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Evaluation of electricity saving potential in China's chemical industry based on cointegration

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ABSTRACT

The purpose of this study is to investigate the future electricity saving potential of China's chemical industry. Applying cointegration, we find that there is a long-run equilibrium relationship between electricity intensity and technology, labor, electricity prices and industry structure. The result shows that more active electricity saving policies are objectively required to be implemented in order to reduce the electricity intensity in China's chemical industry as well as to shrink future electricity saving potential. For this purpose, we have adopted a scenario analysis method to predict the electricity intensity and the electricity saving amount under two different scenarios. It is found that energy conservation policy provides a continuous impetus for reducing the electricity saving potential. In terms of electricity intensity of the chemical industry, China's intensity is approaching the level in Japan, with the gap narrowing significantly by the year 2020. Finally, based on the elasticities obtained in the long-term equilibrium equation, the paper suggests a range of future policy priorities and directions.

1. Introduction

The chemical industry is the pillar industry of the national economy. The products of this industry are extensively applied in various fields such as national economy, peoples' livelihood, and the defense-related science and technology. Thus, it plays an essential role in advancing the development of related sectors and promoting economic growth. Since the beginning of the 21st century, the petrochemical sector in China's chemical industry has experienced an accelerated growth. The industrial added value is estimated to have contributed nearly 1% to the national economy's growth, while the industry grew at an annual average rate of 20% (State Council, 2009). At present, China is the second largest consumer and producer of petrochemical products in the world (CPCIA, 2010). In particular, China has joined the front ranks in terms of the amount of production of fertilizers, pesticides, oil products, ethylene, and synthetic resin. Additionally, 14 bases of ten-million-ton petroleum refining; 3 ethylene production bases of million-ton; 3 phosphate fertilizer production regions in Yunnan, Guizhou, and Hubei provinces; and 1 project for million-ton potash fertilizer production (CPCIA, 2009) were established in succession.

In line with the development of chemical industry, the electrical energy consumption in China's chemical industry has increased sharply in the past few years (see Fig. 1).

According to Fig. 1, the annual power consumption increased by nearly 8% during the period 1994–2000 inspire of a slight decline in the late 1990s. After that, the power consumption of this sector developed more rapidly. In the past 15 years, electricity consumption of China's chemical industry has shown a threefold increase and is expected to continuously grow. In 2008, the total amount of electricity consumed by China's chemical industry reached 275.82 billion kWh, which is about three times the annual power generation of the Three Gorges Hydropower Station and corresponds to approximately 8% of China's total electricity demand.

The rapid growth of industrial electricity demand not only exerted enormous pressure on energy resources but also caused environmental pollution as well as the increasing level of greenhouse gas emissions. In 2008, SO_2 emissions from China's chemical industry accounted for 6% of total industrial emissions; the proportion of the total industrial soot emissions was 8%, and the proportion of the total industrial dust emissions was 2%. In addition, CO_2 emissions in China's chemical industry accounted for 6% of total industrial emissions in 2007.

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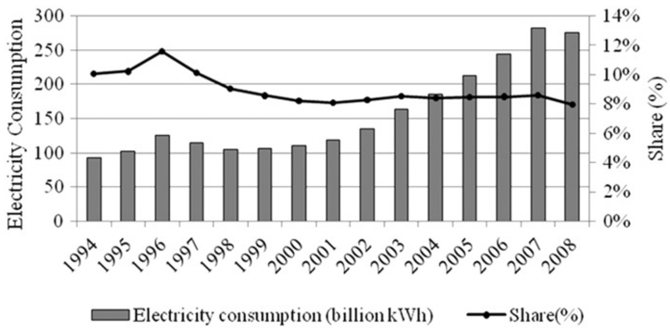

Fig. 1. Electricity consumption in China's chemical industry and share of chemical consumption in total electricity consumption (1994–2008).
Source: CEIC China Database (2007).

Currently, energy security and global warming have become foci of China and the international community. In this context, it is important to study questions such as: (i) what are the factors affecting the electricity conservation of China's chemical industry? (ii) what would be the electricity saving potential of China's chemical industry in the future? The answers to these questions will not only help to offer a scientific basis for the country's future strategies in the chemical industry's stable development, but will also enhance international industrial competitiveness. Furthermore, in terms of industrial development, energy-saving and emission-reduction, this paper could be of some help to developing countries especially for transition economies.

The objective of this article is to estimate future electricity saving potential. The remainder of this paper is organized as follows. Section 2 presents a brief literature review. Section 3 describes the methodology used in this paper. Section 4 outlines main factors determining electricity intensity and the relevant data. Section 5 offers the econometric analysis and empirical results. Section 6 summarizes our findings and attempts to draw some policy implications.

2. Literature review

Generally, there are two ways to study energy or energy saving potential: energy technology model and energy economy model. In this research, we focus on energy economy model.

From the microeconomic perspective, "conservation supply curves" method is the main method of studying energy saving potential. Worrell et al. (2000) and Hasanbeigi et al. (2010) used this method to study energy saving potential of the cement industry of the United States and Thailand, respectively. This method itself can describe the relationship between the cost of energy saving technologies and energy saving potential. However, this method has obvious shortcomings. First, it cannot study the impact of macroeconomic change on energy conservation, so research on energy conservation is not deep enough. Second, it is not suitable to study future energy saving potential since it mainly focuses on existing technologies.

From the macroeconomic perspective, the most common researches of energy economy model analyze the influence of capital, technology, price, etc., on energy conservation. From different researches, these methods of studying energy or energy saving potential can be classified as follows:

(1) *Production function method*: The specific production function could help to discuss substitution between various input factors such as capital, labor, energy and so on. For example, Yuan et al. (2009) analyzed the relationship among energy intensity, labor, capital and technological progress by using the Cobb–Douglas (C–D) production function. However, C–D production function method cannot study the impact of price and structure on energy conservation. In addition, Ma et al. (2008) studied China's energy intensity using a two-stage translog cost function approach. In this research, although the price was taken into account, it still has no consideration for the relationship between economic structure and energy intensity.
(2) *Scenario analysis*: Based on the energy intensity target in the future, Li et al. (2010) studied the impact of gross domestic product (GDP), population, economic structure and energy structure on energy saving potential of Shanghai, China. Although this method is the most basic method of analyzing future energy saving potential, it is not comprehensive enough about energy saving potential since it cannot take into account price, technology, etc.
(3) *Cointegration*: Cointegration approach has been widely used in the study of energy demand and energy intensity because it overcomes the problem of spurious correlation of time series, and can establish relationship between variables in the long term. For example, Atakhanova and Howie (2007) took GDP, population, industrial structure, energy efficiency, and electricity price as dependent variables to estimate the aggregate and the sectorial electricity demand in Kazakhstan's transition economies. Feng et al. (2009) studied the impact on energy intensity in China of energy consumption patterns and economic structure. However, these researches tend to stop analyzing energy saving potential, just at the point of studying energy demand or energy intensity. In fact, cointegration can be used to estimate energy saving potential through analyzing the impacts of various factors and estimating corresponding elasticity coefficients. It should be noted that the stability test of cointegration model is very necessary since this method relies on the stability and availability of historical data.

In addition, the data envelopment analysis (DEA) model (Hu and Wang, 2006; Hu and Kao, 2007) and the index decomposition method (Achão and Schaeffer, 2009; Zhao et al., 2010) were used to study energy demand, but it is also not comprehensive enough about energy saving potential since these two methods cannot take into account price factor.

Table 1 summarizes six economic methodologies used to facilitate the analysis of energy saving potential. Each method has its own strengths and weaknesses.

At present, research on electricity saving potential of the chemical industry using energy economy model is still a blank. Through reviewing literatures, we found that there are many factors affecting electricity conservation of industry, not only including input factors such as capital, technology and labor, but also economic variables such as price, economic structure and so on. In this paper, we firstly attempt to capture the main macroeconomic variables affecting electricity intensity, and study the impact of these variables on electricity intensity of China's chemical industry using cointegration approach; then predict future electricity saving potential of China's chemical industry using scenario analysis method.

3. Methodology

3.1. Cointegration

In reality, the time series of economic variables are often not stationary. However, a linear combination of two or more non-stationary series may be stationary (Engle and Granger, 1987).