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# Clean Energy Consumption and Economic Growth: Using Obor Countries

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***Abstract:*** *The study aims to investigate the relationship between clean energy and economic growth of one belt one road countries year from 1990 to 2014. Random, fixed effects and robust regressions were used to determine the relationship. Results reveals a positive and significant relationship between combustible renewable and waste, energy consumption, alternative, and nuclear energy and economic growth. This study concluded that governments of one belt one road invest in clean energy production in order to get benefit in the form of economic growth.*

***Keyword:*** *One Belt One Road; Clean Energy; Economic Growth*

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## I. Introduction

To affect economic growth and promote regional cooperation, in 2013, China initiated the Silk Road Economic Belt and the 21st−Century Maritime Silk Road, which is abbreviated as "the Belt and Road Initiative". At a critical juncture of time when global economic recovery was in critical need of new growth engine, the initiative to show China's strong willingness and desire to turn into the world economy, and meanwhile China would like to embrace a more open economy. "The Belt and Road Initiative" is a comprehensive project that incorporates a series of political, economic and social programs that would boost the integration and economic development between the Eurasian countries. As statistical data suggested, the infrastructure investment and acquisitions, especially in energy & power industry, were the foci since the inception of the initiative (Du and Zhang, 2018; Xu et al., 2017). Since "the Belt and Road Initiative" was first raised in 2013, China's efforts of expanding infrastructure structure and promoting economic and trade cooperation had effectively bridged the infrastructure gap in Eurasian countries and helped to improve economic growth of some developing countries (Du and Zhang, 2018). Besides, China has attached great importance to climate change and energy cooperation with the rest of the world (X. Zhang et al., 2017). For example, China and European Union (EU) has committed to intensify their political, economic and technical cooperation on climate change and clean energy. During the Belt and Road Forum held in Beijing in March 2017, China's president Xi Jinping vowed to keep carrying forward the Initiative and called for more countries to participate in this prospective and promising project. Given the scale of the Initiative and its bright prospect, some scholars even argued that "the Belt and Road Initiative" would become a global growth engine.

Geographically, the Belt and Road Initiative mainly covers the Eurasian countries and some African states along the Arabian Sea and the Mediterranean Sea. , the countries along the Belt and Road and the schematic diagrams for the Silk Road Economic Belt and the 21st −Century Maritime Silk Road are presented.

Due to the insufficient conventional energy reserves and increasing energy−importing dependence, the Belt and Road Initiative is meant to provide a method for China to diversify energy supply sources and to ensure energy security. In addition, an infrastructure investment is required to develop energy in Central Asian and Southeast Asian countries. Furthermore, aside from the energy investments and trades, the Belt and Road Initiative also promotes cooperation in a series of major international issues and regional hotspot issues, including the problem of global warming. The massive construction, operation, and maintenance of infrastructure, especially roads, dams, bridges and power plants that consume a huge amount of cement and steel, would need substantial fossil energy consumption and in turn generate enormous $CO_2$ emissions (Fan et al., 2017; Zhao et al., 2016). As a result, it is crucial to curb $CO_2$ emissions and improve environmental quality during the implementation of "the Belt and Road Initiative" (N. Zhang et al.,2017). The development of alternative and renewable energy is generally accepted as an effective solution to lower carbon emissions. Even though some developing countries possess abundant renewable resources, there exists a large gap in the development levels of renewable energy between developing and developed countries (Schwerhoffand Sy, 2017).

It is noteworthy that, "the Belt and Road Initiative" could serve as an effective platform through which the relevant countries could contribute more significantly to the shared aim of curbing $CO_2$ emissions (Zhang et al., 2018). Despite the ambitious goals, so far the serious and rigorous academic researches on the foundations and conditions of fulfilling these strategic objectives are still scarce. Therefore, the contribution of this study is fourfold. First, this paper investigates the dynamic relationship between $CO_2$ emissions, energy consumption and economic growth among the countries along the Belt and Road using rigorous quantitative methods. Second, the potential problems of endogenous and long-run correlation in the cointegrating equations and heterogeneity across countries are fully acknowledged. These problems may cause biased or even wrong estimates using conventional panel data methods. Third, this paper distinguishes the long−run and short-run dynamics by adopting DOLS and VECM methods. In this way, the dynamic relationship would be better explained, and corresponding policy suggestions to policymakers could be more targeted. Forth, given the difference in energy endowments and economic development style, the energy−exporting countries and energy−importing countries are studied separately (e.g., Jalil,2014). The conclusions for the two subsamples of countries could provide meaningful and targeted policy implications for these countries as well as China to maximize the effects of "the Belt and Road Initiative".

Lee (2013) defines clean energy as non-carbohydrate energy including nuclear energy, hydro energy, solar energy etc. that does not produce carbon dioxide when generated and in advance discloses a positive relationship between FDI and clean energy use.Clean Energy in the form of nuclear and renewable energy consumption has significantly enhanced the growth and development of the industrial sectors of most economies. Most developed countries adopting this energy source as supplements to other energy production approaches. Clean energy development has been commonly viewed as one of the most important steps to solve the problems of pollutant emission and climate change in the long run (Bilgili et al., 2016). Investment in clean energy has greater benefits and favorable environmental consequences to other unclean energy sources. For instance, Pao and Li (2014) study economic growth, clean energy, and unclean energy in MIST (Mexico, Indonesia, South Korea, and Turkey) economies. They utilized panel co-integration approach discovering a long run causality from clean energy use to economic growth and positive feedback causality in the short run. In the short run, renewable energy increases fossil fuel consumption and induces negative environmental feedback in the long run. Zhang et al. (2014) also examine the possible cooperation in renewable energy between the United States of America and China. Their findings indicate that such practice can raise economic development, mitigate carbon emissions, improve the environmental quality, promotes green growth and mutual benefit between these two countries. Decades ago the quest of China to become the world economic powerhouse has resulted in the establishment and implementation of various economic policies, just to mention one example is the OBOR initiative. This is to connect countries within the Eurasian region and to establish stable political and diplomatic relation among them with the principal objective to promote trade exchange within this region. To investigate the cooperation of clean energy among OBOR countries and to their contributions to the existing literature studying the long run relationship between clean energy consumption, economic growth, and environmental quality. To investigate the cooperation of clean energy among OBOR countries and to their contributions to the existing literature studying the long run relationship between clean energy consumption, economic growth, and environmental quality. There is not any study which investigated the impact of clean energy on economic growth in one belt one road countries. So, this study will fulfill this gap.

## II. Literature review

There are quite a number of works available hashing out the connections and impact of clean energy consumption and economic growth. For instance (Maji 2015) examines the influences of clean energy usage on economic growth in Nigeria establishing a long run significant relationship between the pointers of clean energy. Yet again he found a positive association between combustible renewals and waste and economic growth. Sbia et al. (2014) use solitary country data for their analysis attesting the nexus between economic growth and clean energy, foreign direct investment, trade openness and carbon emissions for UAE establishing that clean energy and economic growth have a positive consequence on energy consumption. Other studies on renewable energy usage (Apergis and Payne, 2011a, 2011b, 2012a, 2012b, 2013) and nuclear energy consumption (Lee and Chiu, 2011; Nazlioglu et al., 2011; Apergis and Payne, 2010) respectively and economic growth employing panel dataset are also available. Nevertheless, diverse empirical reports show different and contradictory results with each other. Nazlioglu et al. (2011) found a unidirectional relationship between nuclear energy consumption and economic growth for Hungary, an inverse causality for the UK and Spain, and no causality for eleven other OECD countries. These outcomes propose that nuclear power may be a comparatively insignificant element of overall production in most OECD countries.

According to Ozturk (2010), the main reasons for this inconsistency is as a result of country difference, characteristic, time period, econometric approach or methodology, and types of energy consumption. Pfeiffer and Mulder (2013) also investigate the diffusion of non-hydro clean energy technology for generating electricity

in 180 developing countries using two-stage estimation techniques. They report that diffusion increases with the enforcement of economic and regulatory instruments. To conclude a study conducted by Perobelli and Oliveira (2013) in 27 Brazilian states developing an indicator for energy development potentials using factor analysis. The results identify three energy development potentials which include; demand for energy, a supply of clean energy and supply of unclean energy. Also, Shahbaz et al. (2015) found that renewable energy consumption enhances economic growth in Pakistan. Furthermore, labor and capital also play an important role in economic growth.

Stern (2010) is a compilation of different approaches and models explaining the effect of energy on economic growth. Bringing together the mainstream, the resource economics, and the ecological economics models of economic growth and discussing theories, which analyze and potentially justify the economic growth in the long run, passing through periods and laps of time covering industrial revolution to our days.

In further studies, Shaari, Hussain, and Ismail (2012) while studying for the case of Malaysia, used annual data from 1980 to 2010, to find the relationship between energy and GDP growth. The findings were that energy consumptions are related to economic growth without catching the direction of the relationship. In order to catch the direction, Granger causality model was used to examine the direction of causality relationships by measuring the causal effect of Gross Domestic Product.

Apergis and Payne (2010) took the case of South America while studying the relationship between energy consumption and economic growth using the Gross Domestic Product to measure that directly and real gross fixed capital formations indirectly. He used annual data from 1980 to 2005, for Venezuela, Argentina, Bolivia, Chile, Ecuador, Brazil, Paraguay, Uruguay, and Peru. To do that he used a panel cointegration test and Error Correction Model. He was able to prove a positive Granger causality running from energy consumption to economic growth, both directly and indirectly (Gross Domestic Product and real gross fixed capital formation in the short run and long run.

Shahbaz, Tang, and Shahbaz Shabbir (2011) is a paper dealing with the possible relationship between electricity consumption, economic growth, financial development, population, and foreign trade. Like Shaari et al(2012) they started with an ADF test which proved the variable is stationary, then a cointegration test to determine the long run. As well they used annual data but for Portugal from 1970 to 2009. The finding was that for all the variables expect the financial development Granger cause each other and that there is a causal effect running from financial development to electricity consumption.

Stern and Enflo (2013) in this study, there is an analysis of the relation between energy and economic growth, for a long period of 150 years. Starting from 1850 in order to catch the transition period from one of the poorer countries in Europe at the mid of the 19th century to one of the richest today. As it was an industrialization period, they checked if the switch in energies quality and the increases in energy consumption affected the economic growth. The Unit Root Test was used in this literature as well, which is fundamental to proceed to the cointegration and Granger cause test, for that PP test was used.

Saam and Schulte (2013), found and concluded a possible substitution between clean and dirty energies. They used a panel of cross-country sectoral data, which was built by European Commission, which include 35 industries combined to Purchasing Power Parities for 30 countries, to Electricity Information Statistics, and to the Annual Energy Outlook from 1995 to 2009. They specified a production function of Constant Elasticity of Substitution using specification from the electric sector and non-energy sector in order to estimate a special case of the CES parameter: the elasticity of substitution between clean and dirty energy inputs. The finding was an evidence of elasticity exceeding one which concord with clean energies could substitute the dirty ones. Saam and Schulte (2013) showed that the dirty and clean energies are substitutable. The expectation is that there is a causal relationship between renewable energies and economic growth. However, Menegaki, A. N. (2011) showed in his studies while studying a multivariate panel data from 1997 to 2007 for European countries, that there is no clear evidence of causality relationship between the renewable energies and the Gross Domestic Product.

Apergis and Payne (2012) used a similar dataset as Menegaki, A. N. (2011). This work was for 80 countries from 1990 to 2007, and they checked the relationship between renewable, non-renewable energies consumption and economic growth. They also used a Unit Root Test by doing the Fisher ADF and the Fisher pp. For the cointegration, they used the Pedroni (1999, 2004) and the Fully Modified OLS (FULLY MODIFIED OLS) technique to determine the long-run equilibrium relationship between the variables. As well, they included, in addition, the capital and the labor. Their finding pointed to the importance of both renewable and non-renewable energies as the long-run relationship exists between all the variables. They also found out and as it is one of my center of interest a possible substitutability between the two kinds of energies, as there is negative bidirectional causality between them.

Zhang, Xing-Ping, and Xiao-Mei Cheng (2009) is a paper studying the relationship between energy consumption, carbon emission, and economic growth for the case of China. The authors used annual data from 1960 to 2007, to check the existence of any relationship between the variables, and if found, the direction of

such relationship. The authors applied a multivariate model of economic growth, energy use, carbon emissions, capital, and urban population. While most of the literature used an Error Correction Model or standard Granger causality to find the causal relationship, they used the TY procedure (augmented VAR approach proposed by Toda and Yamamoto) and generalized impulse response to finding out the Granger causality in the long run. Mainly because according to the authors, it seems to have a higher power of testing larger samples. The main results coming from the empirical tests, suggests evidence supporting that economic growth is affected by neither energies consumption nor carbon emissions.

These evidence are that there are no Granger causalities in the long run between economic growth and carbon emissions and the causality between economic growth and energy consumption is running from the GDP. The test shows also a unidirectional Granger causality running from energy consumption to carbon emissions in the long run. The authors concluded from there that China could decline the use of some fossil energies, especially coal which represents a high proportion. The change to more clean energies would lead to a decline in the carbon emissions without affecting economic growth. The evidence, which supports the benefits of changing the form of energies, is that there is a Granger causality running from energy consumption to carbon emissions.

Soytas, Ugur, and Ramazan Sari(2009) in a similar way as the previous paper, this paper is examining the relationship between energy consumption, gross fixed capital formation, labor, carbon emission, and economic growth, but for the case of Turkey. The authors used annual data from 1960 to 2000 to check the long run Granger causality. The authors used as well the TY procedure (augmented VAR approach proposed by Toda and Yamamoto) and generalized impulse response to check the causality. The results imply that there is no causality in the long run between income and energy consumption, neither between income and carbon emissions, and that all the variables impact on labour innovation. In addition, it seems that there is a unidirectional Granger causality running from carbon emissions to energy consumption. The authors concluded from there that reducing the emissions would not harm the economic growth in Turkey.

Fei, Li, et al (2011) is a paper dealing with the causality effect between the economic growth and energy consumption for China in the long run. The data take into account 30 provinces from China according to the availability with an annual data from 1960 to 2000. Additionally, a cross-sectional data was created in order to investigate two different groups of provinces, the east of China, and the west of China. Like most of the literature, the author checked the stationarity and the cointegration of the variables via panel Unit Root and Panel Cointegration. To check the causality, he used a panel based DOLS (Dynamic OLS) as it is taking into account the co-movement. The main result coming from the test shows a positive cointegrated relationship between economic growth and energy consumption in the long run. The relationship seems to be bidirectional, an increase of the GDP per capita leads to an increase in energy consumption and vice verse.

Chang (2010) is a multivariate co-integration Granger causality study to evaluate the causal effect between economic growth, dioxide emissions, crude oil consumption, natural gas consumption, coal consumption, and electricity consumption in China. The data used, is an annual data from 1981 to 2006. In order to do so, the author used as several other works of literature studying this question, Unit Root Test for the stationarity, a cointegration test for the interaction between the variables an Error Correction Model to check the causality effect. The main results seem to show a bidirectional causality running from economic growth to the dioxide emissions, crude oil consumption, and coal consumption, in addition, a unidirectional causality running from electricity consumption to economic growth. According to Chang (2010), all the variables seem to be highly interacting, and it would be harming the economic growth to pursue an energy conservation policy, where the energy consumption is decreased in order to decrease the dioxide emissions and save some of its consumption. However, the author admitted that this study is limited due to the excluding to all other forms of energies except the fossil ones.

## III. Data & Methodology

Annual data is employed in this paper in order to investigate the countries along belt and road covering the period from 1990 to 2014. Countries included in bale and road are 65 countries. Gross domestic product (GDP) is a proxy used for economic growth and selected from World Bank. Clean energy is presented in separate indicators included: electric power consumption (kWh), combustible renewables and waste and alternative and nuclear energy (% of total energy use) on economic growth in one belt one road countries. Table 2 presented descriptive statistics. In order to measure the relationship between clean energy and economic growth model 1 is constructed as follows:

$$GDP_t = f(EPC_t, CRW_t, ANR_t) \quad (1)$$

*Table 2 here*

By introducing slop of each explanatory variable, a drift parameter and stochastic error term Eq (1) was transformed into an econometric model. Variable were also converted in the natural log in order to estimate results efficiently as below:

$$lGDP_t = \beta_0 + \beta_1 lEPC_t + \beta_2 lCRW_t + \beta_3 lANR_t + \varepsilon_t \quad (2)$$

Here GDP is the gross domestic product. EPC indicted electric power consumption (kWh), CRW represented combustible renewables and waste, ANR indicated alternative and nuclear energy (% of total energy use) $\varepsilon$ represented error term and t is time period.

After developing model we further investigated it through fixed and random effects and also checked through GMM.

**Table 2: Descriptive statistics:**

| | LGDP | LEPC | LCRW | LANE |
|---|---|---|---|---|
| Mean | 24.50348 | 7.197006 | 1.606997 | 1.104474 |
| Median | 2.820864 | 1.943596 | 4.2144 | 3.224339 |
| Maximum | 28.34967 | 2.725624 | 4.567149 | 4.563514 |
| Minimum | 20.38 | -12.50914 | -3.88662 | 3.767771 |
| Std. Dev. | 1.679543 | 1.394129 | 2.0529 | 1.795645 |
| Skewness | 0.0146583 | -0.9081821 | -0.6932864 | -1.256446 |
| Kurtosis | 2.17754 | 3.174727 | 2.745284 | 5.471264 |

## IV. Results and Discussions

Stationary of the variables were tested through Phillips Perron (PP) unit root test presented in table 3. Results from unit root indicated that all of the variables are I(0), that means there is not any unit root in electric power consumption, alternative and nuclear energy, combustible renewables and waste and economic growth. Correlation matrox is present3d in table 3. Then we further proceeded to investigate the relationship through random and fixed effects models.

**Table 3: Correlation Matrix:**

| | **lGDP** | **lEPC** | **lANE** | **lCRW** |
|---|---|---|---|---|
| lGDP | 1.0000 | | | |
| lEPC | 0.2579* | 1.0000 | | |
| lANE | -0.0425 | 0.1394* | 1.0000 | |
| lCRW | 0.0319 | -0.6148* | -0.0277 | 1.0000 |

*Indicated significant at 1%

Fixed and random effects are described in table 4 and 5 respectively. Which showed a significant and positive relationship between energy consumption and economic growth. Results in Table 4 indicated that a 1% increase in energy consumption increases the economic growth by 170%. Alternative and nuclear energy is also significantly positive in table 4 and table 5. That presented that 1 %increase in alternative and nuclear energy increase economic growth by 22% in fixed effects and 19% in the random effects model.

**Table 4: Fixed Effects**

| **Variables** | **Coef.** | **Std. ERR.** | **t** | **p>\|t\|** |
|---|---|---|---|---|
| **lEPC** | 1.701269 | 0.0533385 | 31.90 | 0.000 |
| **lANE** | 0.2235939 | 0.0325336 | 6.87 | 0.000 |
| **lCRW** | 0.2760504 | 0.0408624 | 6.76 | 0.000 |
| | | | | |
| **R-Square** | 0.5518 | **Probability** | 0.0000 | |
| **F(3,974)** | 399.65 | | | |

Coef. Std. ERR. Indicated coefficient and standard error respectively.

**Table 5: Random effects:**

| **Variables** | **Coef.** | **Std. ERR.** | **z** | **p>\|z\|** |
|---|---|---|---|---|
| **lEPC** | 1.625957 | 0.0529952 | 30.68 | 0.000 |
| **lANE** | 0.1969883 | 0.0322423 | 6.11 | 0.000 |
| **lCRW** | 0.3104529 | 0.0399955 | 7.76 | 0.000 |
| | | | | |
| **R-Square** | 0.5510 | **Probability** | 0.0000 | |
| **Wald chi2(3)** | 1100.92 | | | |

Coef. Std. ERR. Indicated coefficient and standard error respectively.

Table 4 and Table 5 also indicated a significant positive association between combustion and renewable and waste and economic growth. The results showed that a 1 % increase in combustion and renewable and waste enhanced economic growth by 27% and 31 in fixed and random models respectively. Different tests were applied to check the stability of data, heteroskedasticity, serial correlation group wise heteroskedasticity and autocorrelation. Table 6 confirmed the heteroskedasticity and spatial correlation and autocorrelation problem therefor this study applied the robust test in order to overcome these problems.

**Table 6: Diagnostic Tests**

| **Test name** | | |
|---|---|---|
| **Doornik- Hansen** | chi2(8) = 1350.144 | Prob>chi2 = 0.0000 |
| **Wooldridge test** | F(1,40) = 350.993 | Prob > F = 0.0000 |

Robust results are presented in table 7. In table 7 GDP is dependent variable and other variables are independent variables. Table 7 showed that energy consumption significantly increases the economic growth as 1% increase the energy consumption increase the economic growth by162% the result is in line with (Gulzara 2018). 1% increase in alternative and nuclear energy enhanced economic growth by 19% which showed significant and positive relationship between alternative and nuclear energy and economic growth, the result is same with (Cowan et al. (2014).).combustion and renewable and waste has a significant positive relationship with economic growth The finding corroborates recent literature of Paoand Li (2014) for MIST economies, Olugasa et al. (2014) for a study in Nigeria, Pfeiffer and Mulder (2013) for developing countries and Brown et al. (2012) for United State.. Table 7 showed that a 1% increase in combustion and renewable and waste increase economic growth by 31%. R-square is 55 % which showed the model is a good fit.

**Table 7: Robust Regression**

| **Variables** | **Coef.** | **Std. ERR.** | **z** | **p>\|z\|** |
|---|---|---|---|---|
| **lEPC** | 1.625957 | 0.1458625 | 11.15 | 0.000 |
| **lANE** | 0.1969883 | 0.0712723 | 2.76 | 0.006 |
| **lCRW** | 0.3104529 | 0.1699237 | 1.83 | 0.068 |
| | | | | |
| **R-Square** | 0.5510 | **Probability** | 0.0000 | |
| **Wald chi2(3)** | 187.69 | | | |

## V. Conclusion & Policy implications

The objective of this study is to evaluate the impact or clean energy on economic growth. Fixed and random effects models were used in order to investigate the relationship but due to problems of heteroskedasticity and autocorrelation, this study further proceeded to robust regression. Results suggested that clean energy enhanced economic growth significantly. This study suggested that any retard in policy may lead to a decrease in economic growth. There should be a separate legal framework in all countries in order to significantly increase the growth and efficiently use of resources. The combustible renewables and waste are positive also suggested that it will more improve the clean energy and economic growth. This depicts future contributions towards economic growth, therefore, governments of all countries pay full attention to clean energy. If resources of clean energy will develop economic growth will also be enhanced.

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