TESTING THE IMPACT OF BANKING SECTOR DEVELOPMENT ON TURKEY'S CO_2 EMISSIONS

SAMOUR, A.* – ISIKSAL, A. Z.* – RESATOGLU, N. G.

Banking and Finance Department, Near East University, Nicosia, Northern Cyprus, via Mersin 10 Turkey

**Corresponding authors*
e-mail: aliya.isiksal@neu.edu.tr, ahmad.samour@neu.edu.tr

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Abstract. This article aims to introduce a new research topic by investigating the role of banking sector development on Turkey's CO_2 emissions for the time period 1980-2014. Autoregressive Distributed Lag (ARDL), Fully Modified-OLS (FMOLS), and Canonical Co-integrating Regression (CCR) models are applied to test the coefficients between the variables. The newly-developed Bayer-Hanck combined co-integration test is used to support the robustness of the ARDL bounds test. The results show that banking sector development led to an increase in CO_2 emissions. The improvements in the Turkish banking sector development could lead to increased investment and energy consumption, which would subsequently cause raise in CO_2 emissions. Furthermore, the results show that an increase in the RIN would lead to decrease in CO_2 emissions. RIN has fundamental repercussions for the economy by either impacting the cost of capital or influencing the availability of credit, which in turn determines the level of savings as well as that of investment in an economy, which may subsequently affect CO_2 emissions. It is suggested that policy-makers should use the banking sector development and RIN channels to reduce environmental degradation by introducing monetary policy reforms, while also encouraging energy investment and the production of electricity using renewable sources.

Keywords: *Bayer-Hanck combined co-integration test, structural breaks, ARDL, environmental degradation, carbon dioxide*

Abbreviations: B.R.S.A: Banking Regulation and Supervision Agency, GDP: Gross domestic product, ARDL: Autoregressive Distributed Lag, CO_2: Carbon emissions, OECD: Organisation for economic co-operation and development, RIN: Real interest-rate, GHG: Greenhouse gas emissions, FDI: Foreign direct investment, E.K.C: Environmental Kuznets curve, VECM: Vector Error Correction Model, SB: Structural break, CMR: Clemente-Montanes-Reyes, A.I.C: Akaike information criterion, S.B.C: Schwarz-Bayesian criteria, CV: critical values, BH: Bayer-Hanck, FMOLS: Fully modified ordinary least square, CCR: Canonical co-integrating regression

Introduction

Since its economy has been liberalized in 1980, Turkey has undergone several key changes in its banking sector. The first major change was introduced in 1985 through the issuance of major banking reform legislation, which was related to the structural problems of the Turkish banking system (Ganioglu, 2008). The second major change in the banking sector was initiated after the economic crisis of 1994. This crisis had a severe impact on the sector due to accumulated risks, including RIN risks, currency risks, liquidity risks and credit risks (Akinci et al., 2013). The third main change in the banking sector occurred in 1999 when the banking sector act was fundamentally reformed in order to support its supervisory authority of the sector and to provide a suitable framework to deal with banks' problems, such as the establishment of the Banking Regulation and Supervision Agency (B.R.S.A.) as an independent agency that aimed to regulate and supervise the sector. The fourth main change happened after the 2001 crisis, whereby the government initiated a comprehensive banking sector restructuring program (Repkova

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and Stavarek, 2014). According to the Banks Association of Turkey, the banking sector experienced positive developments from 2001 to 2014, the share of non-performing loans to total loans substantially decreased.

Sustainable development, particularly in the banking sector is a critical issue for Turkey, which aims to be among the world's top ten-largest economies (Pata, 2018). It has made efforts to promote economic growth by increasing GDP and investment, and this has caused a rise in greenhouse gas emissions (GHG) and CO_2 emissions. Environmental degradation is an important barrier preventing sustainable development in Turkey (Pata, 2018). The main strategic objective for Turkey is to alleviate the harmful influence of CO_2 emissions. The policy makers play an important role in promoting investments in low emission projects. Moreover, they can enforce different techniques to minimize CO_2 emissions, such as by promoting the use of clean energy technologies like solar and wind (Viebahn et al., 2007). In this respect, this study aims to instigate a new discussion by testing the association among banking sector development, RIN and CO_2 emissions in Turkey through examining the environmental Kuznets curve hypothesis (E.K.C.)

Turkey is an emerging economy; it represents an ideal case to examine the influence of banking sector development, RIN, energy consumption and real income on Turkey's CO2 emissions for several reasons. Firstly, the International Energy Agency (IEA) has shown that Turkey has one of the most energy intensive industries among the organisation for economic co-operation and development (OECD) countries. Uzlu et al. (2014) stated that a fundamental part of primary energy consumption in Turkey is supported by imported oil and gas, thus leading to an increase in the budget deficit. Ates (2015) stated that Turkey had the greatest rate of increase in greenhouse gas emissions (GHG) in the period from 1990 to 2010, primarily consisting of CO_2 emissions. Secondly, Turkey's economy has faced prime economic structural changes over the last decades, mainly in the 1980s. Turkey had liberalized its economy, as a result of which, the economic growth was driven by several factors, particularly the free market economy and the increase in international trade. In this respect, the structure of international trade has changed radically, where trade as a percentage of GDP has risen from 17.08% in 1980 to 51.14% in 2014. Furthermore, the total exports in 1980 were 2.9 billion USD, whereas it reached 157.6 billion USD in 2014 (Guloglu, 2016). In addition, foreign direct investment (FDI) has also increased in Turkey over the last three decades (Isiksal et al., 2017). Net cumulative FDI inflows in Turkey reached 127 billion dollars in the period from 2001 to 2012 (Seker et al., 2015). Thirdly, even though Turkey has faced periods of crisis after the introduction of its liberalization program, the banking sector has experienced positive developments, particularly in the period between 2001 and 2014. Finally, after the 2001 Turkish economic crisis, Turkey changed its exchange rate system from a fixed system to a floating exchange rate regime, which is determined by supply and demand processes in the market (Central bank of Turkey).

This study seeks to examine the dynamic relationship between banking sector development, RIN, income, energy use and Turkey's CO_2 emissions from 1980 to 2014. Banking sector development is measured by credits provided by banks as a percentage to GDP. There are few studies that have used this variable to measure the impact of banking sector development on CO_2 emissions. This study argues that the impact of banking sector development and the RIN on CO_2 emissions can be positive or negative depending on how these variables affect economic growth and energy consumption.

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Positive developments in the banking sector, such as an increase in the credits provided by banks to the private sector, may lead to an increase in total assets, an increase in the shareholders' equity of the sector, improvements in the risk management systems, and a decrease in the share of non-performing loans to total loans, which may affect economic growth and energy consumption and cause a subsequent rise in CO_2 emissions.

On other hand, RIN may affect CO_2 emissions in three channels. Firstly, low interest-rate helps corporations to minimize financing costs and also optimizes asset/liability structure management (Isiksal et al., 2018), which causes an expansion of the operation and production through the purchase of new equipment and increased investments in new projects, which leads to an increase in energy consumption and causes an increase in CO_2 emissions. Secondly, RIN can affect trade and FDI, as the boost in economic growth thus may lead to an increase in energy consumption and an increase in CO_2 emissions (Riti et al., 2017). Finally, when RIN has a significant impact on the real income, it may lead to an increase in consumer loans as well as the consumption of electrical machines, automobiles, etc. which would also increase CO_2 emissions (Beck and Demirguc-Kunt, 2006).

The remainder of this study is organized as follows: Section 2 is a literature review focusing on the relationship between real income, energy consumption, the banking sector, RIN and CO_2 emissions; Section 3 presents the materials and methods; Section 4 is the results and discussion; and Section 5 provides conclusion.

Literature review

Real income, energy consumption and CO_2 emissions

The existing empirical studies show that there is a linkage between energy consumption, real income and CO_2 emissions. Recent empirical studies seem to present varied empirical evidence on linkage between energy consumption, real income and CO_2 emissions. Say and Yucel (2006) found that energy consumption led to an increase in CO_2 emissions and proposed that the E.K.C. hypothesis exists in Turkey. Yavuz (2014) examined the linkage between energy, income and CO_2 emissions in Turkey over the period from 1960 to 2007. Seker et al. (2015) used the ARDL model and found that energy consumption led to an increase in CO2 emissions. Recent studies by Katircioglu and Katircioglu (2018) and Pata (2018) used the ARDL testing model and they found that energy consumption led to an increase in CO_2 emissions in Turkey. They suggested that real income is the primary driver for consumption of energy and it was suggested that the policy makers in Turkey should boost and support energy efficiency in order to promote sustainable growth.

Unlike these studies, some authors argue that the inverted U-shaped linkage between CO_2 emissions and income is not valid. Akbostanci et al. (2009) applied the time series model and Ozturk and Acaravci (2010) used a linear logarithmic model. They also did not find that the E.K.C. hypothesis holds for Turkey and they suggested that energy conservation policies such as rationing energy consumption and controlling CO_2 emissions were not likely to have any evident effect on the economic growth in Turkey.

RIN and CO_2 emissions

RIN is an important factor affecting the economy and the spillover effect of RIN on CO_2 emissions depends on how this variable will affect real income, investment, and how

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it may lead to an increase (decrease) in energy consumption and then subsequently affect CO_2 emissions. According to many empirical studies, RIN can affect economic performance by macroeconomic channels (Sokolov et al., 2011; Missio et al., 2015; Almahadin and Tuna, 2017; Sehrawat, 2017). The authors showed that the interest rate can have a different impact on economic performance in developing and developed economies; the mixed results can be attributed to different economic structures (Backhaus et al., 2016), different interest rate policies (tight vs expansive) and different inflation levels (Chari et al., 2002). The authors mainly suggested that the stability of the interest rate might lead to better economic performance (Danish et al., 2017; Backhaus and Isiksal, 2016).

Hence, if there is a real impact of RIN on economic activities, it will affect energy consumption and energy prices. Tolis et al. (2010) analyzed the impact of RIN and inflation rates on energy investments and argued that volatility in RIN affected energy investment. That could have a controversial effect on sustainability and could lead to an increase in CO_2 emissions. By using the US interest rate, Ziaei (2018) indicated that a decrease in RIN was accepted as a positive signal in the energy market and the energy consumed by the residential sector.

Banking sector development and CO_2 emissions

Many empirical studies (Beck and Levine, 2004; Wachtel, 2001; Petkovski and Kjosevski, 2014) have stated that development of the financial sector including developed banking performance accelerates the economic growth rate. Beck et al. (2000) stated that more funds are available for distribution as loans, which should stimulate and support consumption, investment, economic growth, and energy demand, and may cause an increase in energy consumption. Aslan et al. (2014) showed a positive relationship between banking development and energy consumption, and stated that deposit money bank assets and domestic credit to the private sector increases energy consumption, which may cause an increase in CO_2 emissions.

Development of the banking sector is a part of financial development; generally, the role of financial development in ecological degradation has received increased attention in the recent literature. Zhang (2011) tested the role of financial development on CO_2 emissions in China for the period 1980 to 2009 and found that China's financial development acts as an important driver for the increase in CO_2 emissions. Similar results were found in India by Shahbaz et al. (2015), who used the Vector Error Correction Model (VECM) approach and supported the assertion that financial development has a positive impact on CO_2 emissions in India over the time period of 1970–2012. Haseeb et al. (2018) used fully modified ordinary least square (FMOLS) panel data and examined the relationship between financial development measured by domestic credit to the private sector (% of GDP) and CO_2 emissions in the BRICS countries from 1995 to 2014 and found that domestic credit to the private sector (% of GDP) led to an increase in CO_2 emissions. Pata (2018) applied the FMOLS and ARDL models and found that financial development had a positive impact on CO_2 emissions in Turkey over the period from 1974 to 2014. These studies confirmed that financial development plays an important role in increasing and improving the economic efficiency of the financial systems and this can affect economic activities and the demand for energy, thus causing an increase in CO_2 emissions.

In contrast, Saidi and Mbarek (2017) used the GMM panel method to analyze 19 emerging countries and found a negative impact of financial development on CO_2

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emissions for the period from 1990 to 2013. Park et al. (2018) used PMG estimates and data from the period 2001 to 2014 for selected European Union (EU) countries, and their findings showed that financial development led to a decrease in CO_2 emissions. In these studies, the authors suggested that financial development may increase energy efficiency and then decrease energy consumption and CO_2 emissions. Ozturk and Acaravci (2013) used the ARDL bounds test and stated that financial development did not affect CO_2 emissions in Turkey over the period from 1960 to 2007.

However, most of the studies focused on financial development measured by domestic credit provided by the financial sector to the private sector and only a minimal number of studies have focused on the banking sector development variable. Tamazian et al. (2009) analysed the role of financial development on CO_2 emissions in the BRIC countries over the period from 1992 to 2004. The authors found that capital market and banking sector development led to a reduction in CO_2 emissions. Sadorsky (2011) used the dynamic panel demand model and examined the nexus between financial development and CO_2 emissions and stated that deposit money bank assets led to an increase in CO_2 emission in nine Central and Eastern European counties. A summary of the EKC hypothesis and other studies is presented in *Table 1.*

Table 1. *Summary of the studies*

Authors	Period	Country	Methodology	Findings
Zhang (2011)	1980-2009	China	Granger causality	FD is significant.
Shahbaz et al. (2015)	1970–2012	India	VECM	FD is significant.
Saidi and Mbarek1 (2017)	1990-2013	19 counties	GMM panel	FD is significant.
Haseeb et al. (2018)	1995-2014	BRICS	FMOLS Panel	FD is significant.
Tamazian et al. (2009)	1992-2004	BRIC	SSRF Model	BD is significant.
Sadorsky (2011)	1990-2013	EU counties	GMM Model	BD is significant.
Ozturk and Acaravci (2013)	1960-2007	Turkey	ARDL Model	FD is not significant
Jalil and Mahmud (2009)	1971-2005	China	ARDL Model	FD is significant
Yavuz (2014)	1960-2007	Turkey	Time series	Y is significant
Seker et al. (2015)	1974-2010	Turkey	ARDL Model	Y is significant
Pata (2018)	1974-2014	Turkey	ARDL Model	Y is valid
Akbostanci et al. (2009)	1992-2001	Turkey	Time series	Y is not valid
Ozturk and Acaravci (2010)	1968-2005	Turkey.	linear log model	Y is not valid
Say and Yucel (2006)	1970-2005	Turkey	IPCC - TCO2	EN is significant.
Katircioglu and Katircioglu (2018)	1974-2014	Turkey	ARDL Model	EN is significant.

Y is real income, FD is financial development, BD is bank development, EN is energy consumption

Materials and methods

After Grossman and Krueger (1995) proposed the first theoretical linkage between CO_2 emissions and income, many empirical studies (Say and Yucel, 2006; Jalil and Mahmud, 2009; Yavuz, 2014; Katircioglu and Katircioglu, 2018; Pata, 2018) have used the following model:

$$lnCO2_{it} = \beta_0 + \Upsilon_1 lnY_{it} + \Upsilon_2 lnY^2{}_{it} + \varepsilon_{it} \quad \text{(Eq.1)}$$

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where CO_2 is carbon dioxide emissions (measured in metric tons per capita), Y is GDP per capita (constant 2010 US-dollar), Y^2 is the square of GDP, ε_t is the error-term, while *i* and *t* represent the country and years, respectively.

This study is different from the existing literature as it uses other economic factors, namely bank development and RIN. Thus, bank development and RIN are external proxies added to the conventional EKC model. The empirical model of this paper is presented as follows:

$$LnCO2_t = \beta_0 + \Upsilon_1 LnY_t + \Upsilon_2 lnY^2{}_t + \Upsilon_3 LnEG_t + \Upsilon_4 lnBD_t + \Upsilon_5 LnRIN_t + \varepsilon_{it} \quad \text{(Eq.2)}$$

where $lnCO2_t$ represents the logarithm of CO_2, LnY and lnY^2 *are* the logarithms of $Y(GDP)$ and $Y^2(square\ of\ GDP)$, $LnEG_t$ is the logarithm of energy consumption, $LnBD$ represents the logarithm of banking sector development, and RIN is the real interest rate. The data is annual data covering the years between 1980 and 2014. Descriptive statistics of the variables are represented in *Table 2*. A summary of the descriptions of the variables and sources of the data is represented in *Table 3*.

Table 2. *Descriptive statistics of the variables*

	Mean	Median	Maximum	Minimum	Standard deviation
$CO2_t$	1.093758	1.149764	1.502182	0.54398	0.273282
Y_t	8.963046	8.952993	9.496421	8.51459	0.275895
$Y^2{}_t$	80.41015	80.15609	90.18201	72.49824	4.960866
EG_t	6.986357	7.026588	7.368592	6.557903	0.242447
BD_t	3.12257	2.916845	4.093362	2.648661	0.437009
RIN	-0.00272	0.0458	0.2414	-0.85	0.220229

Table 3. *Summary of the variables' descriptions and sources of the data*

Variables	Description	Source of the data
$CO2_t$	CO_2 emissions (metric-tons-per capita)	World-Bank· (website)
Y_t	GDP-per-capita (constant-2010-USD)	World-Bank· (website)
$Y^2{}_t$	the square of GDP	World-Bank· (website)
EG_t	Energy consumption (kt of oil-equivalent)	World-Bank· (website)
BD_t	Credits provided by banks to the private-sector as a % of GDP	World-Bank· (website)
RIN	RIN (interest rate of the time-deposit minus inflation-rate)	World-Bank· (website)

Unit root tests and co-integration tests

This paper uses the Perron-Vogelsang (1999) with one structural break (SB) and Clemente-Montanes-Reyes (CMR) (Clemente et al., 1998) with two SBs to estimate the order of integration of the variables.

To examine the long-term relationship between CO_2 and the *Y*, Y^2, *En*, *BD*, *RIN* variables, this paper uses the ARDL bounds test within the ARDL methodology introduced by Pesaran et al. (2001). The model is distinguished from other models as it uses different lags to estimate the parameters by employing a single reduced form

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equation. Considering the sensitivity of this methodology to the number of lags, the Akaike-information-criterion (A.I.C) and Schwarz-Bayesian-criteria (S.B.C) were applied to select the optimal lag length (p). Additionally, in this test, all variables are treated as endogenous, thus excluding the endogeneity problem. Therefore, by employing this test, the paper aims to determine if there is cointegration or not in three options: I(0), I(1) or mixed. In this vein, the *F*-statistics value was compared to the theoretical values introduced by Pesaran et al. (2001). If the *F*-statistics value exceeds the upper bound I(1), the null-hypothesis will be rejected, indicating that there is cointegration among the variables. If the *F*-statistics value is less than the lower bound I(0), the null-hypothesis will be accepted, indicating that there is no cointegration among the variables. Furthermore, if the *F*-statistics value lies between I(0) and I(1), this means that the result is inconclusive. The ARDL approach equation is as follows:

$$\Delta LnCO_{2t} = \beta_0 + \sum_{i=1}^{n} y_1 \Delta lnCO_{2t-j} + \sum_{i=1}^{n} y_2 \Delta lnY_{t-j} + \sum_{i=1}^{n} y_3 \Delta lnY^2{}_{t-j} + \sum_{i=1}^{n} y_4 \Delta lnEG_{t-j} + \sum_{i=1}^{n} y_5 \Delta lnBD_{t-j} + + \sum_{i=1}^{n} y_6 \Delta RIN_{t-j} + \sigma_1 lnCO_{2t-1} + \sigma_2 lnY_{t-1} + \sigma_3 lnY^2{}_{t-1} + \sigma_4 lnEn_{t-1} + \sigma_5 lnBD_{t-1} + \sigma_6 RIN_{t-1} + \varepsilon_{1t} \quad \text{(Eq.3)}$$

In *Equation 4*, Δ represents the operator of the first difference. $LnCO_{2t}$, LnY_t, $lnY^2{}_t$, $LnEG_t$, $LnBD_t$, RIN_t are the dependent and independent variables, *n* is the maximum number of lags, and ε_t represents the error-term. Once the existence of co-integration is validated, in order to capture the speed of adjustment of the dependent variable, the error correction model is estimated using the following equation:

$$\Delta LnCO_{2t} = \beta_0 + \sum_{i=1}^{n} y_1 \Delta lnCO_{2t-j} + \sum_{i=1}^{n} y_2 \Delta lnY_{t-j} + \sum_{i=1}^{n} y_3 \Delta lnY^2{}_{t-j} + \sum_{i=1}^{n} y_4 \Delta lnEG_{t-j} + \sum_{i=1}^{n} y_5 \Delta lnBD_{t-j} + \sum_{i=1}^{n} y_6 \Delta RIN_{t-j} + \omega ECT_{t-1} + \varepsilon_{1t} \quad \text{(Eq.4)}$$

ECT_{t-1} is the one period lagged error correction-term. It is expected that the ECT will be significant with a negative sign (Gujarati, 2003). ECT shows the speed of adjustment among the short-term and long-term levels of the dependent variable.

The Bayer-Hanck (BH) (2013) combined cointegration test is utilized to investigate the robustness of the ARDL model. It is applied to the data with a unique order of integration. It combines four different cointegration tests, namely Engle and Granger (1987) (EG_t), Johansen (1988) (JO_t), Boswijk (1994) (BO_t), and Banerjee et al. (1998) (BA_t). This test combines the outcomes of previous co-integration tests and provides the *Fisher-F* statistics for more reliable and conclusive outcomes. BH provides functional estimates by disregarding the nature of multiple testing proceedings. This test is a combination of the computed *p*-values with the significance level of cointegration tests based on Fisher's formula as follows:

$$EG_t - JOH_t = -2\left[IN\left(P_{EG_t}\right) + \left(P_{JOH_t}\right)\right] \quad \text{(Eq.5)}$$

$$EG_t - JOH_t - BO_t - BDM_t = -2\left[IN\left(P_{EG_t}\right) + \left(P_{JO_t}\right) + \left(P_{BO_t}\right) + \left(P_{BA_t}\right)\right] \quad \text{(Eq.6)}$$

where *p* are the values of individual cointegrations tests (EG_t, JO_t, BO_t, BA_t). The estimated long-run combined cointegration *Fisher F*-statistics will be compared with the critical values (CV), which were presented by Bayer and Hanck (2013). The null hypothesis of the BH test is no long-run combined co-integration. It will be rejected if the computed *Fisher F*-statistics value is higher than the critical values.

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The paper uses other techniques to estimate long-run coefficient, namely fully modified ordinary least square (FMOLS) and canonical co-integrating regression (CCR), which were introduced by Phillips and Hansen (1990) and Park (1992). These tests consider endogeneity and the serial correlation problems, which may appear in the existence of cointegration. These tests can only be utilized when the variables are I(1).

The direction of the causal relationship between CO_2 emissions, *Y*, Y^2, *EG*, *BD, and RIN* is tested by using Granger causality within $VECM$. This test identifies if there is co-integration among the time series variables and if so, it is possible to analyze the direction of the causal effect linkage by using the error correction model (ECM) since it includes information about the causality in both the short and long run. This test allows for the addition of an (ECT) to capture the short-term deviations of the time series from their long-term equilibrium path. The (ECM) equation is as follows:

$$\Delta lnCO_{2t} = \beta_0 + \sum_{i=1}^{n} \Upsilon_1 \Delta lnCO_{2t-j} + \sum_{i=1}^{n} \Upsilon_2 \Delta lnY_{t-j} + \sum_{i=1}^{n} \Upsilon_3 \Delta lnY^2{}_{t-j} + \sum_{i=1}^{n} \Upsilon_4 \Delta lnEG_{t-j} + + \sum_{i=1}^{n} \Upsilon_5 \Delta lnBD_{t-j} + \sum_{i=1}^{n} \Upsilon_6 \Delta RIN_{t-j} + ECT_{t-1} + \varepsilon_{1t} \quad \text{(Eq.7)}$$

$$lnY_t = \beta_0 + \sum_{i=1}^{n} \Upsilon_1 \Delta lnY_{t-j} + \sum_{i=1}^{n} \Upsilon_2 \Delta lnCO_{2t-j} + \sum_{i=1}^{n} \Upsilon_3 \Delta lnY^2{}_{t-j} + \sum_{i=1}^{n} \Upsilon_4 \Delta lnEG_{t-j} + \sum_{i=1}^{n} \Upsilon_5 \Delta lnBD_{t-j} + \sum_{i=1}^{n} \Upsilon_6 \Delta RIN_{t-j} + {}_1 ECT_{t-1} + \varepsilon_{1t} \quad \text{(Eq.8)}$$

$$\Delta lnY^2{}_t = \beta_0 + \sum_{i=1}^{n} \Upsilon_1 \Delta lnY^2{}_{t-j} + \sum_{i=1}^{n} \Upsilon_2 \Delta lnCO_{2t-j} + \sum_{i=1}^{n} \Upsilon_3 \Delta lnY_{t-j} + \sum_{i=1}^{n} \Upsilon_4 \Delta lnEn_{t-j} + \sum_{i=1}^{n} \Upsilon_5 \Delta lnBD_{t-j} + \sum_{i=1}^{n} \Upsilon_6 \Delta RIN_{t-j} + {}_1 ECT_{t-1} + \varepsilon_{1t} \quad \text{(Eq.9)}$$

$$\Delta lnEn_t = \beta_0 + \sum_{i=1}^{n} \Upsilon_1 \Delta lnEn_{t-j} + \sum_{i=1}^{n} \Upsilon_2 \Delta lnCO_{2t-j} + \sum_{i=1}^{n} \Upsilon_3 \Delta lnY_{t-j} + \sum_{i=1}^{n} \Upsilon_4 \Delta lnY^2{}_{t-j} + \sum_{i=1}^{n} \Upsilon_5 \Delta lnBD_{t-j} + \sum_{i=1}^{n} \Upsilon_6 \Delta RIN_{t-j} + {}_1 ECT_{t-1} + \varepsilon_{1t} \quad \text{(Eq.10)}$$

$$\Delta lnBD_t = \beta_0 + \sum_{i=1}^{n} \Upsilon_1 \Delta lnBD_{t-j} + \sum_{i=1}^{n} \Upsilon_2 \Delta lnCO_{2t-j} + \sum_{i=1}^{n} \Upsilon_3 \Delta lnY_{t-j} + \sum_{i=1}^{n} \Upsilon_4 \Delta lnY^2{}_{t-j} + \sum_{i=1}^{n} \Upsilon_5 \Delta lnEG_{t-j} + \sum_{i=1}^{n} \Upsilon_6 \Delta RIN_{t-j} + {}_1 ECT_{t-1} + \varepsilon_{1t} \quad \text{(Eq.11)}$$

$$\Delta RIN_t = \beta_0 + \sum_{i=1}^{n} \Upsilon_1 \Delta RIN_{t-j} + \sum_{i=1}^{n} \Upsilon_2 \Delta lnCO_{2t-j} + \sum_{i=1}^{n} \Upsilon_3 \Delta lnY_{t-j} + \sum_{i=1}^{n} \Upsilon_4 \Delta lnY^2{}_{t-j} + \sum_{i=1}^{n} \Upsilon_5 \Delta lnEG_{t-j} + \sum_{i=1}^{n} \Upsilon_6 \Delta lnBD_{t-j} + ECT_{t-1} + \varepsilon_{1t} \quad \text{(Eq.12)}$$

In *Equations 7-12*, Δ represents the operator of the first difference, $lnCO_2, LnY, lnY^2, lnEG, lnBD,$ and RIN are the dependent and independent variables, ε_t represents the error-term, and ECT_{t-1} is the lagged error correction-term added to the equations. The short-term causality is examined by Wald test's *F*-statistics to define the significance of the related coefficient by applying the first difference of the stationary variables (Masih, 1996). To examine the long-run causality, the test of the related coefficient of the lagged ECT is used.

Results and discussion

Unit root test results

The results of Perron and Vogelsang and CMR with one and two SBs are reported in *Tables 4* and *5*. The results of the Perron and Vogelsang and CMR unit root test with one and two SBs show that all the variables are stationary at first-difference, I(1). *Figure 1* shows the time series plot of the series at the natural logarithm indicating various economic fluctuations and policy changes in Turkey.

The results of the *F* bounds tests are represented in *Table 6*. The results show that the *F*-statistics is higher than 5% (Pesaran et al., 2001). This confirms that there is co-integration among all the variables.

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Table 6 provides powerful evidence on the level relationship for *Equation 2* of this study. The null hypothesis ($\sigma 1 = \sigma 2 = \sigma 3 = \sigma 4 = \sigma 5 = \sigma 6 = 0$) in *Equation 3* can be rejected and this shows that CO_2 emissions in Turkey are in a long-run relationship with the regressed variables (Y, Y^2, En, BD and RIN).

Table 4. *Perron and Vogelsang unit root test results with one SB*

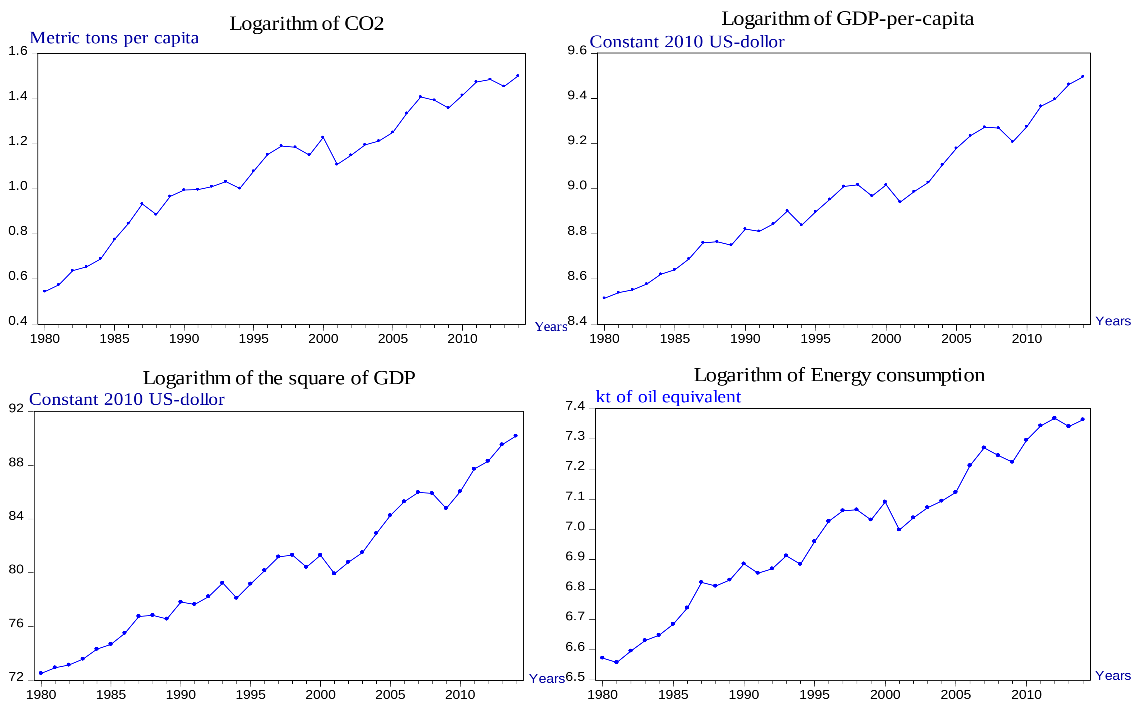
	At level	SB		At 1st difference	SB
lnCo2	-3.488	2002	*ΔLnCO2*	-6.611**	1999
lnY	-3.791	2005	*ΔLnY*	-6.709**	2009
Ln Y^2	-3.655	2005	*ΔLnY^2*	-5.655**	2009
lnEG	-2.772	2010	*ΔLnEG*	-6.751**	1999
lnBD	-2.579	2008	*ΔLnBD*	-5.965**	2003
RIN	-3.120	1990	*ΔRIN*	-7.276**	1999

* and ** denote significantly level at the 5% and 10% levels, respectively

Table 5. *CMR with two structural breaks unit root tests*

	At level	SB 1	SB 2		At 1st difference	SB	SB 2
lnCO2	-4.189	1998	1999	*ΔLnCO2*	-7.222**	1986	2000
lnY	-4.219	1994	2002	*ΔLnY*	-7.780**	2000	2008
Ln Y^2	-4.210	1994	2002	*LnY^2*	-7.941**	2000	2008
lnEG	-5.261	1996	2010	*ΔLnEG*	-6.353**	1996	2003
lnBD	-5.360	2000	2006	*ΔLnBD*	-8.359**	1996	2000
RIN	-5.390	1988	1997	*ΔRIN*	-9.979**	1997	2001

* and ** denote significantly level at the 5% and 10% levels, respectively



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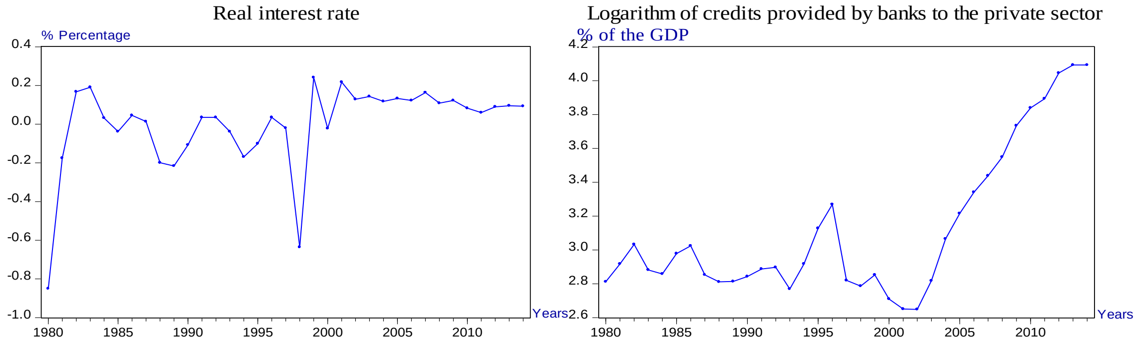

***Figure 1**. Time series plot of series*

***Table 6.** ARDL bounds test results (F-bound-test)*

	Level		t statistics
	I (0)	I (1)	
Critical value at 1% sign level	2.86	4.57	6.502970***
Critical value at 5% sign level	2.39	3.38	

* and ** denote significantly level the 5% and 10%, respectively

The results of the BH combined co-integration test are reported in *Table 7*. The results show that the computed *F*-statistics value is higher than the tabulated *F*-statistics in both $EG_t - JO_t$ and $EG_t - JO_t - BO_t - BA_t$ at 5% and 10% levels of significance. Therefore, the results of the BH (2013) co-integration tests confirm the robustness of the ARDL model. These results imply that there is a long-run association and all the variables are corresponding together in the long term.

***Table 7.** BH combined co-integration test results*

	***Fisher-F* statistics**		**Co-integration results**
	EGT-JOT	*EGT-JOT-BOT-BAT*	
	14.863**	19.252*	Co-integration exits
Sig level at (5)%	10.711	20.788	
sig level at (10)%	8.352	16.239	

*, **shows significantly level at 10%, and 5%, respectively

The normality test results confirm that the model is normally distributed. Furthermore, ARCH, LM and the Breusch-Pagan Godfrey, tests results confirm that the model is homoscedastic and there is no autocorrelation. Furthermore, the Ramsey-Reset test results confirm the stability of the results. The results show that the model is correctly formulated. Moreover, *Figures 2* and *3* show the stability tests using CUSUM and CUSUM squares. The figures show that the blue lines are between the two red lines at the 5% significant level, which means that there is stability in the long-run coefficients.

Table 8 shows that the speed of adjustment is negative and statistically reliable; the rate of convergence from the short-run to long-run equilibrium is 85.5%. The results

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from ARDL, FMOLS and CCR are presented in *Tables 8* and *9*. The results show that the coefficient of GDP(*Y)* is highly elastic, positive and statistically significant, while the squared GDP(Y^2) is negative and statistically significant in the long-run. This finding strongly confirms that the E.K.C. hypothesis is valid for Turkey.

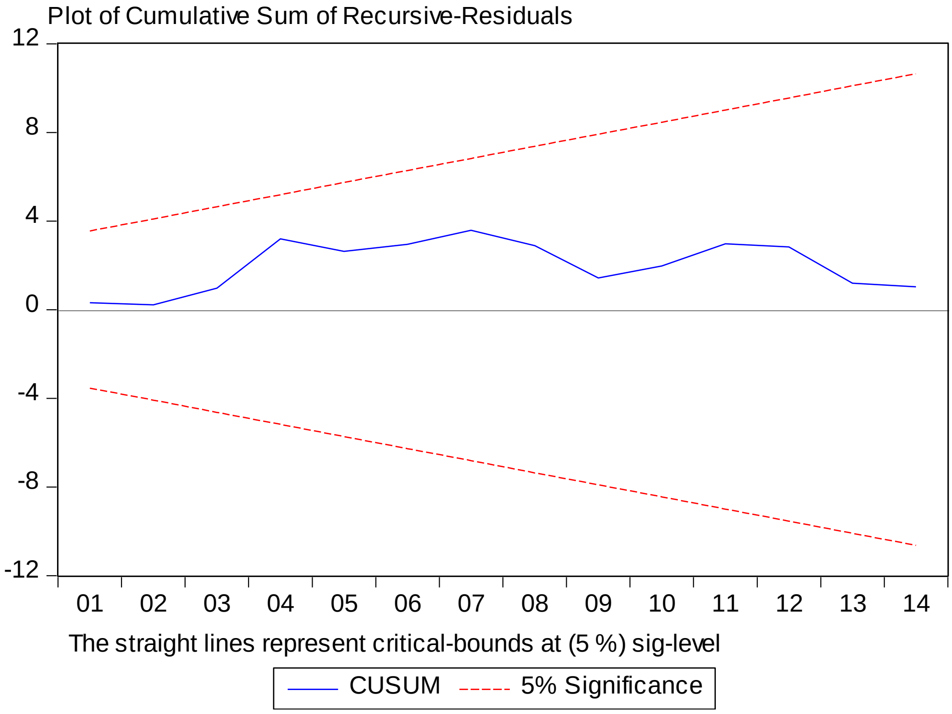

Figure 2. *Plot of CUSUM test*

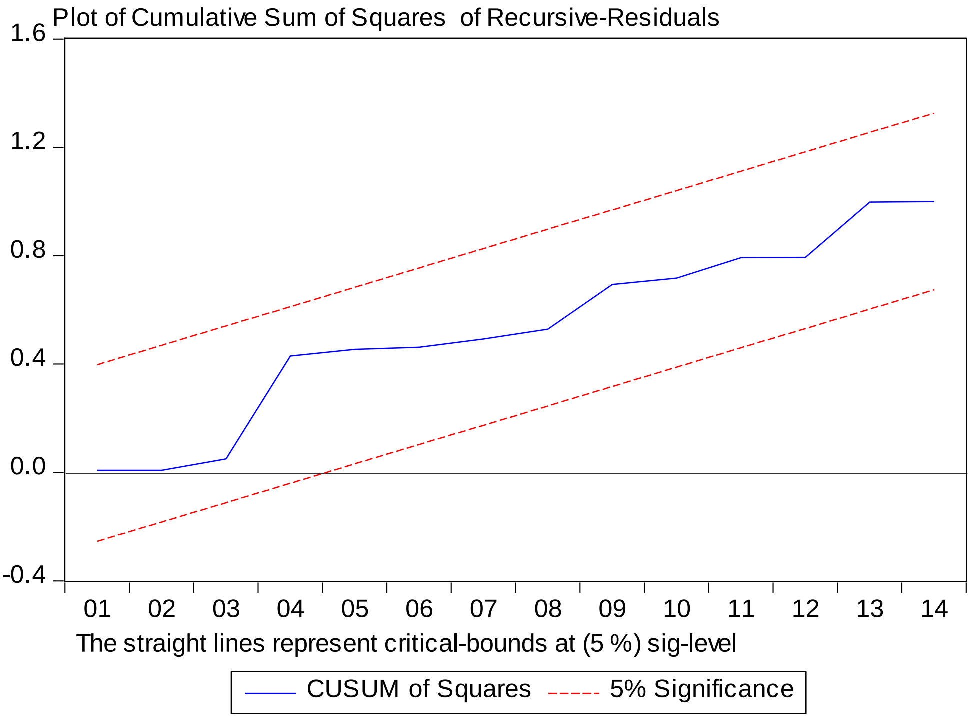

Figure 3. *Plot of CUSUM of squares test*

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Table 8. *Estimated short and long-term coefficients using ARDL (1,3, 3,2, 3,3)*

Variables	Coefficient	*t*-statistics	*p*-value
ΔlnY	1.5566***	6.2321	0.0001
ΔlnY^2	-0.4688*	-1.8351	0.0963
$\Delta lnEG$	1.1468***	2.9691	0.0000
$\Delta lnBD$	0.1042***	5.4067	0.0003
ΔRIN	-0.0007***	-5.4502	0.0003
lnY	2.2224*	1.8532	0.0935
lnY^2	-0.4079*	-2.2750	0.0571
$lnEG$	1.2652***	7.2595	0.0000
$lnBD$	0.0648***	3.3028	0.0080
RIN	-0.0008*	-1.8841	0.0889
$ECT(-1)$	-0.8551***	-8.5342	0.0000
χH^{BPC}	1.215(0.3881)	R.sq	0.98
χH^{Ar}	1.139(0350)	Adjusted	0.96
χN^{JB}	1.952(0.376)	D.W.	2.301
χR^{RT}	0.3075(0.760)		
χB^{CS}	2.075(0.1879)		

χH^{BPC} is heteroscedasticity F-test, χH^{Ar} is ARCH test, χN^{JB} is normality test, χR^{RT} is Ramsey RESET, χB^{CS} is B-Godfrey serial correlation. DW is Durbin-Watson
*, **, *** shows significantly level at 10%, 5% and 1%, respectively

Table 9. *FMOLS and CCR model results*

Regressor	FMO L S				CCR		
	Coeff.	*t*-ratio	*p*-value		Coeff.	*t*-ratio	*p*-value
lnY	1.992***	3.577	0.001	lnY	3.014***	4.170	0.000
lnY^2	-0.204***	-2.959	0.006	lnY^2	-0.332***	-3.708	0.001
$lnEG$	1.093***	16.908	0.000	$lnEG$	1.089***	14.653	0.000
$lnBD$	0.013**	2.261	0.033	$lnBD$	0.014**	2.617	0.015
RIN	-0.001***	-4.626	0.000	RIN	-0.002***	-6.595	0.000
Adjusted R2	0.985	-	-	-	0.985	-	-

*, **, ***shows significantly level at 10%, 5% and 1%, respectively

The coefficient of energy consumption in both the short and long run has a positive significant effect on the level of CO_2 emissions. Furthermore, the proxy for banking sector development is positive and significant in both the short and long run. Thus, an increase in credits provided by banks as a percentage of GDP led to an increase in CO_2 emissions. On the other hand, the proxy of RIN is negative and statistically significant in the short and long run. Therefore, an increase in the RIN leads to a decrease in CO_2 emissions.

The coefficient of GDP makes the highest impact on CO2 emissions, which shows that a 1% increase in GDP will lead to a 2.22%-3.01% increase in emissions. The second highest impact is made by energy consumption, which indicates that a 1% increase in energy consumption will lead to 1.09%-1.26% increase in emissions. The

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results also show that a 1% increase in bank credits will increase the emissions by 0.01%-0.06%; however, with a 1% increase in RIN, the emissions will decline by 0.0008%-0.02%.

Granger causality test results

Table 10 reports the Granger causality results. The null hypothesis of the causality test is that *x* and *y* are independent, or there is no linkage between *x* and *y*. As shown in *Table 10* there is a long-run unidirectional causality from *Y, EG, BD and RIN to* CO_2 *(Y, EN, BD, RIN→*CO_2*)*. The results strongly confirm that the E.K.C. hypothesis is valid for Turkey. Furthermore, the results show that there is a unidirectional short-run causality running from RIN to the bank credits to the private sector and energy consumption (*RIN→BD, RIN→EG*), which confirms that the RIN may cause banking sector development and energy consumption, which may lead to an increase in CO_2 emissions in Turkey. There is a unidirectional causality from the bank credits to the private sector and energy consumption (*BD→EG*). These results confirm our findings for a strong relationship between banking sector development and CO_2 emissions in Turkey.

Table 10. *Granger causality results*

	Short Run causality F-statistics					Long Run causality t statistics	
	$\Delta LnCO2$	ΔLnY	ΔlnY^2	$\Delta LnEG$	$\Delta LnBD$	ΔRIN	$ECTt-1$
$\Delta LnCO2$	-	6.342**	3.451	7.078**	7.221**	6.006**	-2.1940**
ΔLnY	0.472	-	0.033	4.634*	0.655	0.767	-1.1409
ΔlnY^2	0.605	0.034	-	3.983	0.655	0.424	-0.7070
$\Delta LnEG$	0.789	7.154**	1.333	-	5.358*	16.781***	-1.1091
$\Delta LnBD$	0.891	0.244	0.21	0.156	-	5.247*	-0.8843
ΔRIN	1.499	0.112	0.108	0.476	0.326	-	-0.9528

*, **, ***shows significantly level at 10%, 5% and 1%, respectively

Conclusion

This article aims to introduce a new research topic by investigating the role of banking sector development, RIN, real income, and energy consumption on Turkey's CO2 emissions for the time period 1980-2014. This article is different from the existing literature as it introduces a new discussion concerning the role of banking sector development on CO_2 emissions in Turkey. The sophisticated econometric models, Autoregressive Distributed Lag (ARDL), Fully Modified-OLS (FMOLS), and the Canonical Cointegrating Regression (CCR) tests are applied to test the short and long-run coefficients between the variables. The ARDL model was preferred due to its advantages compared to the other models. Firstly, the ARDL model has superior features in small data in particular, and it is not important to test the integration order of the series. This test enables simultaneous analysis of both the short-run and long-run effects of independent variables on the dependent variable. In order to confirm and support the results in the long run, the paper uses the FMOLS, and CCR tests. These tests consider endogeneity and the serial correlation problems, which may appear in the existence of cointegration. The new approach involving the Bayer-Hanck (BH)

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combined co-integration test is used to enhance and support the robustness of the ARDL bounds test. Moreover, the Granger causality test within the VECM model is applied to examine the causality direction among the variables of this study. The empirical results and policy recommendations are as follows:

Real income and energy consumption

The empirical results from the ARDL, FMOLS and CCR models show strong evidence to confirm that the E.K.C. hypothesis holds for Turkey. The results from the ARDL and causality tests show that the increase in real income and energy consumption led to an increase CO_2 emissions. These results are consistent with Say and Yucel (2006), Yavuz (2014), Katircioglu and Katircioglu (2018), and Pata (2018) who found positive relation between energy consumption and real income CO_2 emissions in Turkey, the policy market should design long-term energy strategies to reduce emissions through efficient energy consumption channels and should also implement some strategies that promote the use of the renewable energy sources.

Banking sector development and RIN

The study can make a significant impact in terms of the policies intended to diminish the carbon dioxide emissions in Turkey. The planning of emission levels by using energy consumption and income association might underestimate the real amount of the pollution produced if the financial development variables like bank development and RIN are not considered. Therefore, while banking sector development has lower long-run elasticity than the long-run coefficients of income and energy consumption, it has a positive and statistically significant impact on carbon dioxide emissions. The empirical findings show that increases in banking sector development increase pollution. These results are consistent with Sadorsky (2011) and Pata (2018). These studies confirmed that financial development plays an important role in increasing the economic efficiency of the financial systems and this can affect economic activities and the demand for energy, thus causing an increase in CO2 emissions. The long-run elasticity of RIN is smaller than the long-run coefficient of credits provided by banks, although it is negative and significant. The larger amount of credits provided by banks as a percentage of GDP shows that there are more funds available as loans for the private sector and this increases consumption, economic growth, energy use, and emissions. However, even a small increase in RIN discourages the consumption of durables like automobiles, mobile phones, etc. and therefore worsens the emissions.

The findings of this article are important for several reasons. Emerging economies like Turkey might experience increases in carbon emissions because of the increase in energy consumption and income levels. Making projections of GHG that do not consider bank credits to the private sector and RIN may underestimate or overestimate the real emissions. It will be difficult to meet greenhouse gas emission targets if the impacts of banking sector development and RIN are not considered.

This study has introduced a new research topic by investigating the role of banking sector development and RIN on Turkey's CO_2 emissions; further research for the developing and developed countries or regions is suggested for comparison purposes. Furthermore, different proxies and other methodologies not only via time series models but also panel data can also be adapted as further researches in order to examine the role of banking sector development and RIN in the environmental concerns of countries.

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