Assessment of Financial Development on Environmental Degradation in KSA: How Technology Effect?

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Assessment of financial development on environmental degradation in KSA: How technology effect?

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Abstract

The main purpose of this research is to test the effect of financial development, real GDP, population, technology on dioxide carbon emissions as well the technology effect of financial development and environmental degradation in the Saudi Arabia (KSA) over the period 1970-2016 and the STIRPAT (Stochastic Impacts by Regression on Population, Affluence, and Technology) with an Autoregressive Distributed Lag (ARDL) model is used for the empirical inquest. These empirical findings by the Bounds cointegration tests show that the financial development and technology have a negative and significant impact on environmental degradation, firstly. Secondly, the technology effect of financial development (composite effect of technology and financial development) has an unfortunate effect on environmental mitigation. Finally, lower environmental mitigation is associated by a deepening in total population and affluence. Moreover, findings from the pairwise Granger causality test point that there is no causality running from both financial development and technology to the effect of technology among KSA. On the opposite, we looked at economic growth Granger, cause environmental quality. In addition, a unidirectional causality was seen running from environmental quality to financial development. The same, the relationship between affluence and financial development in KSA is unidirectional. Thus, various policy implications should be proposed to policymakers as enhancing the expansion of technology, especially in the industrial sector by incorporating renewable energy consumption to upgrade environmental quality.

Keywords: Environmental quality; Financial development; CO2 emissions; Technology; STIRPAT.
JEL classification: O14, O16, Q55.

Introduction

For the sake to survive, human devoted all his efforts to invent several and various means and tools shutting for making nature obedient to his will. Unfortunately, his selfishness and greediness do make him unaware and even reckless about the environment and ecosystem services. Accordingly, the economic growth of each country reveals such significant requirements and the fulfillment of some conditions.

Hence, anthropogenic activities boost demand and supply, magnify consumption, and enlarge fossil fuels combustion. Meanwhile, these activities have generated global warming and carbon dioxide emissions which are driven specifically by financial development, real GDP, urbanization, foreign trade, and fossil fuel energy.

Some studies pointed out that the speed of earth temperature is getting higher and even doubles to that of industrial development. In fact, CO_2 emissions is regarded as a severe hazard not only to our environment but also to financial development. Global warming has recently captured the world interest since increasing CO_2 emissions have caused significant and harsh effects on climate change and human welfare. Thus, tremendous attention is turned on the linkage between financial development and environmental degradation which let policymakers feel trapped in having such a trade-off between boosting the economy and degrading the environment.

Moreover, Paris Climate Agreement (PCA) has provided serious opinions and insights aiming at developing strategies to cut down carbon dioxide emissions. Besides, the rapid global economic development was considered as the main cause of greenhouse gas emissions. Moutinho et al. (2018) stated that GDP per capita was the key impact of carbon dioxide emissions growth. It is regarded also that power intensity, energy efficiency, and economic development were significant factors influencing carbon dioxide emissions in the power industry where the energy structure, economic growth, and population size exerted positive influence on carbon dioxide emissions, but the influence of energy intensity was negative.

Many others studies point that STIRPAT is regarded as a suitable analytic means for investigating the driving factors of ecosystem degradation in which GDP and urbanization impacted significantly CO_2 emissions. Furthermore, the STIRPAT model not only was frequently used in investigating the influences of human activities on environmental conditions but also can be employed to check the hypotheses in an empirical way. In this frame work, it is very important to consider that urbanization level, population size, GDP per capita, merchandise trade of GDP, consumption of fossil energy have positive influence on carbon emissions. The later factor is viewed as the fundamental cause of climate degradation and global warning which does emit significantly carbon dioxide into air directly.

In addition, urban population exert such a significant and positive effect on CO_2 emissions resulting from the steady growth of population size and urbanization development proofing a positive correlation between urbanization and carbon emissions since rapid urbanization generates massive demand for power and resulting in an enormous carbon emission. Nevertheless, many studies pointed out that financial development has a significant negative correlation with carbon dioxide emissions where there was such an inverse N-shaped correlation between these basic variables.

Therefore, the big economic powers need to reduce the percentage of environmentally damaging energy and there is an imperative requirement to develop alternative energy, such as geothermal energy, wind power, nuclear energy, and solar energy in order to solve carbon emission.

About Saudi Arabia, we consider that environment degradation appears basically influenced by various factors including financial development, technology,the technology effects of financial development, real GDP, and population intensity. Moreover, KSA maintains such a stable financial development depending a lot on fossil fuel energy that could cause substantial CO_2 emissions. This study may help the kingdom of Saudi Arabia to control its carbon emission in the future and to alleviate global warming. Furthermore, the KSA attempts not only implementing such an innovation-oriented development strategy to encourage innovative firms but also accelerating the development of the service industry that help to achieve the goal of economic growth as well as reducing environmental degradation, and encouraging investors to move towards the green industry. In order to resolve the dilemma between financial development and carbon emissions, it is necessary for the Saudi policymarkers to devote significant efforts to ensure that alternative energy can compete with fossil fuel in the future.

To investigate this linkage relationship between KSA financial development and carbon dioxide emissions via the STIRPAT model valuating the stochastic influences of these factors, our study begins with a first section dealing with the literature review, later it introduces the data as well as methodologies about the STIRPAT model. Besides results and conclusion point out valuable suggestions and insights for developing the strategies that help solving the issues of environmental sustainability in KSA.

Literature review

Building on the framework of Kuznets (1955), Grossman and Krueger (1991) initiator empirical investigation on environmental degradation by incorporating the relationship between income and environmental mitigation which led to the formulation of the environmental Kuznets curve (ECK) hypothesis. The hypothesis denotes that real income degrades the environmental quality initially, but when the threshold of income is overtaken, the environmental mitigation has augmented subsequently. Therefore, the nexus between income-environmental quality will be seen by a standard inverted U-shaped EKC. Therefore, many kinds of research have been examined the linkage between income-environmental degradation, but the financial development and environmental quality relationship are few treated in the last decade. Theoretically, financial development has improved environmental quality in 46 sub-Saharan African countries during the period 2000–2015. The result of empirical estimation by a generalized method of moment (GMM) denotes that financial development moderate energy use to rise dioxide carbon emissions (Acheampong, 2019). Same, Sadowsky (2010), examined the linkage between financial development and energy use in emerging economies between the period 1990-2006. The financial development variable is measured by stock market capitalization and stock market turnover. Therefore, the empirical findings by a generalized method of moment (GMM) estimation show a positive and statistically causality linkage between financial development and energy use. Tamazian, et al. (2009) have developed a contribution between financial development and environmental quality in BRIC countries, by introducing both variables, economic growth and financial development, to examining the environmental quality over the period 1992-2004. The empirical estimations show that financial liberalization and environmental quality are measured to promote environmental degradation. Al-Mulali et al. (2015) tested the relationship between financial development and environmental mitigation in 129 countries between 1980-2011. The granger causality test shows that environmental quality has a negative impact on carbon dioxide emissions. Paramati, et al. (2017), inspected the relationship between environmental quality in G-20 countries over the period 1993-2012 and show that

Foreign Direct Investment (FDI) and the stock market with political globalization have a negative impact on carbon dioxide emissions.

The STIRPAT methodology has been broadly applied to evaluate the driving factors of environmental quality, but many researchers have used STIRPAT models and specify different econometric estimates on different scopes and scales by added and dropped purely traditional variables. Khan et al. (2018) examined the linkage nexus between Financial development and carbon dioxide emissions in Asian countries (Bangladesh, India, and Pakistan) using a STIRPAT model during the period 1980-2014 by introducing income inequality and energy use. The FMOLS methodology shows that financial development has a negative and significant impact on environmental degradation. In addition, Usman et al. (2020) tested the dynamic linkage between financial development and environmental mitigation by incorporating technological innovations in Asia Pacific Economic Cooperation (APEC) countries over the period 1990-2017. The Westerland cointegration test confirms the long-run association between financial development and environmental quality. Wang et al. (2021) found that financial development by a STIRPAT model improves environmental quality in 198 countries over the period 1990-2018 by introducing ecological footprint. Lin et al. (2017) examined the relationship between financial development and carbon dioxide emissions in non-high and middle-income countries over the period 1991-2013 by incorporating nine variables of the IPAT model. The prostrate STIRPAT model shows that financial development decreases environmental degradation in non-high-income countries, but increases environmental mitigation in middle-income countries. Zhang et al. (2016) added the environmental protection technology by a dummy variable into the STIRPAT model in China over the period 2003-2010 to examine the environmental mitigation. Likewise, Zhao et al. (2014) added a water footprint variable on the STIRPAT model on the Chinese agricultural sector over the period 1990 to 2009. The empirical estimation denotes that water footprint has a significant and positive impact on environmental quality. Ren et al. (2016) introduced an environmental settlement in 30 China districts over the period 200-2013 for the STIRPAT model and decomposed this variable into three types. The empirical findings denote that environmental regulation has no significant impact on ecosystems China improvement. Lin et al. (2016) have added agriculture and industrial economic development variables to examine the validity of the environmental Kuznets curve in Africa. The FMOLS approach denotes that the EKC is not valid and both variables, Energy structure and energy intensity, have only a significant and positive impact on carbon dioxide emissions. Nosheen et al. (2020) introduced energy use and urbanization on the STIRPAT to explain the effect of financial development on dioxide carbon emissions in Asian and African regions during the period 1995-20018. The FMOLS and DOLS methods explain that financial development has a negative and significant impact on carbon dioxide emissions in both countries used. Nwani, C. (2021) incorporate government consumption expenditure variable with the STIRPAT model in Venezuela to examine the linkage between financial development and carbon dioxide emissions. The linear ARDL testing approach shows that positive shock in financial development denotes a positive impact on environmental quality. Ahmad et al. (2021) incorporated healthcare expenditures variable into the STIRPAT model to examine the dynamic linkage between used variables and environmental quality in 27 Chinese provinces over the period 1990-2018.The empirical estimation by a STIRPAT model denotes that a bidirectional causality links between healthcare expenditures and carbon dioxide emissions. Munir and Ameer (2021) incorporated standard variables such us, urbanization, trade, economic growth and technology in the STIRPAT approach in emerging economies between 1975-2018.The panel cointegration relationship show that the U-shaped environmental Kuznets curve is validated. Therefore, this research upholds that supplementary variables used in the STIRPAT model, should not be arbitrarily added, but should be relevant for any specification. Guided by Martinez-Zarzoso and Maruotti (2011), we measure the technology variable by the share of the industrial sector in a gross domestic product which is performed by the industry, value added (% of GDP). The technology effect of financial development is expressed by the composite effect of technology and financial development and it's an additional variable to extend the STIRPAT approach.

Data and Methodology

Data

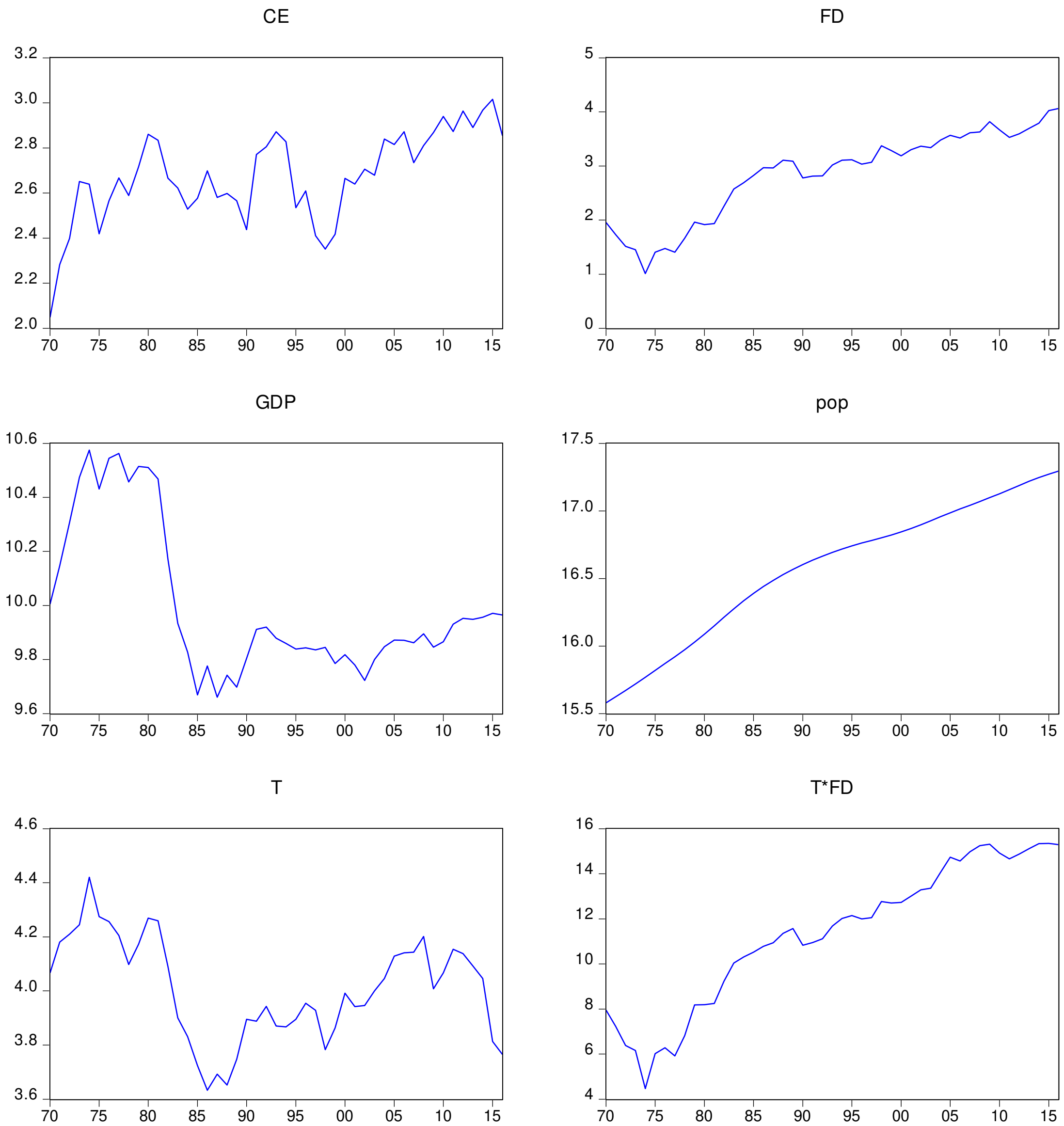
This record explores the dynamic relationship between, real GDP, environmental quality, financial development, Technology, population, and the technology effect of financial development in the Kingdom of Saudi Arabia from 1990 to 2016 that joint real GDP per capita (constant 2010 US$), carbon dioxide emissions (CE) quantified in metric tons per capita, financial development (FD) measured by Domestic credit to the private sector by banks (% of GDP), regarding the technology there is no consensus on the ideal measure. The literature review of many studies has used either trade openness, foreign direct investment, energy intensity...etc. Guided by Martinez-zarzoso and Maruotti (2011), we measure the technology variable by the share of the industrial sector in a gross domestic product which is performed by the industry, value added (% of GDP). The technology effect of financial development is expressed by the composite effect of technology and financial development. All variables are selected from the database of the World Bank (WDI 2018). Logarithmic dealing has been applied from all variables.

Table 1: Descriptive statistics of variables

	(T*FD)	T	POP	FD	GDP	CE
Mean	11.31150	4.009375	16.57168	2.840544	9.997948	2.674032
Median	11.68339	4.007697	16.69264	3.068460	9.879154	2.667106
Maximum	15.34178	4.420375	17.29498	4.062415	10.57521	3.015645
Minimum	4.472612	3.632853	15.57962	1.011817	9.661109	2.048999
Std. Dev.	3.160148	0.187255	0.506397	0.819337	0.275661	0.201143
Skewness	-0.438375	-0.109205	-0.461489	-0.631328	1.052078	-0.682754
Kurtosis	2.082704	2.259696	2.038134	2.232115	2.665236	3.491400
Jarque-Bera	3.153158	1.166681	3.480106	4.276900	8.889924	4.124421
Probability	0.206681	0.558031	0.175511	0.117837	0.011738	0.127173
Sum	531.6407	188.4406	778.8689	133.5055	469.9036	125.6795
Sum Sq. Dev.	459.3806	1.612960	11.79612	30.88041	3.495504	1.861100

To perform the short-run causal links between financial development and environmental quality, as mentioned Pairwise Granger Causality Tests. The time plot of carbon dioxide emissions, financial development, real GDP, technology, population, and the technology effect of financial development are represented in Fig1.

Figure 1: Plot of environmental quality, Affluence, Population, Technology and effect of technology.



Methodology

many researchers have employed the IPAT model to examines the effect of economic growth on environmental quality, but this model has a purview in the econometric model testing hypothesis (Hubacek et al. 2011). Therefore, the modification of Dietz and Rosa (2002) by the IPAT model, the STIRPAT model has appeared and it can solve the problem of heteroscedasticity and nonlinearity of models. The STIRPAT model has often used in inquiring the potency of human spunk on an environmental shape.

The objective of this study is to estimate the existence of relationship between the financial development and the environmental degradation in Saudi Arabia. We use the STIRPAT model (Stochastic Impacts by Regression on Population, Affluence, and

Technology model), which is a multivariate non-linear model and can be expanded to incorporate extra factors, and can be used to check the hypotheses on empirical way. The model can be written as follows:

$$I_t = \alpha_0 P^{\alpha 1} A^{\alpha 2} T^{\alpha 3} \varepsilon_t \qquad (1)$$

This model takes the linear form after taking logarithms:

$$LnI_t = \alpha_0 + \alpha_1 LnP_t + \alpha_2 Ln A_t + \alpha_3 Ln T_t + \varepsilon_t \qquad (2)$$

Where I is the dependent variable and it represents the environmental quality (dioxide carbon emissions), and the independent variables are: Total population (P), Affluence (A) measured by GDP per capita (constant 2010 US$), and Technology (T) are technology measured by the technology variable by the share of the industrial sector in a gross domestic product which is performed by the industry, value added (% of GDP), guided by Martinez-Zarzoso and Maruotti (2011).The residual series (ε_t) and α_0 is constant; α_1, α_2 and α_3 are the coefficient of these variables respectively.
We apply this model in Saudi Arabia, and the variables are derived from the data in KSA over the period 1970-2016. The time series methods are used to analyze the variables with the autoregressive dynamic lagged (ARDL) model is used for the empirical inquest. For three reasons, we apply the stationarity test for these variables and the cointegration test must be applied for a long run equilibrium relationship analysis to confirm the existence long-run cointegration. Therefore, the established STIRPAT model is given by:

$$LnI_t = \alpha_0 + \alpha_1 LnP_t + \alpha_2 Ln A_t + \alpha_3 Ln T_t + + \alpha_4 Ln FD_t + \alpha_5 Ln (T*FD)_t + \varepsilon_t \qquad (3)$$

Where I represent the environmental quality. The factor A is the affluence measured by measured by GDP per capita (constant 2010 US$). The factor (T) represents the technology measured by the share of the industrial sector in a gross domestic product which is performed by the industry, value added (% of GDP) in KSA. FD refers the financial development measured by domestic credit to the private sector by banks (% of GDP). The composite effect (T*FD) by the technology and financial development in

KSA is the proxy of the technology effect of financial development. The residual series is (ε_t) and α_0 is constant; α_1, α_2, α_3, α_4 and α_5 are the coefficient of selected variables respectively.

The ARDL Bounds cointegration tests

This research explores the relationship between environmental quality, financial development, affluence, population, technology and the technology effect of financial development. The autoregressive dynamic lagged (ARDL) model is used to investigate whether the long and short run exists between variables of all models based on the log-linear specification of model in equation (3). The strength of linear autoregressive dynamic (ARDL) lagged model to tender trustworthy estimation in small and large samples, in order to variables are I(0) an I(1) order of integration, in so far as none of used variables in different models is I(2).

Allow to Pesaran and Shin (2001) methodology to survey the dynamic short and long-run association between the environmental quality (CE), financial development (FD), affluence (A), population (P), technology (T) and the effect of technology (T*FD), based in the log-linear specification in equation (3) by different models, the ARDL is defined as follows:

$$\Delta CE_t = \alpha_1 CE_{t-1} + \alpha_2 GDP_{t-1} + \alpha_3 POP_{t-1} + \alpha_4 T_{t-1} + \alpha_5 FD_{t-1} + \alpha_6 (T^*FD)_{t-1} + \sum_{i=0}^{p} \alpha_7 \Delta CE_{t-i} + \sum_{i=0}^{p} \alpha_8 \Delta GDP_{t-i} + \sum_{i=0}^{p} \alpha_9 \Delta POP_{t-i} + \sum_{i=0}^{p} \alpha_{10} \Delta T_{t-i} + \sum_{i=0}^{p} \alpha_{11} \Delta FD_{t-i} + \sum_{i=0}^{p} \alpha_{12} \Delta (TF * D)_{t-i} + \varepsilon_t \quad (4)$$

$$\Delta CE_t = \beta_1 CE_{t-1} + \beta_2 GDP_{t-1} + \beta_3 POP_{t-1} + \beta_4 T_{t-1} + \beta_5 FD_{t-1} + \sum_{i=0}^{p} \beta_6 \Delta CE_{t-i} + \sum_{i=0}^{p} \beta_7 \Delta GDP_{t-i} + \sum_{i=0}^{p} \beta_8 \Delta POP_{t-i} + \sum_{i=0}^{p} \beta_9 \Delta T_{t-i} + \sum_{i=0}^{p} \beta_{10} \Delta FD_{t-i} + \varepsilon_t \quad (5)$$

$$\Delta CE_t = \omega_1 CE_{t-1} + \omega_2 GDP_{t-1} + \omega_3 POP_{t-1} + \omega_4 T_{t-1} + \sum_{i=0}^{p} \omega_5 \Delta CE_{t-i}$$

$$+ \sum_{i=0}^{p} \omega_6 \Delta GDP_{t-i} + \sum_{i=0}^{p} \omega_7 \Delta POP_{t-i} + \sum_{i=0}^{p} \omega_8 \Delta T_{t-i} + \varepsilon_t \quad (6)$$

where P indicates the fixed lag length by the Akaike Information Criterion (AIC) or Schwarz Bayesian criterion (S.B.C) and Δ is the first difference. In addition, bounds cointegration tests must be inspected for all models (4, 5 and 6) prior proceeding to the autoregressive dynamic lagged model assessment. The presence of long-run cointegration between variables is tested by the null hypothesis: H_0: $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = \alpha_6 = 0$ against the alternative hypothesis H_1: $\alpha_1 \neq \alpha_2 \neq \alpha_3 \neq \alpha_4 \neq \alpha_5 \neq \alpha_6 \neq 0$ for model (4), H_0: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = 0$ against the alternative hypothesis H_1: $\beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq 0$, for model (5) and H_0: $\omega_1 = \omega_2 = \omega_3 = \omega_4 = 0$ against the alternative hypothesis H_1: $\omega_1 \neq \omega_2 \neq \omega_3 \neq \omega_4 \neq 0$ for model (6). Furthermore, if the calculated F statistic passes through the upper critical value of the bound cointegration test of Narayan (2005), the null hypothesis is rejected. In addition, if the calculated F statistic is under the critical value of the limits bound cointegration test of Narayan (2005), the null hypothesis of no cointegration is accepted. Finally, if the calculated F statistic is under the superior and the inferior limits critical value of the bound cointegration test of Narayan (2005), the null hypothesis of no cointegration relationship is inconclusive. After estimation results of the log-linear model by the STIRPAT methodology, the diagnostic tests are implemented to uphold the approval results. Furthermore, the heteroskedasticity test of Breusch-Pagan-Godfrey is used to inspect for heteroscedasticity, and the Breusch-Godfrey Serial Correlation LM Test is used to detect the autocorrelation.

Unit root test

Table 2 Results of Ng-Perron unit root test

	At level				At First difference			
Variables	MZa	MZt	MSB	MPT	MZa	MZt	MSB	MPT

CE	-2.80159	-1.02637	0.36635	8.27537	-12.9014	-2.40336	0.18629	2.41652
FD	0.65934	0.47545	0.72110	37.0282	-4.71629	-1.51377	0.32097	5.24148
GDP	-7.79206	-1.97289	0.25319	3.14779	-8.06002	-1.98702	0.24653	3.11697
Pop	1.37093	1.96829	1.43573	146.577	-8.86518	-2.02032	0.22789	3.08693
T	-8.24250	-1.92230	0.23322	3.37334	-19.7950	-3.11830	0.15753	1.33615
T*FD	-0.01686	-0.01069	0.63395	26.4511	-2.30782	-1.06650	0.46212	10.5622

The critical values are − 8.10, − 1.98, 0.233, and 3.17 for the MZa, MZt, MSB and MPT tests respectively. The null hypothesis of NgPerron tests is the non-stationarity. The null hypothesis is rejected if the statistic is lower than critical values. Spectral GLS-detrended AR based on AIC criterion.

To verify the integration order for the component of the STIRPAT model, the involvement of any order, if integration I (2) must be removed, and the claim of the linear ARDL is restricted in the variable, integrated I (1), so the ARDL bound testing approach to long-run cointegration is verified. In this document, we check the stationarity of the STIRPAT model by the Ng-Perron unit root test.

The results of unit root tests of all variables, mentioned in Table 1, are stationary at levels and in the first difference, so integrated into order one I (1), so the log-linear by the STIRPAT model can be used as an ARDL model.

The bound-testing approach

To estimate the cointegration relationship of variables by the log-linear models (STIRPAT) and choose the lag length by the Akaike information criteria (AIC) after appointed the results of the Ng-Perron unit root test. Lütkepohl (2006) peaked up that the AIC criteria supply an efficient result in track down dynamic relationships. The bound testing approach for Model (1), Model (2) and Model (3) are introduced in Table2. The calculated F-statistics of Wald tests of all models are well overhead the upper bound limit of Pesaran et al. (2001) or Narayan (2005) tables at 5% level of significance, so the null hypothesis of no cointegration is rejected, meaning that environmental quality, affluence, population, financial development, technology and the effect of technology are cointegrated in the long run association in Saudi Arabia. The results of Table2 confirmed the long run association between all used variables, because the critical values of cointegration of Narayan (2005) (case III: unrestricted intercept and no trend, K=5) are respectively 2.848 and 4.160.

Tble3 Results of Bounds cointegration tests

Test Statistic	Value	Signif.	I (0)	I (1)
F-statistic (Model 1)	3.44032**	10%	1.81	2.93
F-statistic (Model 2)	4.62114**	5%	2.14	3.34
		1%	2.82	4.21
F-statistic (Model 3)	3.01322***			

** indicate 5% level of significance; *** indicate 10% level of significance.

Empirical results

Table 4 linear ARDL estimation and diagnostic checks (CE dependent variable)

	Model 1: CE=f (GDP, POP, FD, T, T*FD)		Model 2: CE=f (GDP, POP, FD, T)		Model 3: CE=f (GDP, POP, FD)	
Variable	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.
Short-run estimates						
FD	-	-	0.251335***	0.0133	-	-
FD (-1)	-2.575865**	0.0025	-	-	0.195176**	0.0688
GDP	0.721212***	0.0013	0.306279**	0.0424	-	-
GDP (-1)	-	-	-	-	0.218853*	0.1356
POP	-	-	-0.171472*	0.0633	-	-
POP (-1)	0.226632*	0.1204	-	-	-0.107634	0.2703
T	-	-	0.152203	0.2554	-	-
T (-1)	-2.155576**	0.0021	-	-	-	-
(T*FD) (-1)	0.671561***	0.0008	-	-	-	-
Δ (CE (-1))	0.369872**	0.0410	0.097545	0.4883	-	-
Δ (CE (-2))	0.452210***	0.0107	-	-	-	-
Δ (CE (-3))	0.291324**	0.0596	-	-	-	-
Δ (FD)	-1.177294	0.2256	-	-	0.183917*	0.1263
Δ (GDP)	-	-	-	-	0.776174***	0.0007
Δ (POP)	4.592368**	0.0169	-	-	3.108432*	0.1114
Δ (T)	-1.229905	0.1682	-	-	-	-
Δ (T*FD)	0.252419	0.2339	-	-	-	-
Long-run estimates						
Variable	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.
FD	-0.2491966***	0.0030	-0.439170***	0.0068	-0.0398**	0.0398
GDP	0.697722***	0.0003	0.535176**	0.0328	0.0993*	0.0993
POP	0.219251	0.1280	-0.299622**	0.0623	0.2495	0.2495
T	0.2085367***	0.0018	0.265952	0.2583	-	-
(T*FD)	0.649688***	0.0007	-	-	-	-
ECT (-1)	-1.033668***	0.0000	-0.572294***	0.0001	-0.397532***	0.0011
Diagnostic Test	F-Statistic	Prob.	F-Statistic	Prob.	F-Statistic	Prob.
RESET Test	0.018582	0.8927	1.296018	0.2625	0.772075	0.3851
Normality Test	3.019854	0.220926	0.553617	0.758200	0.092994	0.954567
LM Test	2.046008	0.1521	0.054609	0.9496	0.054303	0.9472
Heteroskedasticity Test	0.958103	0.5290	2.436431	0.0322	2.396436	0.0456

* indicates 1% level of significance; ** indicate 5% level of significance; *** indicate 10% level of significance.

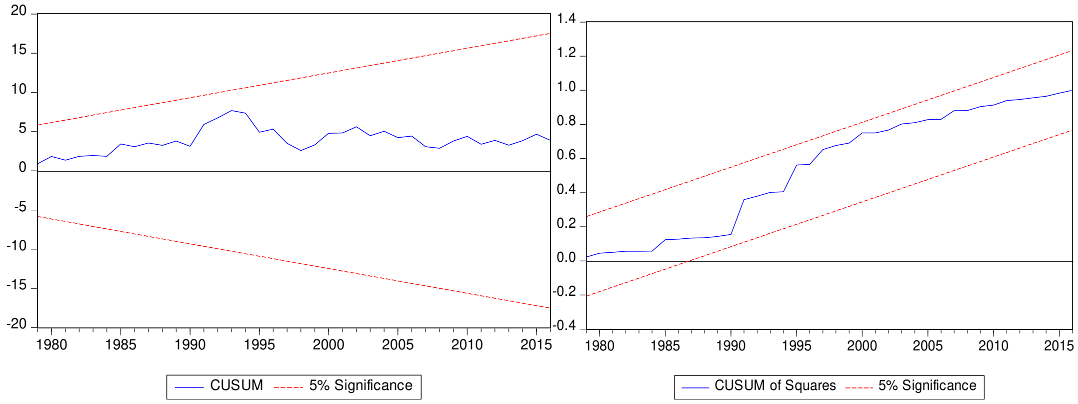


Fig. 2. CUSUM and CUSUMQ from the CE model 1(CE=f (GDP, POP, FD, T, T*FD)).

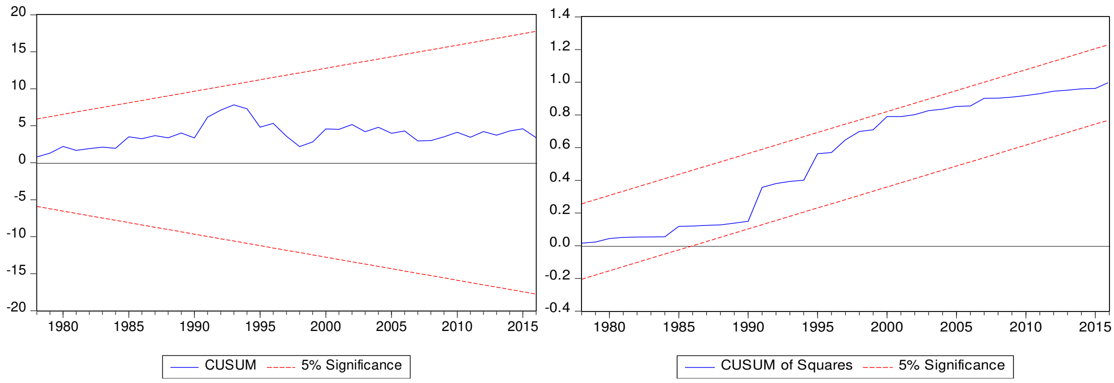


Fig. 3. CUSUM and CUSUMQ from the CE model 2 (CE=f (GDP, POP, FD, T)).

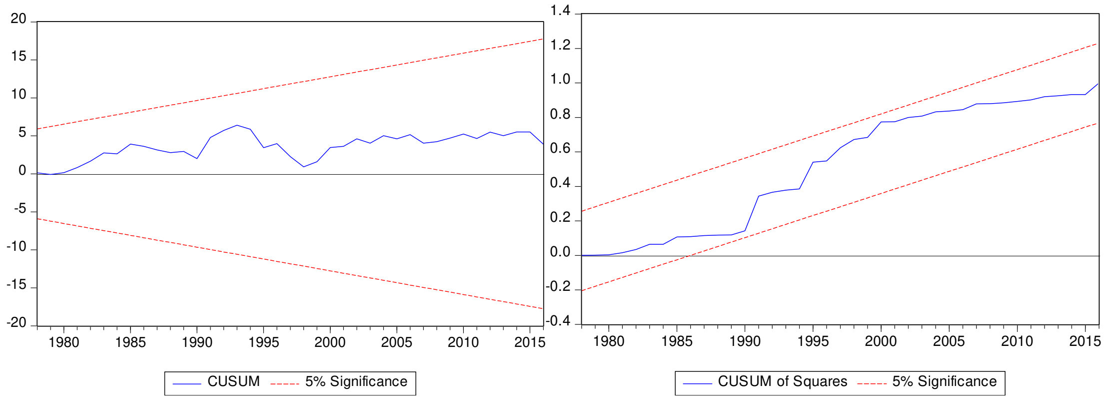


Fig. 4. CUSUM and CUSUMQ from the CE model 3 (CE=f (GDP, POP, FD))

Saudi Arabia maintains such a stable financial development a lot on fossil fuel energy that could cause substantial CO_2 emissions. This study may help the Saudi Arabia to control its carbon dioxide emissions in the future and to alleviate global warming. Furthermore, the Saudi government attempts not only implementing such an innovation-oriented development strategy encouraging the innovative firms but also accelerating the development of the service industry that help achieving the goal of economic growth as well as reducing environmental degradation, and encouraging investors to move towards green industry. In order to resolve the dilemma between financial development and carbon emissions, it is necessary for the Saudi policy markers devotes significant efforts to ensure that alternative energy can compete with fossil fuel in the future.

Table 4 predicts the short and long-run assessment results founded on ARDL models. The coefficient of financial development indicates that a 1% rise in financial development decreases CO_2 emissions by 0.24% in model 1, this outcome supply that financial development upgrades the environmental quality in Saudi Arabia. The increasing of carbon dioxide emissions that are due to the domestic credit to the private sector by banks on industry sector in Saudi Arabia is not amazing because the country's economy is strongly reliant on the oil sector. So, the energy consumption used by the financial sector issued from fossil fuels to spread industrial spunk. In addition, the domestic credit to the private sector by banks used for investment in the oil sector.

The coefficient of technology variable is positive and statistically significant, that indicates that a 1% increase in technology increases CO_2 emissions by 0.20% in the long-run. That denote the technology used in the financial sector is outmoded which leads to deteriorating environmental quality. In addition, the Foreign Direct Investment FDI by foreign investors, based on classical methods of production and inexpensive technology to reduce their inceptive costs. These conservative processes need more energy consumption and eventually release more ejections of dioxide carbon emissions into the environment than more modern technology used.

The elasticity of affluence in all models is positive and statistically significant, indicate that affluence in Saudi Arabia increases environmental quality. Therefore, a 1% increase in affluence, increases dioxide carbon emissions between 0.53-0.69%. This finding suggests that a rise in affluence damage the environmental quality in KSA (Nasir et al. (2020)). The unfavorable effect of affluence in KSA implies that's the production in goods and services led to mitigating poor environmental quality by increasing energy consumption.

The coefficient of the composite effect of technology and financial development is positive and statistically significant, that a 1% increase in technology effect of financial development in KSA led to increases environmental quality by 0.64%. Therefore, our findings affirmed the presence of an unfortunate technology effect of financial development in KSA, and denote that technology is a supplement of financial development and stimulate environmental quality.

Table 3, present the F-statistic values Bounds cointegration tests of models 1,2 and 3 (3.44032, 4.62114 and 3.01322). The latest values are higher than the upper critical value of bound tests of Narayan (2005) Table. Thus, for the STIRPAT methodology denotes the long-term cointegration between environmental quality and affluence, technology, population, technology, the effect of technology variables is confirmed. In addition, the lagged error correction term ECT (-1) of three models (-1.033668, -0.572294, and -0.397532) are negative and statistically significant, confirm the long-run association in the STIRPAT models and are adjusted by (1.033%, 0.57%, and 0.39%) respectively. The fixed optimal lag length in Models (1, 2 and 3) of the first differences of STIRPAT methodology is fixed by the Akaike information criterion (AIC) and the Schwarz information criterion (SIC).

Therefore, all three estimations models combine diagnostic tests, such as Breusch-Godfrey serial correlation LM test, normality tests, and heteroskedasticity test of Breusch-Pagan-Godfrey and the stability tests such us Ramsey RESET test and CUSUM test and CUSUM of squares test (Brown Durbin, & Evans, 2003), thus all tests indicate that no problems of serial correlation and heteroskedasticity affecting residuals. In addition, Figures 2, 3 and 4 exposes that CUSUM and CUSUMSQ tests are stable. Thus, the three graphs validated that all used models were confident and stable since all models bring down within the critical value of bounds test at a 5% significance level.

Pairwise Granger Causality Tests

Bound cointegration long-run relationship techniques denote the relationship between the dependent and the used explicative variables by the STIRPAT approach. However, it is substantial for policymakers to be aware of the direction of the short-run causal linkage between used variables in the STIRPAT model. To this explanation, we use a causality ascertain Dumitrescu and Hurlin (2012), to establish the causal linkage between variables. The null hypothesis of the analysis states that there was no Granger causality under the alternative hypothesis. Therefore, in Table 5 there was no linear causal relationship between environmental quality and the explicative variables (affluence, technology, population, financial development and technology effect). In contrast, there exists a linear Granger causality among the carbon dioxide emissions and the independent variables (affluence, technology, population, financial development and technology effect) as proposed by the alternative hypothesis.

Table 5 Pairwise Granger Causality Tests

Null Hypothesis:	F-Statistic	Prob.
FD does not Granger Cause CE	0.58801	0.5602
CE does not Granger Cause FD	6.20171	0.0045***
GDP does not Granger Cause CE	0.03948	0.8434
CE does not Granger Cause GDP	5.73066	0.0211**
POP does not Granger Cause CE	1.29041	0.2864
CE does not Granger Cause POP	1.40110	0.2582
T does not Granger Cause CE	0.38812	0.6809
CE does not Granger Cause T	1.63598	0.2075
T*FD does not Granger Cause CE	1.41809	0.2541
CE does not Granger Cause T*FD	5.89996	0.0057**
GDP does not Granger Cause FD	5.74770	0.0064***
FD does not Granger Cause GDP	0.72492	0.4906
POP does not Granger Cause FD	11.0528	0.0002***
FD does not Granger Cause POP	2.81443	0.0718*
T does not Granger Cause FD	0.98659	0.3817
FD does not Granger Cause T	1.04101	0.3625
T*FD does not Granger Cause FD	0.80630	0.4536
FD does not Granger Cause T*FD	0.16123	0.8517
POP does not Granger Cause GDP	3.18497	0.0521**
GDP does not Granger Cause POP	11.0625	0.0001***
T does not Granger Cause GDP	0.20955	0.8118
GDP does not Granger Cause T	2.37481	0.1060*
T*FD does not Granger Cause GDP	0.71277	0.4964
GDP does not Granger Cause T*FD	3.82686	0.0301**
T does not Granger Cause POP	13.8417	3.E-05***
POP does not Granger Cause T	2.42345	0.1015*
T*FD does not Granger Cause POP	0.08550	0.9182
POP does not Granger Cause T*FD	12.2812	7.E-05***
T*FD does not Granger Cause T	0.89739	0.4157
T does not Granger Cause T*FD	0.25002	0.7800

Note: * and ** significant value at 1% denote significant value at 5% and 10% respectively.

In Saudi Arabia's status, we establish no bidirectional causality between environmental quality and technology; instead, we looked at economic growth Granger, cause environmental quality. In addition, a unidirectional causality was seen running from environmental quality to financial development. The same, the relationship between affluence and financial development in KSA is unidirectional. Therefore, the environmental degradation causes technology effects at a 1% level of significance, but the affluence causes technology effects at a 5% level significance. However, if we tested the causal relationship between technology, financial development and the technology effect of financial development, there was no significant causality that existed from financial development and technology to the effect of technology. Considering the variable population, we find a short-run unidirectional link from affluence to the population at a 1% level of significance, but the opposite direction is unobservable, in addition the short-term causal relationship between technology and population is bidirectional.

Conclusions and policy implications

Advance environmental mitigation is key respect in the 2015 sustainable development schedule by the United Nations. Following this project, practically the majority of countries in the world are intensifying pains to reinforce the goodness of their environment such as Saudi Arabia. Financial development has been highlighted in many researchers to be a practice force of environmental degradation (Tamazian et al. 2009). This motivates this paper to reexamine the nexus relationship between financial development and environmental mitigation in the Saudi Arabia over the period 1970-2016 and the STIRPAT (Stochastic Impacts by Regression on Population, Affluence, and Technology) with an Autoregressive Distributed Lag (ARDL) model is used for the empirical inquest. We also examine the technology effect of financial development on dioxide carbon emissions. In addition, we establish the Pairwise causal linkage between financial development and environmental degradation.

This study finds the following results. Firstly, financial development in Saudi Arabia is negatively related with dioxide carbon emissions, that denote that financial development upgrade the environmental quality. Secondly, the composite effects of both variables' financial development and technology (technology effects of financial development) is positive and statistically significant in model 1. Thus, the technology effects of financial development are a noxious to the environmental mitigation. The increasing of dioxide carbon emissions that are due to the domestic credit to the private sector by banks on industry sector in Saudi Arabia is not amazing because the country's economy is strongly reliant on the oil sector. Therefore, our findings affirmed the presence of an unfortunate technology effect of financial development in KSA, and denote that technology is a supplement of financial development and stimulate environmental quality. Thirdly, our research indicates that affluence, population and technology are positively allied to environmental quality in KSA. Therefore, the environmental quality reaches to be lower, with a higher technology level, greater affluence and more renewable energy consumptions. Finally, a unidirectional causality was seen running from environmental quality to financial development.

Policymakers in Saudi Arabia should upgrade green financial development which can contribute to emissions mitigation. Therefore, allocate fiscal and taxation action to encourage private financial institutions to invest in green energy. In addition, regarding the result of the technical effects of financial development on environmental quality, policymakers in Saudi Arabia are invited to increase per-capita financial investment in renewable energy, over the estimated threshold to reach the desired effect on reducing environmental degradation and it would be vital to protect the financial development sector provides private sector more funds to develop research in clean energy use and reduce carbon dioxide emissions.

Furthermore, the KSA attempts not only implementing such an innovation-oriented development strategy to encourage innovative firms but also accelerating the development of the service industry that help to achieve the goal of economic growth as well as reducing environmental degradation, and encouraging investors to move towards the green industry. In order to resolve the dilemma between financial development and carbon emissions, it is necessary for the Saudi policymarkers to devote significant efforts to ensure that alternative energy can compete with fossil fuel in the future with the regular technology effect of financial development.

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Data availability All data are available upon request.

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Contributions

Abdussalam Aljadani have equally contributed to designing the study, studying concepts or design, dealing with data collection, and calculation so as to write the manuscript.

Ethics declarations

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Consent to publish Not applicable.

Competing interests

The author declares no competing interests.

References

Abdul Qayyum Khan, Naima Saleem & Syeda Tamkeen Fatima, Financial development, income inequality, and CO2 emissions in Asian countries using STIRPAT model. Environ Sci Pollut Res. (2017).

Abid, M. (2017). Does economic, financial and institutional developments matter for environmental quality? A comparative analysis of EU and MEA countries. Journal of environmental management, 188, 183-194.

Acheampong, A. O. (2019). Modelling for insight: does financial development improve environmental quality? Energy Economics, 83, 156-179.

Ahmad, M., Rehman, A., Shah, S. A. A., Solangi, Y. A., Chandio, A. A., & Jabeen, G. (2021). Stylized heterogeneous dynamic links among healthcare expenditures, land urbanization, and CO2 emissions across economic development levels. Science of The Total Environment, 753, 142228.

Al-Mulali, U., Tang, C. F., & Ozturk, I. (2015). Does financial development reduce environmental degradation? Evidence from a panel study of 129 countries. Environmental Science and Pollution Research, 22(19), 14891-14900.

Amine Lahiani, Is f inancial development good for the environment? An asymmetric analysis with CO2 emissions in China, Environmental Science and Pollution Research. (2019)

Bingyu Zhao and Wanping Yang, Does financial development influence CO2 emissions? A Chinese province-level study. Energy 200 (2020) 117523.

Brown, R. L., Durbin, J., & Evans, J. M. (1975). Techniques for testing the constancy of regression relationships over time. Journal of the Royal Statistical Society: Series B (Methodological), 37(2), 149-163.

Chinazaekpere Nwani & Philip C. Omoke, Does bank credit to the private sector promote low-carbon development in Brazil? An extended STIRPAT analysis using dynamic ARDL simulations. Environmental Science and Pollution Research (2020).

Dumitrescu, E. I., & Hurlin, C. (2012). Testing for Granger non-causality in heterogeneous panels. Economic modelling, 29(4), 1450-1460.

Grossman, G. M., & Krueger, A. B. (1991). Environmental impacts of a North American free trade agreement (No. w3914). National Bureau of economic research.

Hatemi-j, A. (2012). Asymmetric causality tests with an application. Empirical Economics, 43(1), 447-456.

Hongyan Liu and Yanrong Song, Financial development and carbon emissions in China since the recent world fi nancial crisis: Evidence from a spatial-temporal analysis and a spatial Durbin model. Science of the Total Environment 715 (2020) 136771

Hubacek K, Feng K, Chen B (2011) Changing lifestyles towards a low carbon economy: an IPATanalysis for China. Energies 5(1):22–31.

Huo, T., Cao, R., Du, H., Zhang, J., Cai, W., & Liu, B. (2021). Nonlinear influence of urbanization on China's urban residential building carbon emissions: New evidence from panel threshold model. Science of The Total Environment, 145058.

Ibrahim D. Raheem, Aviral Kumar Tiwari & Daniel Balsalobre-Lorente, The role of ICT and f inancial development in CO2 emissions and economic growth. Environmental Science and Pollution Research. (2019).

Khan, A. Q., Saleem, N., & Fatima, S. T. (2018). Financial development, income inequality, and CO 2 emissions in Asian countries using STIRPAT model. Environmental Science and Pollution Research, 25(7), 6308-6319.

Kuznets, S. (1955). Economic growth and income inequality. The American economic review, 45(1), 1-28.

Lin, B., Omoju, O. E., Nwakeze, N. M., Okonkwo, J. U., & Megbowon, E. T. (2016). Is the environmental Kuznets curve hypothesis a sound basis for environmental policy in Africa?. Journal of Cleaner Production, 133, 712-724.

Lin, S., Wang, S., Marinova, D., Zhao, D., & Hong, J. (2017). Impacts of urbanization and real economic development on CO2 emissions in non-high-income countries:

Empirical research based on the extended STIRPAT model. Journal of cleaner production, 166, 952-966.

Lütkepohl, H. (2006). Structural vector autoregressive analysis for cointegrated variables. Allgemeines Statistisches Archiv, 90(1), 75-88.

Mingyuan Guo, Yanfang Hu and Jiandong Yu. The role of fiancial development in the process of climate change: Evidence from diffrent panel models in China. Atmospheric Pollution Research. 10 (2019). 1375-1382.

Munir, K., & Ameer, A. Assessing nonlinear impact of urbanization, economic growth, technology, and trade on environment: evidence from African and Asian emerging economies. GeoJournal, 1-14.

Narayan, P. K. (2005). The saving and investment nexus for China: evidence from cointegration tests. Applied economics, 37(17), 1979-1990.

Nasir, M. A., Canh, N. P., & Le, T. N. L. (2020). Environmental degradation & role of financialisation, economic development, industrialisation and trade liberalisation. Journal of Environmental Management, 277, 111471.

Nosheen, M., Abbasi, M. A., & Iqbal, J. (2020). Analyzing extended STIRPAT model of urbanization and CO 2 emissions in Asian countries. Environmental Science and Pollution Research, 27(36), 45911-45924.

Nwani, C. (2021, February). Taking Venezuela back to the sustainability path: The role of financial development and economic integration in low-carbon transition. In Natural Resources Forum. Oxford, UK: Blackwell Publishing Ltd.

Paramati, S. R., Apergis, N., & Ummalla, M. (2017). Financing clean energy projects through domestic and foreign capital: The role of political cooperation among the EU, the G20 and OECD countries. Energy Economics, 61, 62-71.

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. Journal of applied econometrics, 16(3), 289-326.

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. Journal of applied econometrics, 16(3), 289-326.

Ren, S., Li, X., Yuan, B., Li, D., & Chen, X. (2018). The effects of three types of environmental regulation on eco-efficiency: A cross-region analysis in China. Journal of cleaner production, 173, 245-255.

Sadorsky, P. (2010). The impact of financial development on energy consumption in emerging economies. Energy policy, 38(5), 2528-2535.

Sidi Mohammed Chekouri, Abderrahim Chibi & Mohamed Benbouziane (2020): Examining the driving factors of CO2 emissions using the STIRPAT model: the case of Algeria, International Journal of Sustainable Energy, DOI: 10.1080/14786451.2020.1770758

Tamazian, A., Chousa, J. P., & Vadlamannati, K. C. (2009). Does higher economic and financial development lead to environmental degradation: evidence from BRIC countries. Energy policy, 37(1), 246-253.

Usman, M., & Hammar, N. (2020). Dynamic relationship between technological innovations, financial development, renewable energy, and ecological footprint: fresh insights based on the STIRPAT model for Asia Pacific Economic Cooperation countries. Environmental Science and Pollution Research, 1-18.

Wang, M., Arshed, N., Munir, M., Rasool, S. F., & Lin, W. (2021). Investigation of the STIRPAT model of environmental quality: a case of nonlinear quantile panel data analysis. Environment, Development and Sustainability, 1-16.

Yulong Zhang, Qingyu Zhang & Binbin Pan, Impact of affluence and fossil energy on China carbon emissions using STIRPAT model. Environmental Science and Pollution Research (2019) 26:18814–18824.

Zahra Nasrollahi,Mohadeseh-sadat HashemiSaeed BameriandVahid Mohamad Taghv aee, Environmental pollution, economic growth, population, industrialization, and technology in weak and strong sustainability: using STIRPAT model. Environment, Development and Sustainability (2018).

Zhang, X., Zhao, K., & Jennings Jr, E. T. (2016). Empirical Evidence and Determinants of Region-Based Environmental Injustice in China: Does Environmental Public Service Level Make a Difference? Social Science Quarterly, 97(5), 1082-1095.

Zhao, C., Chen, B., Hayat, T., Alsaedi, A., & Ahmad, B. (2014). Driving force analysis of water footprint change based on extended STIRPAT model: Evidence from the Chinese agricultural sector. Ecological Indicators, 47, 43-49.

Figures

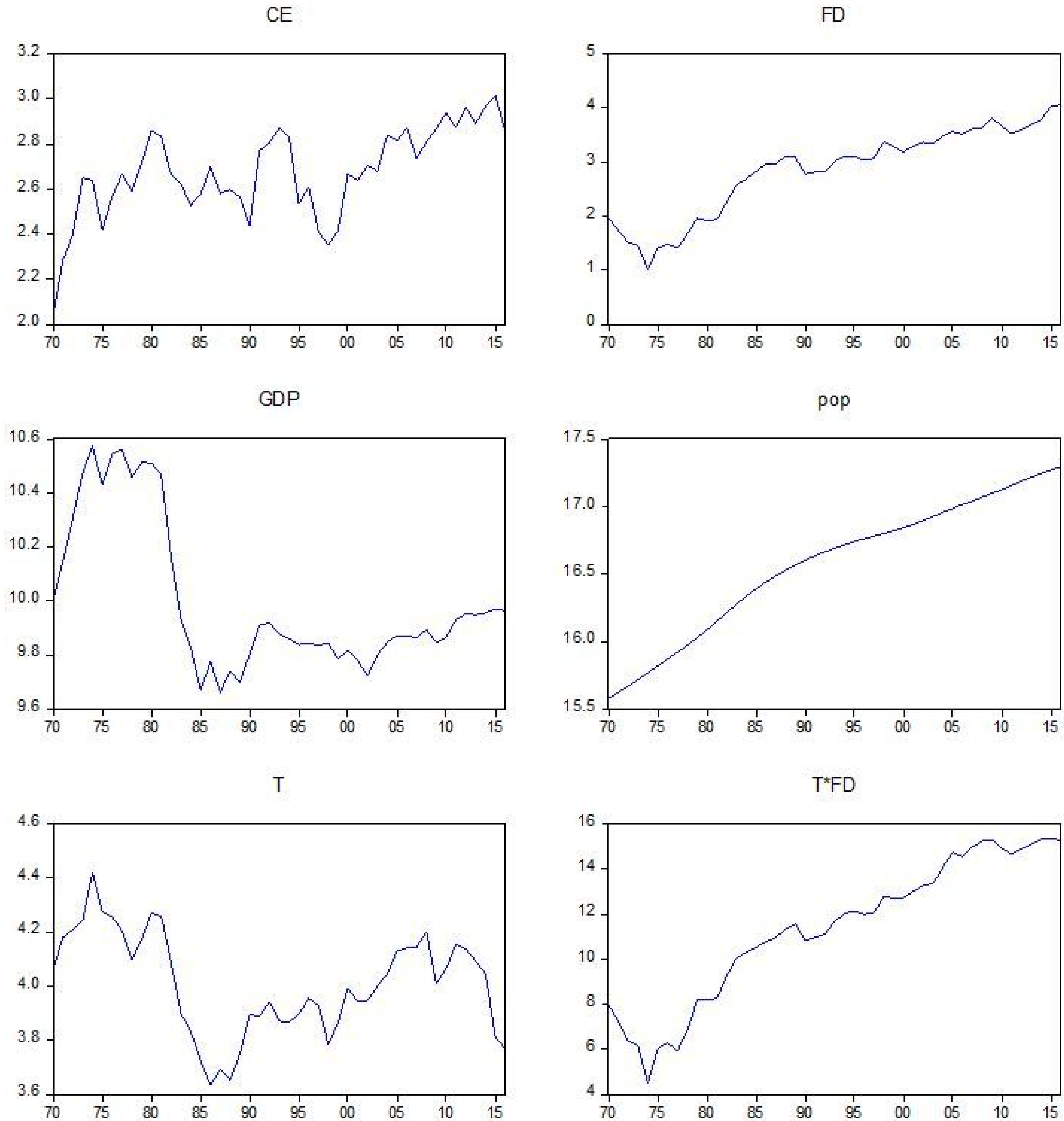

Figure 1

Plot of environmental quality, Affluence, Population, Technology and effect of technology.

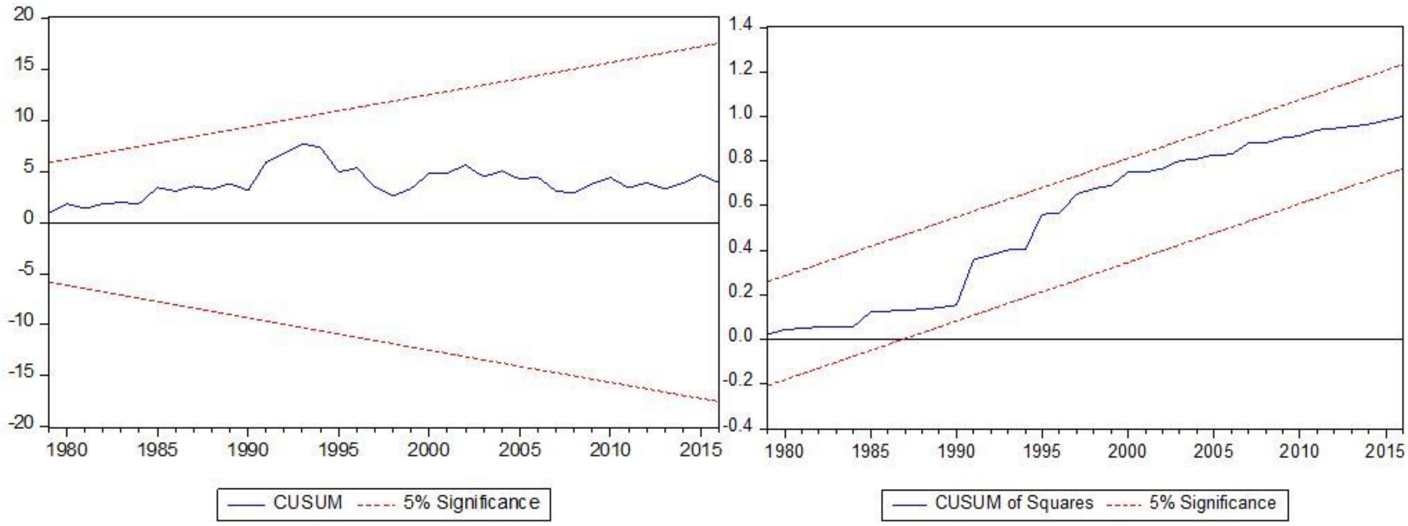

Figure 2

CUSUM and CUSUMQ from the CE model 1(CE=f (GDP, POP, FD, T, T*FD)).

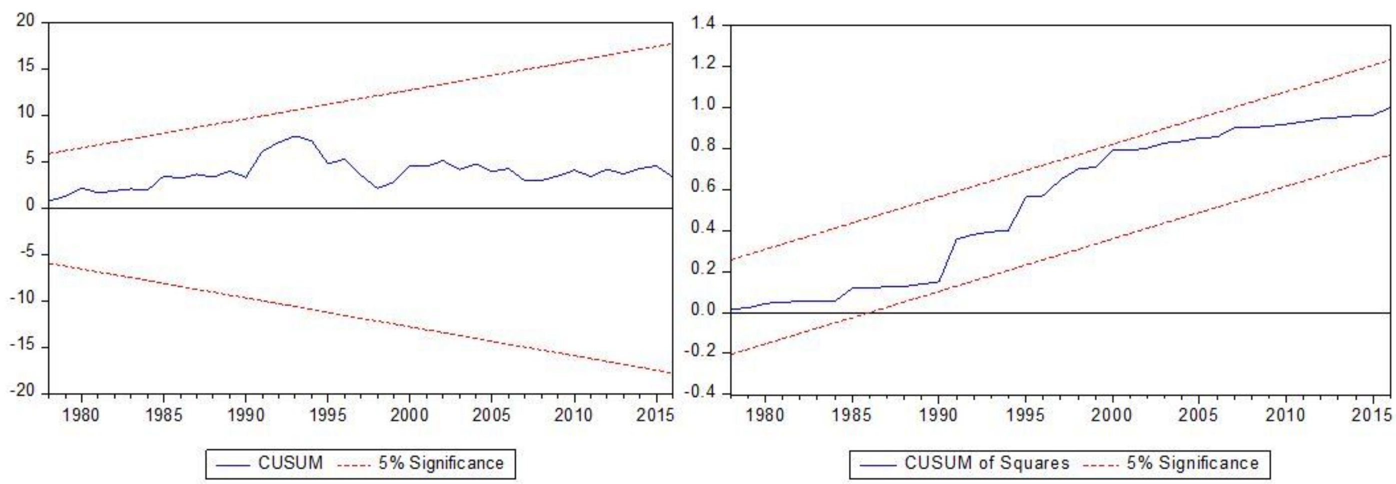

Figure 3

CUSUM and CUSUMQ from the CE model 2 (CE=f (GDP, POP, FD, T)).

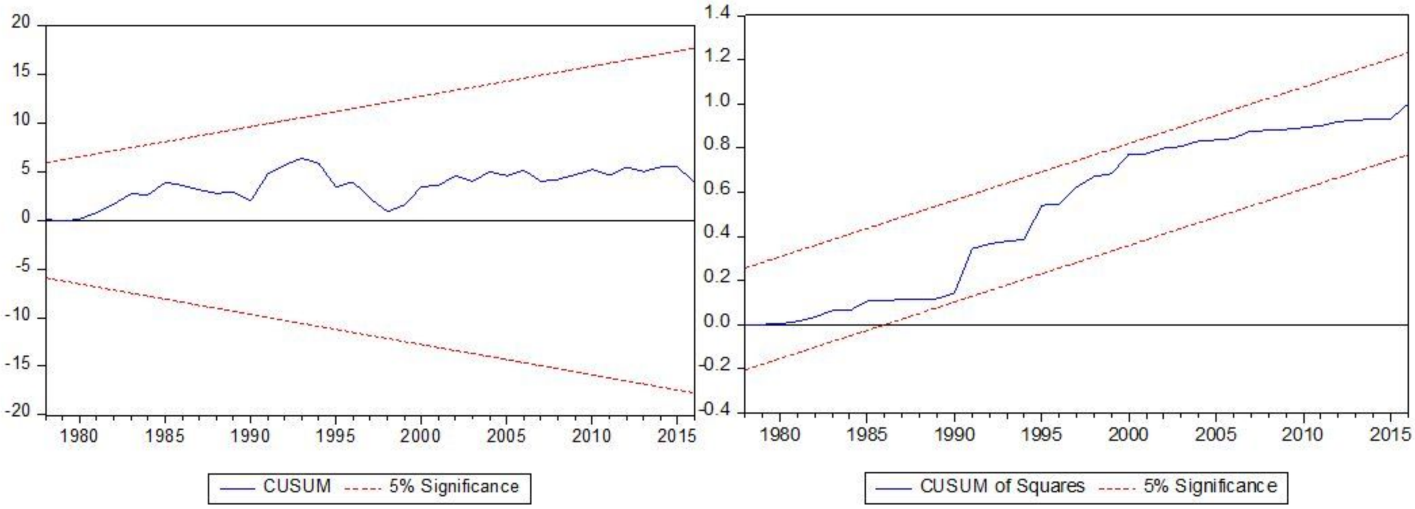

Figure 4

CUSUM and CUSUMQ from the CE model 3 (CE=f (GDP, POP, FD))