln Y_{t-i} + \sum_{i=1}^l \gamma_4 \Delta \ln ENC_{t-i} + \sum_{i=1}^n \gamma_5 \Delta \ln T_{t-i} + \sum_{i=1}^l \gamma_6 \Delta \ln FI_{t-i} + \omega ECT_{t-1} + \varepsilon_t \quad (11)$$

In Equations 6-11, Δ operator represents the first difference, $\ln CO_2$ is the dependent variable and ($\ln Y, \ln ENC, \ln T, FI, \ln EX$) are the independent variables of this research, ECT_{t-1} represents the lagged ECT added to the equations of this research, while ε_t is the error term. The Wald tests test the

causality in the short term (F -statistics) to explore the significance of the related examined coefficient using the Δ level. The (ECT) is employed to explore the causality at the long-run level.

Confirming the ARDL outcomes' reliability and avoiding functional form misspecification caused by the series's volatility, the diagnostic tests for the parameters are used. In this regard, the diagnostic tests are employed to determine the presence of heteroscedasticity, the correlogram of residuals, and the residual serial correlation to confirm that they are white noise. Furthermore, the stability of the ARDL model can be checked by using the ($CUSUM$ and $CUSUM - square$) tests.

5. MODELLING TEST FINDINGS

5.1. Unit root test findings

The ZA test outcomes with one SBD and the CMR test with two SBDs in both levels and Δ first difference are presented in Tables 2 and 3. The outcomes of the unit root tests indicate that the (t) statistics of both ZA and CMR tests were less than the critical values (CV), which means that all variables of this research ($\ln CO_2, \ln Y, \ln ENC, \ln IT, \ln FI, \ln REX$) are not stationary at "level", but they become stationary by taking "the first difference".

Table2: ZA test findings with one SBD

	<i>t-stat</i>	SBD1		<i>t-stat</i>	SBD1
$\ln CO_2$	-3.3256	2001	$\ln CO_2$	-7.6183**	2002
$\ln Y$	-3.3265	2006	$\Delta \ln Y$	-6.0439**	2009
$\ln ENC$	-3.9562	2010	$\Delta \ln ENC$	-6.7511**	2012
$\ln T$	-4.4151	1982	$\Delta \ln I$	-5.6440**	1985
$\ln FI$	-3.2310	1984	$\Delta \ln FI$	-6.8550**	1985
$\ln EX$	-3.6259	2004	$\Delta \ln EX$	-7.1190**	2006

** represent significance at the 5 per cent levels. SBD represents structural break date

Table : CMR unit root tests with two SBD

	<i>t-stat</i>	SBD 1	SBD 2		<i>t-stat</i>	SBD1	SBD 2
$\ln CO_2$	-3.160	1998	1999	$\Delta \ln CO_2$	-6.699**	1999	2001
$\ln Y$	-3.915	1988	2008	$\Delta \ln Y$	-9.572**	1990	2001
$\ln ENC$	-4.113	1985	2004	$\Delta \ln En$	-7.453**	1986	2013
$\ln T$	-4.201	1988	1995	$\Delta \ln T$	-6.699**	1985	2000
$\ln FI$	-3.2310	1984	1989	$\Delta \ln FI$	-7.599**	1990	2005
$\ln EX$	-3.985	1985	2002	$\Delta \ln EX$	-9.321**	1999	2001

* and ** represent significance at 5 per cent. SBD is structural break-date

5.2 ARDL bounds testing approach

The outcomes of the ARDL bounds testing approach to co-integration are shown in Table 4. The outcomes indicate that the F -statistics exceeds the 5% level. This test's outcomes affirm and support that there is co-integration among the variables examined in this research and provide significant

evidence on the level linkage for Equation (2). In addition, these outcomes show that the null hypothesis ($\partial 1 = \partial 2 = \partial 3 = \partial 4 = \partial 5 = \partial 6 = 0$) in Equation (3) cannot be accepted. Thus, the co-integration among the variables examined in this research is valid.

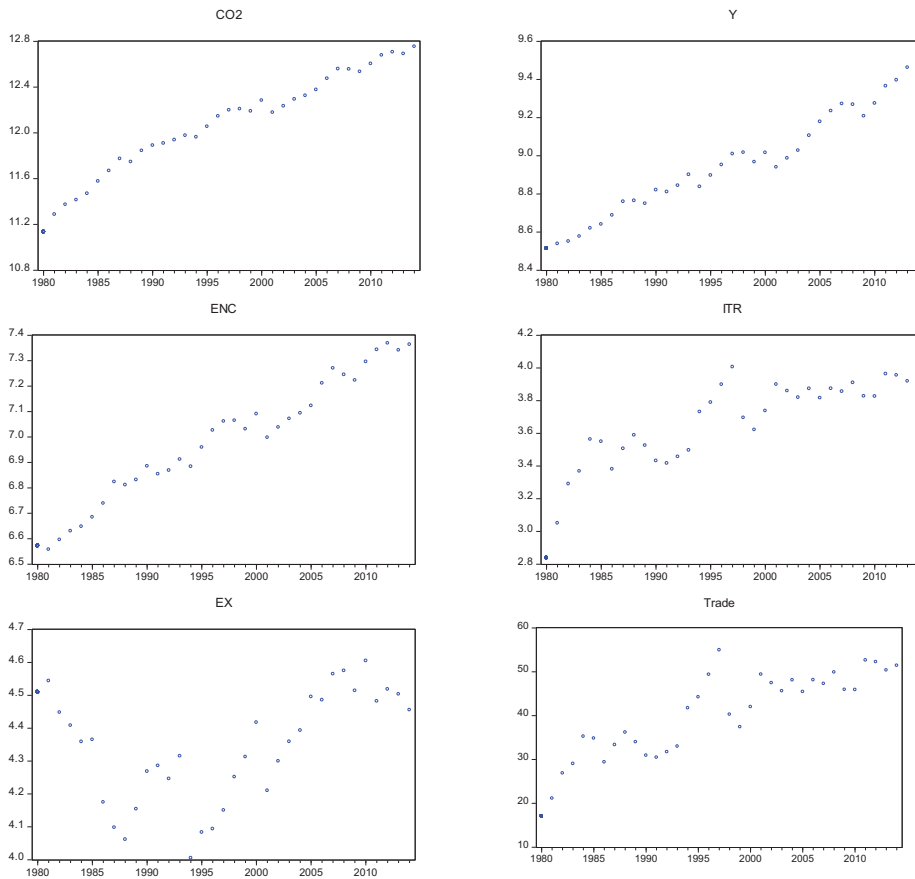


Fig. 1 The tested series plot of variables

Table 4: ARDL bounds testing approach to co-integration

	level		t statistics
	I (0)	I (1)	
CV at1% sign level	2.56	3.88	3.41*
CV at5% sign level	2.21	-3.12	

Note: ** represent significantly level 5%, respectively.

The BH(2013) co-integration test for co-integration findings is presented in Table 5. This test's outcomes indicate that there is robust evidence hypothesis of no co-integration at the (5%) significance level is rejected. Therefore, the BH(2013) co-integration test outcomes provide strong evidence to confirm and support the ARDL bound test.

Table 5: BH 2013 test findings.

	Fisher F statistics	Co-integration-Findings
	<i>EGT/JOT</i>	<i>EGT/JOT/BOT/BAT</i>
	21.2339**	32.344**
<i>Sig level</i>		
<i>at (5%)</i>	10.295	19.688
<i>at (10%)</i>	8.169	15.731

Note: ** represent significantly level 5%, respectively.

Table 9 shows the Jarque-Bera (JB) test outcomes, which aims to test the normal distribution of the series. The outcomes show that the P-value of JB is 0.32, which is greater than the 0.05 value; thus, the outcome confirms normal distribution in our model. The (LM) test aims to test whether the model suffers from the problem of serial correlation. The outcomes show that the P-value (0.79) exceeds the (0.05) value, which confirms the absence of serial correlation. The ARCH test aims to verify whether the model suffers from the heteroscedasticity problem, and the outcome shows that the P-value (0.69) exceeds the (0.05) value, which confirms the absence of (heteroscedasticity); and shows that the distribution of error residuals is homoscedastic. The $Ramsey^{RESET}$ test outcomes show that the P-value (0.59) exceeds the (0.05) value, which confirms the model's stability. However, the LM, ARCH, and Breusch-Pagan Godfrey tests findings affirm that this research's explored model is homoscedastic, and there is no autocorrelation in the model. Also, the Ramsey RESET test findings affirm the level of stability in the explored model. However, the findings of the diagnostic tests affirm that the formulated model of this study is correct. Besides, the stability of the short-run coefficients is evaluated using (CUSUM and CUSUM-square). In this regard, Fig. 2. shows the following tests (CUSUM and CUSUMq). These tests. Demonstrated that the "blue-lines" fall between the two red lines at the (5%) sig level. Hence the findings confirm that the tested model is stable

Table 7 demonstrated that the ECT is (-) negative, and the level of convergence is 90.1%. Tables 6 and 7 showed coefficients in both the long and short-term using the ARDL model. Table 8 presented the findings of the FMOLS model. The outcomes from ARDL and FMOLS show that the coefficients of Y (economic growth) and ENC (energy consumption) are significant and positive in the long run. The findings from Table 7 show that Y and ENC 's coefficients are significant and positive in the short run. This outcome affirms a positive linkage amongst Y , ENC , and CO_2 in both the short and long run. Furthermore, the outcomes from FOMLS imply that international trade has a positive and significant effect on CO_2 emissions in the long run; the findings show that a 1% increase in trade in Turkey led to a 4.10% increase in carbon emissions; however, these findings affirm that the pollution haven hypothesis is valid in Turkey. Moreover, ARDL and FMOLS's outcomes demonstrated that the coefficient of FDI is positive in the short run and long run. Furthermore, the ARDL model outcomes show that the real exchange rate negatively impacts CO_2 in the short and long run. The outcomes from FMOLS support the ARDL model's outcomes; thus, a 1% appreciation of the Turkish lira leads to a 5.14% decrease in CO_2 emissions.

Table 6: long-term coefficients using ARDL approach (3, 1, 1, 1,0) approach.

Variables	Coefficient	t.stat	p-value
<i>lnY</i>	3.2651*	1.8761	0.0556
<i>lnENC</i>	1.0437**	5.9799	0.0000
<i>lnT</i>	0.0557	1.9510	0.10706
<i>lnFI</i>	0.0310**	2.9990	0.0106
<i>lnEX</i>	-0.0514**	-2.5545	0.0175

* and ** represent significance levels of 5% and 10%, respectively

Table 7: Findings of ARDL approach in short-term

Variables	Coefficient	t.stat	p-value
$\Delta \ln Y$	5.9132**	3.1295	0.0059
$\Delta \ln ENC$	0.8950**	8.8332	0.0000
$\Delta \ln T$	0.0226**	2.8356	0.0015
$\Delta \ln FI$	0.0511**	2.3388	0.0101
$\Delta \ln EX$	-0.0131**	-2.3498	0.0391
$ECT(-1)$	-0.9010**	-0.8813	0.0000

* and ** represent significance levels of 5% and 10%, respectively

Table 8: Findings of FMOLS approach

Variables	Coefficient	t.stat	p-value
<i>lnY</i>	2.315**	1.2150	0.0420
<i>lnENC</i>	1.001**	4.7799	0.0000
<i>lnT</i>	0.0410**	2.9510	0.0140
<i>lnFI</i>	0.0121**	2.9990	0.0106
<i>lnEX</i>	-0.042**	-2.5945	0.0075
Adjusted R2	0.98		

* and ** represent significance levels of 5% and 10%, respectively

Table 9: Diagnostic tests findings.

Name of the test	Boar-squared	p-value
J.B normality	1.085	0.32
A.R.C.H test	0.530	0.69
BPG heteroscedasticity -F	0.91	0.79
B-Godfrey serial correlation F (LM)	1.920	0.23
Ramsey-RESET	1.415	0.59

5.3 Findings of Granger causality test

Table 10 present the outcomes of the Granger causality approach. The outcomes confirm that the long-term unidirectional causality from (Y), (ENC), (T), FDI(FI), and (EX) to CO₂ emissions are valid. Also, the outcomes from Table 10 indicate that there is unidirectional causality from (EX), (T), and (Y) to (EN) in the short run. These outcomes affirm that economic growth, trade, FDI, and the real exchange rate affect energy consumption, which may lead to an increase in CO₂ emissions in Turkey. However, these outcomes affirm the strong linkage amongst EN, trade, FDI, EX, and carbon dioxide emissions.

It is also essential to show that the EX Granger causes T and Y (EX→T, FDI, and Y). In this vein, the real exchange rate may lead to an increase in CO₂ emissions through the channels of trade, FDI, and

economic growth. In this regard, we suggest that the depreciation of the local currency generates was beneficial for exports in Turkey over the period 1980 to 2014, while the appreciation of Turkey's currency created benefits for imports; thus, the real exchange rate may indirectly influence CO₂ emissions through the international trade channel.

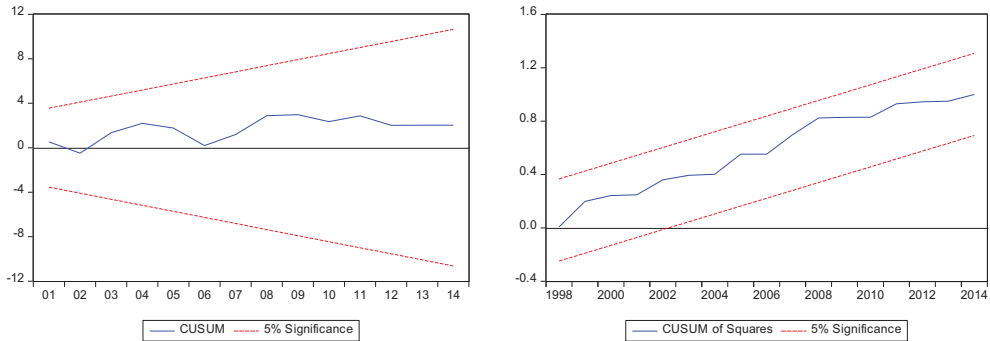


Fig. 2. The plot of CUSUM and CUSUM of squares tests.

Table 10: Findings of the Granger causality test.

	$\Delta \ln CO_2$	$\Delta \ln Y$	$\Delta \ln ENC$	$\Delta \ln T$	$\Delta \ln FI$	$\Delta \ln EX$	ECT_{t-1}
$\Delta \ln CO_2$		7.641**	8.710**	3.952*	3.910*	7.555**	-0.410***
$\Delta \ln Y$	0.189		1.310	1.100	2.001	4.160*	-0.242
$\Delta \ln ENC$	0.311	4.990**		4.364*	4.364*	6.233**	-0.279
$\Delta \ln T$	2.123	0.382	2.417		2.111	6.297**	0.493
$\Delta \ln FI$	1.210	0.250	1.100	1.265		3.364*	0.210
$\Delta \ln EX$	0.228	0.411	0.010	0.035	0.155		-0.591

* and ** represent sig-level at the 5% and 10%

6. CONCLUSIONS AND POLICY RECOMMENDATIONS.

This study explores the effect of energy consumption, trade, economic growth, and FDI on CO₂ emissions in Turkey. The main aim of the current research is to present a new insight by investing the effect of the real exchange rate (EX) on the level of carbon emissions by using a new combined co-integration approach to affirm the outcomes of the ARDL bounds approach to co-integration. The paper used the period of 1980–2015. The ARDL and FMOLS models are used to explore the short and long-run linkage amongst the examined variables. The Granger causality test is applied to test the direction of the causality among the examined variables. The ARDL, FMOLS models tests outcomes demonstrated that an increase in non-renewable energy consumption in Turkey had to an increase in CO₂ emissions, which corresponds to the findings of Katircioglu and Katircioglu (2018), Pata (2018), Samour et al. (2019), and Isiksal et al.,(2019). In other words, an increase in energy consumption raises real income and vice versa in Turkey. These outcomes can be attributed to the fact that Turkey's

economy is undergoing rapid industrialization and development, and Turkey has increased its non-renewable energy consumption by around 220% over the period 1982 to 2015. It is recommended that Turkey should focus on energy sources that take environmental considerations into account to achieve sustainable development. Furthermore, the outcomes from the ARDL test demonstrate that the international trade coefficient is positive and significant. In this regard, an increase in international trade will lead to an increase in CO₂ emissions. These outcomes are in line with J Ozturk and Acaravci (2013), who suggested that an increase in trade led to an increase in Turkey's level of emissions. The outcomes suggest that policymakers in Turkey should design new policies in international trade to reduce environmental degradation.

Also, the ARDL test outcomes show that the appreciation of the real exchange rate leads to a decrease in carbon emissions. The causality relation from real exchange rate (EX) to energy consumption (ENC), economic growth (Y), and international trade (T) confirmed the assumption that EX also affects CO₂ emissions through the level of energy consumption, trade, economic growth, and FDI channels. This is supported by Zhang and Zhang (2018), who used the nominal exchange rate and suggested that the average exchange rate asserts a powerful effect on energy consumption and trade structure. However, exchange rate policies can affect the competitiveness of multinational corporations in terms of their earnings and stock prices, which may affect international trade, foreign direct investments, and economic growth, which may subsequently lead to an increase in the levels of CO₂ emissions. Thus, policymakers should pay more attention to policies and strategies that support renewable energy investment. Furthermore, the outcomes suggest that policymakers should use exchange rate channels to decrease environmental degradation in Turkey because, in the long run, it affects the level of carbon dioxide emissions through consumption of energy, economic growth, trade, and FDI channels.

We believe that our paper will inspire future studies to explore the linkage between exchange rate and CO₂ emissions by using other proxies and methodologies, as there is a considerable gap in this field.

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