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China's farewell to coal: A forecast of coal consumption through 2020

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HIGHLIGHTS

- Provincial panel data is used to investigate the influential factors of coal consumption in China.
- The spatial correlations of coal consumption in neighboring provinces are fully considered.
- An inverted-U shaped Environmental Kuznets Curve for coal consumption in China has been found.
- Based on the estimation results, China's national coal consumption before 2020 is forecasted.
- Under the basic scenario, China's national coal consumption will grow at a decreasing speed till 2020.

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ABSTRACT

In recent decades, China has encountered serious environmental problem, especially severe air pollution that has affected eastern and northern China frequently. Because most air pollutants in China are closely related to coal combustion, the restriction of coal consumption is critical to the improvement of the environment in China. In this study, a panel of 29 Chinese provinces from 1995 to 2012 is utilized to predict China's coal consumption through 2020. After controlling for the spatial correlation of coal consumption among neighboring provinces, an inverted U-shaped Environmental Kuznets Curve (EKC) between coal consumption per capita and GDP per capita in China is detected. Furthermore, based on the estimation results and reasonable predictions of key control variables, China's provincial and national coal consumption through 2020 is forecasted. Specifically, under the benchmark scenario, consumption is expected to continue growing at a decreasing rate until 2020, when China's coal consumption would be approximately 4.43 billion tons. However, if China can maintain relatively high growth rate (an annual growth rate of 7.8 percent), the turning point in total coal consumption would occur in 2019, with projected consumption peaking at 4.16 billion tons.

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1. Introduction

Alongside with rapid economic growth, China's coal consumption has soared over the past 30 years. Currently, the amount of coal consumed by China is larger than any other country in the world, and the annual growth rate of coal consumption was 7.8 percent between 2000 and 2012. As a result, coal has dominated China's energy mix—according to the data of the National Bureau of Statistics, since 1978, the share of coal consumption of total primary energy consumption has remained above 65 percent.

China's coal consumption has grown at nearly the same speed as its economic development, as coal has helped fuel China's rapid economic growth since the late 1970s. However, China's high dependence on and rapid growth in coal consumption have also brought about a series of problems.

The first problem created by China's extensive coal consumption is increasingly serious air pollution. A growing number of hazardous pollution incidents in recent years, represented by the fog and haze that have stricken most regions of eastern and northern China since early 2012, has not only posed a serious threat to citizens' health but also hampered China's sustainable growth. As Poon et al. (2006) have noted, the combustion of fossil fuels, especially coal, is one of the main causes of fine particles (PM2.5), which are the main components of this haze and fog pollution. Some recent studies have estimated the economic and welfare loss caused by the high concentrations of PM2.5 in China

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(Chen and He, 2014). In recent years, the increased air pollution has also attracted widespread international concern and hence damaged China's international image.

The second significant problem related to coal consumption is the emissions of Greenhouse Gas (GHG) emissions generated by coal combustion. Since 1990, China's CO_2 emissions have been growing at a remarkable speed. Currently, as the largest GHG emitter in the world, China accounted for approximately 25 percent of global CO_2 emissions. Given that climate change has become a global threat, Beijing has faced growing pressure from the international community to restrain CO_2 emissions.

The third problem, which is debatable but causing new concern, is that China is increasingly dependent on imported coal and energy supplies. Although China produces the most coal in the world, China has been a net importer of coal since 2007, and the imported amount has increased rapidly. In 2013, the net imported coal was approximately 320 million tons, and China's ratio of dependence on coal imports reached a historical high of 8.1 percent. Because China had been a net importer of oil and gas since the 1990s, all main types of energy consumption rely on imports to varying degrees. Overall, the ratio of net imported energy to total energy consumption has risen rapidly from 3 percent in 1998 to 11 percent in 2011[1]. The expanding gap between energy production and consumption, especially in coal, threatens China's energy security and forms an important sustainable development bottleneck.

Fortunately, China has acknowledged these problems and has begun to make efforts to control coal consumption. The latest effort was made during the 2014 APEC summit, when China and the U.S. issued a *Joint Announcement on Climate Change*. According to the announcement, China vowed to achieve its peak CO_2 emissions and increase the share of non-fossil fuels in primary energy consumption to approximately 20 percent by 2030. As Auffhammer and Carson (2008) noted, in China, most CO_2 emissions come from coal consumption; therefore, whether China's CO_2 emissions can be reduced is highly dependent on the dynamics of coal consumption. Moreover, according to the historical experience of developed countries, such as the U.S., the UK and Germany, total coal consumption reaches its peak only after economic development has reached a certain level. Borrowing the notions of Grossman and Kruger (1991, 1995), an inverted U-shaped Environmental Kuznets Curve (EKC) described coal consumption. Therefore, the question of whether there is a peak in China's coal consumption is equivalent to asking whether there exists an EKC for coal consumption in China. So far, most studies on EKCs have focused on different types of environmental pollutants, and only a few have investigated EKCs for energy consumption (e.g., Suri and Chapman, 1998; Nguyen-Van, 2010). Thus far, no research has specifically examined the EKC for coal consumption. Additionally, many of the existing studies suffer from various problems. For example, spatial correlation in coal consumption is generally ignored, which implies biased estimates. By fully taking account of spatial correlation in coal consumption, this study utilizes the EKC framework and Chinese provincial panel data to estimate the factors that influence China's energy consumption and then forecasts China's total coal consumption through 2020 using reasonable predictions of the key determinants of coal consumption.

Since 1990, studies on the economic analysis of energy consumption have accumulated rapidly. In general, these studies can be classified into three categories:

The first strand of literature explores the causality of Chinese energy consumption and economic growth. Many researchers have examined the causality between energy consumption and income levels. For instance, Zhang (2000) found that the increase in income is the most important determinant of increasing energy consumption by decomposing aggregate CO_2 emissions into different factors. Lee and Chang (2008) and Chontanawat et al. (2008) verified Granger causality from energy consumption to income using a Vector Autoregression (VAR) and a Vector Error Correction Model (VECM), respectively. Using provincial panel data and VECMs, Chang (2010) found that a bi-directional Granger causality relationship between energy consumption and economic growth exists in China. In a recent study, Zhang et al. (2014) found evidence for the long-run causality from China's economic growth to energy consumption-related CO_2 emissions. In addition, Wang et al. (2013) tested and verified a similar relationship between economic growth and energy consumption using the concept of the ecological footprint.[2] Sheng et al. (2014) employed an instrumental regression technique to verify the positive relationship between economic growth and energy demand in China. However, this causal relationship between energy consumption and economic growth has not been found in all studies because many researchers have failed to find evidence of a causal relationship. In other words, the causal relationship is unstable, that is, subject to specific periods in the sample range (e.g., Zou and Chau, 2006; Soytas and Sari, 2006), to specific energy resources (e.g., Zou and Chau, 2006; Chang, 2010), or to certain industries (e.g., He et al., 2008). For instance, Soytas and Sari (2006) found that causality existed only over the short run and may weaken over time. Moreover, He et al. (2008) found that the causality relationship between energy consumption and economic growth is significant only in secondary industries.

The second body of literature examines the existence of EKC for energy consumption. The empirical existence of an EKC was first proposed by Grossman and Kruger (1991, 1995), arguing that there is an inverted U-shaped relationship between environmental quality and economic growth: during the early stages of economic growth, pollution aggregates and the environment deteriorates; after the peak level of pollution is reached, pollution decreases and the environment improves as the economy continues to grow. The vast majority of the research on EKC has investigated various pollutants, including atmospheric pollutants (such as SO_2, CO_2, biological oxygen demand, nitrogen oxides and smoke), water pollutants (such as chemical oxygen demand, COD), deforestation, and solid waste. Because many literature reviews are available for this particular strand, we omit such a description. The second strand is focused on the EKC of energy consumption. Overall, some recent studies use energy consumption as a proxy for environmental pressure and estimate the EKC relationship between energy consumption and economic development because the estimation results for EKC studies are not consistent (Stern, 2004; Dinda, 2004; Auci and Becchetti, 2006). For example, Suri and Chapman (1998) verified the existence of an energy consumption EKC and found that exports and imports of industrial goods drive the upward and downward slopes, respectively. Yoo and Lee (2010) detected a statistically significant inverted U-shaped relationship between per capita consumption of electricity and per capita income. However, as stressed in the survey by Dasgupta et al. (2002), numerous critics have challenged the conventional EKC. The differences in empirical results among EKC examinations are so large that there is not yet consensus regarding whether the

[1] Data are available at: http://data.worldbank.org/indicator/EG.IMP.CONS.ZS (accessed 27.04.15).

[2] The ecological footprint is a measure of human demand on the Earth's ecosystems. It is a standardized measure of demand for natural capital that can be compared with the planet's ecological capacity to regenerate. As a result, the ecological footprint can be used to estimate how much of the Earth (or how many planet Earths) is (are) needed to support humanity if a given lifestyle is followed by every human being on the Earth.

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