Energy Policy 123 (2018) 259–265

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

An evaluation of technical progress and energy rebound effects in China's iron & steel industry

Xiaolei Wang[a], Xiaohui Wen[a], Chunping Xie[b,*]

[a] School of Management, China University of Mining and Technology, Xuzhou, Jiangsu 221116, China
[b] Birmingham Centre for Energy Storage, School of Chemical Engineering, University of Birmingham, Edgbaston, Birmingham B15 2TT, UK

ARTICLE INFO

Keywords:
Technical progress, Price elasticity, Energy rebound effect
China's iron & steel industry

ABSTRACT

As a pillar industry in China, the iron & steel sector have under through rapid growth and technical progress for decades. However, energy polices aiming at energy savings may not be as good as expected due to the existence of rebound effects. The motivation of the paper is to analysis the nexus between technical progress and energy rebound effects. Based on a three-input trans-log cost function model, we first estimate the share equation and the corresponding price elasticity for each input factor. Then, the rebound effect in China's iron & steel industry over 1985–2015 is evaluated through decomposing the energy prices. Empirical results show that: (1) The price elasticities of input factors are negative; (2) Energy/capital and energy/labor show substitute relationships; (3) The average energy rebound effect in the ISI is as high as 73.88%; (4) The energy rebound effect shows a downward trend before the 11th Five-year period and then an upward trend after that. Therefore, policies proposals of lowering the rebound effect should be placed not only on technical progress, but also on energy price reform by reducing energy subsidies and thus accelerating energy price marketization, so as to promote energy substitution, reduce energy rebound effect and produce further economic and environmental benefits.

1. Introduction

1.1. The growth of Iron & Steel Industry (ISI) in China

From the perspective of neoclassical economics, there are two types of driving forces for economic growth: one works as a contributing factor for production, including capital, labor and energy input; the other aims at improving productivity. Any economic growth path which relies on the increase of factor inputs is regarded as unsustainable in the long term. However, improvement in productivity is able to ensure the sustainability of economic growth. Technical progress is seen as an important influencing factor to total factor productivity, which would contribute to economic growth. As technical progress can enhance productivity, changes in technical level will have an impact on the growth of production in ISI. A variety of literature uses the indicator of Research and Development (R&D) expense to indicate technical level (Lin and Xie, 2013).

In past 30 years, China's ISI has been experiencing a sustainable development (see Fig. 1), with a rapid growth in crude steel production and the production value represented by the Industrial Value Added (IVA). During 1985–2015, R&D expense in China's ISI increased significantly from 237 to 6123 million Yuan, at an average growth rate as high as 23% per annum (shown in Fig. 2). The growth rate of R&D expenditure is higher than that of IVA, suggesting that the growth of this industry is the results of technical progress. In 2015, total R&D personnel was 137.8 thousand man-years (measured in full-time equivalent), taking up a proportion of 3.78% in total number of employees in the ISI, with 1.0% higher than that in the industrial sector. The growth of R&D expenditure and higher proportion of R&D personnel means that the technical level of ISI has been improved significantly during past 30 years.

1.2. Technical progress and energy rebound effect

Technical progress can not only lead to the growth of production, but also an improvement in energy efficiency, thus a reduction in energy inputs, which would give rise to energy savings. The contribution rate of technical process to energy savings is around 40–50% in China's ISI (China Steel Yearbook, 2011). Significant energy savings in ISI have been achieved by measures that aiming at advanced producing routes, for example, replacing the open hearth furnaces with the electric arc furnaces; applications of more efficient ways for casting and rolling of the final crude steel product (Napp et al., 2014); etc.

Nevertheless, the amount of energy inputs in China's ISI is still large. As shown in Fig. 3, energy inputs in the ISI was 76.4 mtce in 1985, then this number increased by more than eight times to 639.5 mtce in 2015.

* Corresponding author.

https://doi.org/10.1016/j.enpol.2018.08.016
Received 5 January 2018; Received in revised form 28 July 2018; Accepted 1 August 2018
0301-4215/

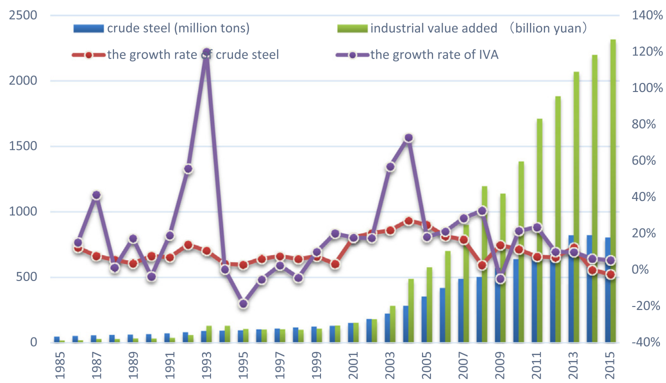

Fig. 1. Production of crude steel in China's ISI. Source: China Statistical Yearbook (China Statistics Press, 1986–2016).

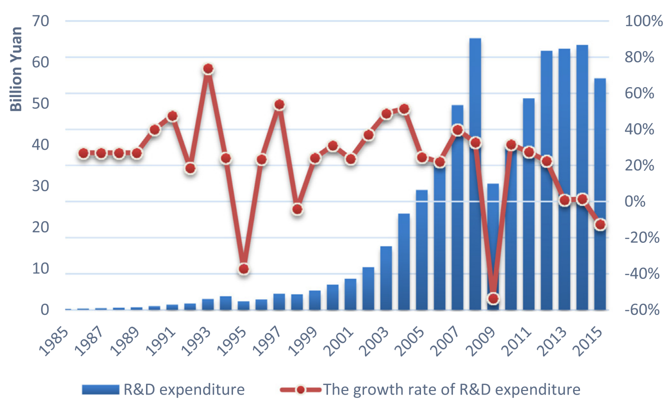

Fig. 2. R&D expenditure in China's ISI. Source: China Statistical Yearbook on Science and Technology (China Statistics Press, 1986–2016).

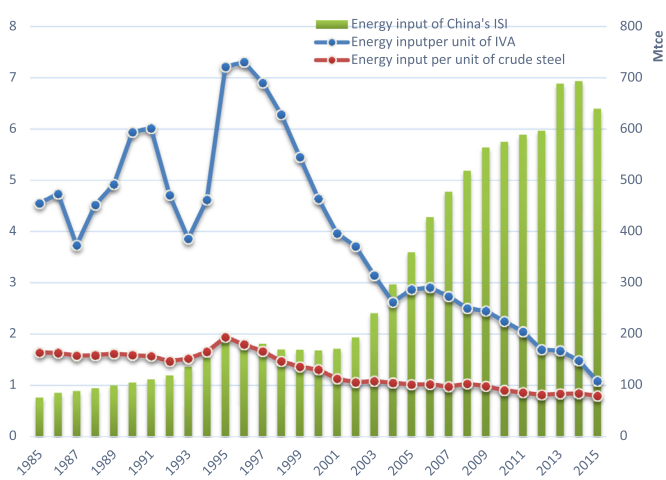

Fig. 3. Changes of energy intensity in the ISI in China. Source: China Statistical Yearbook (China Statistics Press, 1986–2016).

The annual growth rate of energy inputs in the ISI has been 23.1% for the past 30 years, much higher than the overall growth rate of industrial energy consumption (6.3%). As about 70% of energy recourses consumed in China are coal related, the rapid growth in energy consumption brings environmental issue inevitably.

The index of energy intensity is generally applied to represent energy efficiency. During 1985–2015, energy input per unit IVA in China's ISI has dropped by 76.2%, from 0.46 mtce per billion yuan in 1985–0.11 mtce per billion yuan in 2015. In contrast, the fluctuation of energy consumption per ton crude steel was relatively moderate, dropping from 1.64 to 0.80 tce/ton. Both these two indicators show apparent a decrease trend in energy intensity, suggesting that as the industrial output increases, energy efficiency in China's ISI has been improved greatly.

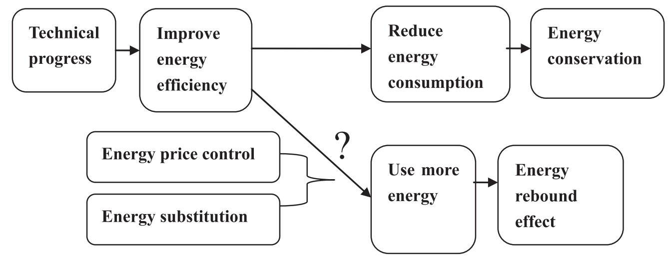

Fig. 4. The relationship between technical progress and rebound effect.

From the above analysis, it is noticed that as the technical level in China's ISI improves, energy efficiency in this sector shows an increasing trend. However, due to the energy rebound effect, the improvement in energy efficiency may not give rise to a decrease on energy use, which can make the energy policies aiming at energy savings less effective. The rebound effect describes the phenomenon that energy efficiency can be improved by the use of new technologies; however, along with the new technologies and increased energy efficiency, industrial enterprises and residents may increase their consumption of energy resources (Khazzoom, 1987; Grubb, 1990; Wirl, 1997; Wang et al., 2012) (see Fig. 4). For iron & steel enterprises, improvement in energy efficiency means that less energy input achieves equivalent output and thus other inputs such as capital and labor will be replaced by energy (Wang and Lin, 2017). Whether technology-induced efficiency improvement could reduce energy consumption, it is strongly related to the effectiveness of energy policy.

Therefore, the purpose of the paper is to evaluate the energy rebound effect in China's ISI, taking into consideration the energy price control and energy substitution. The main contributions are comprised of three aspects: (1) a non-neutral-technical-progress trans-log cost function model is built to interpret the relationship between technical progress and rebound effect; (2) the price elasticities and energy substitution effect between energy and other input factors are evaluated; (3) the energy rebound effect in China's ISI is estimated using asymmetric price method, based on which the changes of rebound effect in each Five-year period are analyzed.

The rest part of the paper is structured as the following sections: Section 2 emphasizes on literature review. Section 3 describes the methodology for building an evaluation model to estimate the energy rebound effect. Section 4 presents variables and data sources. Section 5 shows model results and the corresponding analysis. Section 6 concludes this manuscript and give policy suggestions.

2. Literature review

The concept of energy rebound effect was initially introduced by Khazzoom (1987). After that, there were many researches focusing on theoretical analyses to give in-depth understanding of energy rebound effect, such as Greening et al. (2000) and Jin (2007). Based on Khazzoom (1987), improvements in energy efficiency caused by technical progress would promote energy conservation. However, the improved technical level, along with an increased operational efficiency of production equipment, would lead to a decrease in the corresponding production cost, thus encourage further economic development, and ultimately accelerate energy consuming. Improvement in energy efficiency could boost energy consumption in two ways: (1) through reducing the cost of energy consumption and thus encouraging producers to substitute energy for other production inputs; (2) through making the economy grows more rapidly, thus accelerating energy consumption. Whether energy conservation policies would meet the established goals depends largely on the rebound effect.