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Abstract

The present study is designed to empirically investigate the effect of financial development, per capita income and trade openness on renewable and non-renewable energy consumption in China. To achieve that, we make use of annual data from 1980 to 2016 and employ several robust time series econometric techniques. Our empirical findings from the fully modified ordinary least squares (FMOLS) technique suggest that increase financial development and per capita income contribute for higher energy demand of both renewable and non-renewable energy sources in China. The evidences also show that their impact is more on renewable energy than that of non-renewable energy. These findings indicate that both financial development and per capita income are the important factors in driving renewable energy consumption in China. In contradiction to that, the trade openness positively affects non-renewable energy consumption, while it negatively impacts on renewable energy. This therefore infers that the internationalization of trade is putting more pressure on non-renewable energy sources in China. Given these findings, we discuss and provide numerous practical and policy implications for China.

JEL classification: D53; F14; O47; Q43

Keywords: Disaggregated energy uses; financial development; per capita income; trade openness

1. Introduction

According to "BP Statistical Review of World Energy 2018", China's primary energy consumption has increased from 397.1 million tons oil equivalent to 3.1billion tons oil equivalent during 1978 to 2017, which is an average annual growth rate of 5.4%. At the same time, the world's energy consumption has grown with an average growth rate of 2.8%. It is also equally important to highlight that the growth rate of energy consumption in China is considerably higher than world's average consumption for the 17 consecutive years. In spite of the world's largest energy consumer and biggest emitter of greenhouse gases, China's per capita energy consumption is still less than one-third of the United States per capita energy consumption. It is vital to note that the Chinese economy still has a considerable growth potential; therefore, there will be a substantial growth in per capita energy consumption in China in coming years. Given that there will be considerable challenges for China's energy security; unless the government initiates more affective renewable energy initiatives in the country which can help to sustain the increasing demand for energy from all walks of life.

China's energy resource endowment is characterized by "coal abundance, natural gas inadequacy, and oil shortage". As a result, the structure of China's energy sources has long been dominated by coal. Since the start of China's reform and opening-up in 1978, the country's annual GDP growth rate has grown, on average, by 9.6% during 1978-2017 (World Development Indicators). For the same period, China's demand for non-renewable energy such as coal has increased rapidly (Aslan et al., 2014). The coal consumption is considered to be an important driver of China's rapid economic growth (Sadorsky, 2009). As of 2017, coal accounted for 60.4% of primary energy consumption (BP, 2018). The dominance of non-renewable energy in China's economic growth has led to energy price volatility, carbon emission growth, and especially environmental pollution (Destek and Aslan, 2017, Koçak and Şarkgüneşi, 2017). Given the increasing growth of carbon emissions in China, air pollution and smog crisis have emerged as one of the major environmental issues, which posed a severe threat to the public health in the country. According to the World Bank, the cost of air pollution in China is more than 1.6 million premature deaths and direct economic losses of $1.6 trillion in 2013.

As a result of high economic costs and serious environmental problems caused by non-renewable energy, China has been actively engaged in development of alternative energy sources (Ozturk and Bilgili, 2015). Although the country's emissions are still growing, the emission reduction targets that the Chinese government has already set out include achieving emission peak by 2030, a 60-65% decline in carbon dioxide emissions per unit of GDP, and increasing the share of non-fossil energy in primary energy consumption to 20%. This means the highest point will be reached by 2030 and emissions are expected to fall from thereon. To reduce carbon emissions and the share of fossil energy in energy consumption, China needs to accelerate the development of hydropower, wind power, and solar power generation and actively promote renewable energy sources such as geothermal energy, biomass energy and ocean energy[1]. As of 2017, China's renewable energy consumption accounted for 11.8% of the total energy consumption and it is managed to become the world's largest consumer of renewable energy (IEA, 2018). In the first three quarters of 2018, China has increased its existing capacity by 59.96 million kilowatts of renewable energy generation, accounting for 69% of China's newly installed capacity. Renewable energy has become the main driver of China's power generation growth, and clean energy substitution has played an increasingly prominent role in it. By vigorously developing renewable energy, China will not only promote energy security, but also reduce its heavy dependence on

[1] Liu et al. (2019) provide a detailed overview of energy structure in the present and future in China.

traditional energy sources[2]. If China can achieve the 2030 emission-reduction goal, it will undoubtedly have a significantly positive impact on achieving China's sustainable development goal and also improving overall quality of the environment.

The above discussion clearly indicates that, there is very little evidence on the factors that promote renewable energy consumption in China. This therefore motivates us to thoroughly investigate the factors that are driving both renewable and non-renewable energy. It is important to understand the drivers of China's demand for energy (renewable and non-renewable) for a number of reasons. More specifically, it is crucial for the policy makers and government officials to understand which factors are driving these energy sources. This understanding will play critical role in designing appropriate policies to find alternative ways to address the increasing demand for energy. Further, it also helps them to alter energy demand from fossil fuel energy to renewable energy to achieve sustainable economic development. In addition to that, it helps them to mitigate the growth of carbon emissions and to meet climate change targets. Hence, this research paper investigates the roles of financial development, per capita income and trade openness on renewable and non-renewable energy demand. For this purpose, we make use of yearly data from 1980 to 2016 and employ several robust time series econometric techniques. The findings of this study will play a critical role in framing and developing suitable energy policies in regards to the patterns of energy uses across the renewable and non-renewable energy uses. The findings will also help the policy makers to understand the nature of energy demand from the perspectives of financial development, rise of income levels and internationalization of trade. Consequently, this study will add an important value to the policy and practice in the context of China. Finally, this study also

[2] Using provincial level data, Yang et al. (2019) document that the urbanization is increasing demand for energy.

contributes to the prevailing empirical literature, particularly by identifying the factors that drive both renewable and non-renewable energy demand in China.

The present paper is organized as follows: Section 2 provides a brief literature review on the factors that drive energy demand. Section 3 discusses nature of data, empirical methodology and preliminary investigation. Section 4 provides empirical results and discussion, whereas Section 5 concludes with appropriate policy recommendations in the context of China.

2. Literature Review

Existing research on determinants of energy demand is mainly based on economic growth, financial development, and trade. The impact of economic growth on energy demand is investigated by the existing literature in four scenarios. The “growth hypothesis” believes that higher energy consumption causes economic growth (Al-mulali and Sab, 2012; Ahmad et al., 2017; Lin and Wesseh, 2014; Ozturk, 2010; Smyth and Narayan, 2015). An important implication of this hypothesis is any reduction in energy consumption would undermine growth trajectory. By contrast, the “protection assumption” (e.g., Kraft and Kraft, 1978; Islam et al., 2013) argues for a one-way causal relationship from economic growth to energy consumption. And the implication of this assumption is that policymakers' attempts to change energy consumption would not have any negative impact on economic growth. The “feedback hypothesis” (Soytas and Sari, 2003; Fuinhas and Marques, 2012) considers a two-way causal relationship between energy consumption and economic growth. Finally, “neutrality assumptions” (eg, Stern, 1993; Huang et al., 2008) suggests no causal relationship between energy consumption and economic growth. These arguments indicate that there is no clear consensus on the relationship between economic growth and energy consumption. Further, it is also important highlight that the relationship between these variables various across countries and time period. However, one should note that given growing economic activities around the world, the energy consumption has become a key ingredient in driving economic development and prosperity.

Although the literature on growth-energy relations is abundant, the causal relationship between the two variables has not yet been clearly identified. For example, Sharma (2010) studied the relationship between 6 energy type variables and economic growth in 66 countries during 1986-2005 and confirmed the growth hypothesis for electricity consumption in East/South Asia and the Pacific countries. Apergis and Payne (2012) provided evidence to support both growth hypothesis and feedback hypothesis in the short-term and long-term for renewable electricity consumption. However, for non-renewable electricity consumption, they found only the feedback hypothesis. Huang et al. (2008) used data on 82 countries for the period of 1972 to 2002 an also classified countries into four income groups. The evidences confirmed absence of growth hypothesis. Similarly, Omri and Kahouli (2014) analysed the nexus between economic growth and energy consumption in a sample of 65 countries during the period 1990-2011 and confirmed both feedback and growth hypotheses in low- and middle-income countries. Alam et al. (2017) examined the role of natural gas consumption on economic growth using yearly data from 1990 to 2012. To investigate their objective, authors selected 15 major natural gas consumers, particularly developing economies and employed several panel econometric techniques. Their long-run estimates indicated that the natural gas consumption played an important role in driving the economic growth in these developing countries. Further, their findings indicated that the feedback relationship exists between gas consumption and economic growth in the short-run.

Further, the relationship between economic growth and energy consumption is investigated in a sample of BRIC countries by Pao and Tsai (2010). Using yearly data from 1971 to 2007, authors confirmed the evidence of feedback relationship between growth and energy consumption in these emerging economies. Focusing on China, Jalil and Mahmud (2009) used data from 1953 to 2006 and found one-way Granger causality that runs from growth to energy consumption, which supports the protection hypothesis. Similarly, Paramati et al. (2018) explored the determinants of energy demand in a sample of seven frontier market economies in the African region. Using quarterly data from 1991 to 2012, authors showed that economic growth positively affects energy consumption in the long-run. Further, their results indicated the presence of unidirectional causality that runs from economic growth to energy consumption. On the other hand, the evidences, using data from 1971-201, from Shahbaz et al. (2013) found one-way causality that occurs from energy consumption to growth, which supports the growth hypothesis.

Researchers have examined the impact of GDP or per capita GDP on renewable energy demand as well. Sadorsky (2006) believes that the increase in per capita real GDP is the main driver of the per capita renewable energy consumption. That is, higher income levels would offer higher potential or more resources to promote the consumption of renewable energy. Paramati, Apergis and Ummalla (2018) have used yearly data from 1980 to 2012 and investigated the impacts of renewable and non-renewable energy consumptions on economic activities across agriculture, industry, service and overall economic activities (GDP) in a panel of G20 nations. Their results showed that both renewable and non-renewable energy consumptions positively contributed for economic growth across the sectors. Bhattacharya et al. (2017) investigated the role of renewable energy consumption, along with other key factors in the model, on economic growth in a global sample of 85 developed and developing economies. Authors utilized yearly data from 1991 to 2012 and various econometric techniques to achieve the study objectives. Their results from system GMM and FMOLS methods indicated that the renewable energy consumption has a significant positive affect on economic growth.

The role of renewable and non-renewable energy consumptions on economic growth in a sample of G20 nations is investigated by Paramati, Mo and Gupta (2017). Authors established that both renewable and non-renewable energy consumptions positively contributed for economic growth in the G20 nations during 1991-2012. Kutan et al. (2018) reported similar findings in the case of major emerging economies. Paramati, Sinha and Dogan (2017) also showed that renewable energy consumption positively contributed for economic growth in a sample of the next 11 developing economies. Paramati, Apergis and Ummalla (2017) documented that the clean energy consumption is positively supporting economic growth across panels of the EU, the G20 and OECD economies. In another study, Paramati, Ummalla and Apergis (2016) documented similar results for a sample of emerging market economies. Finally, Bhattacharya et al. (2016) explored the effect of renewable and non-renewable energy consumptions on economic output in a sample of 38 major renewable energy consumption countries. Using panel DOLS and FMOLS methods, authors confirmed that both energy sources positively contribute for economic development in these countries.

As for the relationship between financial development and energy demand, some existing studies have found a two-way relationship between financial development and energy consumption (eg, Shahbaz et al., 2013, Shahbaz and Lean, 2012). But others only found one-way causation from financial development to energy consumption (Al-mulali and Lee, 2013; Komal and Abbas, 2015; Rafindadi and Ozturk, 2016; Zhao et al., 2016), or vice versa (Al-mulali and Binti). Che Sab, 2012; Furuoka, 2015). Sadorsky (2010) and Kakar et al. (2011) argued that in the long run, financial development helps to finance both traditional energy markets and alternative energy sources and the impact of financial development on energy demand is vague. Çoban and Topcu (2013) considered three channels in the relationship between financial development and energy demand: First, through direct channel i.e. the development of financial system helps to promote personal lending to buy more high-energy durable goods (Sadorsky, 2011). Second, through the business lending channel that is, the improvement of economic and financial infrastructure will help companies cutting financing costs, leading to an increase in energy demand (Sadorsky, 2011a; Shahbaz et al., 2013). Finally, the wealth effect channel shows that stock market profitability can help increase consumer confidence and thus increase energy demand. But Islam et al. (2013) argued that if financial development reduces borrowing costs, businesses and households are more likely to access energy-saving technologies to reduce energy demand. Dasgupta et al. (2004) documented that the development of financial markets can help to finance renewable energy projects.

In the existing literature, a number of studies focused to investigate the relationship between trade and environmental pollution (Herrerias et al., 2013; Hu et al., 2020; Yang et al., 2017). Only a few studies have explored the direct relationship between trade and energy demand. For instance, Cole (2006) examined how trade changed energy demand in 32 countries between 1975 and 1995. In general, there was a positive correlation between trade and energy demand, which implied that scale effects tend to dominate. Shahbaz et al. (2013) found a feedback effect of energy demand on trade. Using provincial-level data from 1995 to 2004, Ma et al. (2009) found that the increase in China's energy intensity was driven by the export sector's adaption to energy-intensive technologies after controlling a large number of regional heterogeneities. By contrast, using provincial time series data from 1985 and 2008, Herrerias et al. (2013) concluded that there is an inverse relationship between imports and energy intensity.

The above empirical studies clearly indicated that there is very little evidence on the determinants of energy demand for both the renewable and non-renewable energy in general and China in specific. Given the growing importance of China for its rapid economic development in the global context, it is important for the energy policymakers and government officials to understand the drivers of both renewable and non-renewable energies. Therefore, these issues motivate us to empirically investigate the roles of financial development, per capita income and international of trade on both the energy sources. The results of this study will provide constructive policy recommendations for the Chinese authorities to take necessary actions to improve not only energy security in the country but also to ensure sustainable economic development in the country.

3. Data and methodology

3.1 Data description

In this paper, we use annual data from 1980 to 2016, which is the longest available data set for China on the considered variables. The variables of the study are measured as follows. Precisely, we consider several disaggregated energy indicators. For instance, the renewable energy consumption (REC) which includes all sources of renewable energy plus nuclear energy; non-renewable energy consumption (NREC) which includes coal, natural gas, petroleum and other liquids; and primary energy consumption (PEC) which is the sum of all energy sources, including renewable and non-renewable energy sources. All these energy indicators are measured in Quadrillion BTU. Similarly, we measure the financial development (FD) index by taking into account of both financial institutions and markets; per capita income (PI) is measured by the gross domestic product (GDP) per capita in constant 2010 US dollars; trade openness (TO) is measured by the sum of total exports and imports as a percentage of GDP; finally we use the control variable, namely total trademark applications as a proxy for technological innovations (TECH). The above data has been sourced from various online platforms. For instance, the required data on all the energy indicators (REC, NREC and PEC) are sourced from the International Energy Statistics of the U.S. Energy Information Administration (EIA); whereas data on FD is obtained from the International Monetary Fund (IMF); and finally, the data on PI, TO and TECH are sourced from the World Development Indicators of the World Bank.

3.2 Empirical setting

The current research paper aims to explore the determinants of renewable and non-renewable energy demand in China. For this purpose, we focus on the effect of financial development, per capita income and trade openness on energy demand including renewable and non-renewable energy sources, using annual data from 1980 to 2016. Accordingly, we develop the following empirical models using both theoretical and empirical literature:

$$REC_t = f\,(FD_t, PI_t, TECH_t, TO_t, \varepsilon_t) \quad (1)$$

$$NREC_t = f\,(FD_t, PI_t, TECH_t, TO_t, \varepsilon_t) \quad (2)$$

$$PEC_t = f\,(FD_t, PI_t, TECH_t, TO_t, \varepsilon_t) \quad (3)$$

where, REC, NREC, PEC, FD, PI, TECH and TO represent renewable energy, non-renewable energy, primary energy consumption, financial development, per capita income, technological innovations and trade openness, respectively. Likewise, t and ε imply time period and error term in the models, respectively.

First, we apply a time series unit root test to investigate the order of integration of our considered variables in the study. More specifically, we apply Augmented Dickey-Fuller (Dickey and Fuller, 1979) unit root test. To take into consideration of structural breaks in the data series while testing a unit root, we employ Perron's (1989) approach. For instance, we identify the structural break for each of the series using minimum Dickey-Fuller t-statistic under the *Innovational Outlier* approach and using Schwarz criterion to select the required lag length. We test the null hypothesis of a unit root against the alternative hypothesis of no unit root. The unit root test results are quite important to determine the suitable econometric techniques for the investigation.

Following the result that we obtain from the time series unit root test, we explore the long-run impact of financial development, per capita income and trade openness on various energy indicators using the Ordinary Least Squares (OLS) and Fully Modified OLS (FMOLS) methods. It is important to highlight that the standard OLS estimates are unreliable particularly when a model suffers from an issue of endogeneity. However, the FMOLS technique provides more reliable and robust estimates as it uses a semi-parametric framework to address the issue of endogeneity in the model. Given the nature of our variables, there may be a potential endogeneity issue in the model. Hence, we apply both the standard OLS and FMOLS techniques for the purpose of robustness check on our long-run estimates. The FMOLS technique was introduced and developed by Phillips and Hansen (1990). The authors argue that the FMOLS technique uses a semi-parametric approach to eliminate the issue caused by the long-run correlation between the cointegrating equation and stochastic regressors innovations. The estimator of the FMOLS is asymptotically unbiased and provides standard Wald tests by making use of asymptotic Chi-square statistical inference. Hence, the FMOLS technique provides long-run estimates using a single cointegrating vector. Consequently, the findings derived from this technique are expected to be more reliable and robust.

3.3 Preliminary analysis

Figure 1 shows the global share of China's GDP from 1980 to 2016. The share of Chinese GDP in the global GDP was only 1.2 percent in 1980 and it managed to increase to 12.2 percent by 2016. This clearly shows the tremendous growth that China has achieved over the last four decades. Similarly, we display China's GDP growth rates relative to the World during the study period in Figure 2. The GDP growth rates in China are significantly higher than that of the World. For instance, in 1980 China had nearly 8 percent growth in GDP while the global growth rate was close to 2 percent. It is important to highlight that during the global financial crisis (GFC), 2007-09, China has achieved more than 11 percent growth whereas the average growth rates across the globe were less than 2 percent. However, in the recent period, the growth rate in China has been slightly declining, which is nearly 7 percent in 2016. Figure 3 shows the per capita GDP of China and the World. With a population size accounting for nearly 19 percent of the world, China's per capita GDP was just 5 percent of that of the world in 1980. Due to the significant economic development, China's per capita GDP has increased from 348 US$ to 6894 US$ during 1980-2016. Despite of its considerable growth in economic development and prosperity, still the per capita GDP of China is just two-third of that of the world.

[Insert Figure 1 about here]

[Insert Figure 2 about here]

[Insert Figure 3 about here]

4. Findings and discussion

We begin our analysis by presenting summary statistics on the selected variables of the study in Table 1. These statistics suggest that the use of renewable energy (REC), non-renewable energy (NREC), primary energy consumption (PEC), and disaggregated energy sources of non-renewables like coal, natural gas and petroleum, have all been significantly increasing over the last four decades. Likewise, we also observe that the financial development (FD), per capita income (PI) and technology have also consistently increased over the study period. However, we note that the trade openness and GDP growth rates have shown marginal decline for the recent period, 2010-2016. Overall, these summary statistics confirm considerable growth in energy uses, financial development and per capita income in China during the study period.

[Insert Table 1 about here]

Table 2 reports compounded annual growth rates on the selected variables. The growth rates indicate that all the energy indicators have higher positive growth rates during the study period, 1980-2016. Among the energy indicators, the highest growth rate was found in petroleum and renewable energy consumption. Initially, the financial development had a negative growth rate but since 1990s, its growth rate has been gradually increasing. The growth rate in per capita income has declined slightly in the recent period. This is also the same case for the growth rate in trade openness, which has shown nearly 4 percent negative growth for the recent period i.e. 2010-2016. In summary, the growth rates of energy indicators and per capita income have shown to decline for the recent period.

[Insert Table 2 about here]

The results of time series unit root test are displayed in Table 3. It is important to examine the order of integration of the variables before we undertake rigorous empirical investigation as these findings will guide us to choose appropriate economic methodologies. The results show that the null hypothesis of a unit root can't be rejected for all the variables at both 1% and 5% significance levels. Hence, the unit root test is applied on the first difference of each series. The results then confirm that the null hypothesis is strongly rejected for all the variables at both 1% and 5% significance levels. These results therefore imply that all of the selected variables for this study have the same order of integration that is, they are non-stationary at the levels, while they are stationary in their first order differences.

[Insert Table 3 about here]

Given the unit root test results, our next step is to undertake empirical investigation to explore the long-run impact of financial development, per capita income and trade openness on all the energy indicators. For this purpose, we apply both the standard OLS and FMOLS techniques.[3] The results of OLS method are presented in Table 4. The results show that the growth in financial development seems to have a considerable positive impact on energy uses, with the exception of petroleum uses. Similarly, the increase in per capita income also has a substantial positive effect on energy uses[4], though its impact is not statistically significant for coal and gas consumption. Likewise, the trade openness has an adverse impact on renewable energy and gas uses, while it affects positively other energy indicators but again not statistical significant.

[Insert Table 4 about here]

[3] We also explored the cointegration relationship among the variables of equation (1), (2) and (3) using Bayer and Hanck (2013) test. The results show that there is a considerable long-run equilibrium relationship among these variables. However, we are not reporting these results in this paper as our main focus is on the long-run impact of financial development, per capita income and trade openness on energy indicators than that of their cointegration relationship.

[4] This evidence is consistent with the previous findings of Paramati et al. (2018).

We further apply the FMOLS technique to estimate the long-run coefficients. This technique is particularly reliable when the model is likely to suffer from the endogeneity. The FMOLS results are presented in Table 5. The results show that the increase in financial development and the growth in per capita income seem to be contributing to a rise in energy demand across the renewable and non-renewable energy sources. We further identify that the effect from financial development and per capita income is more on renewable energy uses than that of non-renewable energy.

Given the above evidences, we can discuss how these variables can affect the energy demand. For instance, the financial development can contribute to an increase in energy demand through three channels, namely direct effect, commercial effect, and wealth effect. That is, the development of financial systems helps to promote personal lending, reduce corporate borrowing costs, and increase consumer confidence. Moreover, financial development contributes to the growth in demand for renewable energy. This evidence is consistent with the previous studies (Kutan et al., 2018; Paramati, Ummalla and Apergis, 2016) who find similar results for the emerging economies, which include China. The Chinese government promotes the sales of electric vehicles and new energy vehicles by providing car subsidies and loans. The improvement of these financial channels promotes household demand for renewable energy and clean energy.

[Insert Table 5 about here]

Moreover, with rapid growth in per capita income, household demand for energy-consuming products such as refrigerators, washing machines, and air conditioners, which all have considerably increased in China, particularly in the last two decades. In addition to the effect on total energy demand, rising per capita income is expected to increase demand for renewable energy as well. People's awareness of energy conservation and environmental protection is enhanced with income growth. At a higher level of income, people are more concerned about the quality of life, especially air and environmental quality, and are more willing to purchase environment-friendly products, for example, renewable energy based heating system in replace of the coal based heating system and clean and renewable energy vehicles instead of fuel based.

The increase of trade openness positively affects non-renewable energy uses, while it adversely impacts on renewable energy. China's international trade has been long dominated by processing trade, especially resources and energy-intensive products. Meanwhile, China’s manufacturing sector has once been heavily dependent on coal as the major energy sources. Second, the low price of coal in China further attracted foreign companies to outsource manufacturing of energy-intensive products to China to reduce costs. In order to attract foreign investment, local governments in China compete to offer favourable energy subsidies to foreign investors. As a result, the consumption of non-renewable energy has been further increased with trade openness. Third, with trade liberalization, China's import of cheap, non-renewable energy is further promoted on the one hand and high-cost renewable energy is not favoured on the other hand.

Technological advances increase not only consumption of renewable energy consumption, but also non-renewable energy. This shows that there is a significant rebound effect in China's energy market. That is to say, China's technological progress has been remarkable in both non-renewable and renewable energy markets, which led to an increase in energy efficiency and a decline in energy prices, which promote the consumption of both renewable energy and non-renewable energy. Given that, all of these indicators have significant positive impact on energy demand in China.

5. Conclusion

This study is designed to empirically examine the effect of financial development, per capita income and trade openness on renewable and non-renewable energy demand in China. To achieve this objective, we made use of annual data from 1980 to 2016 and applied robust time series econometric techniques. Our results established that financial development has a considerable positive impact on energy demand. This finding can be attributed to the fact that the growth of financial sector development helps firms and entrepreneurs to acquire capital with lower cost. Therefore, better financed firms and entrepreneurs demand more energy. Likewise, the results of our study show that the growth in per capita income played an important role in increasing both renewable and non-renewable energy demand in China. This implies that higher levels of individuals' income create more demand for electronic goods which in turn consume higher level of energy. Moreover, it is also important to highlight that both financial development and income growth, have considerable higher effect on demand for renewable energy than for non-renewable energy. Trade openness is shown to be driving only non-renewable energy uses in China. It means that higher level of exports and imports of China is putting more pressure on fossil energy sources. As a major trade partner of the world market, China currently accounts for more than one-fourth of the global CO_2 emissions.

Given these empirical findings, we discuss relevant practical and policy implications for China. The evidence showed that financial development has a more positive impact on renewable energy uses is particularly relevant for policy discussion. Precisely, this suggests that the financial development ensures sustainable economic development in China by providing more funds for the renewable energy projects and also promoting demand for renewable energy. In this way, the development of financial sector is expected to help China with the development of a sustainable and environment-friendly growth pattern. The policy makers and practitioners of China should realize the importance of renewable energy in their total energy mix and divert significant amount of funds into renewable energy projects. In such a way, the share of renewable energy in total energy mix can significantly increase, and meet the increasing demand for energy by all sectors of the country. As a result, China will not only meet increasing energy demand but also achieve lower level of CO_2 emissions. The policy makers also should provide tax incentives for the renewable energy firms, which will therefore further motivate the firms to invest more on these projects. Consequently, China will be able to achieve targeted growth rates and meanwhile develop a sustainable economic growth pattern in the country.

In addition to the above policy recommendations, this study also adds an important value to the empirical literature by identifying the potential drivers of renewable and non-renewable energy sources in one of the major emerging economies. Further, our study adds an additional value to the body of knowledge by providing recent evidences on the factors that promote renewable energy. Finally, our study uses a comprehensive financial development index, which takes into account of both financial institutions (banks) and stock markets. Therefore, the findings of financial development on energy indicators are more reliable. Given all of that our study makes significant contribution to the energy literature, particularly in the context of China. The main limitation of this study is that we investigated the determinants of renewable and non-renewable energy at the national level. Therefore, the future study may investigate the determinants of these energy sources at the regional and provincial levels in China, once data becomes available.

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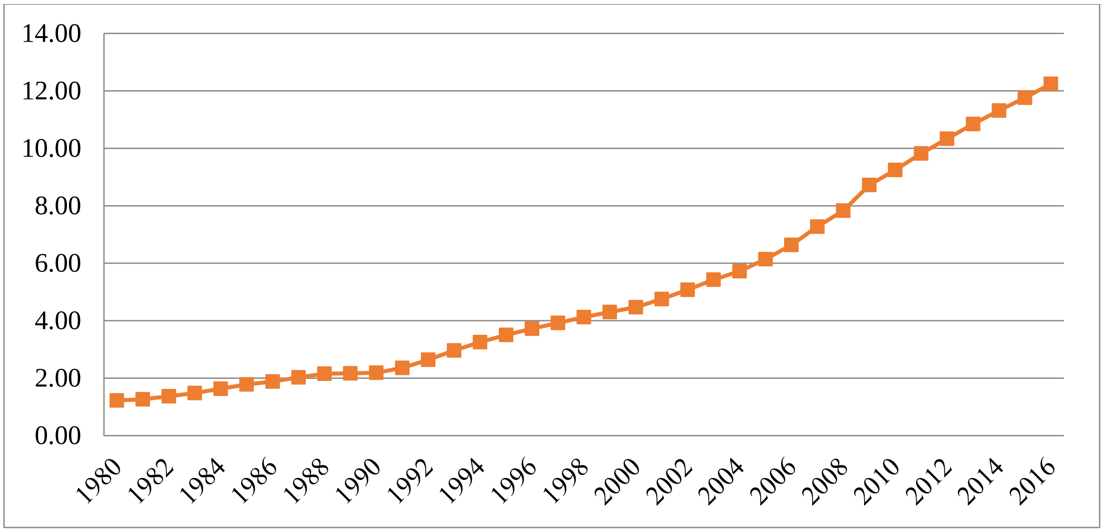

Figure 1: The global share of Chinese GDP (%)

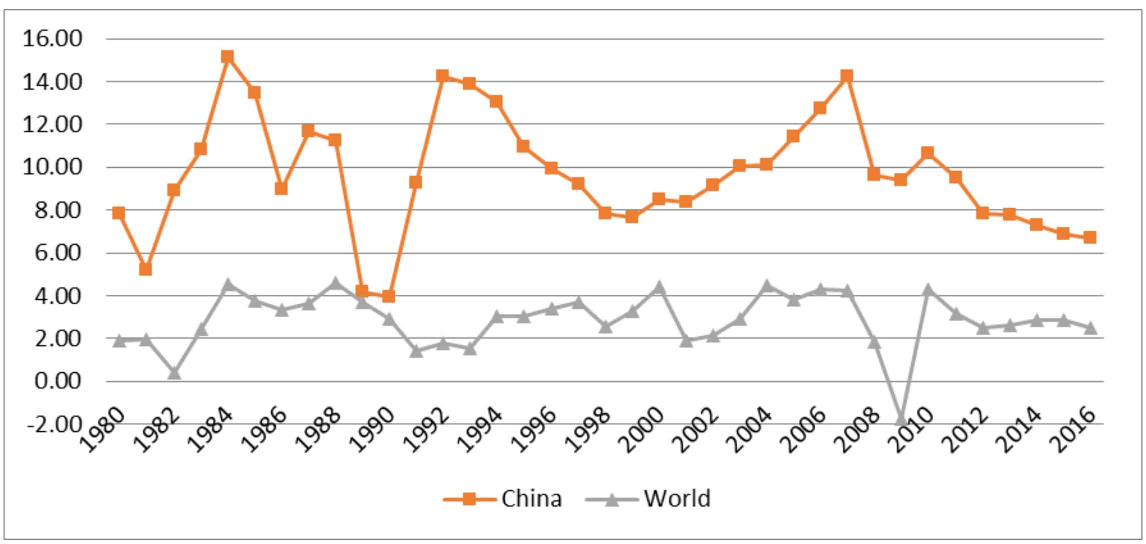

Figure 2: The comparison of GDP growth rates between China and World (%)

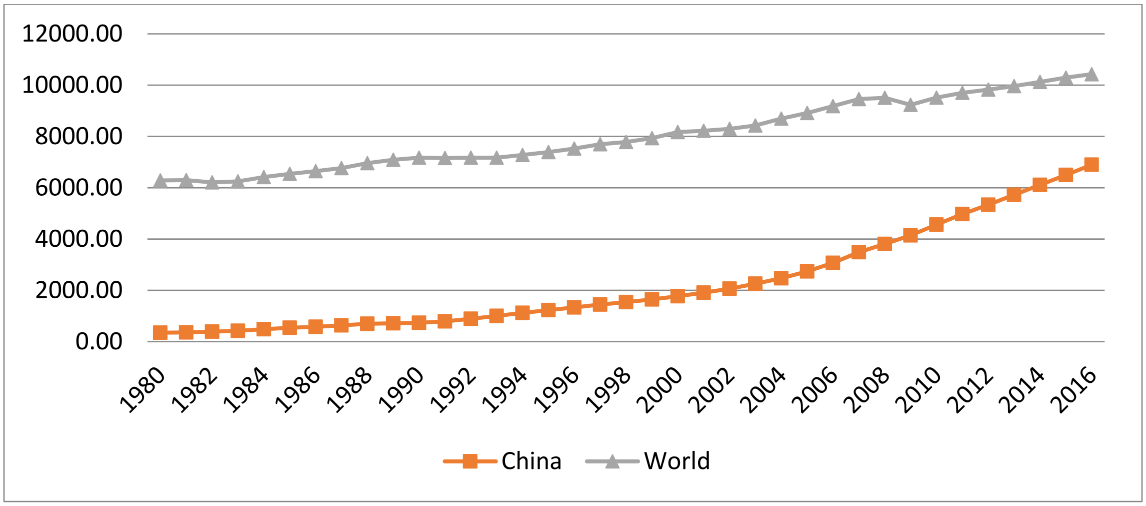

Figure 3: The comparison of per capita GDP between China and World

Table1: Summary statistics on the selected variables, 1980-16

Variables	1980-89	1990-99	2000-09	2010-16	Average
REC	0.90	1.64	4.08	11.71	4.01
NREC	20.39	33.23	66.20	117.60	54.63
PEC	21.29	34.87	70.28	129.32	58.64
CC	17.87	25.69	50.54	89.06	42.28
NGC	0.53	0.70	1.82	5.92	1.95
PC	1.98	6.84	13.83	22.62	10.40
FD	0.28	0.37	0.45	0.58	0.41
PI	516.35	1172.14	2771.70	5727.02	2288.95
TECH	35868.50	127366.30	541672.20	1602823.00	430376.71
TO	20.46	32.08	52.28	45.08	36.86
GDPG	9.74	10.00	10.35	8.10	9.66

Note: Summary statistics were calculated with non-log data.

Table2: Compounded annual growth rates on the selected variables, 1980-16

Periods	1980-89	1990-99	2000-09	2010-16	1980-16
REC	7.15	4.79	13.38	9.89	9.31
NREC	5.88	2.51	8.54	2.43	5.74
PEC	5.93	2.62	8.81	3.11	5.99
CC	3.92	1.53	9.13	1.52	4.95
NGC	0.00	4.80	13.23	9.93	7.21
PC	41.94	6.22	5.88	3.97	14.86
FD	-0.48	1.70	2.19	2.67	1.78
PI	7.45	8.46	8.86	6.08	8.41
TECH	6.41	11.10	14.26	14.77	13.35
TO	7.29	3.28	1.25	-3.89	3.00

Note: Compounded annual growth rates were calculated with non-log data.

Table 3: Results of time series unit root test with structural breaks

	Level			First difference		
Variables	t-Statistic	Prob.	Break date	t-Statistic	Prob.	Break date
REC	-1.342	0.990	2003	-7.290***	0.010	2003
NREC	-2.916	0.731	2002	-5.083***	0.010	2013
PEC	-2.898	0.740	2002	-4.947***	0.010	2013
CC	-3.697	0.284	2002	-4.674**	0.027	2013
NGC	-1.252	0.990	2003	-4.766**	0.020	2003
PC	-3.011	0.680	2003	-6.185***	0.010	1993
FD	-2.702	0.830	2002	-6.370***	0.010	2001
PI	-1.557	0.990	2002	-4.476**	0.046	2007
TECH	-0.729	0.990	2001	-5.605***	0.010	2004
TO	-2.635	0.857	1999	-5.686***	0.010	2009

Notes: ** and ***indicate the rejection of the null hypothesis of a unit root at the 5% and 1% significance levels, respectively. The probability values are based on the Vogelsang (1993) asymptotic one-sided p-values.

Table 4: Long-run estimates using Ordinary Least Square (OLS) method

Models:		Constant	FD	PI	TECH	TO	R^2	Adjusted - R^2
REC = f (FD, PI, TECH, TO)	Coeff.	-3.678***	1.074***	0.444**	0.316***	-0.448***	0.985	0.983
	Prob.	0.000	0.001	0.032	0.009	0.002		
NREC = f (FD, PI, TECH, TO)	Coeff.	-0.039	0.707***	0.316**	0.162*	0.039	0.984	0.982
	Prob.	0.940	0.003	0.046	0.069	0.696		
PEC = f (FD, PI, TECH, TO)	Coeff.	-0.011	0.734***	0.321**	0.174*	0.004	0.985	0.983
	Prob.	0.983	0.002	0.042	0.051	0.967		
CC = f (FD, PI, TECH, TO)	Coeff.	1.383**	1.212***	0.063	0.232**	-0.016	0.979	0.975
	Prob.	0.019	0.000	0.703	0.018	0.879		
NGC = f (FD, PI, TECH, TO)	Coeff.	-1.053	2.347***	0.233	0.310**	-0.626***	0.978	0.974
	Prob.	0.209	0.000	0.343	0.032	0.001		
PC = f (FD, PI, TECH, TO)	Coeff.	-22.934***	-5.730***	3.275**	-0.651	0.992	0.763	0.729
	Prob.	0.000	0.008	0.027	0.420	0.289		

Note: *, ** and *** indicate the significance levels at the 10%, 5% and 1%, respectively.

Table 5: Long-run estimates using Fully Modified OLS method

Models:		Constant	FD	PI	TECH	TO	R^2	Adjusted - R^2
REC = f (FD, PI, TECH, TO)	Coeff.	-3.675***	1.075***	0.444***	0.316***	-0.448***	0.985	0.983
	Prob.	0.000	0.000	0.000	0.000	0.000		
NREC = f (FD, PI, TECH, TO)	Coeff.	-0.038	0.708***	0.316***	0.162***	0.039**	0.983	0.980
	Prob.	0.687	0.000	0.000	0.000	0.027		
PEC = f (FD, PI, TECH, TO)	Coeff.	-0.010	0.735***	0.320***	0.174***	0.004	0.984	0.981
	Prob.	0.916	0.000	0.000	0.000	0.817		
CC = f (FD, PI, TECH, TO)	Coeff.	1.386***	1.213***	0.063**	0.231***	-0.016	0.977	0.974
	Prob.	0.000	0.000	0.021	0.000	0.343		
NGC = f (FD, PI, TECH, TO)	Coeff.	-1.047***	2.349***	0.233***	0.310***	-0.626***	0.977	0.974
	Prob.	0.000	0.000	0.000	0.000	0.000		
PC = f (FD, PI, TECH, TO)	Coeff.	-22.966***	-5.739***	3.274***	-0.647***	0.986***	0.724	0.683
	Prob.	0.000	0.000	0.000	0.000	0.000		

Note: *, ** and *** indicate the significance levels at the 10%, 5% and 1%, respectively.