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Decomposition analysis for assessing the progress in decoupling relationship between coal consumption and economic growth in China

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ABSTRACT

This paper has four purposes. Firstly, the status of coal production and consumption is analyzed. Secondly, the temporal and spatial evolution of the coal consumption in China is studied. Furthermore, the LMDI method is used to explore the factors influencing coal consumption in China. Finally, a new decoupling index is developed based on the decomposition results, which is used to study the decoupling relationship between coal consumption and economic growth in China. This paper draws the following results: (1) Coal for transformation consumption gradually exceeded that for end-use over the study period. During 1991–2013, power generation was the biggest coal consumer among all transformation sectors. Among all end-use sectors, industry sector was the biggest coal consumer. (2) In 1991, Liaoning province was the biggest coal consumer. However, the biggest coal consumer was Shandong in 2013. The center of gravity for coal consumption was an overall movement towards the southwest. (3) The energy intensity effect played the dominant role in decreasing coal consumption over the study period. However, The economic activity effect and population effect maked the continual increase of coal consumption in China. (4) Only three decoupling statuses occurred over the study period: weak decoupling, expansive coupling, and expansive negative decoupling.

1. Introduction

Nowadays, China is the largest coal producer and coal consumer in the world. Compared with the developed countries, China is still at the early stage of urbanization and motorization. It is inevitable that China will require more energy. According to the official figures given by the National Bureau of Statistics, the coal accounted for over 70% of China total primary energy consumption in the past decades (CESY, 2015). Coal-based energy structure has lead to serious environmental pollution. Faced with enormous pressure of domestic environment protection and global climate change, controlling the rapidly increasing coal consumption in China has become an important issue for Chinese government. Therefore, analyzing the decoupling relationship between coal consumption and economic growth may help to make out energy-saving plan and energy policy.

Since the pioneering research of Kraft and Kraft (1978), the relationship between energy consumption and economic growth has widely explored by many scholars. However, these studies did not arrive at an unambiguous conclusion as to the direction of causality between energy consumption and economic growth. Unidirectional causality from output to energy consumption using an extended data set on the USA spanning from 1947 to 1987 was found Abosedra and Baghestani (1989). By examining Australia's data on electricity, GDP and employment, Narayan and Smyth (2005) also found unidirectional causality from output to energy consumption. Some studies also found the bi-directional causality between energy consumption and economic growth. For example, by examining data for G-7 and 10 emerging economies, excluding China, Soytas and Sari (2003) found bi-directional causal relationship between per capita GDP and energy consumption in Argentina over the period from 1950 to 1990.

Further research on this subject has focussed on developing countries. Chiou-Wei et al. (2008) examined the relationship between energy consumption and economic growth using both linear and nonlinear Granger causality tests for a sample of Asian newly industrialized countries along with the US. Salim et al. (2008) examined the short-run and long-run causal relationship between energy consumption and output in six non-OECD Asian developing countries. Yuan et al. (2008) revealed a bi-directional Granger

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causality between GDP and energy use in the long run, and unidirectional Granger causality from GDP to energy use in the short run in China.

Numerous studies are available in analyzing the nexus between energy consumption, and economic growth. Nowadays, many experts have paid attention to analyze the coal consumption and its implication for economic growth using recent and longer time series data. Li et al. (2008) used the granger causality tests to study the differences of causal relationships between coal consumption and GDP in major OECD and non-OECD countries. Nicholas and James (2010) examined the relationship between coal consumption and economic growth for 25 OECD countries within a multivariate panel framework over period 1980–2005. Yemane (2010) revisited the causal relationship between coal consumption and real GDP for six major coal consuming countries for the period 1965–2005 within a vector autoregressive (VAR) framework by including capital and labour as additional variables. Li and Leung (2012) examined the relationship between coal consumption and real GDP of China with the use of panel data. Using both the supplyside and demand-side frameworks, Bloch et al. (2012) investigated the relationship between coal consumption and income in China. Govindaraju and Tang (2013) employed recent and robust estimation techniques of cointegration to provide more conclusive evidence on the nexus of CO_2 emissions, economic growth and coal consumption in China and India.

The causal relationship between energy use and economic growth can be explored by many methods, such as bivariate causality, correlation analysis, unit root testing, multivariate cointegration, simple regressions, variance decomposition, etc. (Climent and Pardo, 2007). However, whether an economy is becoming less dependent on energy resources has become another important issue. The decoupling analysis has become an important method to study that problem. Since the seminal work of Von (1989), the decoupling notion has achieved global recognition as a significant conceptualization of successful economy-energy integration. The definition of decoupling was firstly utilized by Zhang (2000) to study the relationship between economic growth and China's carbon emissions at the beginning of the 2000s. In 2002, the decoupling indicator was formally defined by OECD (2010). Currently, there are two different ways of describing decoupling relationship between energy consumption or energy-related environmental degradation and economic growth.

Based on the elasticity concept, Juknys defined three kinds of decoupling, i.e, primary decoupling, secondary decoupling and doubled ecoupling. Followed the idea given by Juknys, Tapio (2005) redefined the decoupling indicator (Taipo decoupling index), which was used to examine the decoupling status in the European transport industry, and divided the decoupling indicator into decoupling, coupling and negative decoupling. To better distinguish decoupling state, Tapio presented eight logical possibilities, namely, recessive coupling, expansive coupling, weak negative decoupling, strong negative decoupling, expansive negative decoupling, weak decoupling, strong decoupling and expansive decoupling. Then, the Taipo decoupling index was widely used to study the relationship between economic growth and energy consumption or environment issue (Ren and Hu, 2012). For instance, the Taipo decoupling index was utilized by Climent and Pardo (2007) to investigate the relationship between Spanish economic growth and energy consumption. Freitas and Kaneko (2011) also utilized that method to study the occurrence of a decoupling between Brazil's economic growth and energy-related CO_2 emission over the period 2004–2009. The Taipo decoupling index was used to explore the decoupling status between energy-related CO_2 emission and GDP in Jiangsu province (China) from 1995 to 2009 (Zhang et al., 2013). Based on the LMDI theory, Zhang et al. (2015) provided a way to find the deep reason that lead to the decoupling status.

Based on the decomposition result of refined Laspeyres decomposition model, Diakoulaki and Mandaraka (2007) defined a decoupling indicator,which was utilized to assess the real efforts undertaken in each country and their effectiveness in dissociating the economic and environmental dimensions of development. Based on the LMDI (Log-Mean Divisia Index) method, Zhang and Wang (2013) defined a decoupling indicator, which was utilized to study the decoupling of electricity consumption from economic growth in China. That decoupling method was also used by Zhang and Guo (2013) to evaluate the progress in decoupling energy consumption from per capita annual net income of rural households.

So far, many researchers have paid more attention to the decoupling relationship between energy consumption and economic growth in China. There is a close relationship between economic growth and coal consumption in China (Tang et al., 2015). However, no paper has explored whether China economy is becoming less dependent on coal consumption. This paper is to answer this problem. Nowadays, the decoupling indicator based on the decomposition result only defines three kinds of decoupling status, i.e, strong decoupling, weak decoupling and no decoupling, which may not provide rational decoupling positions. Furthermore, the definition of decoupling indicator is determined by whether the economic activity effect is positive or negative. By comparing various decomposition methods, Ang (2004) concluded that the LMDI method was the preferred method. To overcome this problem, this paper redefines a new decoupling indicator (ZM decoupling indicator) based on the decomposition results of the LMDI method. This paper has four purposes. Firstly, the status of coal production and consumption is analyzed. Secondly, the temporal and spatial evolution of the coal consumption in China is studied based on the gravity model. Thirdly, the LMDI method is used to explore the contribution of the factors which influence coal consumption in China over the period 1991–2013. At last, a decoupling index is developed based on the decomposition results, which is used to study the decoupling relationship between coal consumption and economic growth in China.

The remainder of paper is organized as follows: The methods used in this paper and related data are presented in Section 2. The main results are given in Section 3. The conclusions drawn are summarized in Section 4.

2. Methodology

2.1. Gravity model

Hilgard (1872) firstly utilized the concept of a center of gravity to explore the United States' population problems. Nowadays, the gravity concept has been widely utilized to explore geographic distributions of many fields, such as and utilization (Chen and Zhou, 2011), environmental pollution (Wang et al., 2009; Peng and Lin, 2010), ecosystem services (He et al., 2011), consumption goods (Fu et al., 2011), and food provision (Wang et al., 2012). That theory was utilized to study the temporal and spatial differences of energy consumption (Wang et al., 2006, 2014; Zhang et al., 2012).

This paper analyzes centers of gravity for China's coal consumption. Only 30 administrative regions at provincial level are considered in this paper. The position of the center of gravity is calculated using a combination of the geographical coordinates of the 30 regions and their corresponding coal consumption. The position of the center of gravity in yeart, (X^t, Y^t), is expressed as follows,

$$X^t = \frac{\sum_{i=1}^{n} M_i^t \times x_i}{\sum_{i=1}^{n} M_i^t} \quad (1)$$