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Article

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Is Trade Openness the Reason of High Energy Demand in China?

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ABSTRACT

The present study aims to examine the short-run and long-run impact of China's trade liberalization policies on its energy demand over the period from 1980 to 2018. The results of Autoregressive Distributed Lag approach of co-integration show that energy consumption significantly increases as a result of trade openness and increase in real Gross Domestic Product (GDP). The results of the granger causality test also confirm the unidirectional causality running from trade openness and real GDP to energy demand. The results of the study have an important implication because if China wants to continue its trade liberalization policies then it must increase its energy production.

Keywords: Energy Consumption, Gross Domestic Product, Trade Openness, China, Time Series
JEL Classifications: C22, F15, L98, Q43

1. INTRODUCTION

The nexus between energy use and economic growth has been extensively studied over the past years (Akarca and Long, 1980; Akinwale and Ogundari, 2017; Almozaini, 2019; Alter and Syed, 2011; Chan and Lee, 1996; Chen and Rose, 1990; Dong, 2000; Faisal et al., 2018; Gilland, 1988; Hussain and Ali, 2016; Kraft and Kraft, 1978; Kumar, 2011; Shahateet, 2014; Sharmin and Khan, 2016; Tran et al., 2020; Tugcu, 2013). Most of the studies conducted on the Chinese economy, especially after the energy crises of 1973, discuss the energy consumption-Gross Domestic Product (GDP) relationship while ignoring the effect of trade openness (Li and Leung, 2012; Lin and Ouyang, 2014; Zheng and Walsh, 2019). China has adopted trade liberalization policies in 1979 and after that a significant increase in the energy demand is observed (Sandklef, 2004). As a result of its trade liberalization policies, China has now emerged as a number one exporter in the world (WITZ, 2019). The present study is designed to check the effect of trade liberalization on energy consumption in China, controlling for multiple macroeconomic variables.

The interlink between energy consumption and macroeconomic indicators namely GDP growth, urbanization, Foreign Direct Investment (FDI), financial development, oil prices, innovation, technological development is widely studied and is an established phenomenon (Akinwale, 2018; Cao and Xu, 2020; Fernandes and Reddy, 2021; Humbatova et al., 2020; Samuel et al., 2013). There is a dearth of studies that have taken trade as the main determinant of the energy demand while conducting an empirical study on a single country as most of the studies has used panel data for the analysis (Fitriyanto and Iskandar, 2019; Kyophilavong et al., 2015; Nasreen and Anwar, 2014). After the establishment of World Trade Organization (WTO) in 1995, the trade volume of its member countries increased significantly and with that, a significant increase in energy consumption was also observed (Lin and Wang, 2012; Prasad and Barnett, 2004). The total volume of world trade was $12.52 trillion in 1995 which increased to the level of $50.04 trillion in 2018. The world energy demand was 17482.117 kilo-watt hour (KWH) in 1995 which increased to the level 20975.203 KWH in 2018.

The expansion of trade stimulates the energy demand as energy is considered a primary production input. At the end of the year 2001 China became a member of WTO. The exports of China increased from $ 23.52 billion to $ 2643.38 billion from the year 2000 to 2019 (WITZ, 2019). While, during the same period, the energy demand of China increased from 4855.86 per capita KWH to 27452.478 KWH. The export share of China in total export of the world is 13.3% which is highest in the world while the industrial share in total energy consumption of china is 59%.[1] The GDP of China also increased by leaps and bound in the last 20 years i.e. $ 2232.20 billion in 2000 to $ 11537.49 billion in 2019. Figure 1 illustrates the trends of energy demand, GDP and trade volume of China during the last four decades.

It is evident from Figure 1 that, in China, during the last four decades there has been an increasing trend in all three variables: GDP, energy demand, and trade volume. However, a significant change in trend can be observed from the year 2001onwards when China joined WTO. The GDP and energy consumption are increasing since the year 2001-even in the period of global recession (2007-2009) and global slowdown (2015-2016). The upward trend in total trade volume is also evident from Figure 1. There are two dips in the trade volume line, one dip is due to the global financial crises and another dip is in 2015-2016 where the world experienced an economic slowdown. The decrease in commodity prices and the appreciation of the US dollar were the major reason for this slowdown (United Nations, 2016). In short, during the last four decades, GDP, energy demand, and trade volume of China have increased significantly, with noteworthy changes in trend from the year 2001 onwards.

Considering the nexus between GDP, trade volume, and energy consumption the present study aims to test the following hypothesis:

H_1= Trade openness does contribute towards higher energy consumption in China.

1 https://www.enerdata.net/estore/energy market/china/# :~:text= Electricity %20consumption%20has%20increased%20strongly,and%2016%25%2C%20respectively).

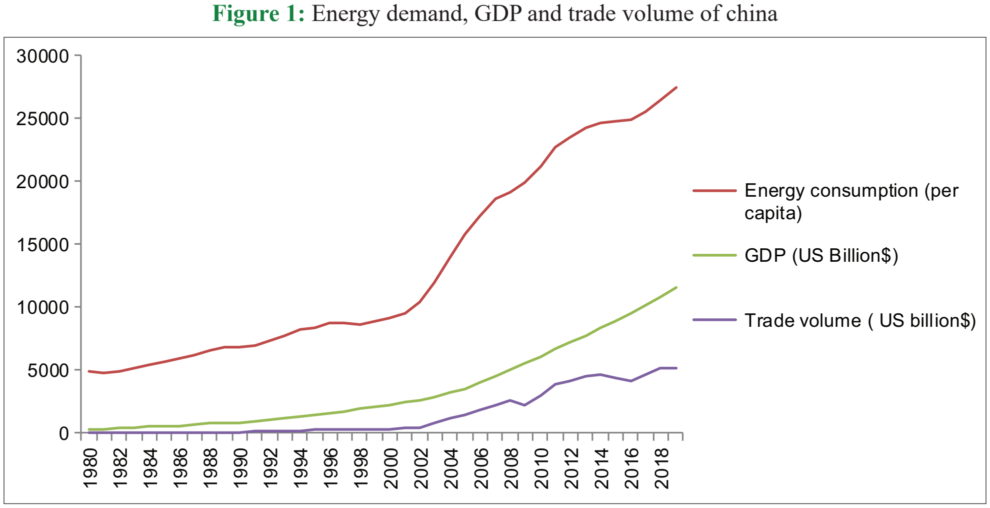
2. LITERATURE REVIEW

After the energy crisis of 1970, a significant amount of studies have tested and confirmed the positive association between energy demand and GDP (Akarca and Long, 1980; Alter and Syed, 2011; Chan and Lee, 1996; Kraft and Kraft, 1978). Efficient use of energy, along with labour, capital and other inputs are considered essential for economic growth for all countries. Labor and capital are primary inputs while fuels and materials (energy sources) are intermediary inputs for production. The shortage of energy hampers economic growth (Alter and Syed, 2011; Mudakkar et al., 2013; Tang, 2009). High growth rate of country shows energy consumption of the country is increasing (Akinwale, 2018; Humbatova et al., 2020; Sineviciene et al., 2017).

There are many factors that are increasing the demand for energy in China including GDP growth rate, FDI, industrial structure, inflation, population size, resource endowment, trade volume, urbanization, etc. By using time series and panel data, many studies have identified the correlation between energy demand and the macroeconomic indicators mentioned above. While talking about the studies that have used time-series data, Xia and Hu (2012) explored the potential drivers of energy use in China by considering city and province-level data. Resource endowment, price, urbanization, industrial structure, urban morphology, and natural condition were included as the potential factors of high energy demand in China. The authors applied the Finite Mixture Model (FMM) and the results of the study showed that industrial structure and urban morphology are the major factors affecting the electricity consumption in China.

The energy consumption, economic development, and technological advancement nexus was investigated by Akinwale (2018) for the case Saudi Arabia. The ARDL co-integration method was used for mix order variables, confirming the short-run (SR) and long-run (LR) relation among the variables of interest. For both the SR and LR, economic growth was positively affecting energy demand while technology innovation was negatively affecting energy demand. Moreover, the results also confirmed unidirectional casual relation of economic growth and technology innovation with energy demand.

Figure 1: Energy demand, GDP and trade volume of china



Likewise, Fuerst et al. (2020) conducted a time-series study and explored the major factors determining energy consumption of the households of the United Kingdom by taking data of 13,600 households from the English Household Survey (EHS). The data was divided into two sets of variables. One set consisting of socioeconomic variables, like household income, size, and type were taken while the second set of variables consists of dwelling variables, for instance, age and no of bedrooms. A multivariate econometric model showed that vicissitudes in energy consumption are mostly due to socioeconomic factors. Cao and Xu (2020) also undertook an empirical study to explore the major determinants of energy demand in China by taking data of 30 provinces of China. The results highlighted that economic development, financial development, and the degree of industrial development were positively and significantly affecting the energy demand. In the same way, Kumar (2011) also found that the energy prices and real GDP are the major factors affecting energy demand in Fiji. A bi-directional causal relationship between the use of energy and growth rate of Taiwan was also found by Humbatova et al. (2020).

There is also a significant amount of literature on panel data that has explored macroeconomic determinants of energy consumption. Mudakkar et al. (2013) conducted an empirical study to check the macroeconomic variables that are affecting the energy consumption of SAARC countries. The results dyed that the growth rate of countries, FDI, and financial development are the major determinants of energy consumption. Similarly, Zeeshan et al. (2021) confirmed the positive and significant effect of FDI and natural resources on the energy consumption of Latin American countries by using structural equation model (SEM) approach of estimation. A large number of studies are available on energy-growth and other determinants of energy consumption but so far the trade-energy linkage is understudied. Few studies in the literature, for instance Zeren and Akkuş (2020), have investigated the relation between energy consumption (both non-renewable and renewable energy) and trade openness by taking fourteen countries. The results confirm the two way causal relation between trade openness and the consumption of energy. By considering 14 countries, Zeren and Akkuş (2020) studied the relationship between energy use and trade openness. The findings affirm the two way causal association between trade openness and the use of energy.

In light of the above discussed studies, it is concluded that most of the studies have discussed the energy-growth linkage. While the literature on the drivers of energy demand (consumption) mostly discussed the effect of urbanization, FDI, financial development, oil prices, and innovation on the energy consumption (Akinwale, 2018; Cao and Xu, 2020; Fernandes and Reddy, 2021; Fuerst et al., 2020; Humbatova et al., 2020; Mudakkar et al., 2013; Samuel et al., 2013). To the best of researcher's knowledge, no study has checked the effect of trade liberalization policies on the energy demand in case of China. The trade openness was relatively overlooked or neglected while establishing the link between economic variables and energy consumption especially in the case of China. This study is conducted to fill this gap in the literature as for china trade openness seems to be one of the major determinants of energy use.

3. DATA AND METHODOLOGY

3.1. Data

Since China opened up its trade in 1979, the present study considers data from 1980 to 2018 to examine the impact of trade openness policy of China on the high consumption of energy. Data on all the variables used in the study is taken from the Penn World Table (PWT) 9.0 and World Development Indicator (WDI) 2019.

3.2. Model Specification

The literature suggests that GDP growth rate, FDI and population are significant macroeconomic indicators that are affecting the energy consumption of any country. The present study has taken all these variables as control variables along with trade openness. The function form the model is as follow:

$$LECOPC=f(LRGDP, LPOPGR, LFDI, LTO) \quad (1)$$

The econometric model of above functional form is as follows,

$$LECOPC_t = \gamma_0 + \gamma_1 LRGDP_{\_t} + \gamma_2 LPOPGR_t + \gamma_3 LFDI_t + \gamma_4 LTO_t + \varepsilon_t \quad (2)$$

Where,

LECOPC = log of energy consumption (kg of oil equivalent per capita)

LPOPGR = log of population growth

LRGDP = Log of real GDP expenditure side

LFDI = Log of FDI, net inflow (% of GDP)

LTO = Log of Trade Openness (total trade as % GDP)

ε = White noise error term

Log of all the values is taken to determine the elasticity of the dependent variable.

3.3. Methodology

The present study has used the Autoregressive Distributive Lag (ARDL) model of co-integration. This approach of co-integration is more efficient, robust, and gives unbiased estimator since it takes care of the problem of endogeneity (Pesaran and Shin, 1998; Pesaran and Shin, 2001). The earlier co-integration approaches namely Engle and Granger (1987), Gregory et al. (1996), and Johansen and Juselius (1990) have some drawbacks, most important of which is that that these approaches, by definition, cannot be applied to data having variables with different order of integration. It is a prerequisite of these approaches that the variables used in the study must be stationary at first difference. ARDL allows the researcher to use variables that have mix order of integration. There is one restriction in ARDL as well that no variable of the study should be stationary at second difference.

Before applying ARDL, Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests were applied to check the stationarity level of each variable. Having checked the order of integration of the variables, the bound test is used to verify the presence of a LR relationship between variables. The bound test puts restrictions on the coefficients that there exists no LR relationship among the variables (null hypothesis). The value of the F-test must lie above the value of the upper bound to reject the null hypothesis. Diagnostic tests are applied to check the problems of heteroskedasticity, model specification, normality of error terms, and serial correlation. After the application of diagnostic tests, the optimum lag length is chosen with the help of Hannan-Quinn criterion (HQ). ARDL approach of co-integration is thereafter applied to the following model:

$$\Delta LECOPC = a + \sum_{i=1}^{p} b_i \, \Delta L(ECOPC)_{t-1} + \sum_{i=1}^{q} c_i \, \Delta L(RGDPE)_{t-1} + \sum_{i=1}^{q} d_i \, \Delta L(POPGR)_{t-1} + \sum_{i=1}^{q} e_i \, \Delta L(FDI)_{t-1} + \sum_{i=1}^{q} p_i \, \Delta L(TO)_{t-1} + \eta_1 LECOPC_{t-1} + \eta_2 LRGDPE_{t-1} + \eta_3 LPOPGR_{t-1} + \eta_4 LFDI_{t-1} + \eta_5 LTO_{t-1} + \varepsilon_t \quad (3)$$

The parameters (a, b, c, d, e, and p) represent the SR dynamics of the ARDL model, whereas (η_1, η_2, η_3, η_4, and η_5) are the LR coefficients. The null hypothesis of bound test is H_0: $\eta_1 = \eta_2 = \eta_3 = \eta_4 = \eta_5 = 0$. The specification of Error Correction Model (ECM) is as follows:

$$\Delta LECOPC = a + \sum_{i=1}^{p} b_i \, \Delta L(ECOPC)_{t-1} + \sum_{i=1}^{q} c_i \, \Delta L(RGDPE)_{t-1} + \sum_{i=1}^{q} d_i \, \Delta L(POPGR)_{t-1} + \sum_{i=1}^{q} e_i \, \Delta L(FDI)_{t-1} + \sum_{i=1}^{q} p_i \, \Delta L(TO)_{t-1} + \lambda ECT_{t-1} + \varepsilon_t \quad (4)$$

Where,

$$\lambda = (1 - \sum_{i=1}^{p} \delta_i) \quad (5)$$

Where, is representing Error Correction Term (ECT)

3.4. Causality Test

Granger causality test, put forward by Granger (1969), is applied to determine the structures of the causal relationships among variables. The null hypothesis of causality test between two variables is that the first variable of interest does not Granger cause the other variable. The causality among three variables namely LRGDP, LTO and LECOPC is tested using the following econometric equations:

$$LRGDP_t = \sum_{i=1}^{n} \alpha_i LECOPC_{t-1} + \sum_{i=1}^{n} \beta_i LRGDP_{t-1} + \varepsilon_{1t} \quad (6)$$

$$LECOPC_t = \sum_{i=1}^{n} \alpha_i LRGDP_{t-1} + \sum_{i=1}^{n} \beta_i LECOPC_{t-1} + \varepsilon_{2t} \quad (7)$$

$$LTO_t = \sum_{i=1}^{n} \alpha_i LECOPC_{t-1} + \sum_{i=1}^{n} \beta_i LTO_{t-1} + \varepsilon_{3t} \quad (8)$$

$$LECOPC_t = \sum_{i=1}^{n} \alpha_i LTO_{t-1} + \sum_{i=1}^{n} \beta_i LECOPC_{t-1} + \varepsilon_{4t} \quad (9)$$

$$LTO_t = \sum_{i=1}^{n} \alpha_i LRGDP_{t-1} + \sum_{i=1}^{n} \beta_i LTO_{t-1} + \varepsilon_{5t} \quad (10)$$

$$LRGDP_t = \sum_{i=1}^{n} \alpha_i TO_{t-1} + \sum_{i=1}^{n} \beta_i LRGDP_{t-1} + \varepsilon_{6t} \quad (11)$$

4. RESULTS

To verify the presence of the unit root (non-stationarity) in the variables, ADF and PP unit root tests are applied. The null hypothesis of ADF and PP tests states that series is not stationary around the mean. The details of ADF and PP tests are given in Table 1.

The results confirm that all the variables under consideration have a mixed order of integration. LTO is stationary at level while LRGDP, LECOPC, and LPOPGR are stationary at first difference. The presence of mixed order paves the way to apply the ARDL bound test to examine the LR relationship between the variables of interest. The bound test results are given in Table 2.

Since the value of F-statistics is higher than the upper bound of the 95% confidence interval, we reject the null hypothesis of the Bound test and conclude that a LR relationship exists among variables. After verifying the LR relationship among variables, diagnostic tests are applied to check the problems of heteroskedasticity, model specification, normality of error terms, and serial correlation in the model. These results are given in Table 3.

To avoid spurious results, it is mandatory to apply the diagnostic tests before estimating the model. The null hypothesis of all the four tests namely Lagrange Multiplier, Breusch-Pagan-Godfrey, Ramsey RESET, and Jarque-Bera state the absence of serial correlation, heteroskedasticity, wrong functional form, and non-normality respectively. The insignificant P-values of all four tests show that the model is a good fit. The results of the LR estimates are presented in Table 4.

The findings suggest that openness to trade has a significant and positive effect on China's energy consumption. The trade elasticity of energy consumption is 0.28, which means that a 1% increase in trade openness raises energy consumption in the long run by 0.28%. We fail to reject the hypothesis of the study that "Trade openness does contribute towards higher energy demand of China." The same positive and significant effect of trade on energy consumption is confirmed by various studies conducted on panel data (Akin, 2014; Nasreen and Anwar, 2014; Shahbaz et al., 2014; Tran et al., 2020; Zeren and Akkuş, 2020). The total trade volume of China has increased from \$ 42.877 billion to \$ 5,122.632 billion (12025.42%) during the last four decades[2]. While during the same time period energy demand per capita increased from 4,855.86 kWh to 26, 416.955 kWh (444.02%)[3]. Real GDP is another important determinant of the energy demand in China which is found positive and highly significant as the P < 0.01. The real GDP elasticity of energy demand for China is 2.24183 which indicate that a 1% increase in the GDP leads to almost 2.242% increase in the energy demand. The same results for China are confirmed by Lin and Ouyang (2014); Rathnayaka et al. (2018); Wang et al. (2011) and for rest of the world by Ahmad and Zhao (2018); Almozaini (2019); Costantini and Martini (2010); Dedeoğlu and Kaya (2013); Hussain and Ali (2016). As a result of trade openness the domestic economic activities increase which boost domestic production and ring about greater economic growth. This increase in energy demand that results from an increase in domestic production and economic growth is referred to as scale effect.

The results also show that the effect of FDI and population growth on energy demand is positive but insignificant (Akinwale, 2018; Gregory et al., 1996). The SR estimates of the model are given in Table 5.

The SR results are consistent with the LR results. The coefficients of trade openness and real GDP are positive and highly significant. FDI and population have a positive but insignificant association with consumption of energy. The coefficient of ECT is significant at 1%. The coefficient of ECT is - 0.8415 (negative and less than one) which shows the convergence of the dependent variable (energy demand) towards its LR equilibrium due to the change in independent variables of the estimated model. The convergence towards LR equilibrium will be 84.15% next year.

The causal relationships among GDP, energy consumption, and trade openness are tested for the Chinese economy. Table 6 shows the granger causality test results.

The findings of the causality test suggest one-way causality from LRGDP to LECPOPC, LTO to LECPOPC, and LTO to LRGDP. The

2 https://wits.worldbank.org/CountryProfile/en/CHN
3 World energy outlook 2020

Table 1: Results of ADF and PP tests

Variables	ADF		PP	
	Intercept	Intercept and trend	Intercept	Intercept and trend
LRGDP	1.009 (0.9956)	−2.739 (0.2293)	0.4857 (0.9839)	−1.794 (0.8670)
ΔLRGDP	−3.715* (0.0081)	-	−4.044* (0.0034)	-
LECOPC	0.2894 (0.9743)	−1.7080 (0.7257)	1.5257 (0.9991)	−1.5522 (0.7913)
ΔLECOPC	−2.9717* (0.0478)	-	−2.9669** (0.0483)	-
LPOPGR	0.3878 (0.9796)	−2.5186 (0.3179)	0.8065 (0.9930)	−1.9046 (0.6335)
ΔLPOPGR	−3.8856* (0.0049)	-	−2.0116** (0.0437)	-
LFDI	−2.443969 (0.1368)	−11.3753* (0.0000)	−9.0100* (0.0000)	-
LTO	−3.048606** (0.0389)	-	−2.9586** (0.0476)	-

*and **indicate significance at 1% and 5% level respectively

Table 2: Results of bound test

F- Statistic	99% confidence interval		95% confidence interval	
	I_0	I_1	I_0	I_1
4.591952	4.4	5.72	3.47	4.57

I_0 = lower bound and I_1 = upper bound

Table 3: Diagnostic tests results

Test applied	F-statistics	Probability value
Lagrange multiplier	1.711656	0.2295
Breusch-Pagan-Godfrey	0.611474	0.8324
Ramsey RESET	0.052548	0.8229
Jarque-Bera	0.9438	0.6238

Table 4: ARDL (2, 5, 2, 0, 4) long run coefficients based on Hannan-Quinn (HQ) test

Variable	Coefficient	Std. error	t-Statistic	Prob. value
LRGDPE	2.24183*	0.123260	18.187779	0.0000
LPOPGR	0.07173	0.090111	0.796032	0.4415
LFDI	0.01532	0.016293	0.939963	0.3658
LTO	0.28009*	0.048069	5.826786	0.0001
Constant	−26.58243*	1.717173	−15.480344	0.0000
@TREND	−0.107654	0.011466	−9.389170	0.0000

*Indicates 1% level of significance

Table 5: ARDL (2, 5, 2, 0, 4) short run coefficients based on Hannan-Quinn (HQ) criterion

Variable	Coefficient	Std. Error	t-Stat	P-value
DECOPC (−1)	0.439252	0.153971	2.852832	0.0145
DRGDPE	0.781864	0.148708	5.257713	0.0002
DRGDPE (−1)	−0.130657	0.365611	−0.357365	0.7270
DRGDPE (−2)	−0.994108	0.321038	−3.096546	0.0092
DRGDPE (−3)	0.713365	0.357270	1.996711	0.0691
DRGDPE (−4)	−0.818940	0.262378	−3.121227	0.0088
DPOPGR	0.025547	0.140977	0.181216	0.8592
DPOPGR (−1)	−0.249889	0.100804	−2.478944	0.0290
DFDI	0.012887	0.013511	0.953809	0.3590
DTO	0.171934	0.039903	4.308753	0.0010
DTO (−1)	−0.104524	0.040856	−2.558340	0.0251
DTO (−2)	−0.105864	0.046614	−2.271061	0.0424
DTO (−3)	0.088837	0.027368	3.245975	0.0070
D(@TREND	−0.090586	0.011129	−8.139439	0.0000
ECT (−1)	−0.841459*	0.090828	−9.264349	0.0000

*Shows 1% level of significance

Table 6: Granger causality test

Direction of causality	F-Stat	P-value
LRGDP→LECPOPC	9.61006	0.0040
LECPOPC→LRGDP	1.53625	0.2242
LTO→ECPOPC	9.61548	0.0040
ECPOPC→LTO	0.28565	0.5961
LTO→LRGDP	3.00244	0.0922
LRGDP→LTO	0.15318	0.6980

results of the causality test also confirm that trade openness is one of the major determinants of energy consumption. Moreover, the results also suggest that energy consumption and economic growth are not promoting trade openness. These results are in line with the ones presented by Sami (2011) Sbia et al. (2017), and Shahbaz et al. (2014).

5. CONCLUSION AND RECOMMENDATIONS

China adopted the trade liberalization policy in 1979 which compelled the researchers to conduct an empirical study to see how trade openness policy has affected the energy demand of China. Considering this, the present study has also analyzed the impact of trade liberalization on energy consumption in China for the period 1980-2018 using ARDL bound test approach. The results highlight that trade openness has led to an increase in energy demand in China in the period under study. The results of ARDL also show that GDP is positively and significantly affecting energy demand. ECT is found to be negative and significant indicating convergence of model towards its LR equilibrium. Causality test was also applied to test the causal relationship among energy consumption, real GDP, and trade openness. The results confirm one-way causality running from trade openness to energy consumption and real GDP.

The results of the study have an important implication because if China wants to continue its trade liberalization policies then it must increase its energy production. The gap between energy consumption and energy production in China is increasing over the period of time. Moreover, China is heavily dependent on the imports of fossil fuels. In 2017, China became the largest crude oil buyer and a 10% increase in its demand for crude oil was experienced from 2018 to 2019[4]. The industrial sector is consuming two-thirds of China's total energy and coal is fueling this heavy demand. Since China is committed to reduce coal-fired energy generation, it must focus on other sources of energy like wind energy and solar energy (renewable energy sources). China is already giving great importance to renewable energy sources and is giving incentives to the investors and seeking FDI in renewable energy generation sector. The present share of renewable energy of China in the total supply of energy is around 10% which must be increased to a significant level so that the expensive sources of energy can be replaced with cheap renewable energy sources. Moreover, it can also help to decrease the cost of production and help to increase exports and the GDP of China. In addition, by benefiting from its trade openness policies, China should import advanced energy-saving technologies from other countries. This will allow the firms to produce more output by consuming less energy, hence bringing efficiency in the production process.

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