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The impacts of removing energy subsidies on economy-wide rebound effects in China: An input-output analysis

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HIGHLIGHTS

- Rebound effects with the consideration of energy subsidies are estimated in China.
- When considering the interactions among sectors, the aggregate rebound effect become small.
- Removing subsidies will reduce energy consumption, thereby declining the rebound effects.
- Removing subsidies for different energy types has varies effects on rebound effect.

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ABSTRACT

Facing with the increasing contradiction of economic growth, energy scarcity and environmental deterioration, energy conservation and emissions abatement have been ambitious targets for the Chinese government. Improving energy efficiency through technological advancement is a primary measure to achieve these targets. However, the existence of energy rebound effects may completely or partially offset energy savings associated with technological advancement. This paper adopted a modified input-output model to estimate the economy-wide energy rebound effects across China's economic sectors with the consideration of energy subsidies. The empirical results show that the aggregate rebound effect of China is about 1.9% in 2007–2010, thus technological advancement significantly restrains energy consumption increasing. Removing energy subsidies will cause the aggregate rebound effect declines to 1.53%. Specifically, removing subsidies for coal and nature gas can reduce the rebound effects signifcantly, while removing the subsidies for oil products has a small impact on rebound effect. The existence of rebound effects implies that technological advancement should be cooperated with energy price reform so as to achieve the energy saving target. In addition, the government should consider the diversity of economic sectors and energy types when design the reform schedule.

1. Introduction

With the introduction of reform and opening-up policy, China has experienced rapid urbanization and industrialization. Because energy is one of the important materials for urbanization and industrialization, China has shown a rapid increasing of energy consumption. Therefore, China has topped the world in energy consumption and CO_2 emissions since the years of 2010 and 2008 respectively. Fig. 1 shows China's energy consumption, which is dominated by coal, increases from 1469.64 million ton of coal equivalent (Mtce) in 2000 to 4169.13 Mtce in 2013, with an annual growth rate of 7.9%. The huge energy demand and its coal dominated structure have taken great pressures on Chinese sustainable economic growth due to its serious environmental deterioration. For example, the fog and haze covered over 1.3 million square kilometers area in east-central China for long period in 2013 and 2014, which has profoundly impact on resident's health. The restriction of energy and environment has became a serious issue which can not be avoid in China. Energy conservation and emissions abatement has become an ambitious target for Chinese government. During 2011–2015, China's energy intensity and carbon intensity declined by 18.2% and 20% respectively, which exceeding the expectations of binding targets in 12th "Five-Year Plan" (2011–2015). In 2016, the Chinese government proposed the phased obligatory indicators of reducing energy intensity by 15%

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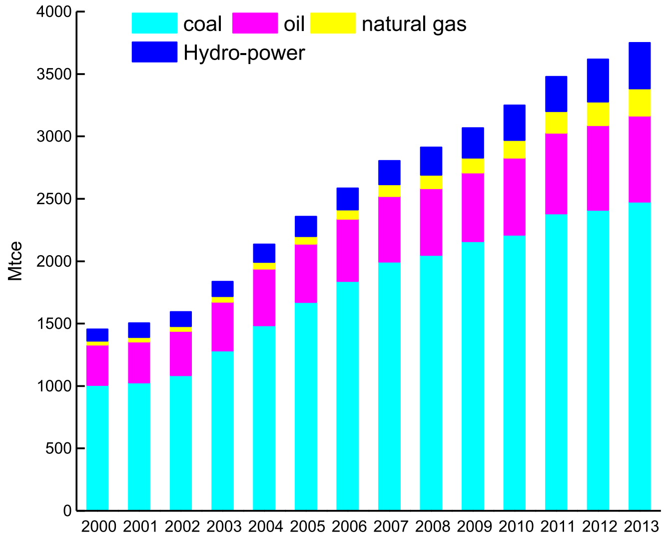

Fig. 1. Energy consumption and structure in China.
Source: China Statistical Yearbook 2014.

and carbon intensity by 18% compared with 2015 levels during the period 2016–2020.

It is generally believed that the improvement of energy efficiency derived by technological advancement can exert the energy-saving effect or reduce energy consumption (Shao et al., 2016a). However, many studies have shown that the actual energy-savings are less than the expected (Antal and van den Bergh, 2014; Bentzen, 2004; Chitnis et al., 2013; Druckman et al., 2011; Freire-González, 2011; Frondel et al., 2012; Jin, 2007). Potential energy savings induced by energy efficiency improvement can be partly or even totally offset by additional energy demand and consumption caused by some economic effects, such as substitution effect, income effect, and output effect (Greening et al., 2000). This phenomenon is called the "energy rebound effect". It refers that although the improvement of energy efficiency induced by technological advancement can intuitively reduce energy consumption. However, energy efficiency improvement will reduce the effective price of energy services, it will also promote economic growth and thus generates new energy demand, and hence at least partially mitigate original expected energy conservation (Lin and Li, 2014; Wang et al., 2016). Therefore, the energy savings from the improved energy efficiency spartially offset by additional energy consumption (Berkhout et al., 2000).

The technological advancement is regarded as the key driving force for energy saving and emission abatement (IPCC, 2000; Shao et al., 2016b). However, how to measure the contribution of technological advancement to energy saving is a daunting task, as the existence of energy "rebound effects" makes it complicated. Herring and Roy (2007) argued that, if we would like to promote technical innovation to achieve higher energy efficiency and reduce energy consumption, we have to combine it with other policies such as taxation. According to the "induced innovation", energy price has a significant impact on rebound effects through its effect on energy efficiency (Li and Lin, 2015a). Energy price is one of the important impulse to decline the energy intensity. In China, most energy price are controlled by the government, and the energy subsidies are usually in the form of depressing the domestic energy price. It is widely believed that removing energy subsides will conducive to energy saving and emissions abatement. Li et al. (2013) also indicates that rebound effects and energy subsidies are closed linked. The effect of energy subsidies is that it could lower the end-use price of energy products or service, so to some extent subsidies would strengthen rebound effect (Dasgupta and Roy, 2015; Jiang and Tan, 2013; Li et al., 2013; Lin and Ouyang, 2014). Therefore, energy subsidies should be taken into account when estimating the rebound effect and making energy-saving target and policy. The purpose of this paper is to discuss the impact of energy subsidies removal on the energy rebound effects in China from sectors perspective. The main contributions of this paper are as follow. First, we want to estimate the energy rebound effects across sectors in China under a consistence framework based on more precise data. Second, an in-depth analysis about the effects of removing subsides for different energy types on rebound effects are presented, which is important for policy-makers to introduce energy price reform.

The remainder of the paper is organized as follows. Section 2 reviews the present literature on energy rebound effects; Section 3 present the methodology adopted in this paper. Section 4 estimates the scale of China's energy subsidies; Section 5 applies the Input-Output (I-O) model to simulate the impact of energy subsidies on the rebound effects. Conclusions and policy suggestions are provided in Section 6.

2. Literatures review

Many studies have confirmed the existence of energy "rebound effects" (Greening et al., 2000; Mayo and Mathis, 1988; Safarzynska, 2012; Saunders, 2000; Van den Bergh, 2011). And it would take an understatement to look at energy consumption and it would undermine the rationale for policy measures to encourage energy efficiency without considering the rebound effects (Saunders, 2013; Sorrell and Dimitropoulos, 2008). The estimation of rebound effect is usually from the macro and sectoral perspectives, and the CGE model and the econometric approach are the mainly methods (Allan et al., 2007; Antal and van den Bergh, 2014; Evans and Schäfer, 2013; Grepperud and Rasmussen, 2004; Hanley et al., 2009; Koesler et al., 2016; Saunders, 2013; Thomas and Azevedo, 2013; Wang et al., 2014; Wei, 2010; Yu et al., 2015). Due to the CGE models only present the analog values of rebound effect, so most studies adopt the econometric approach (Li et al., 2016; Shao et al., 2014).

The pioneering research on China's rebound effects is conducted by Zhou and Lin (2007), and their results showed that energy rebound effects of China fluctuated between 30% and 80% during 1979–2004. Because of different method, the results about China's rebound effect are very different. Zha and Zhou (2010) adopted the CGE model and found that the 4% increase of energy efficiency could induce a 33% rebound. Lin and Liu (2012) estimated the technology-based energy rebound effect in China, and the results showed the averaged value was 53.2% over the period 1981–2009. Antal and van den Bergh (2014) found that the rebound effects in China was 69% for gasoline and 27% for natural gas, and they were the highest among 93 countries. Based on the IPAT equation and Brookes' explanation of the rebound effect, Because technological progress rate cannot be observed directly, Shao et al. (2014) adopted the latent variable approach (LVA) to measure it, and found the rebound in China varies before and after reform and opening-up policy. In addition, some literatures focus on the energy rebound effects in industrial sectors (Guo et al., 2010), and some focus on the rebound effect in household energy efficiency (Lin and Liu, 2013; Ouyang et al., 2010; Wang et al., 2014; Yu et al., 2013). Generally speaking, the government wants to obtain the best performance of energy savings induced by technological advancement. However, most studies about rebound effect ignore the interactions among different economic sectors. Li and Lin (2015a) estimates the energy rebound effects during the period 2006–2010. But the data they used are published by the World Input-Output Database (WIOD), which may be not