Shrikant Krupasindhu Panigrahi; Noor Azlinna Azizan; Kumaraswamy, Sumathi

Article

Investigating dynamic effect of energy consumption, foreign direct investments and economic growth on CO2 Emissions between Oman and United Arab Emirates: evidence from co integration and causality tests

Reference: Shrikant Krupasindhu Panigrahi/Noor Azlinna Azizan et. al. (2020). Investigating dynamic effect of energy consumption, foreign direct investments and economic growth on CO2 Emissions between Oman and United Arab Emirates: evidence from co integration and causality tests. In: International Journal of Energy Economics and Policy 10 (6), S. 288 - 298. https://www.econjournals.com/index.php/ijeep/article/download/10026/5454. doi:10.32479/ijeep.10026.

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2020, 10(6), 288-298.

Investigating Dynamic Effect of Energy Consumption, Foreign Direct Investments and Economic Growth on CO_2 Emissions between Oman and United Arab Emirates: Evidence from Co Integration and Causality Tests

Shrikant Krupasindhu Panigrahi[1]*, Noor Azlinna Binti Azizan[2], Sumathi Kumaraswamy[3]

[1]University of Buraimi, College of Business, Oman, [2]Prince Sultan University, Saudi Arabia, [3]University of Bahrain, Bahrain.
*Email: shrikant@uob.edu.om

Received: 03 June 2020 **Accepted:** 03 September 2020 **DOI:** https://doi.org/10.32479/ijeep.10026

ABSTRACT

The main objective of this paper is to examine the dynamic impact of energy consumption, foreign direct investments, and economic growth on carbon emissions by employing dynamic estimation techniques of co-integration for Oman and the United Arab Emirates. This study used quarterly panel data of Oman and UAE over the period 1991-2018. Generalized method of moments (GMM), Granger causality test is applied to perform causal relationships among the constructs. The empirical econometric results revealed that there is a strong co-integration of the variables in the case of Oman but not for the United Arab Emirates. In other words, there is a strong positive effect of energy consumption and foreign direct investment on CO_2 emission in Oman and the United Arab Emirates; whereas economic growth possesses a strong negative effect on CO_2 emissions. The estimation did not support the EKC hypothesis and was found to be not applicable in Oman and UAE. Further discussions on the implications of the results are provided.

Keywords: Energy Consumption, Foreign Direct Investment, Economic Growth CO_2 Emissions, Oman, UAE
JEL Classifications: F43, F16, L94

1. INTRODUCTION

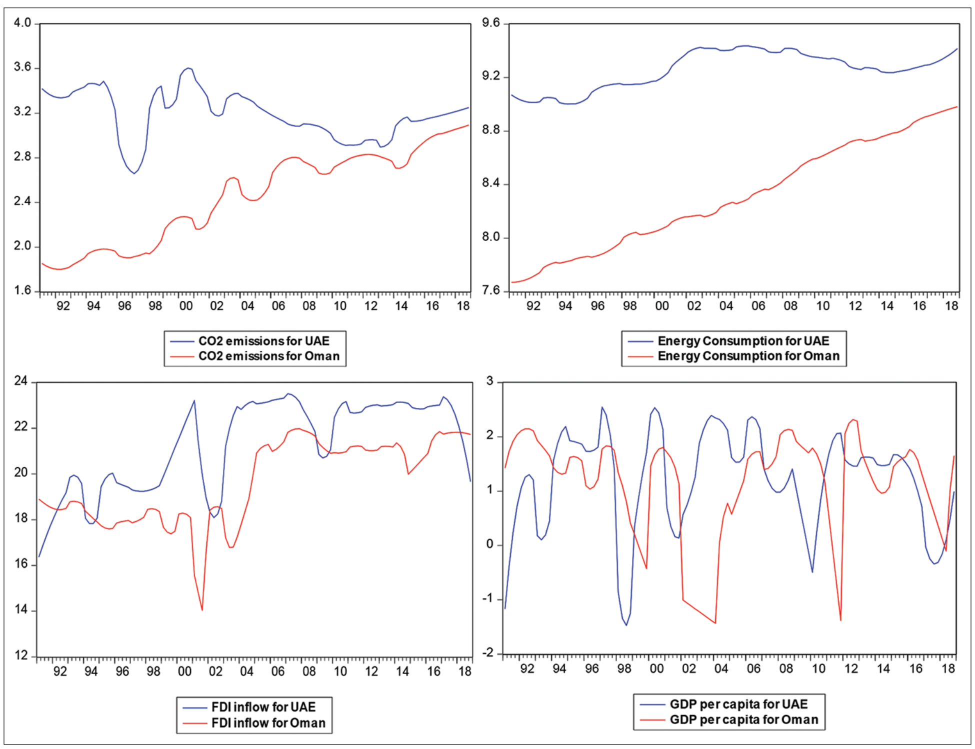
Climate change is one of the most defining environmental threats that impact the sustainable economic growth of any nation in the world. Change in weather patterns, rise in sea levels, intense droughts on food productions, and freshwater suppliers intimidate the livelihood of humans and other livings organisms' life at stake. The increasing concentration of GHG, especially Carbon dioxide (CO_2) due to deforestation, excess usage of fossil fuels, and other human actions are considered to be the major reason for global warming (Abdul-Wahab et al., 2015). Countries are in the race of achieving goals of rapid development and economic growth, leading to a strong environmental deterioration of environmental and resource consumptions (Govindaraju and Tang, 2013). Foreign Direct Investments (FDI) which fosters economic development results in industrialization and manufacturing sector development which demands more energy consumption. This increased energy consumption eventually alleviates the CO_2 emissions.

During the past few years, Oman and United Arab Emirates (UAE) have been facing multiple environmental challenges such as high temperature and humidity; reduced seawater quality, coastal erosion, increased pressure on food supply and production and lost productivity and higher health cost due to heat stress, allergies and infectious diseases (Ministry of climate change and environment, 2018). Based on the analysis by environmentalists, there will be an increase of 1°C temperature in UAE by 2020 and 1.5°C by 2040 (Abu Dhabi Global Environment Data Initiative, 2015). Such climate change could have severe implications on the growth and development objectives of Oman and UAE. Environmentalists have argued that carbon emissions are the main source of this climate change and global warming (Ahmad et al., 2017; Andreoni and Galmarini, 2016) due to increased energy consumption and growth (Antonakakis et al., 2017; Olivier et al., 2017). There has been an increasing trend for energy consumption, CO_2 emissions, FDI, and the real GDP of Oman and UAE over the period of 1991-2018 (Figure 1). Oman and UAE had shown remarkable growth on CO_2 emissions in the period of 2010-2018, at an average rate of 17.86% and 21.60% respectively in comparison to economic growth at an average rate of 3.45% and 3.64%, respectively (Table 1). As shown in (Figure 1) Oman has shown a significant increase in energy consumption as compared to UAE (from 7.6% in 1991 to 8.8% in 2018 for Oman and from 9% in 1991 to 9.4% in 2018 for UAE).

Oman and UAE have been the most populous GCC countries for CO_2 emissions and in the future are expected to increase in a rapid pace (Abdul-Wahab et al., 2015; Asif et al., 2015; Radhi, 2009; Yousif et al., 2017). Oman and UAE with large oil reserves for the same periods used an average of 6617 and 10929 kg of oil equivalents and are expected to increase in the future. Therefore, the biggest challenge for these two countries is to keep balance the energy consumption and CO_2 emission together with maintaining economic growth. Nevertheless, both countries have significant economic growth decline in the year 2011 and 2017, there might be the existence of decoupling of CO_2 emissions from economic growth (Riti et al., 2017; Wang et al., 2017).

Notwithstanding the considerable efforts made by Oman and UAE Governments to address the effect of climate change to mitigate further environmental deterioration, it is imperative at this point for these countries to control their energy consumption especially fossil fuel, and increase the usage of renewable energy resources. In other words, the high usage of fossil fuels will not only diminish its availability in the future but will contribute to more carbon emissions. Nevertheless, fossil fuel in the form of crude oil plays a critical role in the economic growth of these countries, the reduction

Figure 1: Line graph plots of CO_2 emissions, energy consumption, FDI inflow and GDP per capita for UAE and Oman, 1991-2018



Source: World Development Indicators, Data Bank

Table 1: Growth rates of Oman and UAE, 2010-2018

Years	Oman Energy onsumption	CO_2 emissions	Real GDP	FDI inflows	UAE Energy consumption	CO_2 emissions	Real GDP	FDI inflows
2010	5521.1	15.5	4.8	1.24E+09	11451.9	18.81	1.60	9E+09
2011	5854.0	16.62	−1.1	1.63E+09	11294.2	18.49	6.93	7E+09
2012	6176.9	16.91	9.33	1.36E+09	10618.8	19.29	4.48	1E+10
2013	6207.2	16.30	4.37	1.61E+09	10610.0	18.56	5.05	1E+10
2014	6445.6	15.19	2.75	1.29E+09	10287.1	22.94	4.40	1E+10
2015	6703.4	17.86	4.74	−2.17E+09	10416.0	22.91	5.06	9E+09
2016	7231.9	19.87	4.98	2.27E+09	10724.5	23.60	2.99	1E+10
2017	7556.4	20.76	-0.92	2.92E+09	11088.4	24.43	0.79	1E+10
2018	7858.3	21.70	2.12	2.89E+09	11878.5	25.40	1.42	1E+09

Source: World Bank database and Author's calculation in energy consumption is a viable option. However, this move might limit the rapid economic development of Oman and UAE.

Indeed of the growth of economy in both the countries, government's effort to develop renewable resources may reduce their reliance on fossil fuel for energy production. Therefore, a wide range of questions arises for these oil producing countries. Will the economic growth affect if energy production using fossil fuels is controlled or if it is replaced with environmental friendly resources as an alternative? How CO_2 emissions is influenced by economic growth and energy consumption? Will FDI inflows be affected due to high CO_2 emissions? In order to answer all these questions, this study attempts to insight with careful investigation on such factors that allows appropriate formulation of strategies for the policymakers.

There have been numerous attempts performed by previous studies like (Bastola and Sapkota, 2015; Bouznit and Pablo-Romero, 2016; Kasman and Duman, 2015; Wang et al., 2016), there exist two main fundamental gaps in the literature. First, investigating the long-run relationship between energy consumption and CO_2 emissions using long-range data (e.g., 1991-2018). According to the World Economic Development Indicators, in 2018, carbon emissions per capita for Oman was 17.64 metric tons whereas carbon emissions per capita for UAE was 22.44 metric tons. It is very crucial for the study to include long-range data series for robust estimation of results using co-integration analysis. Also, investigating two highly resilient economies like Oman and UAE will provide meaningful insight on whether there exists any differences in the relationships despite heavy consumption and reliance on fossil fuels. In light of the above mentioned economic and environmental differences between Oman and UAE, this study will examine the long-run influence of energy consumption, CO_2 emissions, FDI inflows on economic growth for the period of 1991-2018.

2. LITERATURE REVIEW

There have been significant studies performed examining the relationship and association between CO_2 emissions, energy consumption, FDI inflows and economic growth using series and panel data to validate the environmental Kuznets curve (EKC) hypothesis in the past few decades. Theoretical foundations of the EKC hypothesis examining the nonlinear function of economic activity leads to deterioration of environmental quality. EKC postulates that at a certain level as income increases environmental pressure also increases. An extensive review of previous researches to test EKC and their conclusions are provided in the below lines. For Saudi Arabia, (Mahmood and Alkhateeb, 2017) explored the relationship between trade and income on CO_2 emissions through the EKC hypothesis and found that trade has a negative impact on CO_2 emissions confirming the EKC hypothesis. For GCC countries, (Al-Mulali et al., 2015) used ecological footprints for environmental degradation and found that energy consumption, urbanization, and trade openness damage the environment confirming positive ecological footprints. They also found that environmental degradation can be reduced through financial development in the GCC countries confirming that loan is favored to the companies investing in the projects that are mostly environmental friendly. Diverting from GCC countries to some of the literature of countries that damage environment severely, like for China, (Li et al., 2016) investigating the EKC curve applying dynamic panel model for 28 provinces in China using GMM and ARDL model found that EKC hypothesis is supported across China for all three major pollutants (CO_2, wastewater and waste solid emissions). In contrary to this result, (Wang et al., 2011) earlier mentioned that there is a U shaped relation between CO_2 emissions and economic growth confirming EKC is not valid in China. Also, (Usman et al., 2019) revisited the EKC hypothesis in India investigating the role of energy consumption for the period of 1971 to 2014 using ARDL and Granger Causality test. They found that the EKC hypothesis is valid for India as energy consumption increases environmental degradation in the long and short run. The reviewed literature provides mixed result on confirming the EKC hypothesis and are contrary to each other. This conflicting results in different countries can be due to different variables selected, time, method, and country's financial situation during the period of investigation. Table 2 summarizes previous relevant studies with their key features, methodology and main findings. From the Table 2 it can be seen that several studies have investigated the nexus between pollution, energy consumption, FDI and economic growth based on the aggregate data at country level. Thus, it is important to reexamine this relationships comparing Oman and UAE.

Many recent and past studies (Bilgili et al., 2016; Dogan and Turkekul, 2016; Dong et al., 2018; Pata, 2018) investigating energy-growth relationships have confirmed this postulate; however, many studies (Charfeddine, 2017; Dogan and Turkekul, 2016; Khan et al., 2019) have doubted this relationship too. The EKC hypothesis implies that in the initial stage of growth, environmental pollution increases, and then at the later stages it starts declining (Alam et al., 2016). This indicates that there is an inverted U-shape relation between growth and environmental deterioration supporting the EKC hypothesis. Although there have been several research investigations performed on the energy consumption-CO_2 emissions-economic growth-FDI nexus (Ahmad et al., 2019; Akadiri et al., 2019; Khan et al., 2019; Salahuddin et al., 2018), to the best of the author's knowledge no study have been undertaken in the context of Oman and UAE, which is very crucial for such investigation. This study will attempt to fill this gap.

2.1. Economic Growth-pollution Nexus

The nexus between economic growth and pollution through CO_2 emissions have been investigated extensively. In the case of Kuwait, (Salahuddin et al., 2018) using the auto-regression distributed lag (ARDL) approach found that CO_2 emissions are stimulated by the economic growth for both the short and long run. Similarly, (De Freitas and Kaneko, 2011) for Brazil investigated the decoupling of CO_2 emissions and economic growth and found that between 2004 and 2009, the intensity of carbon and energy mix are the key factors for emissions reduction. In the case of India, (Alam et al., 2011) investigated the dynamic modeling relationship between CO_2 emissions and economic growth and found that in the long run, CO_2 emissions do not cause the growth of the economy. Furthermore, (Stamatiou and Dritsakis, 2017) found that there is a unidirectional relation between economic growth and CO_2 emissions in the short run for Italy. For the panel of 28 provinces in China (Wang et al., 2011) found that in the short-run and long-run CO_2 emissions will not decrease, and reducing CO_2 emissions may handicap the economic growth of China at some level. Also, (Saidi and Hammami, 2015) investigating a panel of 58 countries found that economic growth has a positive impact on CO_2 emissions. Previous studies utilized different approaches and econometric techniques (Generalized method of moments (GMM), auto-regressive distributed lag (ARDL), and Vector error correction model (VECM) Granger causality for investigating the panel or time-series data.

2.2. Energy Consumption-pollution Nexus

The nexus between energy consumption and pollution has been reviewed in most of the literature to test EKC. Gu et al., 2019 used an interaction model of data from 30 provinces of China from 2005 through 2016 evidenced from China that technological progress on energy consumption leads to reduce carbon emissions. They also suggested that different technological progress levels have a direct and technical effect on carbon emissions. Also (Batur et al., 2019) assessed the impact of supply and demand-side policies on energy consumption and carbon emissions in Istanbul. Based on the historical data from 2000 to 2015, resulting in different scenarios they found that a 10% improvement in the fuel economy of the vehicles would lead to a 10% reduction in carbon emissions.

2.3. FDI Inflows-pollution Nexus

Capital inflows have been an important topic of discussion in the current years due to the high volatility of capital flows weakens the financial systems (Muhammad and Khan, 2019). The nexus between FDI leading to pollution has been investigated for the emerging and developing nations. FDI outflows are usually from developed countries. An increase in carbon emissions leads to environmental change and ongoing anxiety for both emerging and developed countries. Using linear and nonlinear autoregressive distributed lag modeling (Haug and Ucal, 2019) investigated how FDI inflows affect CO_2 emissions and found that in the long run, FDI inflows have no significant effect on carbon emissions.

3. ECONOMETRIC METHODOLOGY

3.1. Economic Modelling

To test the EKC hypothesis for Oman and UAE, quarterly panel data from 1991 to 2018 has been used that was retrieved from World Development Indicators (WDI) and International Energy Statistics (IES) database, respectively. Real GDP per capita was measured using constant 2000 US$, per capita energy consumption, and CO_2 emission per capita was measured by dividing them with the mid-year population as suggested by (Salahuddin et al., 2018). These constructs were then transferred to natural logs to avoid the issue of heteroscedasticity between the constructs. The econometric model estimated for this study takes the following form:

$$CO_{2it} = \beta 0 + \beta 1EC_{it} + \beta 2FDI_{it} + \beta 3GDPit + \varepsilon_{it} \quad (1)$$

where, CO_2 it is the carbon dioxide emissions for ith countries at time t. EC_{it} is energy consumption for ith countries at time t, FDI_{it} is the foreign direct investment for ith countries at time t and GDP_{it} is the gross domestic product for ith countries at time t. The coefficients β0 represents the constant, β1, β2, β3 represents the long run estimation between CO_2 emissions, energy consumption (Kwh), foreign direct investment (FDI) and real GDP per capita, respectively.

To investigate the relationships, data were sourced for the following constructs:

- CO_2 emissions per capita for country i at time t (C_{it})
- Energy consumption per capita for country i at time t (EC_{it})
- Real GDP per capita for country i at time t (GDP_{it})
- Foreign direct investment inflows for country i at time t as share of GDP (FDI_{it}).

In panel data, we usually face the issue of serial correlation and heteroskedasticity that may distort the model. Attari et al. (2016) defined serial correlation as the disturbance to any construct due to correlation. Panigrahi (2017) heteroskedasticity issue arises when the changes in the error terms differentiate from the observations. Dynamic GMM model helps to solve the issue of heteroskedasticity and serial correlation (Khan et al., 2019). Jacob and Osang (2020) explained that the GMM model is more suitable for the panel invariant constructs.

3.2. Dynamic GMM Model

Generalized method of moments (GMM) suitable for the number of moment conditions was first developed by (Hansen, 1982) to estimate the parameters with endogenous regress in the panel data model with unobserved individual accurate heterogeneity. GMM has been consistently proposed by (Arellano and Bond, 1991; Bennett et al., 2019; Panigrahi, 2017) converting the model into the first difference to wipe up individual effect and employ lag wherever lag levels of constructs are instruments. Such a model shows no consistent for fixed and random effect estimators for a finite period and a huge number of observation data (Muhammad, 2019).

The following equations are used for empirically observing the four-way relationship between energy consumption, economic growth, FDI inflows, and CO_2 emissions:

$$\ln CO2_{it} = \alpha_0 + \alpha_1 \ln CO_{2it-1} + \alpha_2 \ln EC_{it} + \alpha_3 \ln GDP_{it} + \alpha_4 \ln FDI_{it} + \varnothing_{it} \quad (2)$$

$$\ln EC_{it} = \beta_0 + \beta_1 \ln CO_{2it-1} + \beta_2 \ln CO2_{it} + \beta_3 \ln GDP_{it} + \beta_4 \ln FDI_{it} + \varepsilon_{it} \quad (3)$$

$$\ln GDP_{it} = \lambda_0 + \alpha_1 \ln GDP_{it-1} + \alpha_2 \ln EC_{it} + \alpha_3 \ln CO2_{it} + \alpha_4 \ln FDI_{it} + \sigma_{it} \quad (4)$$

$$\ln FDI_{it} = £_0 + \alpha_1 \ln FDI_{it-1} + \alpha_2 \ln EC_{it} + \alpha_3 \ln GDP_{it} + \alpha_4 \ln CO_{2it} + \Theta_{it} \quad (5)$$

Equation (2) – (5) include In CO_{2it}, $InEC_{it}$, $InGDP_{it,}$ and $InFDI_{it,}$ as dependent constructs, whereas; α, β, λ, and £ represents the constant terms for the equation. $\varnothing_{it}$, ε_{it}, σ_{it} and Θ_{it} are the error terms for the equation.

4. DATA ANALYSIS

The analysis began with testing descriptive statistics and the properties of the unit root test for the time series data in the study. We used traditional unit root tests like (Said and Dickey, 1984) ADF unit root test by allowing the lag terms that provide serial correlations and (Perron and Phillips, 1987) PP test for autocorrelation detection. We also presented GMM estimation using a dynamic panel taking into account lagged levels of CO_2 emissions following (Arellano and Bond, 1991).

Descriptive statistics results are depicted in Table 3 having all positive mean, standard deviation, and median with a significant peak of distribution confirming strong CO_2 emissions together with energy consumption, FDI inflows, and real GDP per capita for Oman and UAE. Pollution in the form of CO_2 emissions is significantly affected by positive mean and standard deviation of energy consumption, FDI inflows, and real GDP per capita. CO_2 emissions were measured in terms of metric tons per capita. Energy consumption was measured at the equivalent of electricity usage per capita. The mean growth of CO_2 emissions, energy consumption, and FDI inflows was highest for UAE as compared to Oman. Moreover, the average real GDP per capita for Oman was found to be higher as compared to the UAE.

4.1. Unit Root Test

The first step of this empirical investigation was to test the stationarity of the constructs using different unit root tests. In the time series data checking stationarity is an econometric process to avoid spurious results. Table 4 shows the Phillips and Perron (1988) and Dickey and Fuller (1979) panel unit root tests at the level form and the first difference of each series. The difference between the Phillips and Perron (1988) test and the Dickey and Fuller (1979) unit root tests is that the latter uses lag length to solve the issues of autocorrelation and to improve the resulting robustness.

Table 2: Summary of previous studies on growth-pollution-consumption and FDI relationships

Authors-year	Period	Sample	Methodology	Key findings
Economic growth-pollution				
(Kasman and Duman, 2015)	1992-2010	EU nations	Panel Cointegration	Causal relation between carbon emissions and GDP
(Wang et al., 2016)	1990-2012	China	Co-integration test	Marginal shock in economic growth due to CO_2 emissions
(Ahmad et al., 2017)	1992Q1-2011Q1	Croatia	ARDL & VECM approach	Unidirectional causality from economic growth to CO_2 emissions in long run
(Ozturk and Acaravci, 2016)	1980-2006	Cyprus and Malta	ARDL	CO_2 emissions have no adverse effect on growth of Malta
(Begum et al., 2015)	1970-2010	Malaysia	DOLS and Sasabuchi-Lind-Mehlum (SLM) test	In long run, economic growth may have an adverse effect on CO_2 emissions
Energy consumption-pollution				
(Muhammad, 2019)	2001-2017	MENA	GMM	Energy consumption increase together with CO_2 emissions, but economic growth decreases in MENA region
(Wang et al., 2018)	1990-2011	China	Correlation analysis	Energy consumption and CO_2 emissions are heavily impacted by urbanization
(Nain et al., 2017)	1971-2011	India	ARDL	Short run causality from electricity consumption to CO_2 emissions
(Shan et al., 2017)	2014	Tibet	Quantitative	CO_2 emissions are associated from cement production and road transportation with high emissions intensity
(Cai et al., 2018)	1965-2015	G7 Countries	ARDL	Clean energy consumption is caused by CO_2 emissions
FDI-CO_2 emissions-economic growth nexus				
(Shahbaz et al., 2019)	1990-2015	MENA	GMM	Connection between energy consumption and CO_2 emissions is bidirectional
(Salahuddin et al., 2018)	1980-2013	Sub-Saharan African	Pooled OLS	Energy consumption lead to higher economic growth at the cost of environmental degradation
(Sarkodie and Strezov, 2019)	1982-2016	India, China, Iran, Indonesia, South Africa	Panel quantile regression	FDI increases the level of CO_2 emissions; positive effect of energy consumption on CO_2 emissions
(Mert and Bölük, 2016)	1970-2010	21 Kyoto annex countries	ARDL	FDI inflows mitigate emissions, economic growth cannot ensure environmental protection
(Gökmenoğlu and Taspinar, 2016)	1974-2010	Turkey	Causality test	Carbon emissions and FDI, energy consumption and CO_2 emissions have bidirectional causal relationships

Table 3: Descriptive statistics

Descriptive	Oman			
	CO_2 emissions	Energy consumption	FDI inflows	Real GDP per capita
Mean	2.452085	8.311014	19.61401	1.123549
Median	2.566713	8.262612	19.94079	1.445773
Maximum	3.093687	8.982997	21.98178	2.31812
Minimum	1.800834	7.670551	14.0408	-1.433871
Std. Dev.	0.410171	0.39718	1.834437	0.96101
Skewness	-0.217837	0.094393	-0.437649	-1.343163
Kurtosis	1.606638	1.722916	2.360092	3.922411
Jarque-Bera	9.94592	7.777388	5.486272	37.64687
Descriptive	**UAE**			
	CO_2 emissions	Energy consumption	FDI inflows	Real GDP per capita
Mean	3.187408	9.256687	21.2037	1.203706
Median	3.191884	9.275403	21.63412	1.443193
Maximum	3.605051	9.436163	23.51415	2.548346
Minimum	2.657809	9.002483	16.36265	-1.471816
Std. Dev.	0.210458	0.140415	1.933213	0.903637
Skewness	-0.355472	-0.456208	-0.483289	-0.879014
Kurtosis	2.664352	1.895548	1.940457	3.460417
Jarque-Bera	2.884473	9.577483	9.598893	15.41237

Table 4: Unit root tests

Variables	Oman		UAE	
	PP	ADF	PP	ADF
$\ln CO_{2t}$	−2.262	−2.757	−2.762*	−2.760*
$\Delta \ln CO_{2t}$	−4.987***	−3.327***	−6.315***	−5.487***
$\Delta\Delta \ln CO_{2t}$	−51.736***	−6.878***	−24.150**	−4.345***
$\ln EC_{2t}$	3.831	1.914	−1.357	−1.814
$\Delta \ln EC_{2t}$	−5.162***	−1.823	−3.326**	−3.301**
$\Delta\Delta \ln EC_{2t}$	−34.053***	−6.285***	−10.194***	−6.616***
$\ln FDI_{2t}$	−2.333	−1.777	−2.579	−2.616***
$\Delta \ln FDI_{2t}$	−5.998***	−3.579***	−7.664***	−6.790***
$\Delta\Delta \ln FDI_{2t}$	−35.798***	−5.340***	−20.511***	−7.400***
$\ln GDP_{2t}$	−3.281***	−3.470**	−5.007**	−4.897**
$\Delta \ln GDP_{2t}$	−9.023***	−9.055***	−15.337***	−6.188***
$\Delta\Delta \ln GDP_{2t}$	−56.791***	−11.174***	−23.165***	−9.025***

The unit root test results as shown in Table 5 are integrated if the null hypothesis is rejected. The results of Phillips and Perron's (1988) test and the Dickey and Fuller (1979) indicate that the variables were stationary after the first differences whereas the level unit root shows the existence of stationarity.

4.2. Model Specification

This paper used the GMM model introduced by (Hansen, 1982) for estimation and testing together with plots of residual leverage. The robustness of the model is provided by the Hansen J-statistics. The Hansen test of over-identifying restrictions is a joint test of the hypothesis that the instruments are distributed independently of the error process. Table 6 presented the results of GMM estimation, OLS, FMOLS, and DOLS using aggregated panel quarterly data from 1991 to 2018 for Oman and UAE.

The presence of the EKC hypothesis was not confirmed from the results of the panel as the influence of electricity consumption and FDI inflows were severe on the CO_2 emissions for Oman and UAE. However, we found that GDP growth deteriorates CO_2 emissions in the long run. The result was supported by (Shahbaz et al., 2013) who found that sustainable economic growth by controlling the environment with efficient usage of resources degrade carbon emissions. Similarly, (Al-Mulali, 2014) found that energy consumption was an important factor than real GDP to control environmental degradation.

Table 5: Estimation of panel GMM, OLS, FMOLS AND DOLS

	Oman			
	GMM	OLS	FMOLS	DOLS
LnELECT	0.872	0.812	0.749	0.603
	(11.450)	(19.090)	(8.616)	(4.856)
	0.000*	0.000*	0.000*	0.000*
LnFDI	0.041	0.059	0.076	0.120
	(2.030)	(6.182)	(3.710)	(4.145)
	0.047*	0.000*	0.000*	0.000*
LnGDP	−0.110	−0.102	0.099	0.014
	(−6.665)	(−6.170)	(4.240)	(1.209)
	0.002	0.004	0.020	0.134
R-square	0.943	0.948	0.951	0.963
Prob.	0.001	0.000		
Long run variance			0.029	0.021
	GMM	**OLS**	**FMOLS**	**DOLS**
LnELECT	0.497	0.469	0.477	0.483
	(10.660)	(17.860)	(9.130)	(8.017)
	0.000*	0.000*	0.000*	0.000*
LnFDI	−0.066	−0.053	−0.050	−0.060
	(−3.150)	(−4.600)	(−2.510)	(−2.260)
	0.002*	0.000*	0.013*	0.025*
LnGDP	−0.101	−0.119	−0.118	−0.111
	(−6.004)	(−6.008)	(−4.007)	(−4.098)
	0.004*	0.008*	0.007*	0.008*
R-square	0.932	0.956	0.936	0.923
Prob	0.005	0.005		
Long run variance			0.159	0.151

CO_2 emissions is the dependent variable; ***, **, * represents 10%, 5% and 1% significant; small bracket shows t-statistics values

Appendix A provides the residual leverage plots providing the relationship between CO_2 emissions versus the independent constructs and shows that carbon emissions have high leverage towards economic growth as compared to that of energy consumption and FDI inflows. From Table 6 presenting the

VECM short and long-run Granger causality F statistics, it is evident that GDP and energy consumption are significant to FDI inflows indicating that in short and long-run causality running from GDP and energy consumption to FDI for UAE. For Oman, it was evident that energy consumption granger bi-directionally causes CO_2 emissions in both the short and long run. It was also found that granger causality f statistics for GDP and energy consumption towards FDI inflows were significant indicating that in the short and long run FDI inflows are heavily dependent on the GDP and energy consumption of Oman. Figure 2 provides the plot of CUSUM and CUSUMSQ test statistics that falls inside the critical bounds of 5% significance implying that the estimated parameters are stable over the periods.

Table 6: Granger causality test for Oman and UAE

Countries	Real hypothesis	F-statistics	Prob.		F-statistics	Prob.
UAE	Energy consumption→ CO_2	0.2554	0.775	CO_2→energy consumption	2.78	0.066*
	FDI inflows→ CO_2	1.7207	0.183	CO_2→FDI inflows	0.46	0.632
	GDP per capita→ CO_2	1.006	0.369	CO_2→GDP per capita	0.216	0.805
	FDI inflows→energy consumption	0.205	0.814	Energy Consumption→FDI inflows	3.747	0.026**
	GDP per capita→energy consumption	0.074	0.928	Energy Consumption→GDP per capita	0.163	0.849
	GDP per capita→FDI inflows	3.276	0.041**	FDI inflows→GDP per capita	0.664	0.516
	Real hypothesis	**F-statistics**	**Prob.**		**F-statistics**	**Prob.**
Oman	Energy consumption→ CO_2	5.866	0.003***	CO_2→energy consumption	1.617	0.203
	FDI inflows→ CO_2	0.316	0.729	CO_2→FDI inflows	4.218	0.016**
	GDP per capita→ CO_2	0.2	0.818	CO_2→GDP per capita	2.432	0.092*
	FDI inflows→energy consumption	0.825	0.440	Energy Consumption→FDI inflows	4.291	0.001***
	GDP per capita→energy consumption	0.19	0.827	Energy Consumption→GDP per capita	0.968	0.382
	GDP per capita→FDI inflows	3.742	0.022**	FDI inflows→GDP per capita	3.285	0.041**

*** denotes the significance acceptance level at 0.01; ** denotes the significance acceptance level at 0.05; * denotes the significance level at 0.1

Figure 2: Graphical plot of cusum sum and cusum of squares for UAE and Oman

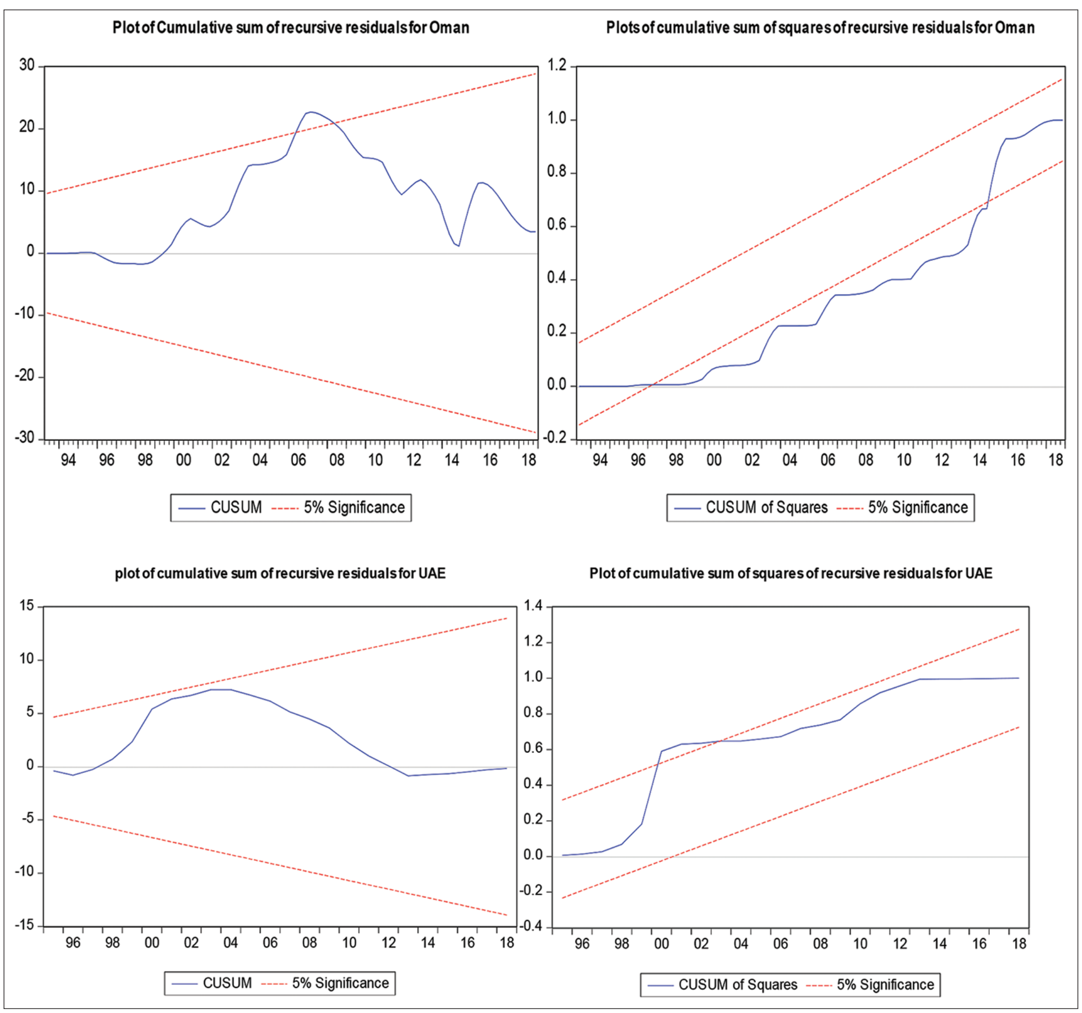
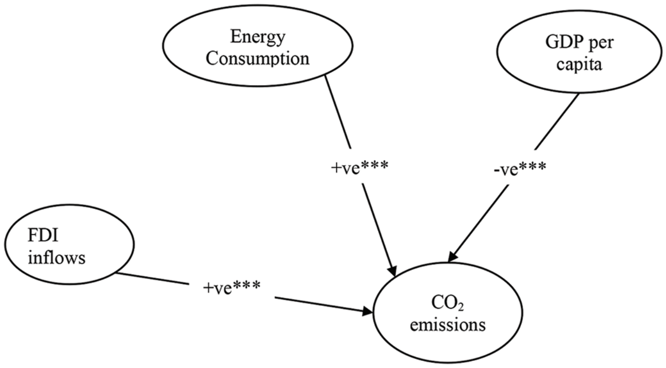


Figure 3: Causal Direction among the variables for Oman and UAE



CUSUM and CUSUM of squares for UAE and Oman show that over a while the variables in the model are stable and are within the bounds. Thus, the model is reliable and perfect.

5. CONCLUSIONS

This study employed a multi-panel estimation model to predict the long-run relationship between electricity consumption, FDI inflows, economic growth, and CO_2 emissions for Oman and UAE. Figure 3 provides the causal direction among the variables that confirmed electricity consumption and FDI inflows towards CO_2 emissions for Oman and UAE. Based on the GMM and other regression techniques the estimated value shows that there is a long term equilibrium relationship between energy consumption and CO_2 emissions and was an important factor than the GDP and FDI inflows. Also, the results indicated that real GDP negatively impacts carbon emissions. Therefore, economic growth has a negative effect on carbon emissions in Oman and UAE. This result was also supported by previous studies in (Pao et al., 2012) China, South Africa, India, ASEAN-5 countries The EKC hypothesis is not applicable to Oman and UAE.

Deployment of renewable energy technologies on a large scale can be an initiative for climate action. Although climate change is a threat to Oman and UAE, it can be regarded as an opportunity for diversifying the economy in the form of innovative green products. Stronger policies and regulations are needed to stimulate investment flows into sustainable green projects. Creating an integrated framework that could play an important role in international climate action through a technology transfer mechanism is required to be implemented. Green sectors such as clean energy, green manufacturing, and environmental goods and services need to be focused in the course of implementing a climate action plan.

6. ACKNOWLEDGMENT

We would like to thank the anonymous reviewers for the comments and suggestions that significantly improved the previous version of this study. In addition, the remaining flaws in this study are solely our responsibilities and the usual disclaimer applies.

REFERENCES

Abdul-Wahab, S.A., Charabi, Y., Al-Maamari, R., Al-Rawas, G.A., Gastli, A., Chan, K. (2015), CO_2 greenhouse emissions in Oman over the last forty-two years. Renewable and Sustainable Energy Reviews, 52, 1702-1712.

Abu Dhabi Global Environment Data Initiative. (2015), Regional Atmospheric Modeling for the Arabian Gulf Region Future Scenarios and Capacity Building. Final Report for AGEDI's Local, National, and Regional Climate Change Programme. Abu Dhabi: Global Environment Data Initiative.

Ahmad, M., Zhao, Z.Y., Li, H. (2019), Revealing stylized empirical interactions among construction sector, urbanization, energy consumption, economic growth and CO_2 emissions in China. Science of the Total Environment, 657, 1085-1098.

Ahmad, N., Du, L., Lu, J., Wang, J., Li, H.Z., Hashmi, M.Z. (2017), Modelling the CO_2 emissions and economic growth in Croatia: Is there any environmental Kuznets curve? Energy, 123, 164-172.

Akadiri, S.S., Bekun, F.V., Taheri, E., Akadiri, A.C. (2019), Carbon emissions, energy consumption and economic growth: A causality evidence. International Journal of Energy Technology and Policy, 15(2-3), 320-336.

Alam, M.J., Begum, I.A., Buysse, J., Rahman, S., Van Huylenbroeck, G. (2011), Dynamic modeling of causal relationship between energy consumption, CO_2 emissions and economic growth in India. Renewable and Sustainable Energy Reviews, 15(6), 3243-3251.

Alam, M.M., Murad, M.W., Noman, A.H.M., Ozturk, I. (2016), Relationships among carbon emissions, economic growth, energy consumption and population growth: Testing Environmental Kuznets Curve hypothesis for Brazil, China, India and Indonesia. Ecological Indicators, 70, 466-479.

Al-Mulali, U. (2014), Investigating the impact of nuclear energy consumption on GDP growth and CO_2 emission: A panel data analysis. Progress in Nuclear Energy, 73, 172-178.

Al-Mulali, U., Weng-Wai, C., Sheau-Ting, L., Mohammed, A.H. (2015), Investigating the environmental Kuznets curve (EKC) hypothesis by utilizing the ecological footprint as an indicator of environmental degradation. Ecological Indicators, 48, 315-323.

Andreoni, V., Galmarini, S. (2016), Drivers in CO_2 emissions variation: A decomposition analysis for 33 world countries. Energy, 103, 27-37.

Antonakakis, N., Chatziantoniou, I., Filis, G. (2017), Energy consumption, CO_2 emissions, and economic growth: An ethical dilemma. Renewable and Sustainable Energy Reviews, 68, 808-824.

Arellano, M., Bond, S. (1991), Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. The Review of Economic Studies, 58(2), 277-297.

Asif, M., Sharma, R.B., Adow, A.H.E. (2015), An empirical investigation of the relationship between economic growth, urbanization, energy consumption, and CO_2 emission in GCC countries: A panel data analysis. Asian Social Science, 11(21), 270.

Attari, M.I.J., Hussain, M., Javid, A.Y. (2016), Carbon emissions and industrial growth: An ARDL analysis for Pakistan. International Journal of Energy Sector Management, 10, 642-658.

Bastola, U., Sapkota, P. (2015), Relationships among energy consumption, pollution emission, and economic growth in Nepal. Energy, 80, 254-262.

Batur, İ., Bayram, I.S., Koc, M. (2019), Impact assessment of supply-side and demand-side policies on energy consumption and CO_2 emissions from urban passenger transportation: The case of Istanbul. Journal of Cleaner Production, 219, 391-410.

Begum, R.A., Sohag, K., Abdullah, S.M.S., Jaafar, M. (2015), CO_2 emissions, energy consumption, economic and population growth in Malaysia. Renewable and Sustainable Energy Reviews, 41, 594-601.

Bennett, A., Kallus, N., Schnabel, T. (2019), Deep Generalized Method of Moments for Instrumental Variable Analysis. Paper presented at the Advances in Neural Information Processing Systems.

Bilgili, F., Koçak, E., Bulut, Ü. (2016), The dynamic impact of renewable energy consumption on CO_2 emissions: A revisited environmental Kuznets Curve approach. Renewable and Sustainable Energy Reviews, 54, 838-845.

Bouznit, M., Pablo-Romero, M.D.P. (2016), CO_2 emission and economic growth in Algeria. Energy Policy, 96, 93-104.

Cai, Y., Sam, C.Y., Chang, T. (2018), Nexus between clean energy consumption, economic growth and CO_2 emissions. Journal of Cleaner Production, 182, 1001-1011.

Charfeddine, L. (2017), The impact of energy consumption and economic development on ecological footprint and CO_2 emissions: Evidence from a markov switching equilibrium correction model. Energy Economics, 65, 355-374.

De Freitas, L.C., Kaneko, S. (2011), Decomposing the decoupling of CO_2 emissions and economic growth in Brazil. Ecological Economics, 70(8), 1459-1469.

Dickey, D.A., Fuller, W.A. (1979), Distribution of the estimators for autoregressive time series with a unit root. Journal of the American statistical association, 74(366a), 427-431.

Dogan, E., Turkekul, B. (2016), CO_2 emissions, real output, energy consumption, trade, urbanization and financial development: Testing the EKC hypothesis for the USA. Environmental Science and Pollution Research, 23(2), 1203-1213.

Dong, K., Sun, R., Li, H., Liao, H. (2018), Does natural gas consumption mitigate CO_2 emissions: Testing the environmental Kuznets curve hypothesis for 14 Asia-Pacific countries. Renewable and Sustainable Energy Reviews, 94, 419-429.

Gökmenoğlu, K., Taspinar, N. (2016), The relationship between CO_2 emissions, energy consumption, economic growth and FDI: The case of Turkey. The Journal of International Trade and Economic Development, 25(5), 706-723.

Govindaraju, V.C., Tang, C.F. (2013), The dynamic links between CO_2 emissions, economic growth and coal consumption in China and India. Applied Energy, 104, 310-318.

Gu, W., Zhao, X., Yan, X., Wang, C., Li, Q. (2019), Energy technological progress, energy consumption, and CO_2 emissions: Empirical evidence from China. Journal of Cleaner Production, 236, 117666.

Hansen, L.P. (1982), Large sample properties of generalized method of moments estimators. Econometrica: Journal of the Econometric Society, 50, 1029-1054.

Haug, A.A., Ucal, M. (2019), The role of trade and FDI for CO_2 emissions in Turkey: Nonlinear relationships. Energy Economics, 81, 297-307.

Jacob, J.A., Osang, T. (2020), Democracy and growth: A dynamic panel data study. The Singapore Economic Review, 65(01), 41-80.

Kasman, A., Duman, Y.S. (2015), CO_2 emissions, economic growth, energy consumption, trade and urbanization in new EU member and candidate countries: A panel data analysis. Economic Modelling, 44, 97-103.

Khan, M.W.A., Panigrahi, S.K., Almuniri, K.S.N., Soomro, M.I., Mirjat, N.H., Alqaydi, E.S. (2019), Investigating the dynamic impact of CO_2 emissions and economic growth on renewable energy production: Evidence from FMOLS and DOLS tests. Processes, 7(8), 496.

Li, T., Wang, Y., Zhao, D. (2016), Environmental Kuznets Curve in China: New evidence from dynamic panel analysis. Energy Policy, 91, 138-147.

Mahmood, H., Alkhateeb, T.T.Y. (2017), Trade and environment nexus in Saudi Arabia: An environmental Kuznets Curve hypothesis. International Journal of Energy Economics and Policy, 7(5), 291-295.

Mert, M., Bölük, G. (2016), Do foreign direct investment and renewable energy consumption affect the CO_2 emissions? New evidence from a panel ARDL approach to Kyoto Annex countries. Environmental Science and Pollution Research, 23(21), 21669-21681.

Ministry of Climate Change and Environment. (2018), National Climate Change Plan of the United Arab Emirates. Available from: https://www.moccae.gov.ae/assets/30e58e2e/national-climate-change-plan-for-the-united-arab-emirates-2017-2050.aspx.

Muhammad, B. (2019), Energy consumption, CO_2 emissions and economic growth in developed, emerging and Middle East and North Africa countries. Energy, 179, 232-245.

Muhammad, B., Khan, S. (2019), Effect of bilateral FDI, energy consumption, CO_2 emission and capital on economic growth of Asia countries. Energy Reports, 5, 1305-1315.

Nain, M.Z., Ahmad, W., Kamaiah, B. (2017), Economic growth, energy consumption and CO_2 emissions in India: A disaggregated causal analysis. International Journal of Sustainable Energy, 36(8), 807-824.

Olivier, J.G., Schure, K., Peters, J. (2017), Trends in Global CO_2 and Total Greenhouse Gas Emissions. PBL Netherlands Environmental Assessment Agency. p5.

Ozturk, I., Acaravci, A. (2016), Energy consumption, CO_2 emissions, economic growth, and foreign trade relationship in Cyprus and Malta. Energy Sources, Part B: Economics, Planning, and Policy, 11(4), 321-327.

Panigrahi, S. (2017), Economic value added and traditional accounting measures for Shareholder's wealth creation. Asian Journal of Accounting and Governance, 8, 125-136.

Pao, H.T., Fu, H.C., Tseng, C.L. (2012), Forecasting of CO_2 emissions, energy consumption and economic growth in China using an improved grey model. Energy, 40(1), 400-409.

Pata, U.K. (2018), Renewable energy consumption, urbanization, financial development, income and CO_2 emissions in Turkey: Testing EKC hypothesis with structural breaks. Journal of Cleaner Production, 187, 770-779.

Perron, P., Phillips, P.C. (1987), Does GNP have a unit root? A re-evaluation. Economics Letters, 23(2), 139-145.

Phillips, P.C., Perron, P. (1988), Testing for a unit root in time series regression. Biometrika, 75(2), 335-346.

Radhi, H. (2009), Evaluating the potential impact of global warming on the UAE residential buildings a contribution to reduce the CO_2 emissions. Building and Environment, 44(12), 2451-2462.

Riti, J.S., Song, D., Shu, Y., Kamah, M. (2017), Decoupling CO_2 emission and economic growth in China: Is there consistency in estimation results in analyzing environmental Kuznets curve? Journal of Cleaner Production, 166, 1448-1461.

Said, S.E., Dickey, D.A. (1984), Testing for unit roots in autoregressive-moving average models of unknown order. Biometrika, 71(3), 599-607.

Saidi, K., Hammami, S. (2015), The impact of CO_2 emissions and economic growth on energy consumption in 58 countries. Energy Reports, 1, 62-70.

Salahuddin, M., Alam, K., Ozturk, I., Sohag, K. (2018), The effects of electricity consumption, economic growth, financial development and foreign direct investment on CO_2 emissions in Kuwait. Renewable and Sustainable Energy Reviews, 81, 2002-2010.

Sarkodie, S.A., Strezov, V. (2019), Effect of foreign direct investments, economic development and energy consumption on greenhouse gas emissions in developing countries. Science of the Total Environment, 646, 862-871.

Shahbaz, M., Balsalobre-Lorente, D., Sinha, A. (2019), Foreign direct investment CO_2 emissions nexus in Middle East and North African countries: Importance of biomass energy consumption. Journal of Cleaner Production, 217, 603-614.

Shahbaz, M., Tiwari, A.K., Nasir, M. (2013), The effects of financial development, economic growth, coal consumption and trade openness on CO_2 emissions in South Africa. Energy Policy, 61, 1452-1459.

Shan, Y., Zheng, H., Guan, D., Li, C., Mi, Z., Meng, J., Ma, Z. (2017), Energy consumption and CO_2 emissions in Tibet and its cities in 2014. Earths Future, 5(8), 854-864.

Stamatiou, P., Dritsakis, N. (2017), Dynamic modeling of causal relationship between energy consumption, CO_2 emissions, and economic growth in Italy. Advances in Applied Economic Research. Berlin, Germany: Springer. p99-109.

Usman, O., Iorember, P.T., Olanipekun, I.O. (2019), Revisiting the environmental Kuznets Curve (EKC) hypothesis in India: The effects of energy consumption and democracy. Environmental Science and Pollution Research, 26(13), 13390-13400.

Wang, S., Li, G., Fang, C. (2018), Urbanization, economic growth, energy consumption, and CO_2 emissions: Empirical evidence from countries with different income levels. Renewable and Sustainable Energy Reviews, 81, 2144-2159.

Wang, S., Li, Q., Fang, C., Zhou, C. (2016), The relationship between economic growth, energy consumption, and CO_2 emissions: Empirical evidence from China. Science of the Total Environment, 542, 360-371.

Wang, S., Zhou, D., Zhou, P., Wang, Q. (2011), CO_2 emissions, energy consumption and economic growth in China: A panel data analysis. Energy Policy, 39(9), 4870-4875.

Wang, W., Li, M., Zhang, M. (2017), Study on the changes of the decoupling indicator between energy-related CO_2 emission and GDP in China. Energy, 128, 11-18.

Yousif, J., Alattar, N., Fekihal, M. (2017), Forecasting models based CO_2 emission for Sultanate of Oman. International Journal of Applied Engineering Research, 12(1), 95-100.

APPENDIX A

Residual leverage plots.
Residual leverage plot for Oman and UAE to identify influential data point