Renewed Evidence of Environmental Sustainability from Globalization and Energy consumption over Economic growth in China

Festus Victor Bekun[1]
Faculty of Economics Administrative and Social sciences,
Istanbul Gelisim University, Istanbul, Turkey
Corresponding author: Email: fbekun@gelisim.edu.tr

Kürşat Yalçiner
Faculty of Economics, Administrative and Social Sciences,
Istanbul Gelisim University, Istanbul, Turkey
Email: kyalciner@gelisim.edu.tr

Mfonobong Udom Etokakpan
Department of Economics, Famagusta,
Eastern Mediterranean University,
North Cyprus, via Mersin 10, Turkey
Email: etokakpanmfonudom@yahoo.com

Andrew Adewale Alola
Faculty of Economics Administrative and Social sciences,
Istanbul Gelisim University, Istanbul, Turkey.
E-mail: aadewale@gelisim.edu.tr

Abstract

This study is primarily motivated by exploring the role of globalization, energy intensity over economic expansion and it impact on environmental sustainability in China. To this end, sequence of econometrics tests were conducted to address this hypothesized concern. The choice of China is informed by intense industrial activities and being one of the leading world economies. Annual frequency data from 1971-2015 is utilized for the current study. Stationarity properties of the variables under investigation namely globalization index, ecological footprint, energy consumption and real gross domestic product is examined using the conventional unit tests of Augmented Dickey Fuller (ADF) unit root and Philips-Perron (PP) unit test complemented by the Zivot-Andrews unit root that accounts for single structural break. For cointegration analysis, the novel and unique Bayer and Hanck (2013) combined cointegration test in conjunction with

[1] Corresponding author: Festus Victor Bekun
Email: fbekun@gelisim.edu.tr

Pesaran's Autoregressive Distributed Lag (ARDL) methodology as robustness check is employed while Granger causality test is utilized to detect the direction of causality among the variables. Empirical finding from Bayer and Hanck supports cointegration equilibrium relationship among the variables under review. This indicate a convergence between the explanatory variable to the explained variable in the fitted model. Further empirical evidence shows a positive statistically significant relationship between the variables real income, ecological footprint and globalization index. This outcome is insightful for environmental economist and policymakers. The causality analysis presents supports the growth induced energy consumption hypothesis. Based on these revelations policy direction for the energy sector in China in the face of global interconnectedness are offered in the concluding remark of this study.

Keywords: Energy intensity, globalization, energy conservation, pollutant emission, China.

1. Introduction

The Republic of China (35 00 N, 105 00 E) like other advanced states have continued to pioneer and drive the awareness for environmental sustainability amidst the drive for competitive economic strength and advantage. With a population of over 1.3 billion people (estimated at 1,384,688,986 in 2018) and total area of 9,596,960 square kilometers (comprising of 9,326,410 square kilometers of land and 270,550 square kilometers), China's climatic condition is being described as extremely diverse and tropical from South subarctic in the North (Central Intelligence Agency, CIA, 2019). The global effect of climate change and human activities has neither spared the country's natural resources (such as coal, iron ore deposits, e.t.c) nor its natural terrains (high plateaus, western plains, e.tc.), thus posing a persistent threat to its agricultural land, arable land, forest, and others (component of the ecological footprint (EFP) accounting).

The seemingly threat to the national ecological footprint of China is attributed to the country's carbon emissions trend. In recent time, China is noted with the highest emission of 9232.6 million tons of carbon dioxide (CO_2) (Alola, 2019 a&b). Also, with the global increase in the CO_2 emission from 29, 714.2 million tons to 33, 444.0 million tons between 2009 and 2017 (British Petroleum, BP, 2018), the world environmental and intergovernmental agencies have continued to urge more commitment of stakeholders to the 2015 Paris Agreement[2]. The fact that a global economic race exists especially among the leading economies make it a daunting challenge to averting the global environmental disaster such as the global warming. For instance, the unprecedented growth of the Chinese economy in the last decades has not happen without environmental imbalances. Since the China shifted to a more market-based economy, it has continued to experience about 10% in average annual Gross Domestic Product (GDP) growth, thus making it the fasted sustained economic expansion of a major economy (The World Bank, 2019). Interestingly, the World Bank indicated that China was able to make significant contribution to the global Millennium Development Goals (MDGs) achievements after achieving it national MDGs target in 2015. Although induced energy consumption has been arguably attributed to the source of economic expansion and environmental concern in the past decades, the recent trend in (market) globalization is gradually becoming a source for both paradigm concerns.

In the wake of global trade dichotomy, the pros and cons of the global integration of markets and societies has further been put forward by the lingering trade rows, financial settlement disputes, economic and political fragmentations between countries of the world. Notwithstanding, globalization has availed countries to export good and service with comparative advantage, thus

[2] The Paris Agreement is the United Nations Framework Convention on Climate Change [38] of 2015. More details relating to the Paris Agreement of 2015 are available at: https://unfccc.int/process/conferences/pastconferences/ paris-climate-change-conference-november-2015/ Paris-agreement.

earning significantly from trade as a result of specialization. A shred of evidence provided by the Global Economic Dynamics (2019) posits that countries significantly earns from growing integration in the world economy since 1990, thus suggesting that globalization have positive impact on the GDP of both the advanced and emerging economies. Adding to the complexity of the integration of the world market is the increasing competitiveness and uncertainty associated with the leading markets such as the oil market. For instance, in spite of the uncertainty in the oil market, the World Energy Outlook 2018 implies that energy demand is predicted to grow by over 25% in 2040, thus suggesting more investment opportunities (International Energy Agency, IEA, 2018). Therefore, as much as there is drive for global integration of market amidst global energy demand (consumption), this is expected to have persistent demand on the earth's cropland, grazing land, fishing grounds, built-up land, forest area, and carbon demand capacities (EFP accounting).

In light of the above motivations and considering the peculiarity of China because of the continuous and historic shift in the geography of energy consumption to Asia, the current study considers the underpinning of the role of globalization and energy consumption on the environmental sustainability of China. While employing the experimental period of 1971 – 2014, the objective of the study is set at hypothesizing that (1) the globalization led growth have significant impact on the ecological footprint vis-a-vis environmental sustainability, (2) induced energy consumption affects the country's environmental sustainability, and (3) there is dynamic and causal nexus of between the concern factors. Importantly, the current study is designed to significantly contribute to the existing literature because the ecological footprint accounting is employed as the dependent variable in lieu of carbon or Greenhouse gas emissions. In summary, this study complements the existing literature by the adoption of a broader measure of environmental degradation called ecological footprint (EFP) which has been ignored in the energy-environment literature. This present study seek to bridge and fill this identified void for vast/robust debate in the energy-environment literature. This is an innovation and distinction into the related literature. Ecological footprint stands out given it broader ingredients and qualities that consist of its ability to account for natural essentials and economic expansion (Bello et al.,2018). The natural areas accounted for includes availability of water resource, fresh water and availability of arable farmland, forest reserves and fresh air. Theses aforementioned constituents have ability to support life and ecosystem as well as terrestrial acidity, eutrophication strong point, and ecotoxicity of the ecosystem by extension. These are the key traits that distinct EFP from other measures like greenhouse gases (GHG) and carbon dioxides emissions (CO_2) which the current study adopts. (Katircioglu et al., 2018) To the best of authors knowledge, the use of EFP is rarely used in the pollutant-environment and economic growth literature. Thus, the present study seek to bridge this gap and serves as an addition to the relevant literature[3]. In addition, the case of China is peculiar in the context of market, economic and political globalization because it potentially factored in the current trade row with the United States.

The remaining part of this study is planned as follow. The extant studies underpinning the relationship between globalization and the environment and that of energy consumption and the environment is highlighted in section 2. Section 3 presents the data and the empirical approaches employed, while section 4 reports and discusses the estimated results and findings. Section 5 concludes by providing policy suggestions and the potential future research directions.

2. Globalization and Energy Consumption: An Environmental insight

[3] For more insights into EFP interested reader can see https://www.footprintnetwork.org/our-work/ecological-footprint/

The world global energy market has consistently remains an integral part of the component of transnational corporations resulting from the globalization of global markets. That there is an environmental side to this perspective remains a subject of investigation among academicians, environmentalists, and other stakeholders.

2.1 Globalization and the Environment

In line with the global environmental trend, recent studies have captured the role of globalization. Through different perspectives, extant studies have shown that globalization can be linked to environmental sustainability either by virtue of carbon emissions, Greenhouse gas, and other environmental or anthropogenic gases (Shahbaz et al., 2017; Ding, Ning & Zhang, 2018; Saint Akadiri et al., 2019; Saint Akadiri, Alola & Akadiri, 2019; Shahbaz et al., 2019; Zaidi et al., 2019). For instance, Saint Akadiri et al (2019) and Saint Akadiri, Alola and Akadiri (2019) examined the role of globalization in achieving environmental sustainability target for Italy and Turkey respectively. Significantly, Saint Akadiri et al (2019) found that globalization actually mitigates CO_2 emissions, thus responsible for increased environmental quality (environmental sustainability) in Italy. This desirable impact observed by Saint Akadiri et al (2019) is significantly associated with both short-run and the long-run situations. In addition, Saint Akadiri, Alola and Akadiri (2019) employed the Autoregressive Distributed Lag (ARDL) and the Bayer-Hanck combined cointegration techniques and found a non-significant negative impact of globalization on CO_2 emissions in Turkey.

Importantly, Shahbaz et al (2017) and Ding, Ning and Zhang (2018) are separate studies that recently examined the role of China's globalization drive in the context of environmental sustainability. Shahbaz et al (2017) employed the ARDL and the Bayer-Hanck combined cointegration techniques to examined the Environmental Kuznets Curve (EKC) hypothesis in the context of globalization for China. The study supports the EKC hypothesis for China in both the immediate period and the long-run situation. Interestingly, the study found that globalization mitigates CO_2 emissions irrespective of using the overall index or sub-indices of globalization metrics. A similar perspective is held by Ding, Ning and Zhang (2018) while considering the bilateral trade activities of China. In the context of globalization, China is reportedly the world largest exporter and second world largest importer and thereby contributing massive CO_2 emissions annually. Within the same context of globalization-carbon emissions nexus, newly conceived trends of the nexus of globalization and CO_2 is being examined. For instance, the concept of asymmetric relationship and spillover effects of globalization on the CO_2 emissions are being considered in the respective study of Shahbaz, Shahzad and Mahalik (2018) and You and Lv (2018).

2.2 Energy Consumption and the Environment

The importance of energy is responsible for the broad scope of the context of energy and essentially akin to a multidisciplinary subject. In the past decades, the concept of energy has been associate linked to handful of macroeconomic, financial and socio and welfare economics among others. But, the current trend in energy is largely associated with the economy and the environment. As such, extant studies have widely examined the linkage between energy and the environment, courtesy of the persistent awareness of the intergovernmental organizations such as the United Nations Framework Convention on Climate Change. Most of the recent studies have applied disaggregation of primary energy by studying it nexus with environmental indicators (Alola & Alola, 2018; Alola, Alola, & Saint Akadiri, 2019; Alola, Bekun & Sarkodie, 2019; Balcilar, Bekun & Uzuner, 2019; Bekun, Alola & Sarkodie, 2019; Bekun, Emir & Sarkodie, 2019; Emir & Bekun, 2019; Saint Akadiri et al., 2019; Saint Akadiri, Bekun & Sarkodie, 2019; Samu, Bekun & Fahrioglu, 2019).

For instance, the studies of Saint Akadiri et al (2019), Saint Akadiri, Alola & Akadiri (2019), and Saint Akadiri, Bekun and Sarkodie (2019) separately examined the nexus of energy consumption and the environment sustainability without necessary employing the disaggregate primary energy forms. Each of the studies found that energy consumption is a vital determinant of environmental quality. By using difference case studies, the renewable energy is being utilized along the non-renewable energy (fossil fuel) to examine the differential nexus or effect of the two major energy components on carbon emissions. Specifically, for the case of China, Wang et al (2016) found the unidirectional causality from energy consumption to CO_2 emissions for the period 1990–2012. Similarly, Wang, Zeng & Wu (2016) found that the impact of energy consumption on carbon emissions in China varies across the cities. The study explains that the point-industrial stage cities such as Beijing and Shanghai are associated with larger emissions. For the western and central China that is characterized with low energy efficiency technologies, higher emissions are also reported in the region. Considering the energy-environmental nexus projection for 2050, there seems to be no ease of the impact of energy consumption on environmental quality in China (Hao et al., 2015). In specific term, Hao et al (2015) opined that energy consumption was responsible for 8% of nationwide Greenhouse gas in China in 2013. The study however noted that if the Business-As-Usual (BAU) pattern is not addressed, energy consumption will cause an estimate of 2.4 times the current values by 2050.

3 Methodological Framework

3.2 Data

A multivariate framework is set up to investigate the relationship that exists between globalization, ecological footprint, electricity consumption and economic output of china economy. Globalization index as developed by Dreher (2006) is used and it accounts for important dimensions (political, economic and social) of globalization. Ecological footprint (EFP) is used as proxy for environmental quality, electricity consumption measured in kilowatt per hours and real gross domestic product (RGDP) measured in constant 2010 USD. The data for ecological footprint measured in global hectares (gha) was retrieved from Global Footprint Network National Footprint Account (2018 edition), whereas data for electricity consumption and economic growth were retrieved from World Bank Development Database Indicators and globalization index data was retrieved from KOF Swiss Economic Institute database. Annual data used for the econometric analysis covers 1971 – 2014 time period. Data description, unit and source is presented in Table 1 below:

Table 1: Series description and unit of measurement

Variable	Unit of Measurement	Source
Globalization index (GLDX)	percentage	KOF
Ecological footprint (EFP)	Global hectare of land	GFP
Energy consumption (EU)	Oil equivalent per in kg	WDI
Real Gross Domestic Product (RGDP)	Constant 2010n$ USD	WDI

Author's compilation

The study follows this empirical sequence: Augmented Dickey-Fuller (1981) and Phillips-Perron (1988) unit root tests analysis and complemented with Zivot-Andrews (1992) unit root test with structural break. Then, Bayer and Hanck (2013) combined cointegration test is used together with bounds test of Pesaran et al. (2001) testing for long run relationship among the variables. Lastly, Granger causality test is applied to ascertain causal relationships between the series.

3.3 Model Specification

The current study builds on the existing study of Shahbaz et al (2016). Thus, this study functional form is presented below as:

$$EFP = f(EU, GLDX, RGDP) \quad (1)$$

Logarithm transformation in the above equation is necessary to ascertain homoscedasticity in the series.

$$LnEFFP_t = \alpha + \delta_1 LnEU_t + \delta_2 LnGLDX_t + \delta_3 RGDP_t + \varepsilon_t \quad (2)$$

Where α denotes constant and δ_1, δ_2 and δ_3 are partial slope parameters.

3.4 Test of Stationarity

To avoid spurious regression testing for stationarity among variables is necessary to establish order of integration of the series. Augmented Dickey-Fuller (1981), Phillips and Perron (1988) and Elliot et al. (1992) tests are needed in determining the order of integration of variables. These are usually referred to as the conventional unit root test which is deficient in accounting for structural breaks and as a result, produces inconsistent and invalid estimates in the presence of structural breaks in the data series. When confronted with economic datasets that is characterized with structural breaks as it is the case of times series data, then conventional unit root tests are complemented with Zivot-Andrews which has the unique feature of capturing structural break in a singular manner.

Below is Zivot-Andrews test model:

$$\Delta S_t = \alpha_1 + \alpha_2 t + \text{Ɣ} Y_{t-1} + \gamma DU_t + \sum_{i=0}^{k} \xi_i \, \Delta S_{t-i} + \varepsilon_t \quad (3)$$

$$\Delta S_t = \alpha_1 + \alpha_2 t + \text{Ɣ} Y_{t-1} + \phi DT_t + \sum_{i=0}^{k} \xi_i \, \Delta S_{t-i} + \varepsilon_t \quad (4)$$

$$\Delta S_t = \alpha_1 + \alpha_2 t + \text{Ɣ} Y_{t-1} + \gamma DU_t + \phi DT_t + \sum_{i=0}^{k} \xi_i \, \Delta S_{t-i} + \varepsilon_t \quad (5)$$

The null hypothesis of Zivot-Andrews unit root $H0$: Ɣ > 0 is tested against the alternative of stationarity $H1$: Ɣ< 0. The implication of this is, the inability to reject null hypothesis validates the presence of unit roots, whereas rejection ascertains stationarity.

3.5 Measuring Cointegration Relationships

The econometrics literature provides us with plethora of processes for testing cointegration relationship between variables. These cointegration relationships ranges from short run to long run cointegration relationship them (Carrion-i-Silvestre & Sansó, 2006; Gregory & Hansen, 1996; Johansen, 1991; Phillips & Ouliaris, 1990; Johansen & Juselius, 1990; Engle & Granger, 1987). However, due to the diverse conclusions arrived at by these cointegration tests, there is consideration of a more robust results that can be achieved by individually exploring the test statistics of Bayer and Hanck (2013), Banerjee et al. (1998), Boswijk (1995), Johansen (1991) and Engle and Granger (1987).

3.6 Autoregressive Distributive Lag (ARDL) Approach

The ARDL bounds testing technique is efficient and robust when used to test for cointegration in small sample size among globalization index, ecological footprint, energy consumption and economic output. The striking feature of this approach is the long run and short run dynamics of the fitted regression with error correction model reported simultaneously. The technique also has the ability to determine unknown order of integration of series so far as it I(0) and I(1). The unrestricted version of error correction model assumes that all the variables are endogenous and it is specified.

$$\Delta Y = \delta_0 + \delta_1 t + \beta_1 y_{t-1} + \sum_{k=1}^{Z} \gamma_1 v_{kt-1} + \sum_{n=1}^{X} \varphi_n \Delta Y_{t-n} + \sum_{k=1}^{Z} \sum_{n=1}^{X} \mu_{kn} \Delta V_{kt-n} + \theta D_t + \varepsilon_t$$

(6)

D_t is an exogenous variable which accommodates structural breaks in the framework, while V_k represents the vector. F statistics computed from the bounds test is used to validate null hypothesis when there is no cointegration. Three different scenarios exist in making this decision; (i) where F value computed is greater than the upper bounds of the critical values reported. The conclusion is to reject null of no cointegration (ii) where F value lies within both lower and upper bounds, an inconclusive result, and (iii) where F value lies below the upper bounds, a case of no cointegration. Below is the specification of the hypotheses for bounds test:

$$H_0: \beta_1 = \beta_2 = \ldots\ldots = \beta_{k+2} = 0$$

$$H_1: \beta_1 \neq \beta_2 \neq \ldots\ldots \neq \beta_{k+2} \neq 0$$

3.6.1 Bayer and Hanck Combined Cointegration test

The statistics and econometrics body of knowledge have good compilations of much documented techniques to equilibrium (cointegration) analysis since the 1980s. The recently developed Bayer and Hanck (2013) methodology to cointegration ameliorate for the shortcomings of the previous test. The Bayer and Hanck (B-H) combines different individual tests statistics, which offers the test unique traits to combine both single and multiple cointegration procedures. This makes results from B-H more robust to cointegration estimations. The B-H test is based on the Boswijk and Banerjee test Johansen, Engle and Granger test .The statistical computation is given below:

$$EG - JOH = -2[\log(P_{roEG}) + (P_{roJOH})] \tag{7}$$

$$EG - JOH - BO - BDM = -2[\log((P_{roEG}) + (P_{roJOH}) + (P_{roBO}) + (P_{roBDM}) \tag{8}$$

Where, $P_{roEG}, P_{roJOH}, P_{roBO} and P_{roBDM}$ represents the individual test probability test statistics. The B-H test have a null hypothesis of no cointegration. This implies that if the null is rejected the fisher test statistics greater than outlined critical values, we report cointegration among the interest variables.

3.7 Granger Causality Approach

In determining the direction of causality between variables, causality is necessary though it is a norm that a traditional regression does not necessarily mean causal relationships. However, this allows and arm policymakers and stakeholders good insight with their predictability powers among variables of interest. Where variable X Granger causes Y, this simply means in its entirety that both present and past realizations of the X variable is a good predictor of variable Y. This is usually specified in the bivariate form as:

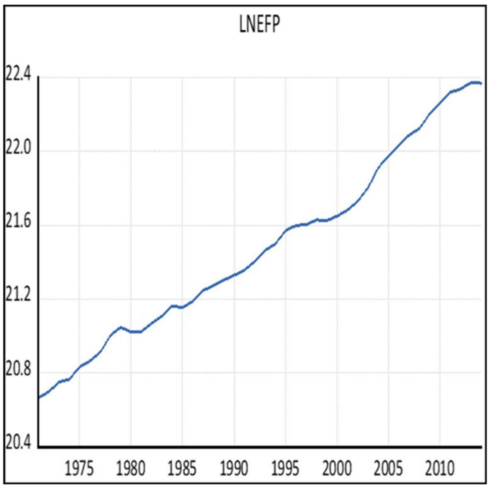
$$X_t = \delta_0 + \delta_1 X_{t-1} + \delta_2 Y_{t-1} + \varepsilon_t \tag{9}$$

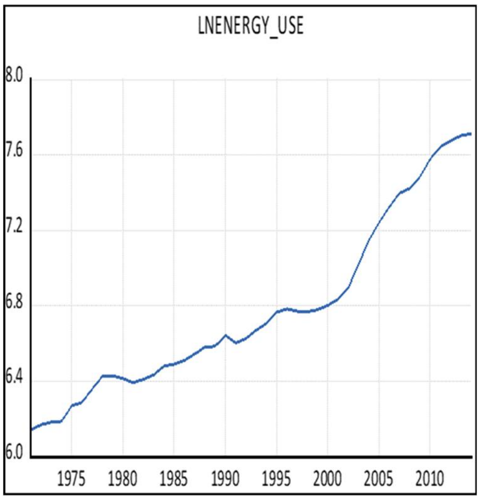
$$Y_t = \delta_0 + \delta_1 Y_{t-1} + \delta_2 X_{t-1} + \varepsilon_t \tag{10}$$

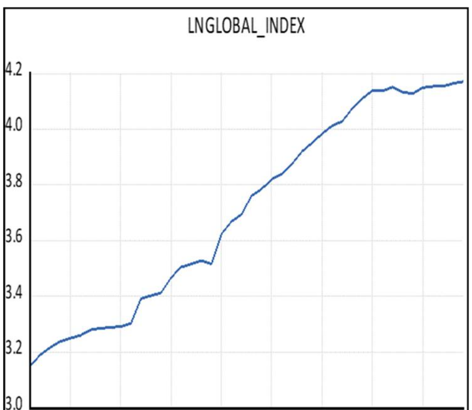
From equation (9) the null hypothesis is usually tested against the alternative hypothesis and same is done for equation (10). Granger causality can come in the following form; (a) neutrality which implies no causal interaction or relationship between variable X and Y; (b) unidirectional denoting the interaction from X to Y or otherwise and (c) bidirectional representing a feedback relationship from X to Y and Y to X.

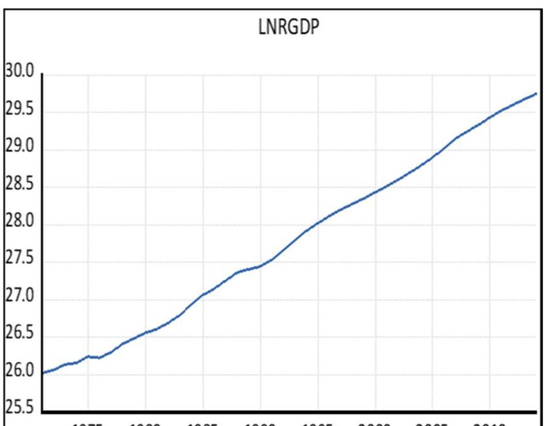
4 Empirical Results and Discussions

As a preliminary step in empirical analysis, a graphical plot of the dataset is necessary especially for time series estimations to assess the behavior and pattern of the variables under review. Figure 1 shows series that are upward trending with scanty structural break, however measures are taken by the model to account for structural breaks in the course of estimation. Table 2 captures the variables used in the study and reports the descriptive statistics as being normally distributed. The table further reveals wide gap between the maximum and the minimum values for the period under consideration. Table 3 reports the correlation matrix analysis and reveals high and very significant positive association between globalization, energy use, ecological footprint and economic growth over the sampled period. Similar trend is observed with energy use, ecological footprint and globalization. Ecological footprint is positively correlated with energy use. The observed positive correlation among the variables in Chinese economy is quite intuitive and should be explored by various stakeholders for maximum benefits.









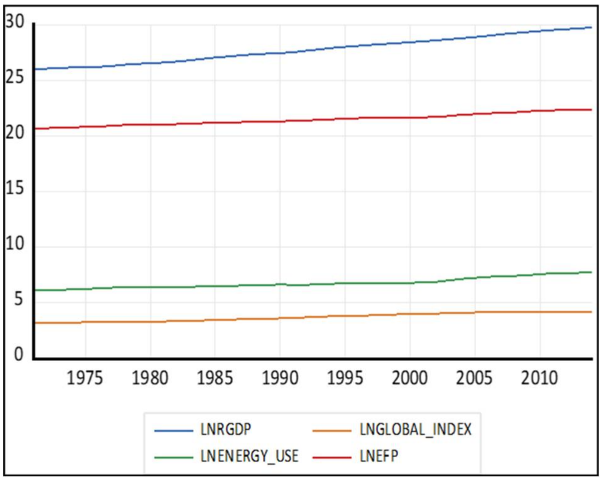


Figure 1: Visual plots of RGDP, GLIDX, EU and EFP

Table 2: Basic summary statistics of underlined variables

	Y	GLIDX	EU	EFP
Mean	27.7708	3.7075	6.7784	21.4786
Median	27.7309	3.7281	6.6561	21.4340
Maximum	29.7513	4.1712	7.7128	22.3743
Minimum	26.0217	3.1512	6.1419	20.6640
Std. Dev.	1.1793	0.3575	0.4664	0.5079
Skewness	0.0956	-0.0623	0.7037	0.2555

Kurtosis	1.7274	1.4570	2.3494	1.9876

Author's compilation.
Y represents RGDP, GLIDX stands Globalization index, EGU means Energy Use, and EFP means ecological footprint

Table 3: Coefficient of Correlation Matrix

	Y	GLIDX	EU	EFP
Y	1.0000			
T-Statistics	-----			
Probability	-----			
GLIDX	0.9871*	1.0000		
T-Statistics	40.0290	-----		
Probability	0.0000	-----		
EU	0.9631*	0.9210*	1.0000	
T-Statistics	23.1916	15.3268	-----	
Probability	0.0000	0.0000	-----	
EFP	0.9931*	0.9688*	0.9846*	1.0000
T-Statistics	54.8089	25.3420	36.5387	-----
Probability	0.0000	0.0000	0.0000	-----

Author's compilation
Y denotes RGDP, GLIDX means globalization index, Energy Use is for EU and EFP stands for ecological footprint.

Subsequently, Augmented-Dickey Fuller and Philips and Perron unit root tests is used to test the integrating properties of series of a study and a such useful in providing major stakeholders sound basis for informed decision. Table 4 and 5 reports results of unit root tests.

The variables (economic growth, globalization, energy use and ecological footprint) are integrated of order one. From the result, it is observed that structural break does not allow stationarity at levels except at difference. This allows the integrated variables at order one at significance level of 1%. Zivot-Andrews (ZA) is introduced in other to ameliorate inherent issues associated with

ADF and PP unit root tests thereby leading to unreliable and ambiguous results. The ZA test is presented in Table 5, both non-stationarity test are in harmony of unit root at level form and concludes first difference stationarity for considered variables.

Table 4: Unit Root Results (Without break)

Variables	ADF	PP
Panel A: Level		
Y	0.6450	1.4686
GLIDX	-1.0909	-1.0184
EU	0.6430	1.3387
EFP	0.1438	0.4953
Panel B: First Difference		
Y	-3.1641**	-4.3267*
GLIDX	-5.63453*	-5.6805*
EU	-3.5655**	-3.5689**
EFP	-4.5313*	-4.5313*

Author's compilation.
Asterisks (,**) denotes 1% and 5% significance level of rejection*

Table 5: Unit Root Test (with Break)

	Statistics (Level)			Statistics (Difference)			
	ZA_I	ZA_T	ZA_B	ZA_I	ZA_T	ZA_B	Conclusion
LNGLINDEX	-2.7894	-2.5829	-2.3861	-7.2876*	-7.0484*	-8.1045*	I (1)
Time Break	1990	2005	2003	1990	1994	1990	
Lag Length	1	1	1	1	1	1	
LNEU	-4.5736	-4.2425	-4.1411	-5.0824**	-3.8818*	-5.7834*	I (1)
Time Break	2003	2000	1997	2003	2007	2003	
Lag Length	1	1	1	3	1	1	
LNEFP	-4.2391	-3.7754	-3.8136	-5.1161*	-4.5939**	-5.8471*	I (1)

Time Break	2004	2001	1999	2002	2007	2003	
Lag Length	1	1	1	1	1	1	
LNRGDP	-3.5859	-3.2662	-3.8137	-5.0169**	-5.0562*	-6.6988*	I (1)
Time Break	1992	2004	1999	1982	1985	1981	
Lag Length	1	1	1	4	1	1	

Note: *LnGlindex is globalization index, LnEngyuse is energy use, Lnefp is the ecological footprint and Lnrgdp is real gross domestic product per capita. All of the variables are at their natural logarithms.* ZA_I *represents the model with a break in the intercept;* ZA_T *is the model with a break in trend;* ZA_B *is the model with a break in both the trend and intercept. Asterisks (*,**) denotes 1% and 5% significance level of rejection*

Table 6: Lag Length

Lag	LogL	LR	FPE	AIC	SC	HQ
0	138.5404	NA	1.7E-08	-6.6E+00	-6.4E+00	-6.5E+00
1	400.1785	459.4619	1.0E-13	-1.9E+01	-17.70940*	-18.24091*
2	420.5995	31.87670*	8.61e-14*	-18.76095*	-1.7E+01	-1.8E+01
3	430.8996	14.0685	1.2E-13	-1.8E+01	-1.6E+01	-1.8E+01

AIC denotes Akaike information criterion, LR represents sequential modified LR statistic, HQ means Hannan Quinn, SC signifies Schwarz information criteria and finally FPE stands for Final prediction error.

Table 7: ARDL Bounds Test Result

Test Statistic	Value	k
F-statistic	5.34**	3
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	3.47	4.45
5%	4.01	5.07
2.50%	4.52	5.62
1%	5.17	6.36

Table 8: Bayer and Hanck result

Fitted Model	EG-JOH	EG-JOH-BO-BDM	Cointegration Remark
LnEFP= f(LnEU,LnGLINX,LnY)	50.464**	20.988	Yes
Critical values	29.857	19.878	Yes

Author's compilation: The asterisk (**) represents a percent significance level of rejection.

Table 9: Short and Long run ARDL Result

EFP = f(EU, GLDX,RGDP)				
Variable	Coefficient	Std Error	t-statistics	Probability
Short run result				
ECT (-1)*	-0.4629^{*}	0.0587	-7.8876	0.0000
ΔEU	0.2714^{*}	0.0394	6.8787	0.0000
ΔGLDX	0.1547^{*}	0.0720	2.1499	0.0382
ΔRGDP	0.0464^{*}	0.0474	0.9796	0.3336
Constant	6.2360^{*}	0.9258	6.7361	0.0000
Long run result				
EU	0.5862^{*}	0.0861	6.8078	0.0000
GLDX	0.3343^{*}	0.1943	1.7202	0.0938
RGDP	0.1003^{*}	0.0872	1.1502	0.2575
Constant	13.4722^{*}	1.1852	11.3668	0.0000
Diagnostic test Results				
Autocorrelation 2.402 (0.105)				
Heteroscedasticity (ARCH) 0.220 (0.641)				
Ramsey (RESET) 1.667(0.203)				

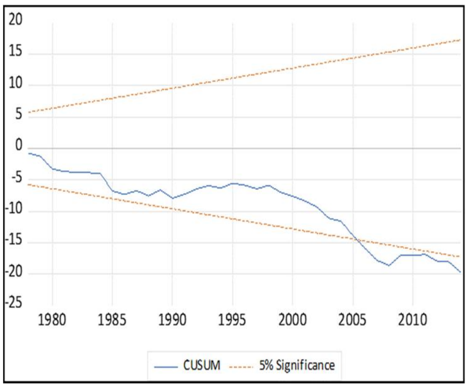
Author's compilation. The asterisk (*) represents a percent significance level of rejection.

The present study proceed to investigate for long-run equilibrium relationship among the choice variables with the aid of Pesaran's ARDL bounds in conjunction with the recent and novel Bayer and Hanck (2013) combined cointegration test. Prior to the cointegration test the optimum lag selection test is conducted as rendered in Table 6, the Schwarz Bayesian information criteria is chosen as the most parsimonious lag criterion and robust given the sampled data structure. The cointegration analysis shows equilibrium relationship between energy consumption, globalization and economic expansion and proxy for environmental degradation (EFP) over the sampled period.

Both the results of ARDL and B-H reported in Tables 7 and 8 respectively are consistent of convergence between the outlined variables ($p < 0.05$) statistical level.

In Table 9 both short and long run analysis are reported. The error correction term (ECT) that show the speed of adjustment of the fitted model pass the ($p<0.01$) statistical level. This implies that in case of disequilibrium in the system the outlined explanatory variables adjust with magnitude of 46.3% to its equilibrium path on an annual basis with the contribution of its explanatory variables. Furthermore, we observe a statistical positive relationship at ($p<0.01$) level between energy consumption and environmental degradation in the short run and long run over the sampled period. This is indicative and informative to policymakers in China. This implied that the Chinse economy energy mix is not clean, that is her energy basket are fossil fuel driven which dampens the quality of the environment (Shahbaz & Sinha.2019). This also indicate the short run focus of the chinse economy is on economic expansion. That is the chinses economy is at the scale stage of her growth trajectory. However, in the long-run there is need for a paradigm shift to clean energy sources such are renewables like hydro, photovoltaic, wind and biomass are encouraged (Emir & Bekun, 2019). Furthermore, the wave of globalization also had its toll on the quality of Chinses economy, given the interconnectedness of the world in recent time. This phenomenon has infiltrated into depletion of the quality of the environment in china. This outcome raises concern for energy specialist in china and government administrator that formulate and design macro economy framework (blue prints). Thus, as much as globalization has its good side the negative impact should be watch closely by the Chinese government as it has negative effected in both long and short run over the sampled period with deterioration of quality of the environment. This outcome is consistent with the findings of Shahbaz et al (2017) and Ding, Ning and Zhang (2018). The quest by most government official is to increase economic growth, which translate into better living standard for citizenry; the chinses economy is no exception. This explains the recent strides by the chinses economy on the Belt and Road Initiative (BRI) establish in 2013 to join the rest of the world via aggressive road and infrastructure. However, these laudable fit does not come without its implication on the environment and ecosystem at large in China. Thus, the need for caution in policy construction is pertinent for increase economic expansion a well not jeopardy for the quality of the environment.

The fitted model is free from serial correlation issues, heteroscedasticity and properly specified model as reported at bottom of Table 9. The Stability of the model is presented in figure 2, which shows the model is fit and suitable for policy direction



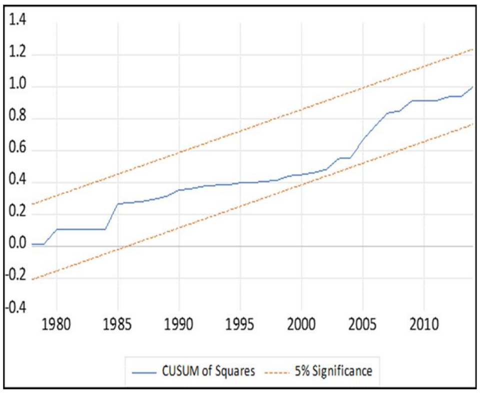


Figure 2: Stability graphical plots of the CUSUM and CUSUMsq

Table 10: Granger Causality Test

Null Hypothesis:	Causality	F-Statistic	Prob.
EU does not Granger Cause EFP	EU → EFP	2.40228***	0.0847
EFP does not Granger Cause EU		0.56555	0.6415
GLDX does not Granger Cause EFP	EFP → GLDX	1.53149	0.2241
EFP does not Granger Cause GLDX		2.6135***	0.0671
RGDP does not Granger Cause EFP	RGDP ≠ EFP	1.34586	0.2758
EFP does not Granger Cause RGDP		0.05086	0.9846
GLDX does not Granger Cause EU	GLDX ↔ EU	3.36867*	0.0296
EU does not Granger Cause GLDX		3.21155*	0.0351
RGDP does not Granger Cause EU	RGDP ≠ EU	2.03592	0.1273
EU does not Granger Cause RGDP		0.19993	0.8957
RGDP does not Granger Cause GLDX	GLDX → RGDP	0.49194	0.6902
GLDX does not Granger Cause RGDP		2.65058***	0.0644

Author's compilation. Asterisk(s) (*,**,***)represents 1%, 5% and 10% significance level of rejection accordingly. Note that $\leftrightarrow$ represents bidirectional causality, while $\rightarrow$ denotes unidirectional causality and $\neq$ means neutrality.

Generally, regression does not depicts causation. Thus, the need for causality test to determine the predictability power of one variable over another is crucial for policy construction. The present study applied the Granger causality test to detect the direction of casualty flow among the variables under review. Table 10 resents the causality analysis; we observe one-way causality running from energy consumption to EFP. This outcome is insightful, this implies that energy consumption drives environmental degradation in china. In addition, the wave of globalization further deplete environment al quality as uni-direction causality is seen running from EFP to Globalization. Feedback causality is experience between wave of globalization and energy consumption this is in line with the study of Shahbaz et al (2017) and Ding, Ning and Zhang (2018) of china. This means the quest for increase economic output as seen in the uni-directional causality seen from globalization to economic growth should be watch with caution not to dampen the quality of the environment in china given the high wave of globalization and industrial commerce and energy intensification for clean environment.

5. Conclusion

This study offers new insight into the interconnectedness of the world as it concerns increase energy consumption to determine its implications on environmental sustainability. This has made it possible for the global economies to be connected in various means such as integration of financial systems, politics, trade volumes and other areas. Thus, this study examined the role of globalization-led growth and induced energy consumption hypothesis in environmental sustainability using a multivariate approach for the case of China. The variables of interest were used in a multivariate framework to avoid the omitted variable bias. To this end, annual data from 1971 to 2015 were sourced from World Bank Development Database Indicators and KOF Swiss Economic Institute Database and used for the econometric analyses.

The key findings from this presents study includes validation of equilibrium relationship between the studied variables as traced by B-H and ARDL bounds test. Subsequently, energy intensification drives environmental degradation over the investigated period. This is instructive for chinse government officials given the recent BRI wave and wave globalization. There is need for policy mix to mange adequately increase energy consumption without compromise for the quality of the environment. Based on these findings the following policy prescription were suggested;

(i) The adoption of more efficient and updated energy technologies like renewables such as hydro, wind, photovoltaic and biomass energy sources are needed in China energy portfolio mix. This is a precondition for successful decarbonization of economic expansion from pollutant emissions.

(ii) There is need for china to reinforce her commitment on environmental treaties such as Kyoto protocol and many others. This will foster the attaining the SDGs 2030 targets.

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