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Energy consumption and economic growth in China: A reconciliation

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ABSTRACT

In conventional causality testing based on asymptotic distribution theory, there is a high risk of wrongly rejecting the true null of no causality especially when the sample size is as small as typically seen in the literature. In this study, we offer a formal diagnosis of the existing contradictory results on the causal relationship between energy consumption and real GDP. We also employ a time series oriented advanced data generation process to perform simulation based inference for the People's Republic of China. Our study covers the 1971–2007 period and considers five different aggregated and disaggregated energy consumption measures as well as three different lag orders in both a bivariate as well as a multivariate frameworks. Our maximum entropy bootstrap based analysis, which avoids pretest biases and is also robust to Type I errors, supports the neutrality hypothesis in 53 out of the total of 60 model estimations. The strong results show that coarse aggregate data has a limited potential to observe the complex causal linkages between energy consumption and economic growth. Future policy oriented research on this nexus requires more focused analyses based on sectoral and provincial data.

1. Introduction

In the energy economics literature, a worthwhile research question has long been and still continues to be the nature of the causal relationship between energy consumption and economic performance. Taking into account such factors as the growing population and environmental concerns along with the energy prices increasing worldwide and the need for reducing dependence on foreign energy resources, the significance of the subject for designing effective and prudent energy policies is beyond question. Perhaps befitting the importance of the subject, the energy–growth relationship has also been one of the most controversial topics in the literature. This is evident from the dozens of empirical studies reporting conflicting results on this nexus.

The dispute was present almost from the very beginning. In an initiatory investigation, Kraft and Kraft (1978) had focused on the 1947–1974 period and had found for the United States unidirectional causality running from energy consumption to GNP. Shortly after, however, this result was questioned by Akarca and Long (1980), who showed that a causal relationship is not observed when the study period is shortened only by 2 years. A large volume of subsequent research, focusing on different countries as well as different periods of time, far from settling the dispute, added more controversy to the point that it has now become impossible to make policy recommendations on this particular issue. Ozturk (2010) mentions about 100 studies with a roughly uniform distribution of results supporting all of the four obtainable outcomes namely unidirectional causality from energy consumption to growth, unidirectional causality from growth to energy consumption, bidirectional causality, and neutrality.

In view of the increasing number of contradicting results based on the "usual" methods, Karanfil (2009) and Ozturk (2010) concluded that the methodology used and the time period considered are the two major sources of the high degree of sensitivity of the estimation results. Yalta (2011) concurred and also observed three sources of possible bias in the existing studies. First, in conventional causality testing based on asymptotic theory, there is a high risk of wrongly rejecting the true null of neutrality, especially when the sample size is as small as typically seen. Second, preliminary testing for unit roots and cointegration can do induce incorrect results into the causality tests. Third, there seems to be a common misinterpretation in the literature that cointegration always requires causality in at least one direction, and this can bias results toward Type I errors. To overcome these difficulties, Yalta (2011) proposed a maximum entropy bootstrap (meboot) based framework and presented for Turkey a set of results that are robust to both the number of lags and the time period chosen, regardless of the integration/cointegration properties of the data.

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Our main objective in this paper is to highlight the importance of robustness issues of econometric estimates in policy studies. Also, we propose an appropriate method to obtain consistent findings on the energy consumption and gross domestic product (GDP) nexus. Finally, we perform rigorous analysis that can put the aforementioned observations to test and provide conclusive results for the People's Republic of China. Our approach is based on the meboot data generation process (DGP), which allows reliable bootstrap inference for nonstationary time series showing high levels of state dependency. The analysis considers five different aggregated and disaggregated energy consumption measures as well as three different lag orders in both a bivariate as well as a multivariate frameworks. The scope of our analysis, which involves running millions of regressions and estimating 60 different models using different parameters and specifications, is unparalleled in the energy economics literature.

Conducting this study for China is particularly useful for three reasons. First, China is the most populous and the second largest economy in the world (International Monetary Fund, 2010) with continuously increasing energy needs that cause a significant impact in energy prices and make the country a key player in the world energy markets. Second, China is the world's largest emitter of greenhouse gases (GHGs), which leads to important environmental concerns, and also brings forth the question of whether sustainable growth can be achieved with energy conservation policies. Third, there exists a relatively large number of conflicting results for China on the energy consumption and GDP nexus, which points out the need for conclusive results that can be guiding for future research as well as energy policy directions.

The rest of the paper is organized as follows: in the next section, we provide a brief overview of China's energy issues and the various findings of the earlier studies on the energy–growth nexus in China. Section 3 includes our discussion of the methodology, explanation of the data, and the presentation of the empirical results for both the bivariate and the multivariate analyses. This is followed by a review of the policy implications of the empirical results. Section 5 concludes.

2. An overview of energy issues in China

China has maintained rapid economic growth for three decades, during which the GDP increased from 189,399 million U.S. dollars in 1980 to 4,985,461 in 2009, in current prices. The average annual income growth in the recent years has been 9% (The World Bank, 2010), which resulted in China surpassing Japan in the second quarter of 2010 to become the world's second largest economy (International Monetary Fund, 2010). Also, the large volume of investment that goes into infrastructure construction projects, year after year, has promoted an extreme boom in the cement, steel, and other energy intensive sectors. Thanks to the continuous development of these industries and the improvement of the living standards, the energy demand has increased tremendously in the last 10 years in China.

According to U.S. Energy Information Administration (2011), currently China is the second largest energy consumer behind the United States, with a total energy consumption of 85 quadrillion British thermal units. 71% of the total energy use is supplied by coal, which is followed by oil (19%), hydroelectric sources (6%), natural gas (3%), nuclear power (1%), and other renewables (0.2%) respectively. Furthermore, China is also one of the biggest energy producers in the world. Between 2007 and 2008 alone, the total energy production has increased 11% and has reached 79 quadrillion British thermal units. The country has recoverable reserves of 176.8 billion tons of coal, 21.2 billion tons of crude oil, 14.3 billion tons of non-conventional oil, 22.03 trillion cubic meters of natural gas, and 400 GW of hydropower (Wang et al., 2011).

Being one of the biggest countries in energy consumption as well as production results in China having a significant influence in the world's energy sector. China is the second largest oil consumer after the United States. In 2009, the net oil imports has reached about 4.3 million barrels per day, making the country the second largest oil buyer in the international markets (U.S. Energy Information Administration, 2011). In addition, China is both the largest consumer and the largest producer of coal in the world. While the country has been a net coal exporter for many decades, the share of imports started to increase after 2002, causing China to eventually become a net coal importer in 2009 (U.S. Energy Information Administration, 2011). The tremendous amount of fossil fuels used in energy consumption also makes China the number one source of GHG emissions in the world, causing serious environmental concerns both domestically and internationally.

Recognizing the difficulty to achieve sustainable growth with an ever increasing energy demand and environmental footprint, in 2005, the Chinese government agreed that energy consumption has to be brought under control. The subsequent 11th Five-Year Plan has called on the nation to reduce energy intensity by 20% in 5 years. Between 2005 and 2010; a series of policies, notices, measures, and government reorganizations that were put in place to support the realization of the target have provided mixed results (Zhou et al., 2010). One important step has been the completion of the Three Gorges Dam in 2008, which is now the world's largest hydropower plant. Recently, the plans to cut energy intensity have been updated as 17.3% and 16.6% for the 2011–2015 and 2016–2020 periods respectively (Press Release Point, 2010). Currently, China is taking steps to build dozens of new nuclear reactors over the next 20 years. In addition, China has also recently initiated the largest national effort to develop thorium based molten salt reactors for clean energy (Press Release Point, 2011).

The special conditions and characteristics discussed above makes China a source of interest in the energy economics literature. However, when it comes to short run precedence known as Granger causality, China is not an exception in contradicting empirical results regarding energy consumption and GDP. In the last several years, there have been at least eight studies reporting conflicting results on this topic. Shiu and Lam (2004) employed an error correction model (ECM) approach and found unidirectional Granger causality running from electricity consumption to GDP between 1971 and 2000. Using the Toda and Yamamoto (1995) (TY) procedure for the 1971–2002 period, Soytas and Sari (2006) concluded that total energy consumption and GDP are neutral to each other. Zou and Chau (2006) undertook a bivariate ECM specification for the period between 1953 and 2002, and concluded that causality runs from oil consumption to GDP. Zhang and Li (2007) focused on the 1980–2004 period and reported bidirectional Granger causality between coal consumption and GDP. Chen et al. (2007), using a bivariate VAR model for the 1971–2001 period, found no evidence of causality between GDP and electricity consumption for China. Yuan et al. (2007) employed a bivariate ECM and reported that unidirectional Granger causality runs from electricity consumption to GDP for the 1978–2004 period. Yuan et al. (2008) used a multivariate ECM specification for the 1963–2005 period and concluded that there exists Granger causality running from electricity and oil consumption to GDP, but no casual relationship exists between coal and total energy consumption and GDP. They also found that Granger causality exists from GDP to total energy, coal and oil consumption, but does not exist from GDP to electricity consumption. Finally, Zhang and Cheng (2009) focused on the