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Natural Gas Industry B 3 (2016) 387–397

www.elsevier.com/locate/ngib

Research Article

Possibilities of coal–gas substitution in East Asia: A comparison among China, Japan and South Korea

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Received 6 June 2016; accepted 12 December 2016
Available online 1 February 2017

Abstract

Natural gas is currently playing an increasingly significant role in low carbon development, as it provides a credible pathway to meet rising energy demand while emitting fewer greenhouse gases than from using other fossil fuels such as coal and oil. In this paper, a log linear trans-log production function model is established to investigate inter-fuel elasticity of substitution between coal, oil, natural gas and electricity in China, Japan and South Korea, respectively. In order to overcome the problem of multicollinearity, the ridge regression approach is therefore adopted to estimate the parameters of the function. Results show elasticity estimates of both coal–gas substitution and coal–electricity substitution to be positive over 1985–2012, suggesting that these two energy input pairs are substitutes at least to some extent. It also reveals that relatively higher substitution possibilities between coal and natural gas, and less opportunities to substitute coal with other fuels in China. In addition, the model results also suggest the elasticities of coal–gas substitution in China are much larger than that in Japan and South Korea, indicating there is higher possibilities of coal–gas substitution in China.

Keywords: Substitution possibilities; Trans-log production function; Ridge regression; Natural gas

1. Introduction

1.1. China's natural gas market

China holds the largest natural gas reserves in the Asia–Pacific region. Its proved reserves of natural gas rank 13th in the world, with an amount of around 3.8 trillion cubic meters (tcm) in 2015.[1] What's more, according to the estimation of the U.S. Energy Information Administration (EIA), China holds the largest shale gas reserves in the world, with technically recoverable shale gas reserves of 31.57 tcm in 2014.[2] Though there is huge potential for the growth of China's shale gas industry, it stays in nascent stage facing various kinds of challenges. Both production and consumption have risen rapidly in China in recent years, as shown in the following Fig. 1.

In 2015, natural gas consumption in China rose to 197.3 bcm, ranking the third in the world, just after the U.S.

Abbreviation: bcf, billion cubic feet; bcm, billion cubic meters; GHG, greenhouse gas; LNG, liquefied natural gas; EIA, The U.S. Energy Information Administration; IEA, International Energy Agency; OECD, Organization for Economic Co-operation and Development; OLS, ordinary least squares; VIF, variance inflation factor.

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Peer review under responsibility of Sichuan Petroleum Administration.

[1] Data Source: BP Statistical Review of World Energy 2016.

[2] U.S. Energy Information Administration, "Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formations in 41 Countries Outside the United States", June 10, 2013.

http://dx.doi.org/10.1016/j.ngib.2016.12.004

and Russia. While natural gas production in China increased to 138.0 bcm in 2015, ranking the sixth worldwide. With rapidly increasing use of natural gas in China, it has become the third-largest natural gas consumer worldwide. Natural gas production keeps growing as well, but in a lower rate than that in consumption, causing an ever-increasing gap between natural gas consumption and production. As a result, China has sought to raise natural gas imports via pipeline and as liquefied natural gas (LNG) to fill the gap. Fig. 2 shows China's natural gas imports from 2006 to 2015.

China became a net importer of natural gas ever since 2007. Rapid growth in natural gas demand in recent years has led to an accelerating development of China's LNG and pipeline infrastructure. China's total natural gas imports ranked the 4th in the world, with an amount of 59.8 bcm in 2015. Also, it is now the third-largest LNG importer in the world, after Japan and South Korea.

Energy structure centering on coal as well as the rapidly increasing energy demands are main reasons why a large area of haze is seen in China. The effective haze treatments are largely depending on the optimization of energy mix, in other words, on reducing China's heavy use of coal. However, a huge amount of energy is needed to sustain its rapid economic growth. Under this background, China has to seek for alternate energies to offset the supply gap of reducing coal consumptions. The most practical alternate energy is natural gas within the short term in China. For the past few years, natural gas industry in China has developed fast and natural gas consumption has continuously maintained a double-digit growth rate.

As one of the largest natural gas consumers in the world, China's future demand for natural gas is of much concern. Though China is now the third-largest natural gas consumer, with natural gas consumption of 197.3 bcm in 2015. However, it only accounted for around 5 per cent of the country's total primary energy consumption in that year. According to China's development plan on natural gas, the share of natural gas consumption in its total energy use will rise up to 10 per cent

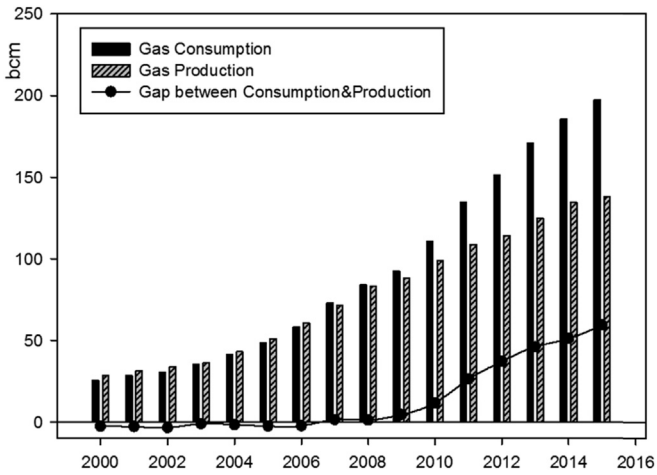

Fig. 1. Natural gas production & consumption in China. Data Source: BP Statistical Review of World Energy 2001–2016.

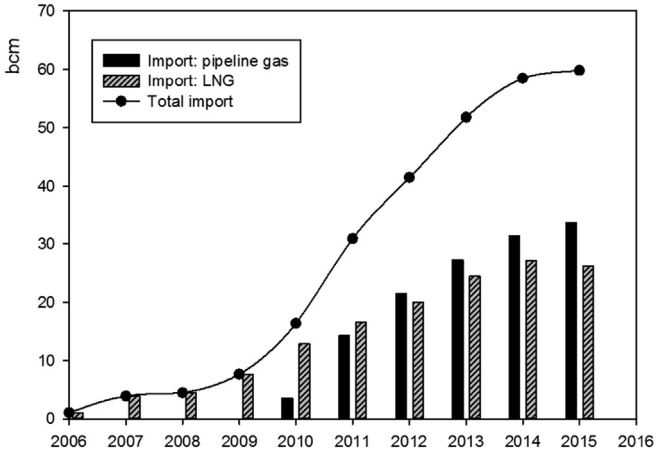

Fig. 2. Pipeline gas & LNG imports in China. Data Source: BP Statistical Review of World Energy 2001–2016.

by the year of 2020, in order to alleviate the serious pollution causing by the China's heavily use of coal. That is to say, future natural gas consumption in China is likely to maintain a rapid growth.

1.2. Natural gas market in Japan and South Korea

Both Japan and South Korea have limited domestic energy resources, and rely heavily on imported energy to meet their demands. As a result, both Japan and South Korea's domestic natural gas productions are negligible compared to their gas consumptions.

For Japan, after the removal of nuclear power due to the Fukushima plant accident in 2011, Japan's energy self-sufficiency rate fell from 20% to no more than 9%. With its primary energy consumption ranking the fifth in the world, Japan has been seeking for reliable energy sources to meet its national energy demands. Japan's demand for natural gas maintains a comparatively fast growth ever since 2009, while its domestic production is just the opposite, leading to an ever higher gas dependency on foreign countries.

Fig. 3 shows natural gas consumptions and imports in Japan. Due to the geographical location as well as other factors, natural gas imports through pipeline to Japan presents serious difficulties. In 2015, Tokyo Gas showed interest in building a gas pipeline which would connect Russia's Sakhalin Island with Japan. However, it is believed that the construction of an underwater pipeline to Japan indicates great risks. As a result, all natural gas imports in Japan are imported as LNG, and it is currently the world's largest LNG importer.

Fig. 4 shows natural gas consumptions and imports in South Korea. Similar to Japan, South Korea has an even higher foreign dependency on natural gas and its domestic production of natural gas is very limited. What's more, South Korea does not have any international natural gas pipeline connections and must therefore import all gas via LNG tankers. As a result, although South Korea is not among the group of top natural gas-consuming countries, it is the second-largest importer of LNG in the world after Japan. Despite the recent lower natural