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Coal consumption, CO_2 emission and economic growth in China: Empirical evidence and policy responses ☆

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ABSTRACT

This article investigates the relationship between coal consumption and income in China using both *supply-side* and *demand-side* frameworks. Cointegration and vector error correction modeling show that there is a unidirectional causality running from coal consumption to output in both the short and long run under the *supply-side* analysis, while there is also a unidirectional causality running from income to coal consumption in the short and long run under the *demand-side* analysis. The results also reveal that there is bi-directional causality between coal consumption and pollutant emission both in the short and long run. Hence, it is very difficult for China to pursue a greenhouse gas abatement policy through reducing coal consumption. Switching to greener energy sources might be a possible alternative in the long run.

1. Introduction

The Copenhagen Climate Change Conference came to an end without any concrete commitment or a new accord on greenhouse gas emissions reduction from any of the developed and developing economies. However, with increased demand for energy in developing countries, especially from emerging economies like China and India, studies on identifying statistically significant associations between energy consumption and economic activities in developing economies are worth pursuing. Standard economic theories do not provide any clear-cut answer to whether economic growth is the cause or effect of energy consumption.

Studies identifying the relationship between energy consumption and output primarily take two different approaches. The *supply-side approach* analyzes the contribution of energy consumption in economic activities within the traditional production function framework (see, for example, Stern, 1993, 2000 and Oh and Lee, 2004a,b). The *demand-side approach* analyzes the relationship between energy consumption, gross domestic product (GDP) and energy prices (often taking CPI as a proxy) in a tri-variate energy demand model (see, for example, Masih and Masih, 1997; Asafu-Adjaye, 2000; Salim et al., 2008 and Rafiq and Salim, 2009). All previous studies in this field follow one or the other of these two approaches and, on that basis, devise energy conservation policies. However, application of both models to a particular country or group of countries provides more robust estimates and more meaningful policy implications. Also, carbon emission is one of the important bi-products of energy consumption. However, studies on *demand side* have not yet incorporated carbon emission in their analysis. This paper applies both *supply-side* and *demand-side approaches* to Chinese data and comments on the possibilities for energy conservation and carbon emission reduction. Since coal is the biggest source of Chinese energy consumption this study focuses on coal in its empirical analysis.

Why is China a suitable case study? China has been on the 'news' for its spectacular GDP growth as well as high energy demand growth (particularly coal) in recent years. Many economists and social scientists argue that the increased demand for energy from developing countries, especially from China is one of the major reasons for the energy price hikes in recent times. Also, China is blamed for high pollutant emission by the Western countries. Based on the amount and growth potential of demand for coal in the Chinese economy it is now high time to search for the causal relationship between coal consumption and national output (GDP) in China.

The rest of the article is structured as follows. The next section presents an overview of the energy consumption profile of China. The third section discusses the range of findings on the relationship between energy consumption and economic growth as well as providing a critical review of the methods used in generating these findings. Section 4 introduces the theoretical framework used in this paper, while a description of data sources and methodologies is presented in Section 5. Section 6 presents the empirical results. Conclusions and policy implications are given in the final section.

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2. An overview of Chinese energy consumption demand

The Chinese economy experienced phenomenal growth over the last three decades. Since the initiation of market reforms in the late 1970s, China's growth has been about 9.70% per annum (World Bank, 2009). Being the world's most populous country with a population of over 1.3 billion, this rapid economic growth has enabled China to lift several hundred million people above the absolute poverty level. However, with strong economic growth, China's demand for coal is surging, as is China's pollutant emission (Fig. 1). According to BP (2010), in 2009 China was the largest consumer of crude coal in the world (46.9% of world total, Appendix Table 1).

Not only coal but consumption of all other types of fuel has increased significantly in recent years to support output growth in China. Crompton and Wu (2005) show that China consumed 31% of the world's total coal, 7.6% of oil, 10.7% of hydroelectricity and 1.2% of world's total gas in 2003. More recent data reveal that the consumption figures for all these types of fuels have increased further. For example, China accounted for 46.9% of the world's coal consumption, 10.4% of oil consumption, 18.8% of hydroelectricity consumption and 3.0% of gas consumption in 2009 (Appendix Table 2). The growth of output and energy consumption has environmental consequences. During this period pollutant emission has increased enormously, which has raised much concern from the world's environmentalists and Green groups. Coal consumption is particularly important in this regard as a dirty fuel on which China is heavily reliant (Soytas and Sari, 2006a).

According to the Energy Information Administration [EIA] (2009) data China is the world's largest producer and consumer of coal, an important factor in world energy markets. China is also the world's second largest oil consuming country and the third-largest importer of oil after the US and Japan. Coal makes up 71% of China's total primary energy consumption, and China is both the largest consumer and producer of coal in the world. According to the World Energy Council, as of 2009, China held an estimated 114.5 billion short tons of recoverable coal reserves, the third largest in the world behind the United States and Russia and about 14% of the world's total reserves. Fig. 2 shows that with increase economic activity both coal consumption and production have increased since 2000 in China. China's coal imports started growing strongly after 2002 as imported coal prices including transportation became competitive with domestic production prices, and the coal industry began suffering from frequent bottlenecks in transmission to consumer markets. In 2009, China, typically a net coal exporter, became a net importer from countries such as Indonesia, Australia, Vietnam, and Russia.

China's coal industry has traditionally been fragmented among large state owned coal mines, local state-owned coal mines, and thousands of town and village coal mines. The top three state-owned coal companies produce less than 15% of the domestic coal. Shenhua Coal, the world's largest coal company, holds 9% of the domestic market in China.

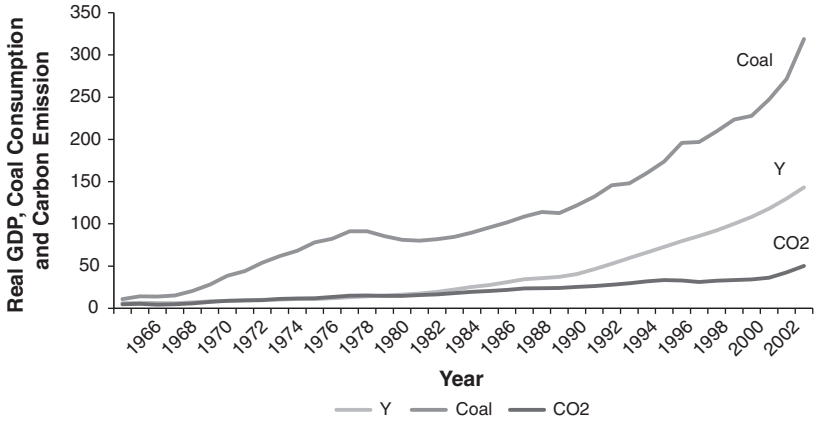
There are 27 provinces in China that produce coal. Northern China, especially the Shanxi and Inner Mongolia Provinces, contains most of China's easily accessible coal and virtually all of the large state-owned mines. Coal from southern mines tends to be higher in sulfur and ash, and therefore unsuitable for many applications. In 2009, China consumed an estimated 3.5 billion short tons of coal, representing over 46% of the world total and a 180% increase since 2000. Coal consumption has been on the rise in China over the last nine years, reversing the decline seen from 1996 to 2000. Coal production, has also been rising, at almost 3.4 billion short tons in 2009 as shown in Fig. 2.

3. Evidence on energy consumption and economic growth

Research on the relationship between energy consumption and economic growth has primarily been aimed at providing guidelines in designing energy conservation policies. Pioneering research in this area is the study by Kraft and Kraft (1978). The authors find a unidirectional causality running from output to energy consumption in the USA over the period 1947–1974.

Further research on this subject has focussed on both developed and developing countries. However, these studies do not arrive at an unambiguous conclusion as to the direction of causality between energy consumption and economic growth. This may be due to three different causes. First, the studies differ in the econometric methodologies employed. Second, they consider different data with different countries and time spans. Third, there may be problems created by non-stationarity of data.

Some studies find unidirectional causality running from output to energy consumption. Abosedra and Baghestani (1989) find unidirectional causality from output to energy consumption using an extended data set on the USA spanning from 1947 to 1987. Unidirectional causality from output to energy is also found in Narayan and Smyth (2005), who examine Australia's data on electricity, GDP and employment; in Al-Iriani (2006), who examines energy consumption



Notes: Y, C and CO_2 represent real output in billion US dollar, coal consumption in million tonnes and carbon emission in hundred million tonnes, respectively. Real output data are collected from World Development Indicators (WDI) by World Bank, while coal consumption and carbon emission data are taken from BP (2011).

Fig. 1. Real GDP, coal consumption, and carbon emission in China, 1960 to 2008.