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Effects of energy consumption of top 24 polluted countries on their GDP: New evidence based on natural resources and production of electricity

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Abstract:

Results of rapid economic growth, China, USA, and India have become the largest energy stealer and the greatest emitter of CO2 in the world and burn over 45% of global fuels in 2016. Meanwhile, the developing strategies of 24 polluted countries to decrease the energy consumption without additional economic output. This paper is exploring the effect of world top polluted countries C02 emission and their GDP and the production of electricity by energy indicators. The GLM model is not predict logistic and probit analysis directly; instead, it is mainly used for instinct to response of CO2 emission, using data for the period 1968-2017. The huge production of electricity will cause of abnormal CO2; this study offers true indication of exploring consumption of energy issues from the perspective of Granger casual and a positive unidirectional causality is detected between energy consumption to economic growth, while short-run bidirectional casualty exists among energy indicators.

Keyword: CO2 emission; energy consumption; production of Electricity; GDP

1. Introduction

Fossil fuel: Petroleum fossil fuel, natural gas and coal have estimated at 80% of energy consumption in United States, and highest value recorded 101 quadrillion British thermal units (Btu) record only at 2018, which was 81(Btu) comparatively fossil fuel. Fossil fuel flow is driven by increases in natural gas consumption and petroleum in 2018, and the coal consumption fell by 4.3%. In 2005, USA consumption was in peaked and since then decline 42%. The onset of petroleum, coal, renewable energy and nuclear power plant was major energy indicator of energy consumption in the USA in the period of 18th to 21st centuries. Additionally, the natural gas consumption was reached on turning point with value of 82.1 billion feet per day in 2018, only 37% consumption has been increased in last 8 to 10 years. In 2018, the petroleum product supplied is reached 20.5 million barrels per day relatively 2005. Fig-3 signifies the energy difference between production and consumption in the period of 2010-2016. The renewable energy consumption, which includes hydroelectricity, wind, biomas and solar was 11.4% in 2018 its slightly quite less in 2017.

Highest populated country China coal production has increased ten-fold since than 1960 and a result of fossil-fuel CO2 emission more than doubled alone 2000. The China emission of CO2 have phenomenally increased in the period of 1950 to 1997 and the world largest emitter of CO2 due to fossil-fuel. It recorded annual 5.4% and rapidly growing with huge development. Furthermore, almost half of world cement produced in China 2008, it was 1.38 billion metric tons. Per capita emission rate now stand at 1.34 metric tons of carbon.(Boden et al. 2011, Etemad et al. 1991) China is the third largest natural gas consumption market and highly significant on the economic growth, comparatively other primary energy sources the natural gas has been optimal good choice to resource energy transition because it produces less CO2 emissions. The annual natural gas consumption was 16.26% in 2000 to 2007 with 10.5% average annual economic growth (Fadiran et al. 2019, Li et al. 2019). China natural gas consumption was recorded at 27.381 Cub ft/Day bn in 2018 and it 1.17% increased from 2017. The consumption of petroleum coke (CO2, N2O and CH4) in China is growing rapidly and increased by 18.9% from 2010 to 2016. The petroleum related-CO2, N2O and CH4 emissions reached 28, 143, and 870 million tonnes in 2016, respectively. (Shan et al. 2018, Xu et al. 2018)

China renewable energy is consisting on hydroelectric, solar power, wind power, biofuel, biomass and geothermal. In the field of electricity, China is one of the leading country in form of renewable energy sources and who produce comparatively double electricity from USA. In 2013, the country had produced 378 GW of renewable power, namely from hydrochloric and wind power. Fig-3 signifies the energy difference between production and consumption in the period of 2010-2016.The renewable energy sector of China is growing faster than its fossil fuels and nuclear power. The largest rise of CO2 emissions grew 3% in China since 2013. Hence, in 2013 to 2016, China CO2 emissions fell and shift away from smokestack industries, also renewable energy is source of booming power generation and implement policies to tackle air pollution. Furthermore, China started another construction boom by coal and increased 4.5% production in 2018 and 3.3. % in 2017. With the world's largest population and fastest growing economy, China is far world's top one country from 25 highest CO2 emitters. The China CO2 emission is rapidly growing up cause of huge economic development. In 2017, the CO2 emission from fossil fuel was 46.44% and 74.92% higher from USA and India. Table 1.

Fig 1:

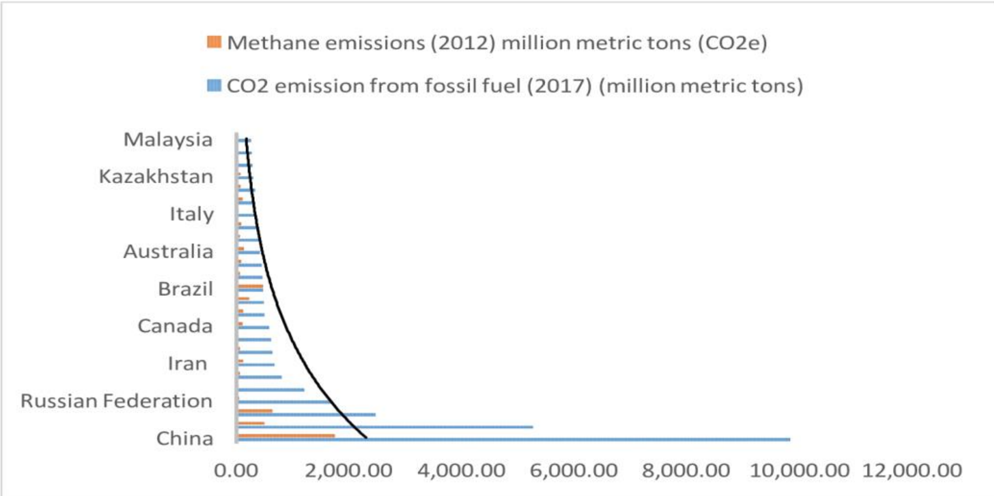

Figure 1: Highest CO2 emission

Carbon dioxide emission of India has increased from 7.1% to 10.1% in 2011 to 2014, which has been stemming from burning of fossil fuel and the cement manufacture. Overall growth of energy consumption will higher for future industries and economic development in India. The non-conventional sources of energy are reduced 11.8% CO2 emission (Gupta et al. 1995, Kumar and Sinha 1995). The fourth largest country is Russia who contribute in CO2 emission after India and 14% overall is recorded with 0.99 kg in 2010 ($GDP). The Russian federation has been declared the level of greenhouse (GHG) emission by 20 to 30% in the period of 1990 to 2030. (Ketenci 2018, Pao and Tsai 2011)

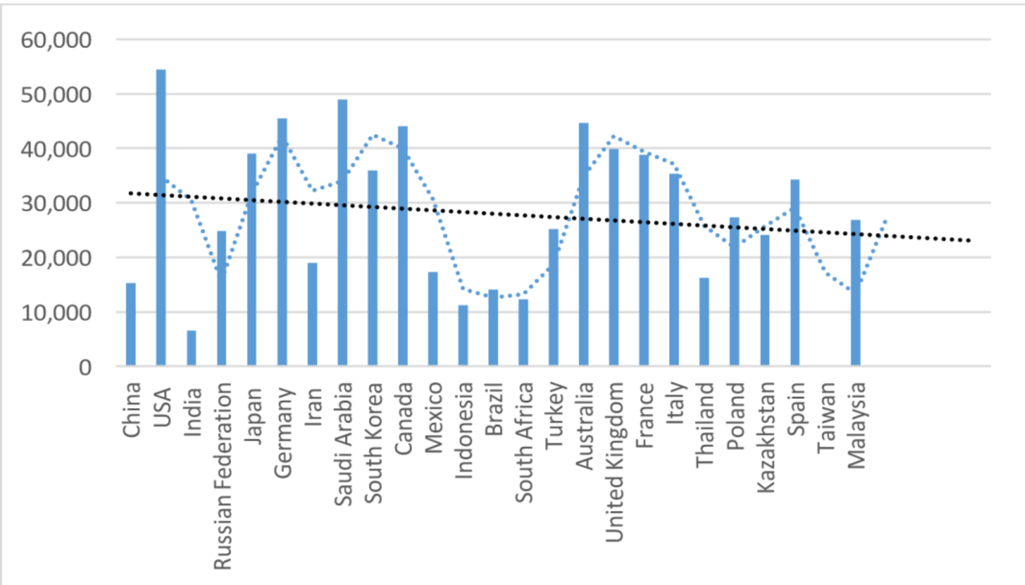

Figure 2: GDP per capita 2017 ($)

Table 1: 25 highest CO2 emitted countries

Countries
China
USA
India
Russian Federation
Japan
Germany
Iran
Saudi Arabia
South Korea
Canada
Mexico
Indonesia
Brazil
South Africa
Turkey
Australia
United Kingdom
France
Italy
Thailand
Poland
Kazakhstan
Spain
Taiwan
Malaysia

The world 15 top countries are responsible for 72% CO2 emission and according to **CEOWORLD** magazine 25 countries ranked nations based on regional emission-CO2 emission from fossil fuel, methane emission, CO2 emission change-published in 2018 Global Carbon Project Table 1. This research paper is based on the explanation of rapid increase in CO2 emission by Petroleum, natural gas, coal, nuclear, biomas, other renewable energy and hydroelectric power, and its effects on GDP of top 24 polluted countries. Furthermore, the question raised on huge production of electricity by natural resources and results of CO2 emission. The question can be answered by important factor of CO2 emission change and individual territory economic development and to identify the force that changes emission.

Monetary term of economic data, Gross Domestic Product (GDP) and per capita of GDP used in early studies to compare energy intensity and not examine top 24 countries of high ranking CO2 emission by economic development. However, energy efficiency indicators are influenced by Petroleum, natural gas, coal, nuclear, Biomas, other renewable energy and hydroelectric with percapita of GDP, therefore, lead to misleading efficiency conclusions. If, such as the economic growth of 24 countries will increase, whereas energy use then economic efficiency indicator will rise although energy use per unit output, does not change.

Sources: Author compiling by the World's Top 25 countries CO2 Emission

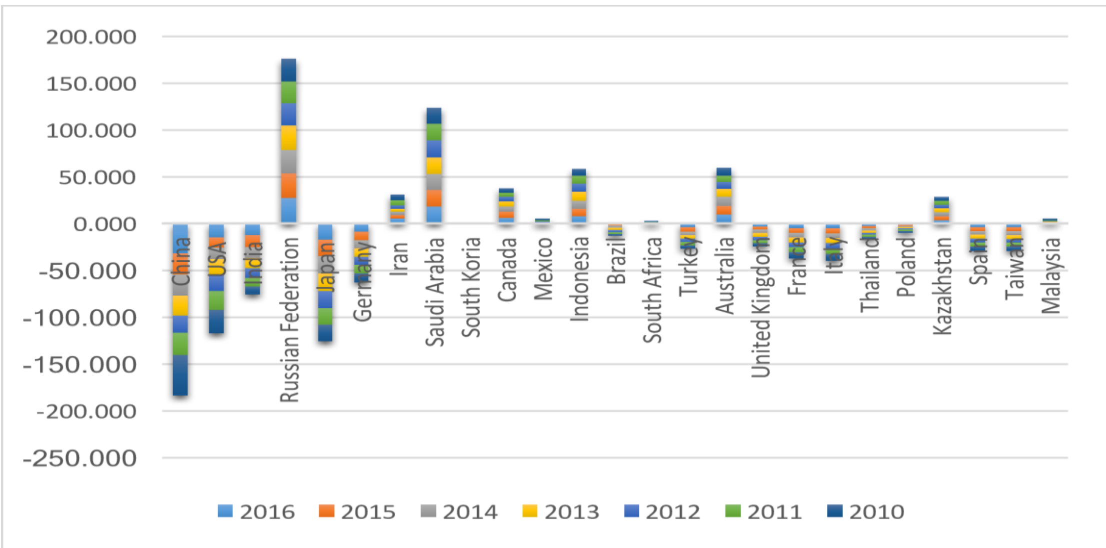

Figure 3: Difference b/w energy production and consumption. Source: US. Energy Information Admiration

The economic growth of countries makes worse environment until it reaches to maximum level of growth, the peak of the Kuznets Curve, at which civilize people are making a free zone of CO2 for living. And using a more advance technology to reduce the impact of CO2 on the economic growth (Kong and Khan 2019). Further, if population and the poverty control by economic development policies, through its effect on rural and urban population for timber and fuel lead to increase in CO2 and therefore causes air pollution. By doing so, the possibility of a bias in result due to population and briskly economic growth are eliminated.(Baek 2017)

This study utilized the GLM method to identify the basic factors that contribute to changes in environment in 24 top polluted countries. Eight indicators Petroleum, natural gas, coal, nuclear, Biomas, other renewable energy and hydroelectric are examined with GDP per capita. The outline of this paper is as follows. After literature, 3rd section is based on methodology, 4th section is based on results and problems and the last section of research paper is indicated recommendation and conclusion of main findings.

2. Literature review

In the early studies, researchers examine the effects of CO2 emission by oil, gas and renewable energy of 79 different countries in the period of 1965-2017 but didn't classify the top 24 countries economic development and CO2 emission level by Petroleum, natural gas, coal, nuclear, Biomas, other renewable energy and hydroelectric.(Valadkhani et al. 2019a) We investigate how changes the primary energy production and consumption individually in panel data of 24 countries. The World Bank database are the reliable source of CO2 emissions has been employed in the current analysis. The effect of primary energy consumption has been elaborated the CO2 emission under optimal thresholds without nuclear and coal emission. And the energy consumption classifies on the bases of income and emission levels (Valadkhani et al. 2019b). The climate change policies have examined and results indicated transport carbon emission increased in top 7 countries. (Solaymani 2019). The EU-27 aggregated energy consumption with LMDI at 3 level and the researcher indicated the R&D, efficiency technologies are main indicating elements of low CO2 emission (Fernández González et al. 2014). The BRICS countries results is analyzed the use of biomass energy consumption to sustainable environment and indicated energy dependency along rapid economic growth.(Aydin 2019) The 17 emerging countries is examined and results shows the change of economic growth and renewable energy consumption. The result show the conservation policies of energy do not have any adverse effect on economic development of 16 countries (Kong and Khan 2019) Some strengths of current analysis in earlier applications, are as follows

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Countries	Study	Database	Econometric techniques	Periods	Outcomes
China	(Kang et al. 2019, Xu and Lin 2019, Xu et al. 2019)	International Energy Agency (IEA)	Non parametric regression model, NARX and VAR model.	2000-2015 1965-2015 2017-2050	Natural gas consumption has effect in the eastern region. The coal consumption adds huge emissions. Impact of CO2 on GDP and a positive shock to CO2.
USA	(Chen et al. 2019, Jiang et	World Input-Output Database (WIOD)	Geographical Detector Model	1995-200	45% global CO2 emission produced from China and USA and production structure effect on environment.
India	(Anandarajah and Gambhir	The Energy Resources Institute (TERI)	TIAM-UCL model	2030-2050	34% energy consumption by renewable energy and 52% in 2050
Russian	(Cheng et al. 2019)	Organization for Economic Cooperation and Development (OECD)	OLS regression	2000-2012	GDP has created negative impacts on CO2 emission in EU-28 countries.
Japan	(Cai et al. 2018)	World Development Indicators (WDI)	ARDL	1965-2015	As a dependent variable the integration exists in Japan
Germany	(González et al. 2019)	EU-13	Dynamic panel data	1990-2105	CO2 emission have been given positive implementation to technological progress and changes.
Iran	(Hosseini et al. 2019)	WDI	multiple linear regression (MLR)	1971-2014	Iran include top CO2 emitted country and 30% increase in 2030.
Saudi Arabia	(Alkhathlan and Javid 2015)	BP Statistical Review of World Energy	Structural Time Series Models (STSMs)	1971-2013	The CO2 emission grow by oil consumption
South Korea	(Jeong et al. 2018)	MFHC Multi-family housing complex	Quartile	CO_2 emission reduction target by 2030	The results indicated CO2 emission benchmark for MFHCs can be applied.
Canada	(Cai et al. 2018)	WDI	ARDL	1970-2015	Canada use energy efficiency to reduce CO2 emission.

Sources: Author compiling by the literature of 10 top countries

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3. Methodology

3.1 Generalized Liner Models (GLMs)

GLM model is mainly to analysis that extended linear regression to non-linear systematic and non-normal stochastic components (McCullagh 1989). The purpose of establishing GLM model in this paper is not to predict logistic and probit analysis directly; instead, it is mainly used for instinct to response individually six (Energy, Natural Gas, Coal Rent, Nuclear Energy, Oil Gas and Coal, and Renewable Energy Consumption) groups of CO2 emission by different structure analysis. CO2 emission hypothesis, we followed the approach (Dong et al. 2018, Kang et al. 2019, Ohashi et al. 2017). The relationship between GDP, Energy, Natural Gas, Coal rent, Nuclear Energy Oil, Gas, Coal Renewable Energy consumption and Total population Eq 1 and GDPG Eq 2 are given as follows:

$$GDP_{it} = \alpha_{it} + \gamma_{1t} + \beta_{1t}CO2_{A_{it}} + \beta_{2t}CO2_{B_{it}} + \beta_{3t}CO2_{C_{it}} + \beta_{4t}TGGE_{it} + \beta_{5t}CO2_{INT_{it}} + \beta_{6t}CO2\_F_{it} + \beta_{7t}PT_{it} + \epsilon_{it} \quad (1)$$

$$GDPG_{it} = \alpha_{it} + \gamma_{2t} + \beta_{8t}CO2\_A_{it} + \beta_{9t}CO2\_B_{it} + \beta_{10t}CO2\_C_{it} + \beta_{11t}TGGE_{it} + \beta_{12t}CO2\_INT_{it} + \beta_{13t}CO2\_F_{it} + \beta_{14t}PT_{it} + \epsilon_{it} \quad (2)$$

Where GDP and GDPG indicates the growth rate and growth rate per capita and i=1….,50 and t=1968,….,2017 divulge the country and time, respectively where the GDP and GDPG effects, which we take from the CO2 emission from Energy, Natural Gas, Coal Rent, Nuclear Energy, Oil Gas and Coal, and Renewable Energy Consumption. α_{it} indicates country fixed effect and $\beta_{1t} - \beta_{14t}$ are parameters for elasticities in Eq 1 and Eq 2, which are indicating each explanatory variable of the panel ϵ_{it}, indicates estimated residual further in each group of variables. Furthermore, the research intention based on causal link between Energy, Natural Gas, Coal Rent, Nuclear Energy, Oil Gas and Coal, and Renewable Energy Consumption with GDP and GDPG. The GLM yield sturdy and useful tool to estimate in a regression and estimated variables are not sternly exogenous, autocorrelation and heteroscedasticity within exist. (Chong et al. 2019, Hosseini et al. 2019). The GLM is applied on individual group to analyze the impact of explanatory variable in each group on CO2 emission.

The Energy consumption is analyzed by energy use and natural resources Eq 3a-3d. and cause of CO2 emission. Natural gas consumption is analyzed by production of electricity and natural gas Eq 4a-4d. and cause of CO2 emission. Coal rent consumption is analyzed by production of electricity and coal rents with causes of CO2 from solid fuel Eq 5a-5d. Nuclear energy consumption is analyzed by production of electricity of nuclear resources and nuclear energy with causes of green gas emission Eq 6a-6d. Oil gas and coal consumption is examined by electricity access and production of electricity from oil gas and coal with causes of intensity of CO2 Eq 7a-7d. Renewable energy consumption is analyzed by renewable and waste combustion and net saving includes emission damages with causes of CO2 from manufacturing industries Eq 8a-8d.

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Group 1: Energy consumption

$$CO2\_A_{it} = a_{it} + \mu_{1t} + \eta_{1t}EG_{it} + \eta_{2t}ANRD_{it} + \partial it \quad (3a)$$

$$\Delta CO2\_A_{it} = a_{1s} + \sum_{k=1}^{q}\mu_{1ik}\ \Delta CO2\_A_{it-k} + \sum_{k=1}^{q}\mu_{2ik}\ \Delta EG_{it-k} + \sum_{k=1}^{q}\mu_{3ik}\ \Delta ANRD_{it-k} + \vartheta_{1i}\varepsilon_{t-k} + \tau_{1i} \quad (3b)$$

$$\Delta EG_{it} = a_{2s} + \sum_{k=1}^{q}\mu_{4ik}\ \Delta CO2\_A_{it-k} + \sum_{k=1}^{q}\mu_{5ik}\ \Delta EG_{it-k} + \sum_{k=1}^{q}\mu_{6ik}\ \Delta ANRD_{it-k} + \vartheta_{2i}\varepsilon_{t-k} + \tau_{2i} \quad (3c)$$

$$\Delta ANRD_{it} = a_{3s} + \sum_{k=1}^{q}\mu_{7ik}\ \Delta CO2\_A_{it-k} + \sum_{k=1}^{q}\mu_{8ik}\ \Delta EG_{it-k} + \sum_{k=1}^{q}\mu_{9ik}\ \Delta ANRD_{it-k} + \vartheta_{3i}\varepsilon_{t-k} + \tau_{3i} \quad (3d)$$

Group 2: Natural gas consumption

$$CO2\_B_{it} = a_{it} + \mu_{2t} + \eta_{3t}EPNG_{it} + \eta_{4t}NGR_{it} + \partial it \quad (4a)$$

$$\Delta CO2\_B_{it} = a_{4s} + \sum_{k=1}^{q}\mu_{10ik}\ \Delta CO2\_B_{it-k} + \sum_{k=1}^{q}\mu_{11ik}\ \Delta EPNG_{it-k} + \sum_{k=1}^{q}\mu_{12ik}\ \Delta ANGR_{it-k} + \vartheta_{2i}\varepsilon_{t-k} + \tau_{4i} \quad (4b)$$

$$\Delta EPNG_{it} = a_{5s} + \sum_{k=1}^{q}\mu_{13ik}\ \Delta CO2\_B_{it-k} + \sum_{k=1}^{q}\mu_{14ik}\ \Delta EPNG_{it-k} + \sum_{k=1}^{q}\mu_{15ik}\ \Delta ANGR_{it-k} + \vartheta_{2i}\varepsilon_{t-k} + \tau_{5i} \quad (4c)$$

$$\Delta ANGR_{it} = a_{6s} + \sum_{k=1}^{q}\mu_{16ik}\ \Delta CO2\_A_{it-k} + \sum_{k=1}^{q}\mu_{17ik}\ \Delta EG_{it-k} + \sum_{k=1}^{q}\mu_{18ik}\ \Delta ANGR_{it-k} + \vartheta_{3i}\varepsilon_{t-k} + \tau_{6i} \quad (4d)$$

Group 3: Coal rent consumption

$$CO2\_C_{it} = a_{it} + \mu_{3t} + \eta_{5t}EPCS_{it} + \eta_{6t}CR_{it} + \partial it \quad (5a)$$

$$\Delta CO2\_C_{it} = a_{2s} + \sum_{k=1}^{q}\mu_{10ik}\ \Delta CO2\_B_{it-k} + \sum_{k=1}^{q}\mu_{11ik}\ \Delta EPNG_{it-k} + \sum_{k=1}^{q}\mu_{12ik}\ \Delta ANGR_{it-k} + \vartheta_{2i}\varepsilon_{t-k} + \tau_{7i} \quad (5b)$$

$$\Delta EPNG_{it} = a_{3s} + \sum_{k=1}^{q}\mu_{13ik}\ \Delta CO2\_B_{it-k} + \sum_{k=1}^{q}\mu_{14ik}\ \Delta EPNG_{it-k} + \sum_{k=1}^{q}\mu_{15ik}\ \Delta ANGR_{it-k} + \vartheta_{2i}\varepsilon_{t-k} + \tau_{8i} \quad (5c)$$

$$\Delta ANGR_{it} = a_{3s} + \sum_{k=1}^{q}\mu_{16ik}\ \Delta CO2\_A_{it-k} + \sum_{k=1}^{q}\mu_{17ik}\ \Delta EG_{it-k} + \sum_{k=1}^{q}\mu_{18ik}\ \Delta ANGR_{it-k} + \vartheta_{3i}\varepsilon_{t-k} + \tau_{9i} \quad (5d)$$

Group 4: Nuclear energy consumption

$$TGGE_{it} = a_{it} + \mu_{4t} + \eta_{7t}EPNS_{it} + \eta_{8t}ANE_{it} + \partial it \quad (6a)$$

$$\Delta TGGE_{it} = a_{2s} + \sum_{k=1}^{q}\mu_{19ik}\ \Delta TGGE_{it-k} + \sum_{k=1}^{q}\mu_{20ik}\ \Delta EPNS_{it-k} + \sum_{k=1}^{q}\mu_{21ik}\ \Delta ANE_{it-k} + \vartheta_{2i}\varepsilon_{t-k} + \tau_{10i} \quad (6b)$$

$$\Delta EPNS_{it} = a_{2s} + \sum_{k=1}^{q}\mu_{22ik}\ \Delta TGGE_{it-k} + \sum_{k=1}^{q}\mu_{23ik}\ \Delta EPNS_{it-k} + \sum_{k=1}^{q}\mu_{24ik}\ \Delta ANE_{it-k} + \vartheta_{2i}\varepsilon_{t-k} + \tau_{11i} \quad (6c)$$

$$\Delta ANE_{it} = a_{2s} + \sum_{k=1}^{q}\mu_{25ik}\ \Delta TGGE_{it-k} + \sum_{k=1}^{q}\mu_{26ik}\ \Delta EPNS_{it-k} + \sum_{k=1}^{q}\mu_{27ik}\ \Delta ANE_{it-k} + \vartheta_{2i}\varepsilon_{t-k} + \tau_{12i} \quad (6d)$$

Group 5: Oil, Gas and Coal consumption

$$CO2\_INT_{it} = a_{it} + \mu_{5t} + \eta_{9t}AE_{it} + \eta_{10t}EPOGC_{it} + \partial it \quad (7a)$$

$$\Delta CO2\_INT_{it} = a_{2s} + \sum_{k=1}^{q}\mu_{28ik}\ \Delta CO2\_INT_{it-k} + \sum_{k=1}^{q}\mu_{29ik}\ \Delta AE_{it-k} + \sum_{k=1}^{q}\mu_{30ik}\ \Delta EPOGC_{it-k} + \vartheta_{2i}\varepsilon_{t-k} + \tau_{13i} \quad (7b)$$

$$\Delta AE_{it} = a_{2s} + \sum_{k=1}^{q}\mu_{31ik}\ \Delta CO2\_INT_{it-k} + \sum_{k=1}^{q}\mu_{32ik}\ \Delta AE_{it-k} + \sum_{k=1}^{q}\mu_{33ik}\ \Delta EPOGC_{it-k} + \vartheta_{2i}\varepsilon_{t-k} + \tau_{14i} \quad (7c)$$

$$\Delta EPOGC_{it} = a_{2s} + \sum_{k=1}^{q}\mu_{34ik}\ \Delta CO2\_INT_{it-k} + \sum_{k=1}^{q}\mu_{35ik}\ \Delta AE_{it-k} + \sum_{k=1}^{q}\mu_{36ik}\ \Delta EPOGC_{it-k} + \vartheta_{2i}\varepsilon_{t-k} + \tau_{15i} \quad (7d)$$

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Group 6: Renewable Energy consumption

$$CO2\_F_{it} = a_{it} + \mu_{6t} + \eta_{11t}CRW_{it} + \eta_{12t}ANSE_{it} + \partial it \quad (8a)$$

$$\Delta CO2\_F_{it} = a_{2s} + \sum_{k=1}^{q} \mu_{36ik}\ \Delta CO2\_F_{it-k} + \sum_{k=1}^{q} \mu_{37ik}\ \Delta CRW_{it-k} + \sum_{k=1}^{q} \mu_{38ik}\ \Delta ANSE_{it-k} + \vartheta_{2i}\varepsilon_{t-k} + \tau_{16i} \quad (8b)$$

$$\Delta CRW_{it} = a_{2s} + \sum_{k=1}^{q} \mu_{39ik}\ \Delta CO2\_F_{it-k} + \sum_{k=1}^{q} \mu_{40ik}\ \Delta CRW_{it-k} + \sum_{k=1}^{q} \mu_{41ik}\ \Delta ANSE_{it-k} + \vartheta_{2i}\varepsilon_{t-k} + \tau_{17i} \quad (8c)$$

$$\Delta ANSE_{it} = a_{2s} + \sum_{k=1}^{q} \mu_{42ik}\ \Delta CO2\_F_{it-k} + \sum_{k=1}^{q} \mu_{43ik}\ \Delta CRW_{it-k} + \sum_{k=1}^{q} \mu_{44ik}\ \Delta ANSE_{it-k} + \vartheta_{2i}\varepsilon_{t-k} + \tau_{18i} \quad (8d)$$

Where i=1…,50 and t=1968,….,2017 for all above six groups in panel data of each country. Alongside, the parameter a_i and μ_t are identified effect with deterministic trend. It is estimated by Engle Granger Table 4, long-term model, indicated in Eq 3a-8d is assessed one period lagged. Furthermore, all above six groups Granger with F-test individually among them. Where the first difference specifies by Δ, as lag of length indicated by q at one conferring to likehood ratio-test, and τ indicate uncorrelated serial error term.

3.2 Source of data and description

This paper investigates into the relationship of CO2 in six groups individually. Additionally, the economic growth and per-captia indicates the dynamic relationship with CO2_A, CO2_B, CO2_C, TGGE, CO2_INT and CO2_F. The level of CO2 emission is analyzed, and its effects on GDP of top 24 polluted countries with huge production of electricity by natural resources in the period of 1968-2017 are selected as the research samples Table 3. Research variables are erected as follow with the meaningful statistics tools in Table 4.

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Table 3: Variables descriptions

Variables	**Symbol**	**Description**	**Data Source**
Natural resources	ANRD	Natural resource depletion and mineral depletion	NY.ADJ.DRES.GN. ZS
Energy use	EG	Primary energy before transformation	EG.USE.PCAP.KG. OE
Energy consumption	**CO2_A**	C02 produced during consumption of solid, liquid and gas	EN.ATM.CO2E.KT
Natural gas	NGR	Natural gas rents and total costs of production	NY.GDP.NGAS. RT. ZS
Production of electricity from natural gas	EPNG	Electricity sources and natural gas	EG.ELC.NGAS.ZS
Natural gas consumption	**CO2_B**	CO2 emission from liquid fuel consumption	EN.ATM.CO2E.GF. KT
Coal rents	CR	Coal rent value and their costs of production.	NY.GDP.COAL. RT. ZS
Production of electricity from coal sources	EPCS	Sources of electricity used to generate electricity	EG.ELC.COAL. ZS
Carbon emission from solid fuel	**CO2_C**	CO2 emissions from consumption of solid fuel	EN.ATM.CO2E.SF. KT
Nuclear Energy	ANE	Non carbohydrate energy does not produce CO2, when generated	EG.USE.COMM.CL. ZS
Production of electricity from nuclear sources	EPNS	Electricity produced by nuclear power plants	EG.ELC.NUCL. ZS
Greenhouse gas emission	**TGGE**	CO2 excluding burning of short cycle biomass	EN.ATM.GHGT. KT. CE
Production of electricity from oil, gas, and coal sources	EPOGC	Oil, gas and liquids is source of electricity	EG.ELC.FOSL. ZS
Electricity access	AE	Electrification data collected from industries	EG.ELC.ACCS. ZS
Intensity of Carbon dioxide	**CO2_INT**	CO2 emission from use of coal as source of energy	EN.ATM.CO2E.EG. ZS
Net saving includes emission damages	ANSE	Natural savings and particular emissions damage.	NY.ADJ.SVNG.GN. ZS
Renewable and waste combustion	CRW	Combustible renewables as percentage of energy use	EG.USE.CRNW. ZS
Carbon emission from manufacturing industries	**CO2_F**	CO2 emissions from combustion of fuels industry	EN.CO2.MANF. ZS
Total population	**PT**	De facto population	SP.POP.TOTL
Growth of domestic product	**GDP**	Annual percentage growth on local currency	NY.GDP.MKTP.KD. ZG
Per-capita growth (GDP)	**GDPG**	Annual percentage growth rate of GDP	NY.GDP.PCAP.KD. ZG

Sources: Selection based on accessibility of database. Variable's definition indicated in **Table 3**

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Table 4: Descriptive statistics

Descriptive analysis		Mean	Median	Std. Dev.	Observations
Energy consumption	**ANRD**	2.848	1.236	4.516	1030
	EG	2848.151	2512.106	2080.778	1059
	CO2_A	754203.900	346876.200	1336399.000	1021
Natural gas consumption	**NGR**	0.370	0.068	0.771	1032
	EPNG	16.525	8.180	20.226	1071
	CO2_B	121734.000	46985.270	248984.800	1021
Coal rent consumption Coal rent consumption	**CR**	0.411	0.048	0.901	1028
	EPCS	35.664	27.698	30.069	1071
	CO2_C	308747.000	72293.070	768653.000	1044
Nuclear energy consumption	**ANE**	6.312	2.941	8.429	1058
	EPNS	8.005	0.316	14.958	1059
	TGGE	1160331.000	550135.800	1649953.000	997
Oil, Gas and Coal consumption	**EPOGC**	68.787	75.064	24.639	1071
	AE	95.263	100.000	12.024	559
	C02_INT	2.703	2.623	0.955	993
Renewable energy consumption	**ANSE**	9.260	8.738	7.136	600
	CRW	9.802	3.880	14.474	1059
	CO2_F	23.270	21.289	11.517	1047
GDP effects	**PT**	153000000.000	57000451.000	281000000.000	1195
	GDP	3.846	3.707	4.809	1075
	GDPG	2.483	2.544	4.602	1075

Sources: Reckoning by authors. Variable's definition indicated in **Table 3** .

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4. Empirical estimation results and discussions

Table 1, indicates the Energy, Natural Gas, Coal rent, Nuclear Energy Oil, Gas and Coal Renewable Energy consumption, variables mean in the period of 1968-2017, and countries analyzed by the type of CO2 emission individually. In each group CO2_A, CO2_B, CO2_C, TGGE, CO2_INT and CO2_F have been statistically tested individual with explanatory variables. The descriptive statistics test is applied to judge whether the explanatory variable in each group individually employed with response variables. The China (CO2_C), USA (CO2_A, CO2_B, TGGE), Saudi Arabia (CO2_INT) and Korea (CO2_F) are indicated the highest mean value Fig 1 While, Korea, Malaysia, Indonesia (CO2_A, CO_B), Iran Islamic Republic, Malaysia, Mexico (C02_C, TGGE), Indonesia, Brazil and Russian Federation (CO2_F) register the lowest mean. The highest mean value concludes that all predictor with CO2_A, CO2_B, CO2_C, TGGE, and CO_F is integrated countries economic development. Table 7 indicate the correlation, relationship between carbon emission and selected instrumental variables, emanation such as CO2_A, CO2_B, CO2_C, TGGE, and CO_F were noticed. The results computed by Generalized Linear Model (GLM) and in order to remove inconvenience, consider stationary test by 1st generation unit root test and individual intercept in level. The most of statistics test is reject the null hypothesis, including the variables are stationary at level in individual groups.

4.1 Unit root and co-integration

Before statistically analysis, the unit root test is applied by ADF, PP, LLC, IPS and BR whether the variables in group A (ANRD, EG, CO2_A), group B (NGR, EPNG, CO2_B), group C (CR, EPCS, CO2_C), group D (ANE, EPNS, TGGE), group E (EPOGC, AE, CO2_INT), group F (ANSE, CRW, CO2_F) and group G (PT, GDP, GDPG) have unit-root or not. Most of statistically test rejected the null hypothesis, including the selected variables are stationary at level and in the same order variables are tested, whether the co-integration exist among the variables or not. In 1st step VAR is estimated and model prove to be stable Table 5. Furthermore, all the six group variables are tested by co-integration methods reject the null hypothesis and there is no co-integration relationship among variables. (Kao C 1995, P. 2004).

4.2 Pairwise Granger causality test

Granger causality test is applied for confirm whether an endogenous treated as exogenous in individual groups. Ahead, selected variables are co-integrated, a panel Vector Error Correlation (VEC) is assessed in order to perform Granger Causality Test (GCT) among variables Table 6. Additionally, we cull the null hypothesis that CO2_A does not granger cause EG and ANRD and EG does not granger cause of ANRD and vice versa found in Energy consumption.

In the Natural Gas, Coal rent, Nuclear Energy Oil, Gas and Coal Renewable Energy consumption, CO2_B, CO2_C, TGGE, CO2_INT and CO2_F does not granger cause of EPNG, EPCS, TGGE, EPOGC and CRW. (Emirmahmutoglu and Kose 2011, Hao et al. 2018, Pao and Tsai 2011). It is remarkable that though an excessive number of researcher examining the relationship of energy consumption with economic growth, very few on the group consumptions. Moreover, a consent has not been made China energy consumption between economic development. USA and India 2nd highest level of energy consumption cause of economic changes, the panel data of 24 top polluted countries examine in the six different groups of consumption. In contrast literature examined unidirectional causality running from output to Energy, Natural Gas, Coal rent, Nuclear Energy Oil, Gas and Coal Renewable Energy consumption (Cheng et al. 2017, Herrerias et al. 2013, Liang et al. 2019, Lin et al. 2018, McGee and Greiner 2019, Wolde-Rufael and Menyah 2010). It should also be noted that many countries except China, still user of bulky of natural resources, Natural gas, Coal rent, Nuclear energy and renewable energy in different group consumption. The offered literature has already inveterate that the use of coal rent, natural gas, nuclear energy and renewable energy would impede economic development (Dong et al. 2019, Jin and Kim 2018).

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Natural gas to electricity causality and vice versa found (Uribe et al. 2018). USA and China play important role to production of electricity by Coal and is a crucial factor for economic growth (Morales Pedraza 2019, Wang et al. 2019). The USA provided substantial electricity by Nuclear power and economically meaningful increase in capacity of production (Karney 2019). The production of electricity by different fuel sources (oil, coal and water) and prices of coal and oil are similar, found in the in the long run (Kharbach and Chfadi 2018).

The results of estimation may be the reason of Granger causality for Natural Gas, Coal rent, Nuclear Energy Oil, Gas and Coal Renewable Energy consumption. The conclusion that ANRD, EG, NGR, EPNG, CR, EPCS, ANE, EPNS, EPOGC, AE, ANSE and CRW are not a Granger cause of CO2_A, CO2_B, CO2_C, TGGE, CO2_INT and CO2_F differs from the earlier study, some prior research using mass of macro data, as most of earlier research found positive effect on ANRD, CR, EPCS and ANSE on CO2_A, CO2_B, CO2_C (Acheampong 2018, Mezghani and Ben Haddad 2017). However, one possible reason for disparity may be that this study emphases on the 25 polluted countries except Taiwan, while the majority of previous study have already discussed the environmental causes of GDP but this study determined the six different groups of emission and individual effect of each variable with CO2_A, CO2_B, CO2_C, TGGE, CO2_INT and CO2_F.

Moreover, the Granger causality existence from energy consumption to ANRD, EG, NGR, EPNG, CR, EPCS, ANE, EPNS, EPOGC, AE, ANSE and CRW specifies that the level of growth. Energy consumption precedes to increase of ANRD, EG, NGR, EPNG, CR, EPCS, ANE, EPNS, EPOGC, AE, ANSE and CRW in 24 top polluted countries, which can be assumed as a feature of individual country economic growth. There is a caution that the co-existent casualty in the coherent might not be occur though the calculated results, it suggests that the presence of Granger causality. Test results is indicated significant causality among the variables. Almost, a uni-directional casualty could run from energy consumption and its effected on GDP. In fact, however, if CO2_A, CO2_B, CO2_C, TGGE, CO2_INT and CO2_F is mismanaged into barren economic sectors, then economic growth of individual state valor be insignificant or fail to occur at all and create big problems for nations.

4.3 Particular analysis by GLM

After computation of the Granger causality among the variables, specify the relationship and it is needed by Generalized Linear Model (GLM), that linear regression to permit non-linear systematic components with non-normal stochastic in each group of energy consumption (Hardin 2007 , McCullagh 1989). The conclusions of covariance of GLM by GDP are obtained presented in following Table 3. The covariance of reliant variables is estimated with GDPG in Ordinary and Huber-White. It can be observed that CO2_A, CO2_B, CO2_C, TGGE, CO2_INT and CO2_F positively effect GDPG at the significant level of 1% in the long term and that 1% increase in energy consumption CO2_A, will cause of GDPG increase with a 2.238. Additionally, a 1% increase in CO2_B, CO2_C, TGGE, CO2_INT and CO2_F will cause a 0.436, 2.277,2.435 and 2.953 increase in GDPG. The impact of CO2_A, CO2_B, CO2_C, TGGE, CO2_INT, CO2_F and GDPG is also positive at significant level of 1% and 1% rise is related to an increase in the GDPG results Table 3. The individual state consumption is stated in Figure 4. Furthermore, the group covariance individually computed with Wald test. The impact of CO2_A, TGGE and CO2_INT is indicating negative significant level of 1% in ANRD, ANE and AE with 11.248, 3.145 and 0.913 Wald test.

4.4 Additional analysis

The above analysis implies the influence of each group and employed on the other variables. Conversely, the result does not specify the 10 years' period of Energy, Natural gas, Coal rent, Nuclear energy, Oil gas and Coal, and Renewable energy consumption. Furthermore, the stepwise regression, indicate five periods and each period is consisted 10 years 'duration Table 7.

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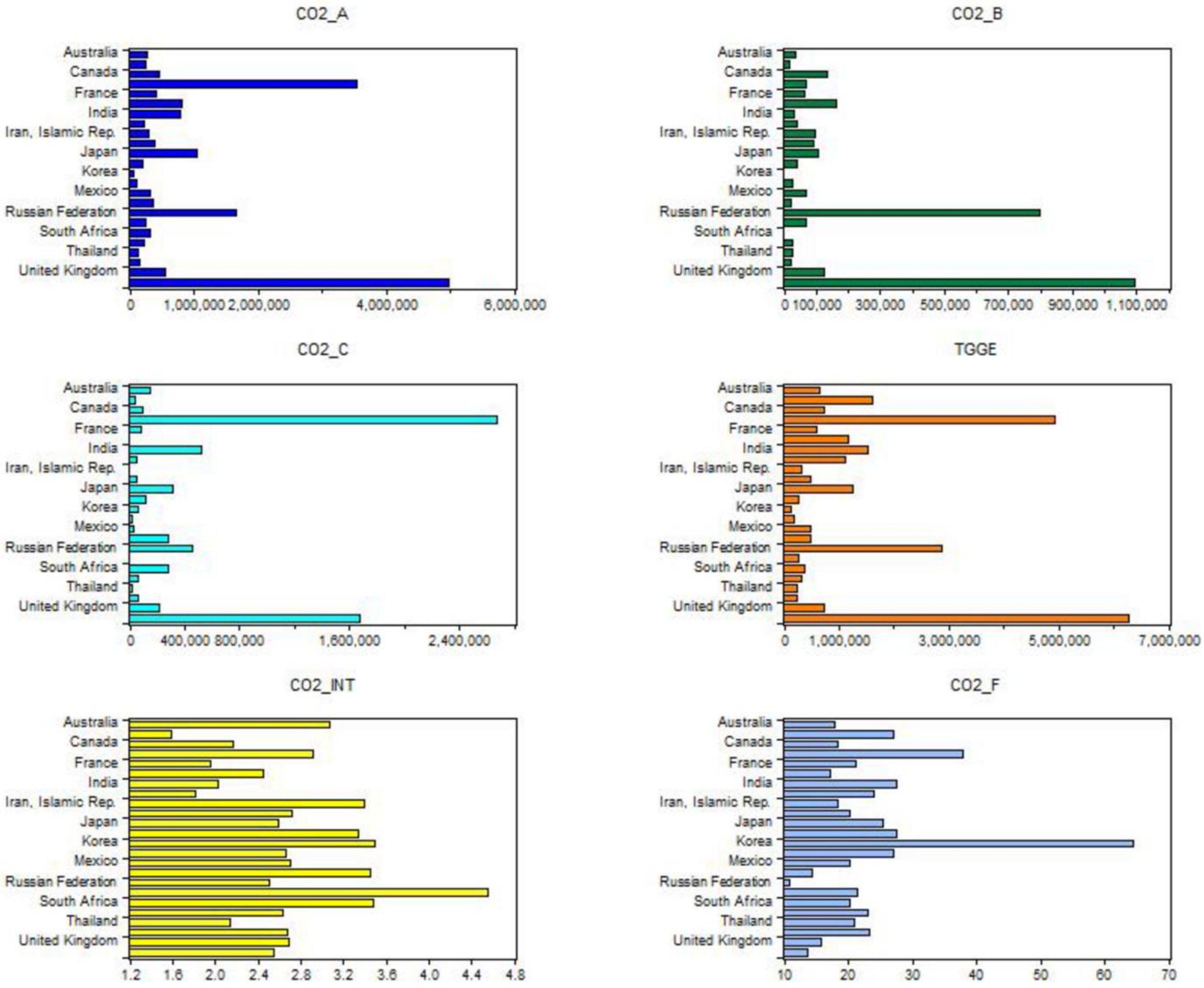

Figure 4: Countries distribution by mean

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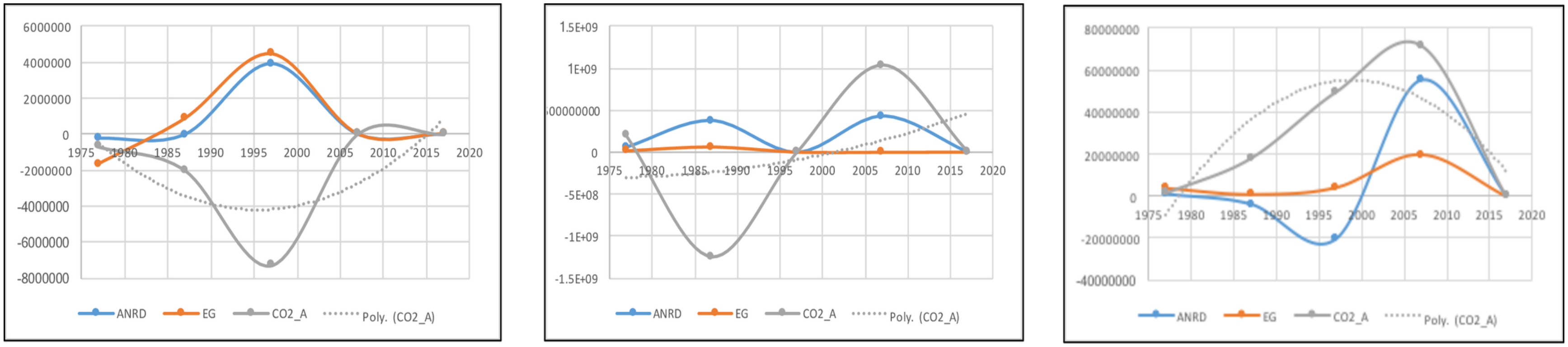
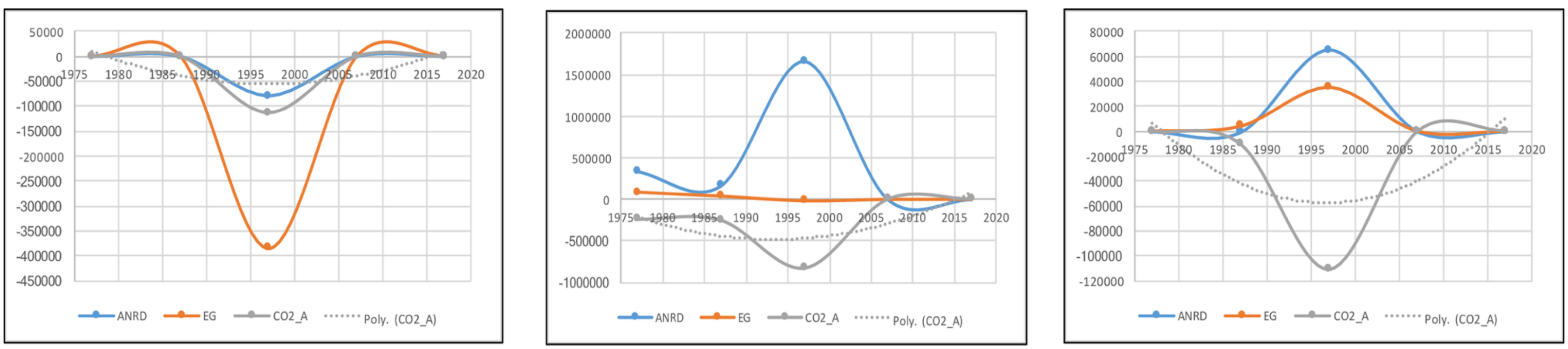


China consumption *USA consumption* *India consumption*

Figure 5: High level of consumption

The 1st period of Energy consumption is indicated negative at significant level of 1% and employ that 1% increase CO2_A is related to decrease 1% in ANRD and EG. In the Natural gas consumption 1st and 3rd periods are specified negative at significant level and 1% increase in CO2_B is related to decrease NGR and EPNG. However, 4th and 5th period is specified positive at the significant level of 1% that a 1% rise in CO2_A, CO2_B, CO2_C, TGGE, CO2_INT and CO2_F are employed that 1% used of ANRD, NGR, EPNG, CR, EPCS, and ANE. The estimated results are influence of a shock of specific periods on group of the variables. This paper utilizes individual states energy consumption and their impact, computation of results shown in Fig 5 and Fig 6 with high and low level of consumption.



Kazakhstan consumption *Spain consumption* *Malaysia consumption*

Figure 6: Low level of consumption

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Group A [t-test]	ANRD (-1)	ANRD (-2)	EG (-1)	EG (-2)	CO2_A (-1)	CO2_A (-2)
ANRD	0.841[25.502]	0.072[2.206]	0.000[-0.032]	0.000[-0.003]	0.000[0.796]	0.000[-0.821]
EG	3.676[1.525]	3.525[1.470]	1.028[27.910]	-0.028[-0.763]	0.000[2.291]	0.000[-2.311]
CO2_A	(755.402) [-0.767]	1446.458[1.475]	(81.432) [-5.407]	77.684[5.110]	1.700[58.061]	(0.692) [-22.764]
Group B [t-test]	NGR (-1)	NGR (-2)	EPNG (-1)	EPNG (-2)	CO2_B (-1)	CO2_B (-2)
NGR	1.029[30.557]	(0.128) [-3.739]	(0.002) [-0.660]	0.004[1.312]	0.000[2.103]	0.000[-2.019]
EPNG	0.317[0.852]	(0.406) [-1.073]	1.150[33.597]	(0.154) [-4.444]	0.000[-0.010]	0.000[-0.032]
CO2_B	(2363.177) [-1.640]	2431.678[1.664]	176.159[1.331]	(157.399) [-1.174]	1.133[32.576]	(0.129) [-3.695]
Group C [t-test]	CR (-1)	CR (-2)	EPCS (-1)	EPCS (-2)	CO2_C (-1)	CO2_C (-2)
CR	0.670[20.059]	0.142[4.279]	(0.001) [-0.217]	0.005[0.774]	0.000[0.964]	0.000[-0.979]
EPCS	0.039[0.211]	0.261[1.437]	0.990[29.446]	(0.004) [-0.105]	0.000[0.093]	0.000[-0.091]
CO2_C	(2224.419) [-0.828]	3786.855[1.421]	(1644.893) [-3.335]	1645.273[3.355]	1.676[58.142]	(0.666) [-21.959]
Group D [t-test]	ANE (-1)	ANE (-2)	EPNS (-1)	EPNS (-2)	TGGE (-1)	TGGE (-2)
ANE	0.977[17.483]	0.016[0.276]	0.164[5.353]	(0.155) [-5.043]	0.000[0.400]	0.000[-0.332]
EPNS	0.087[0.871]	(0.099) [-0.980]	1.284[23.492]	(0.277) [-5.032]	0.000[-0.071]	0.000[0.106]
TGGE	(19665.7) [-1.065]	22779.000[1.226]	8362.019[0.828]	(10844.630) [-1.066]	0.696[21.843]	0.333[10.166]
Group E [t-test]	EPOGC (-1)	EPOGC (-2)	AE (-1)	AE (-2)	CO2_INT (-1)	CO2_INT (-2)
EPOGC	0.924[17.984]	0.077[1.483]	(0.054) [-0.725]	0.050[0.702]	1.602[1.263]	(1.967) [-1.553]
AE	0.036[1.478]	(0.023) [-0.963]	0.529[15.075]	0.404[12.162]	0.112[0.187]	(0.716) [-1.207]
CO2_INT	(0.001) [-0.565]	0.002[0.795]	(0.003) [-1.097]	0.003[0.961]	0.866[17.336]	0.096[1.934]
Group F [t-test]	ANSE (-1)	ANSE (-2)	CRW (-1)	CRW (-2)	CO_F (-1)	CO_F (-2)
ANSE	0.840[18.716]	0.027[0.631]	(0.394) [-1.751]	0.378[1.716]	0.116[1.785]	(0.048) [-0.754]
CRW	0.006[0.747]	(0.014) [-1.678]	1.160[25.769]	(0.179) [-4.068]	(0.022) [-1.741]	0.012[0.975]
CO_F	(0.026) [-0.877]	0.031[1.067]	(0.131) [-0.859]	0.142[0.948]	0.764[17.195]	0.199[4.554]

Table 5: Estimation by VAR

Sources: Reckoning by authors. Variable's definition indicated in **Table 3.** VAR estimation were estimated with individual group restrictions and provide first lag coefficients of each group with t-test.

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Table 6:Pairwise Granger Causality Test

Distribution	Null Hypothesis	F-Statistics
Energy consumption	EG does not Granger Cause CO2_A	22.529***
	CO2_A does not Granger Cause EG	2.026*
	ANRD does not Granger Cause CO2_A	0.695*
	CO2_A does not Granger Cause ANRD	1.098*
	ANRD does not Granger Cause EG	25.303***
	EG does not Granger Cause ANRD	0.899*
Natural gas consumption	EPNG does not Granger Cause CO2_B	1.486*
	CO2_B does not Granger Cause EPNG	0.576*
	NGR does not Granger Cause CO2_B	1.478*
	CO2_B does not Granger Cause NGR	4.00***
	NGR does not Granger Cause EPNG	0.820*
	EPNG does not Granger Cause NGR	8.860***
Coal rent consumption	EPCS does not Granger Cause CO2_C	5.198***
	CO2_C does not Granger Cause EPCS	0.101*
	CR does not Granger Cause CO2_C	1.214*
	CO2_C does not Granger Cause CR	0.508*
	CR does not Granger Cause EPCS	3.583***
	EPCS does not Granger Cause CR	12.524***
Nuclear energy consumption	EPNS does not Granger Cause TGGE	1.516*
	TGGE does not Granger Cause EPNS	0.059*
	ANE does not Granger Cause TGGE	0.94*
	TGGE does not Granger Cause ANE	0.280*
	ANE does not Granger Cause EPNS	0.392*
	EPNS does not Granger Cause ANE	16.941***
Oil, Gas and Coal consumption	AE does not Granger Cause CO2_INT	1.031***
	CO2_INT does not Granger Cause AE	1.802*
	EPOGC does not Granger Cause CO2_INT	14.266***
	CO2_INT does not Granger Cause EPOGC	0.648*
	EPOGC does not Granger Cause AE	2.659**
	AE does not Granger Cause EPOGC	0.161*
Renewable Energy consumption	CRW does not Granger Cause CO2_F	2.492*
	CO2_F does not Granger Cause CRW	0.756*
	ANSE does not Granger Cause CO2_F	0.655*
	CO2_F does not Granger Cause ANSE	7.376***
	ANSE does not Granger Cause CRW	7.148***
	CRW does not Granger Cause ANSE	3.148***

Sources: Reckoning by authors. Variable's definition indicated in **Table 3** *** specifies the significance levels at 1% ** specifies the significance levels at 5% * specifies the significance levels at 10

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Table 7: Covariance of GLM by GDPG

Variables	GDPG		CO2_A		CO2_B		CO2_C		TGGE		CO2_INT	
Cov.	Ordinary	Huber-White	Ordinary	Huber-White	Ordinary	Huber-White	Ordinary	Huber-White	Ordinary	Huber-White	Ordinary	Huber-White
GDPG			(2.238)***	(-1.836)**	(0.436)***	(0.344)**	2.277***	1.978***	2.435***	2.586***	2.953***	1.177**
CO2_A	(2.239)***	(1.913)***			32.626***	21.572***	36.245***	17.555***	11.833***	14.330***	2.681***	4.200***
CO2_B	(0.437)**	(0.341)**	32.620***	15.149***			(46.465)***	(19.122)***	6.660***	7.531***	1.295**	2.610***
CO2_C	2.277***	2.052***	36.245***	18.615***	(46.465)***	(43.388)***			7.438***	8.589***	3.591***	6.936***
TGGE	2.243***	2.535***	11.833***	5.624***	6.660***	3.778***	7.438***	4.283***			(9.354)***	(7.431)***
CO2_INT	2.954***	1.414**	11.833***	3.908***	1.295**	1.812***	3.591***	3.119***	(9.354)***	(4.788)***		
CO2_F	1.604**	1.558**	2.681***	0.244**	(10.871)***	(-8.406)***	(2.592)***	(2.626)***	7.546***	10.040***	(0.529)***	(0.574)**

Note: Variable's definition indicated in **Table 3** *** specifies the significance levels at 1% ** specifies the significance levels at 5% * specifies the significance levels at 10%. **Sources:** Reckoning by authors

Table 8: Padroni Residual Co-integration Modified table by Weighted level

Distribution	Dimensions	Panel v-Statistic	Panel rho-Statistic	Panel PP-Statistic	Panel ADF-Statistic
Energy consumption	Within	5.283***	(1.833)***	(4.157)***	(1.744)***
	Between		0.224**	(3.088)***	(1.595)***
Natural gas consumption	Within	1.749**	1.711**	1.199**	2.562**
	Between		1.262**	(0.851)**	1.103**
Coal rent consumption	Within	(0.291)**	2.488**	(0.433)**	2.41**
	Between		0.373**	(2.122)***	(0.148)**
Nuclear energy consumption	Within	5.562***	(1.261)**	(4.168)***	(2.712)***
	Between		0.028**	(4.701)***	(1.761)***
Oil, Gas and Coal consumption	Within	(1.705)**	0.192**	(2.803)***	(4.354)***
	Between		1.027**	(2.716)***	(1.284)***
Renewable energy consumption	Within	(2.366)**	1.191**	(3.486)***	(0.250)**
	Between		1.329**	(4.620)***	(1.905)***

Note: Variable's definition indicated in **Table 3** *** specifies the significance levels at 1% ** specifies the significance levels at 5% * specifies the significance levels at 10%. **Sources:** Reckoning by authors

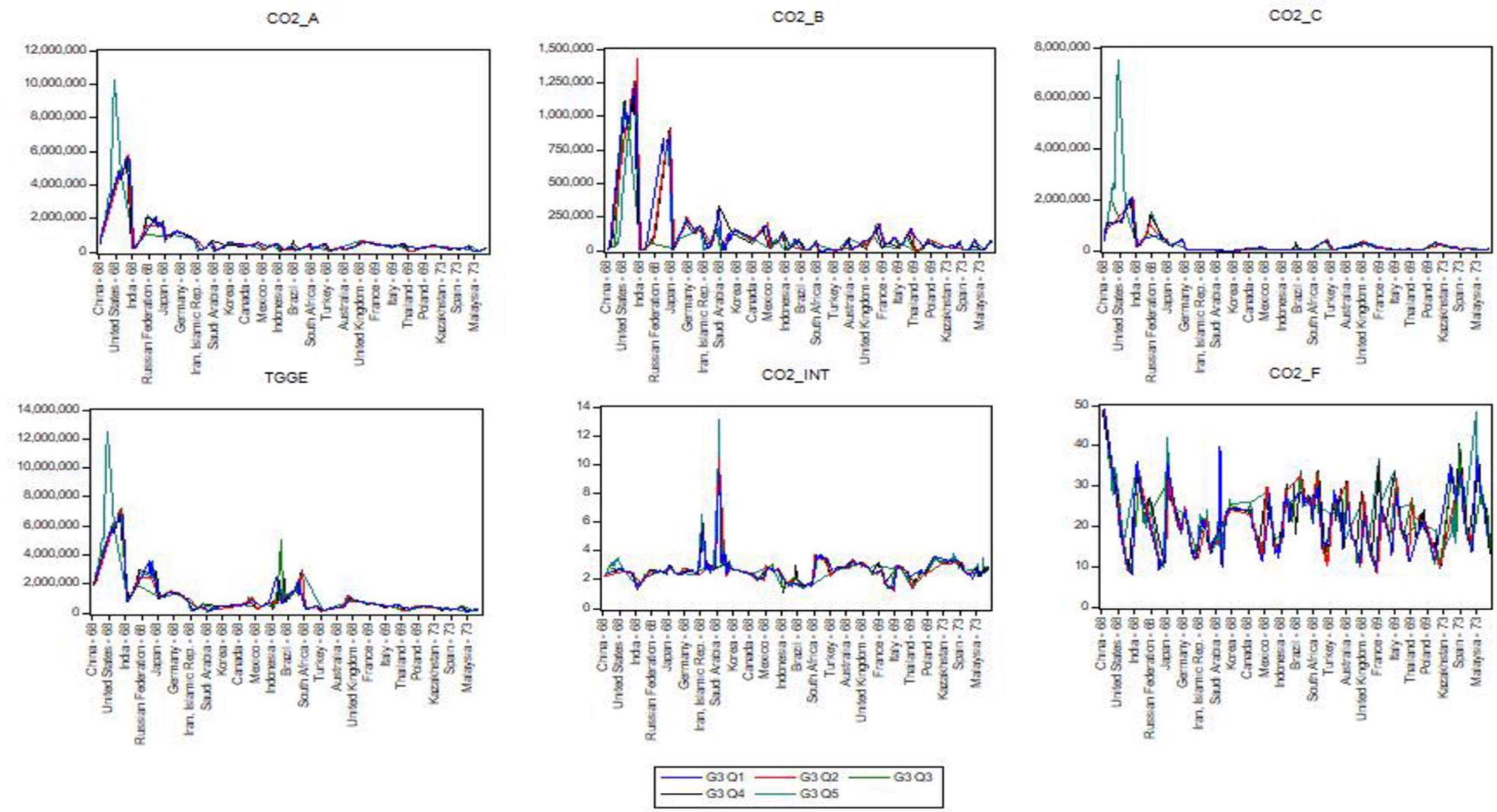

Figure 7: Consumption level by individual state

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Table 9: Covariance of GLM by groups

Variables	ANRD		EG		CO2_A		Wald-test
Covariance	Ordinary	Huber-White	Ordinary	Huber-White	Ordinary	Huber-White	
ANRD			(1.114)**	(1.1318)**	(2.253)***	(4.949)***	2.831***
EG	(1.114)**	(1.318)***			11.248***	7.896***	(2.253) ***
CO2_A	(2.253)***	(3.752)***	11.248***	6.047***			11.248***
	NGR		EPNG		CO2_B		
NGR			12.308***	7.314***	9.984***	9.381***	7.804***
EPNG	12.308***	11.089***			1.228**	1.986***	9.984***
CO2_B	9.984***	4.782***	1.228**	2.067***			1.228**
	CR		EPCS		CO2_C		
CR			18.697***	8.263***	3.125***	1.870**	0.554**
EPCS	18.694***	12.749***			7.795***	7.048***	3.125***
CO2_C	3.125***	2.038***	7.795***	6.032***			7.795***
	ANE		EPNS		TGGE		
ANE			69.596***	47.339***	(2.535)***	(4.198)***	16.684***
EPNS	69.596***	77.593***			3.145***	4.512***	(2.535)***
TGGE	(2.535)***	(4.485)***	3.145***	4.706***			3.145***
	EPOGC		AE		CO2_INT		
EPOGC			(0.358)**	(0.173)**	24.442***	23.864***	11.681***
AE	(0.358)**	(0.143)**			(0.913)**	(0.353)**	24.442***
CO2_INT	24.442***	19.584***	(0.913)**	(0.347)***			(0.913)**
	ANSE		CRW		CO2_F		
ANSE			1.360**	1.060***	8.198***	5.659***	36.042***
CRW	1.360**	1.041**			10.542***	11.380***	8.198***
CO2_F	8.198***	5.516***	10.542***	9.354***			10.542***

Note: Variable's definition indicated in **Table 3** *** specifies the significance levels at 1% ** specifies the significance levels at 5% * specifies the significance levels at 10%. **Sources:** Reckoning by authors

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Table 10: Stepwise regression

	Variables	Periods				
		1st	2nd	3rd	4th	5th
		1968-1977	1978-1987	1988-1997	1998-2007	2008-2017
Energy consumption	**ANRD**	4.800***	(0.379)**	3.655***	8.222***	4.744***
	EG	3.332***	(0.631)**	(0.628)**	0.610**	(2.124)***
	CO2_A	(0.933)**	2.997***	3.161***	6.277***	6.318***
Natural gas consumption	**NGR**	0.502**	1.789**	(2.631)***	4.360***	0.784**
	EPNG	3.059***	(2.936)***	6.181***	2.858***	1.367**
	CO2_B	(0.918)**	1.144**	(0.256)**	1.557**	0.848**
Coal rent consumption	**CR**	(1.347)**	(0.376)**	(5.083)**	1.886**	0.434**
	EPCS	2.802***	1.701***	5.996***	5.834***	3.358***
	CO2_C	0.837**	2.919***	2.575***	3.947***	4.274**
Nuclear energy consumption	**ANE**	4.394***	1.118**	1.322**	1.842**	0.946**
	EPNS	(0.906)**	(0.360)**	(0.848)**	(1.345)**	(1.325)**
	TGGE	1.783**	3.463***	4.092***	8.350***	5.601***
Oil, Gas and Coal consumption	**EPOGC**	-	-	0.411**	(1.883)**	(1.444)**
	AE	-	-	(1.126)**	(2.845)***	(3.019)***
	C02_INT	-	-	0.986**	4.862***	3.485***
Renewable energy consumption	**ANSE**	-	-	6.378***	(0.122)**	3.568***
	CRW	-	-	0.496**	(1.436)**	1.359**
	CO2_F	-	-	1.109**	7.257***	0.974**

Note: Variable's definition indicated in **Table 3** *** specifies the significance levels at 1% ** specifies the significance levels at 5% * specifies the significance levels at 10%. **Sources:** Reckoning by authors

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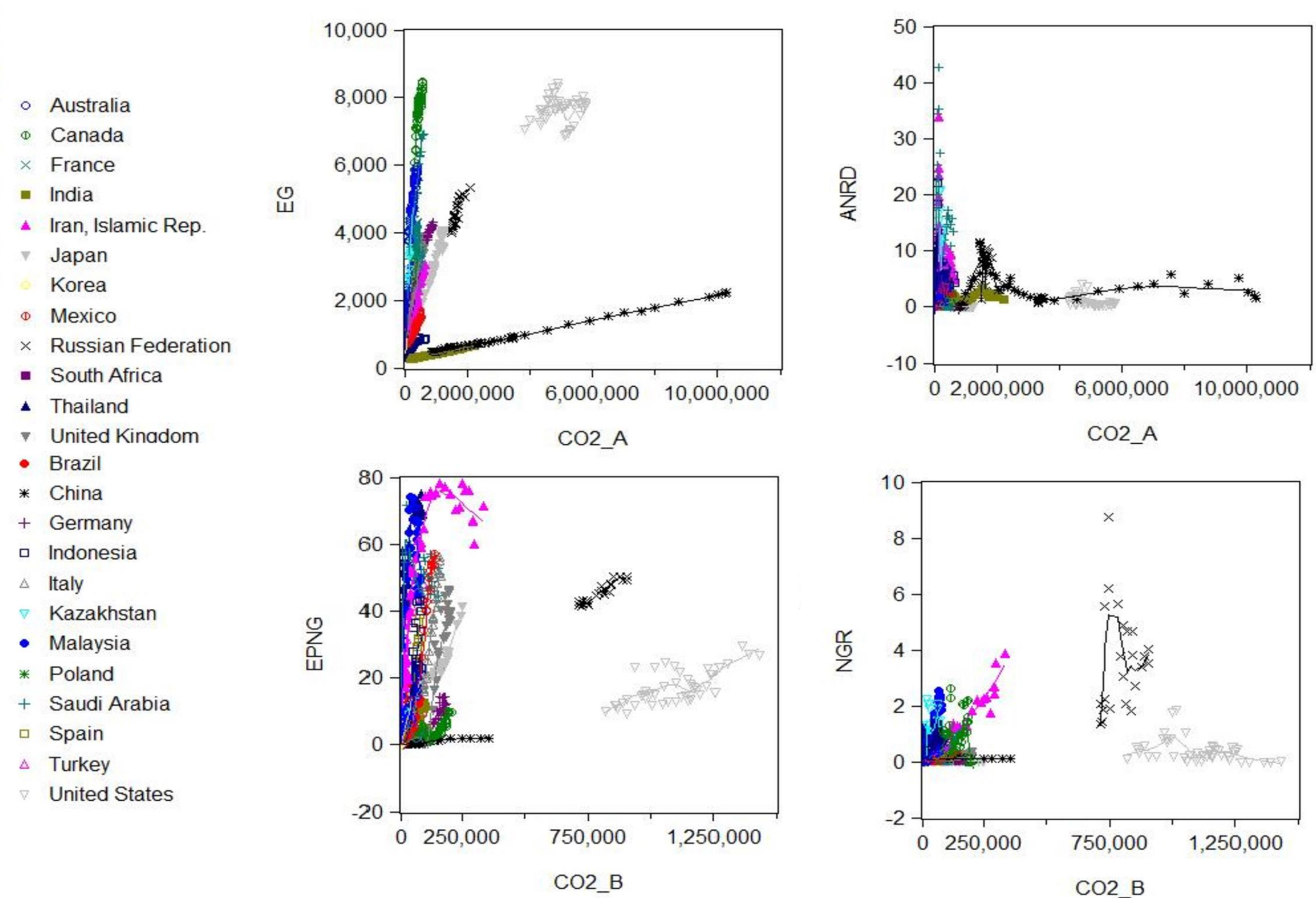

Figure 8: Group A & B

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Table 11: Correlation

Cor.	ANRD	EG	CO2_A	NGR	EPNG	CO2_B	CR	EPCS	CO2_C	ANE	EPNS	TGGE	EPOGC	AE	C02_INT	ANSE	CRW	CO2_F	PT	GDP	GDPG
ANRD	1.000																				
EG	-0.058	1.000																			
CO2_A	-0.049	0.222	1.000																		
NGR	0.582	0.185	0.002	1.000																	
EPNG	0.199	-0.069	-0.122	0.337	1.000																
CO2_B	0.019	0.564	0.638	0.355	0.204	1.000															
CR	0.423	-0.133	0.231	0.119	-0.228	-0.077	1.000														
EPCS	0.079	-0.055	0.260	-0.131	-0.412	-0.067	0.553	1.000													
CO2_C	-0.003	-0.003	0.925	-0.061	-0.210	0.326	0.370	0.368	1.000												
ANE	-0.347	0.336	-0.073	-0.129	-0.286	0.047	-0.326	-0.477	-0.148	1.000											
EPNS	-0.319	0.311	-0.022	-0.100	-0.209	0.122	-0.284	-0.333	-0.116	0.934	1.000										
TGGE	-0.016	0.132	0.969	0.041	-0.155	0.600	0.225	0.228	0.912	-0.101	-0.083	1.000									
EPOGC	0.258	-0.230	0.113	0.067	0.337	0.008	0.362	0.631	0.168	-0.828	-0.608	0.058	1.000								
AE	-0.024	0.474	0.081	0.091	0.131	0.208	-0.264	-0.250	-0.003	0.271	0.252	0.001	-0.210	1.000							
C02_INT	0.275	-0.030	0.208	0.034	0.000	-0.038	0.481	0.747	0.315	-0.675	-0.528	0.127	0.790	0.057	1.000						
ANSE	-0.137	-0.204	0.271	-0.177	-0.054	-0.179	-0.001	0.003	0.389	0.019	0.020	0.290	-0.015	-0.187	-0.061	1.000					
CRW	0.020	-0.615	-0.059	-0.111	-0.163	-0.279	0.131	0.053	0.051	-0.232	-0.319	0.099	-0.009	-0.762	-0.319	0.292	1.000				
CO2_F	0.225	-0.564	0.100	-0.141	-0.247	-0.454	0.235	0.068	0.335	-0.151	-0.247	0.195	-0.053	-0.251	-0.006	0.382	0.539	1.000			
PT	-0.013	-0.388	0.594	-0.109	-0.240	0.010	0.322	0.355	0.737	-0.226	-0.210	0.649	0.166	-0.437	0.147	0.546	0.519	0.550	1.000		
GDP	0.347	-0.270	0.243	0.103	-0.148	-0.119	0.341	0.354	0.383	-0.290	-0.268	0.285	0.246	-0.223	0.307	0.411	0.282	0.408	0.475	1.000	
GDPG	0.323	-0.250	0.253	0.138	-0.138	-0.091	0.316	0.361	0.388	-0.257	-0.218	0.284	0.247	-0.135	0.331	0.356	0.190	0.375	0.442	0.980	1.000

Note: Cor. is indicating Correlation. Variable's definition indicated in **Table 3** *** specifies the significance levels at 1% ** specifies the significance levels at 5% * specifies the significance levels at 10%. **Sources:** Reckoning by authors

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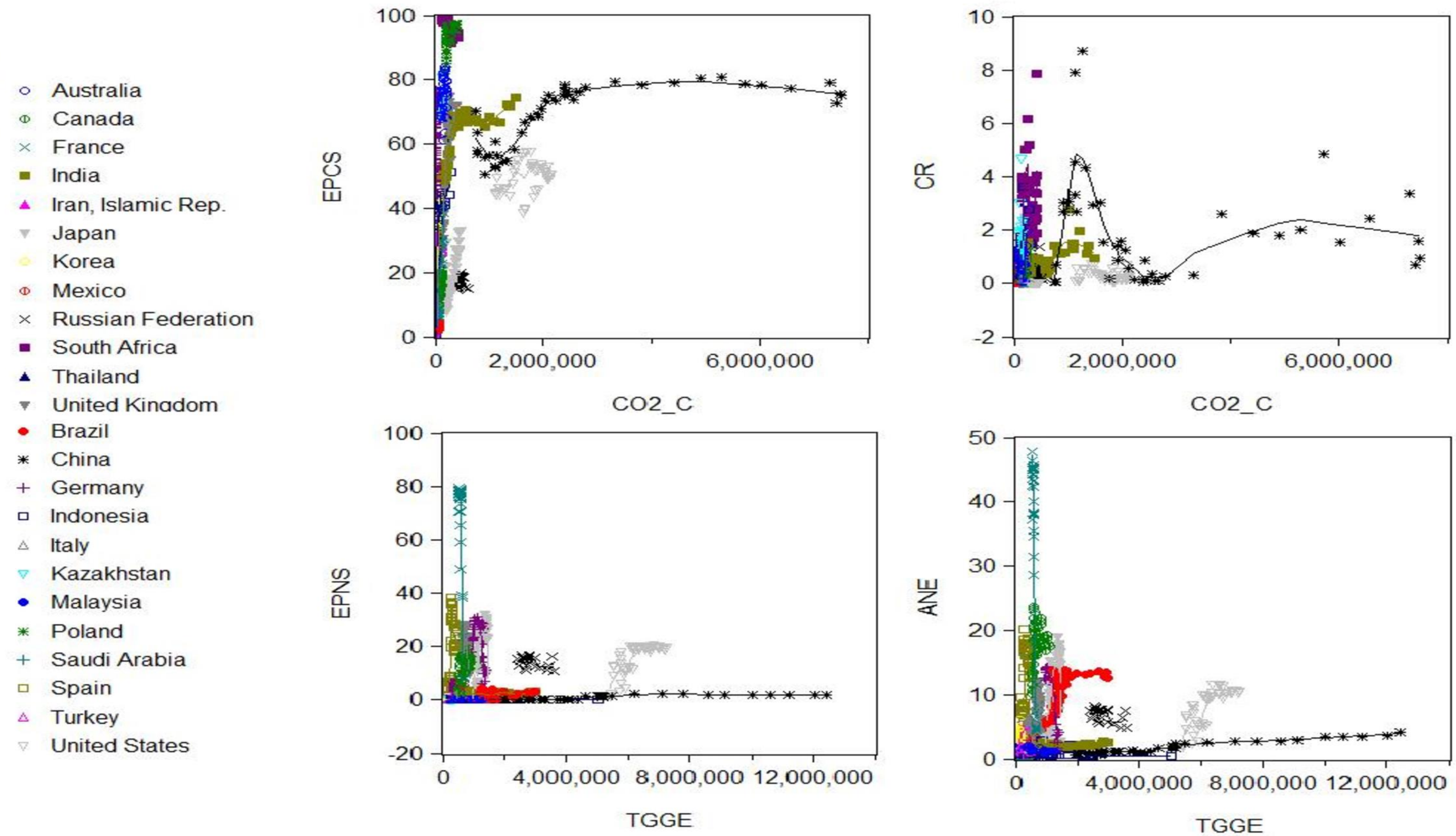

Figure 9: Group C & D

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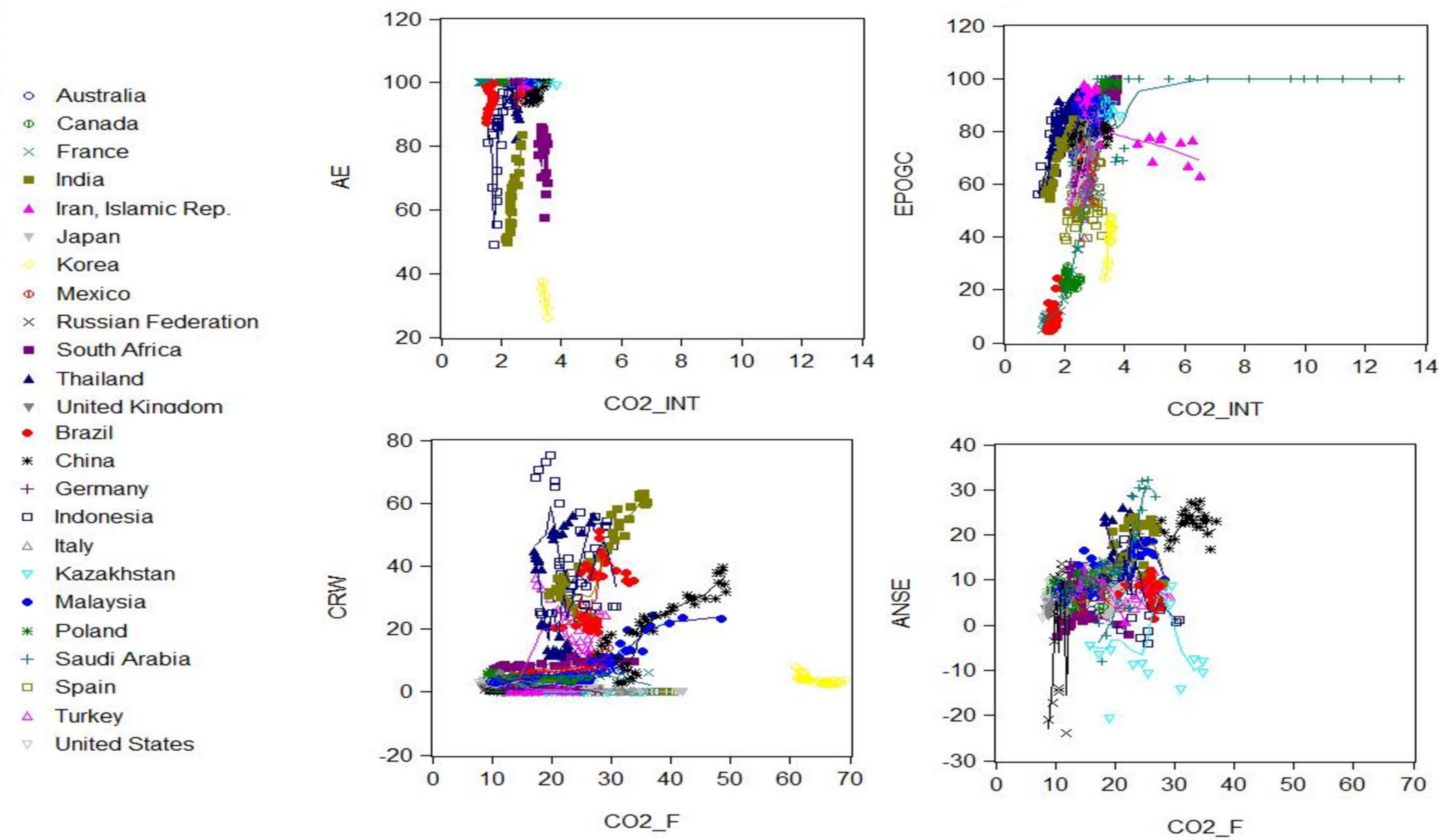

Figure 10: Group E & F

5. Conclusion and policy implication

This research study assesses the relationship of energy computation by Energy, Natural Gas, Coal Rent, Nuclear Energy, Oil Gas and Coal, Renewable Energy and its effect on GDP in the period of 1968 and 2017 using a panel data set. The co-variance of GLM and stepwise regression are applied to investigate the relationship among individual group of explanatory variables, then after the Granger causality and variance analysis are employed of the energy consumption and contribution of relevant factor of production of electricity by difference sources and intensity of CO2 emission in 24 highly polluted countries. It is significant that in each group there is indication for a unidirectional relationship of Granger causality found in the energy consumption. Furthermore, that ANRD, EG, NGR, EPNG, CR, EPCS, ANE, EPNS, EPOGC, AE, ANSE and CRW are not a Granger cause of CO2_A, CO2_B, CO2_C, TGGE, CO2_INT and CO2_F differed from earlier study and specifies that the level of growth of energy consumption precedes in highly polluted countries, which can comprehend as a feature of economic growth. It temporarily, the results estimation also suggests that if CO2_A, CO2_B, CO2_C, TGGE, CO2_INT and CO2_F is mismanaged into barren economic sectors, then economic growth of individual state might be trifling or fail to occur at all. Additionally, the existence of unidirectional causality running from economic growth to energy consumption. Analysis estimation results indicate that huge production of electricity from different sources cause of CO2 emission and positively influence on economic growth and validity has slightly decrease after continuous increase and eventually steadies. However, a positive unidirectional causality from 24 pullulated counties energy consumption to economic development is detected, while short-run bidirectional casualty exists among above six group of variables. The above results are also indicated some valuable strategy and implication as follows.

First, energy and natural gas intake policy should be revised and modified in China, USA, India, Russia and Japan to reduce energy, natural gas and green gas consumption in 6th (Next ten years) period and control the production of electricity by natural resources in group 1,2,3 and 4. However, the oil, gas and renewable energy consumption in Saudi Arbia, Iran, Korea and China should be modified with new equips and policies to control CO2 emission and production of electricity. Second, the Granger causality test results suggest that the presence of unidirectional causality from Energy, Natural Gas, Coal rent, Nuclear Energy Oil, Gas and Coal Renewable Energy consumption to economic growth. And the consequences of results impulse response, the impact of 24 top polluted countries energy consumption would at first increases than decrease and upcoming 6th and 7th period more stabilize with new modified strategies for control energy consumption. Third, clean energy consumption role should be endorsed and restrained in above countries, so that energy environmental quality and affordability might be enhanced and the ecosystem is secure in upcoming period. Unilateral causality is found in between energy consumption and economic growth. Therefore, consumption of energy might be conductive of 24 top polluted countries and better economic development, the consumption of energy should be facelifted and guaranteed, while the resources of countries should be limited. Thus, varying current consumption of the energy mix in above countries, likewise, endowing and impelling of clean energy is necessary for coming generation.

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Reference

((Acheampong 2018) Acheampong, Alex O. 2018. Economic growth, CO2 emissions and energy consumption: What causes what and where? *Energy Economics* 74: 677-92. https://doi.org/10.1016/j.eneco.2018.07.022.

((Alkhathlan and Javid 2015) Alkhathlan, Khalid, and Muhammad Javid. 2015. Carbon emissions and oil consumption in Saudi Arabia. *Renewable and Sustainable Energy Reviews* 48: 105-11. https://doi.org/10.1016/j.rser.2015.03.072.

((Anandarajah and Gambhir 2014) Anandarajah, Gabrial, and Ajay Gambhir. 2014. India's CO2 emission pathways to 2050: What role can renewables play? *Applied Energy* 131: 79-86. https://doi.org/10.1016/j.apenergy.2014.06.026.

((Aydin 2019) Aydin, Mucahit. 2019. The effect of biomass energy consumption on economic growth in BRICS countries: A country-specific panel data analysis. *Renewable Energy* 138: 620-27. https://doi.org/10.1016/j.renene.2019.02.001.

((Baek 2017) Baek, J.Choi, Y.J. . 2017. Does Foreign Direct Investment Harm the Environment in Developing Countries? Dynamic Panel Analysis of Latin American Countries. *Economies* 5. https://doi.org/10.3390/economies5040039.

((Boden et al. 2011) Boden, T.A, G.Marland, and R.J.Andres. 2011. *Global, Regional, and National Foossil-Fuel CO2 Emission*. USA.

((Cai et al. 2018) Cai, Yifei, Chung Yan Sam, and Tsangyao Chang. 2018. Nexus between clean energy consumption, economic growth and CO2 emissions. *Journal of Cleaner Production* 182: 1001-11. https://doi.org/10.1016/j.jclepro.2018.02.035.

((Chen et al. 2019) Chen, Jindao, Qian Shi, Liyin Shen, Yao Huang, and Ya Wu. 2019. What makes the difference in construction carbon emissions between China and USA? *Sustainable Cities and Society* 44: 604-13. https://doi.org/10.1016/j.scs.2018.10.017.

((Cheng et al. 2019) Cheng, Cheng, Xiaohang Ren, Zhen Wang, and Cheng Yan. 2019. Heterogeneous impacts of renewable energy and environmental patents on CO2 emission - Evidence from the BRIICS. *Science of The Total Environment* 668: 1328-38. https://doi.org/10.1016/j.scitotenv.2019.02.063.

((Cheng et al. 2017) Cheng, Zhilong, Jingyu Wang, Shangshang Wei, Zhigang Guo, Jian Yang, and Qiuwang Wang. 2017. Optimization of gaseous fuel injection for saving energy consumption and improving imbalance of heat distribution in iron ore sintering. *Applied Energy* 207: 230-42. https://doi.org/10.1016/j.apenergy.2017.06.024.

((Chong et al. 2019) Chong, Chin Hao, Wei Xin Tan, Zhao Jia Ting, Pei Liu, Linwei Ma, Zheng Li, and Weidou Ni. 2019. The driving factors of energy-related CO2 emission growth in Malaysia: The LMDI decomposition method based on energy allocation analysis. *Renewable and Sustainable Energy Reviews* 115: 109356. https://doi.org/10.1016/j.rser.2019.109356.

((Dong et al. 2019) Dong, Feng, Ying Wang, Bin Su, Yifei Hua, and Yuanqing Zhang. 2019. The process of peak CO2 emissions in developed economies: A perspective of industrialization and urbanization. *Resources, Conservation and Recycling* 141: 61-75. https://doi.org/10.1016/j.resconrec.2018.10.010.

((Dong et al. 2018) Dong, Kangyin, Renjin Sun, and Xiucheng Dong. 2018. CO2 emissions, natural gas and renewables, economic growth: Assessing the evidence from China. *Science of The Total Environment* 640-641: 293-302. https://doi.org/10.1016/j.scitotenv.2018.05.322.

((Emirmahmutoglu and Kose 2011) Emirmahmutoglu, Furkan, and Nezir Kose. 2011. Testing for Granger causality in heterogeneous mixed panels. *Economic Modelling* 28: 870-76. https://doi.org/10.1016/j.econmod.2010.10.018.

((Etemad et al. 1991) Etemad, B, J.Luciani, P.Bairoch, and J.C.Toutian. 1991. *World Energy Production 1800-1985*. Librarie DROZ, Switzerland.
((Fadiran et al. 2019) Fadiran, Gideon, Adebisi T. Adebusuyi, and David Fadiran. 2019. Natural gas consumption and economic growth: Evidence from selected natural gas vehicle markets in Europe. *Energy* 169: 467-77. https://doi.org/10.1016/j.energy.2018.12.040.
((Fernández González et al. 2014) Fernández González, P., M. Landajo, and M. J. Presno. 2014. Multilevel LMDI decomposition of changes in aggregate energy consumption. A cross country analysis in the EU-27. *Energy Policy* 68: 576-84. https://doi.org/10.1016/j.enpol.2013.12.065.
((González et al. 2019) González, Rosa Marina, Gustavo A. Marrero, Jesús Rodríguez-López, and Ángel S. Marrero. 2019. Analyzing CO2 emissions from passenger cars in Europe: A dynamic panel data approach. *Energy Policy* 129: 1271-81. https://doi.org/10.1016/j.enpol.2019.03.031.
((Gupta et al. 1995) Gupta, N. C., V. K. Jain, and N. K. Bansal. 1995. CO2 reduction potential through non-conventional energy sources in India. *Energy* 20: 549-53. https://doi.org/10.1016/0360-5442(94)00093-I.
((Hao et al. 2018) Hao, Yu, Ling'ou Wang, Lingyun Zhu, and Minjie Ye. 2018. The dynamic relationship between energy consumption, investment and economic growth in China's rural area: New evidence based on provincial panel data. *Energy* 154: 374-82. https://doi.org/10.1016/j.energy.2018.04.142.
((Hardin 2007) Hardin, James W. and Joseph M. Hilbe 2007 *Generalized Linear Models and Extensions*. Second ed.
((Herrerias et al. 2013) Herrerias, M. J., R. Joyeux, and E. Girardin. 2013. Short- and long-run causality between energy consumption and economic growth: Evidence across regions in China. *Applied Energy* 112: 1483-92. https://doi.org/10.1016/j.apenergy.2013.04.054.
((Hosseini et al. 2019) Hosseini, Seyed Mohsen, Amirali Saifoddin, Reza Shirmohammadi, and Alireza Aslani. 2019. Forecasting of CO2 emissions in Iran based on time series and regression analysis. *Energy Reports* 5: 619-31. https://doi.org/10.1016/j.egyr.2019.05.004.
((Jeong et al. 2018) Jeong, Kwangbok, Taehoon Hong, and Jimin Kim. 2018. Development of a CO2 emission benchmark for achieving the national CO2 emission reduction target by 2030. *Energy and Buildings* 158: 86-94. https://doi.org/10.1016/j.enbuild.2017.10.015.
((Jiang et al. 2018) Jiang, Xue-ting, Qiang Wang, and Rongrong Li. 2018. Investigating factors affecting carbon emission in China and the USA: A perspective of stratified heterogeneity. *Journal of Cleaner Production* 199: 85-92. https://doi.org/10.1016/j.jclepro.2018.07.160.
((Jin and Kim 2018) Jin, Taeyoung, and Jinsoo Kim. 2018. What is better for mitigating carbon emissions – Renewable energy or nuclear energy? A panel data analysis. *Renewable and Sustainable Energy Reviews* 91: 464-71. https://doi.org/10.1016/j.rser.2018.04.022.
((Kang et al. 2019) Kang, Sang Hoon, Faridul Islam, and Aviral Kumar Tiwari. 2019. The dynamic relationships among CO2 emissions, renewable and non-renewable energy sources, and economic growth in India: Evidence from time-varying Bayesian VAR model. *Structural Change and Economic Dynamics* 50: 90-101. https://doi.org/10.1016/j.strueco.2019.05.006.
((Kao C 1995) Kao C, Chen B. . 1995. *On the estimation and inference of a cointegrated regression inpanel data when the cross-section and time-series dimensions are compa-rable.* . Syracuse University: Department of Economics, .
((Karney 2019) Karney, Daniel H. 2019. Electricity market deregulation and environmental regulation: Evidence from U.S. nuclear power. *Energy Economics*: 104500. https://doi.org/10.1016/j.eneco.2019.104500.
((Ketenci 2018) Ketenci, Natalya. 2018. The environmental Kuznets curve in the case of Russia. *Russian Journal of Economic* 4: 249-65.

((Kharbach and Chfadi 2018) Kharbach, Mohammed, and Tarik Chfadi. 2018. Oil prices and electricity production in Morocco. *Energy Strategy Reviews* 22: 320-24. https://doi.org/10.1016/j.esr.2018.10.006.

((Kong and Khan 2019) Kong, YuSheng, and Rab Khan. 2019. To examine environmental pollution by economic growth and their impact in an environmental Kuznets curve (EKC) among developed and developing countries. *PloS one* 14. https://doi.org/10.1371/journal.pone.0209532.

((Kumar and Sinha 1995) Kumar, Sanjay, and S. Sinha. 1995. Non-CO2-emitting renewable energy sources in India: Paths, realisable potential and requirement of industry related forestry pattern. *Energy Conversion and Management* 36: 885-88. https://doi.org/10.1016/0196-8904(95)00145-4.

((Li et al. 2019) Li, Zhi-Guo, Han Cheng, and Tian-Yao Gu. 2019. Research on dynamic relationship between natural gas consumption and economic growth in China. *Structural Change and Economic Dynamics* 49: 334-39. https://doi.org/10.1016/j.strueco.2018.11.006.

((Liang et al. 2019) Liang, Ting, Jian Chai, Yue-Jun Zhang, and Zhe George Zhang. 2019. Refined analysis and prediction of natural gas consumption in China. *Journal of Management Science and Engineering*. https://doi.org/10.1016/j.jmse.2019.07.001.

((Lin et al. 2018) Lin, Jiang, David Fridley, Hongyou Lu, Lynn Price, and Nan Zhou. 2018. Has coal use peaked in China: Near-term trends in China's coal consumption. *Energy Policy* 123: 208-14. https://doi.org/10.1016/j.enpol.2018.08.058.

((McCullagh 1989) McCullagh, Peter, and J. A. Nelder. 1989. *Generalized Linear Models*. Second ed. London: Chapman & Hall.

((McGee and Greiner 2019) McGee, Julius Alexander, and Patrick Trent Greiner. 2019. Renewable energy injustice: The socio-environmental implications of renewable energy consumption. *Energy Research & Social Science* 56: 101214. https://doi.org/10.1016/j.erss.2019.05.024.

((Mezghani and Ben Haddad 2017) Mezghani, Imed, and Hedi Ben Haddad. 2017. Energy consumption and economic growth: An empirical study of the electricity consumption in Saudi Arabia. *Renewable and Sustainable Energy Reviews* 75: 145-56. https://doi.org/10.1016/j.rser.2016.10.058.

((Morales Pedraza 2019) Morales Pedraza, Jorge. 2019. Chapter 4 - Current Status and Perspective in the Use of Coal for Electricity Generation in the North America Region. In *Conventional Energy in North America*. Edited by Jorge Morales Pedraza. Elsevier, pp. 211-57.

((Ohashi et al. 2017) Ohashi, Mizue, Yuko Maekawa, Yoshiaki Hashimoto, Yoko Takematsu, Sasitorn Hasin, and Seiki Yamane. 2017. CO2 emission from subterranean nests of ants and termites in a tropical rain forest in Sarawak, Malaysia. *Applied Soil Ecology* 117-118: 147-55. https://doi.org/10.1016/j.apsoil.2017.04.016.

((P. 2004) P., Pedroni. 2004. Panel cointegration: Asymptotic and Finite Sample Properties of Pooled Time Series Tests with an Application to the PPP Hypothesis. *Econometric theory* 3: 579-625.

((Pao and Tsai 2011) Pao, Hsiao-Tien, and Chung-Ming Tsai. 2011. Multivariate Granger causality between CO2 emissions, energy consumption, FDI (foreign direct investment) and GDP (gross domestic product): Evidence from a panel of BRIC (Brazil, Russian Federation, India, and China) countries. *Energy* 36: 685-93. https://doi.org/10.1016/j.energy.2010.09.041.

((Shan et al. 2018) Shan, Yuli, Dabo Guan, Jing Meng, Zhu Liu, Heike Schroeder, Jianghua Liu, and Zhifu Mi. 2018. Rapid growth of petroleum coke consumption and its related emissions in China. *Applied Energy* 226: 494-502. https://doi.org/10.1016/j.apenergy.2018.06.019.

((Solaymani 2019) Solaymani, Saeed. 2019. CO2 emissions patterns in 7 top carbon emitter economies: The case of transport sector. *Energy* 168: 989-1001. https://doi.org/10.1016/j.energy.2018.11.145.

((Uribe et al. 2018) Uribe, Jorge M., Montserrat Guillen, and Stephania Mosquera-López. 2018. Uncovering the nonlinear predictive causality between natural gas and electricity prices. *Energy Economics* 74: 904-16. https://doi.org/10.1016/j.eneco.2018.07.025.

((Valadkhani et al. 2019a) Valadkhani, Abbas, Jeremy Nguyen, and Mark Bowden. 2019a. Pathways to reduce CO2 emissions as countries proceed through stages of economic development. *Energy Policy* 129: 268-78. https://doi.org/10.1016/j.enpol.2019.02.024.

((Valadkhani et al. 2019b) Valadkhani, Abbas, Russell Smyth, and Jeremy Nguyen. 2019b. Effects of primary energy consumption on CO2 emissions under optimal thresholds: Evidence from sixty countries over the last half century. *Energy Economics* 80: 680-90. https://doi.org/10.1016/j.eneco.2019.02.010.

((Wang et al. 2019) Wang, Changbo, Lixiao Zhang, Peng Zhou, Yuan Chang, Dequn Zhou, Mingyue Pang, and Hao Yin. 2019. Assessing the environmental externalities for biomass- and coal-fired electricity generation in China: A supply chain perspective. *Journal of Environmental Management* 246: 758-67. https://doi.org/10.1016/j.jenvman.2019.06.047.

((Wolde-Rufael and Menyah 2010) Wolde-Rufael, Yemane, and Kojo Menyah. 2010. Nuclear energy consumption and economic growth in nine developed countries. *Energy Economics* 32: 550-56. https://doi.org/10.1016/j.eneco.2010.01.004.

((Xu and Lin 2019) Xu, Bin, and Boqiang Lin. 2019. Can expanding natural gas consumption reduce China's CO2 emissions? *Energy Economics* 81: 393-407. https://doi.org/10.1016/j.eneco.2019.04.012.

((Xu et al. 2019) Xu, Guangyue, Peter Schwarz, and Hualiu Yang. 2019. Determining China's CO2 emissions peak with a dynamic nonlinear artificial neural network approach and scenario analysis. *Energy Policy* 128: 752-62. https://doi.org/10.1016/j.enpol.2019.01.058.

((Xu et al. 2018) Xu, Xinwanghao, Hong Huo, Jingru Liu, Yuli Shan, Yuan Li, Heran Zheng, Dabo Guan, and Zhiyun Ouyang. 2018. Patterns of CO2 emissions in 18 central Chinese cities from 2000 to 2014. *Journal of Cleaner Production* 172: 529-40. https://doi.org/10.1016/j.jclepro.2017.10.136.