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The role of technology on the dynamics of coal consumption–economic growth: New evidence from China

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HIGHLIGHTS

- An integrated growth model is developed to explain coal demand in China.
- Technological development in coal sector is significant for sustainable growth.
- Trade liberalisation in China affects coal demand.
- Coal prices play an important role in influencing coal demand.
- China is right in shifting subsidies from coal to other renewable resources.

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ABSTRACT

Coal comprises 70% of primary energy sources and 80% of electricity generation in China. This paper investigates the coal consumption–economic growth nexus in an integrated demand–supply framework over the period from 1978 to 2010. We incorporate the role of coal technology to explain the growth process. Using the Autoregressive Distributed Lag bounds testing approach, we find improvement in the coal-to-electricity efficiency indicator, a proxy for coal technology, causing almost a 35% increase in real GDP in the long run. The Toda–Yamamoto causality test indicates unidirectional causality from coal consumption to economic growth, feedback effects both for coal-to-electricity efficiency indicator to economic growth and coal demand and openness to coal consumption. For a robustness check, we forecast the validity of the causal relationships beyond the sample horizon using the generalised forecast error variance decomposition method. Our analysis suggests that improving overall efficiency in coal sector will continue to play a significant role in maintaining sustainable growth in China in the long run.

1. Introduction

Since the initiation of economic reform in the late 1970s, China has enjoyed a spectacular growth rate for over three decades. Apart from being the second largest economy in the world, China is the largest merchandise exporter and has a significant global market share of tradable goods. Expansion of heavy industries for the domestic and export markets and urbanisation in the growth process created a high demand for energy, particularly for coal as the primary source of energy. During this process, China has become the largest CO_2 emitter in the world. According to [1] published by the U.S. Energy Information Administration (EIA), coal consumption comprises 70% of the total energy mix. Electricity generation in China has increased more than three times since 2000, raising the coal consumption significantly in recent years. In 2011, total coal consumption was 3.45 billion metric tons, nearly half of the global coal consumption.

The Chinese government has recently diversified its energy-mix from coal and oil to renewables, gas and nuclear, with underlying changes in the industrialisation process. In the 'Twelfth Five-year Plan' (2011–2015), the Chinese government set various targets in the energy sector to meet increasing energy demand in a low-carbon path, viz., 16% decline in energy intensity, 11.4% share of non-fossil energy in total energy use and a 17% reduction in carbon intensity are expected by 2015.[1] By 2020, China aims to reduce greenhouse gas (GHG) emissions by 40–45% per unit of gross

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[1] *Source:* [2] http://www.c2es.org/international/key-country-policies/china/energy-climate-goals-twelfth-five-year-plan.

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domestic product. The decline in carbon and energy intensity will depend on many factors, including use of advanced technology and structural policy changes. Increasing energy efficiency has been in priority for Chinese policy makers to maintain sustainable growth in an environment of increasing energy demand.

While coal is the primary source of energy in China[2], the demand–supply imbalance of coal has steadily increased in recent years. Since 2009, China has been importing coal from Australia, Indonesia and South Africa. Faced with this increasing use of coal, China is under pressure domestically and from international bodies to mitigate CO_2 emissions. Therefore, since the early 1990s, China has been actively implementing world class technology in coal-fired power plants. The development of technology in the domestic market and adoption from international sources form part of the industrial policies with high priority. These priorities have been pursued effectively through the successive Five year plans.

This study contributes to the literature incorporating the role of coal and technology development in reducing CO_2 intensity and their effects within the Chinese growth process. Between 1980 and 2001, China maintained stable coal and energy demand through energy-efficiency programs. Since 2002, there has been a surge in the newly built coal-fired power plants, which have increased coal demand. Total power generation capacity exceeded 700 GW in 2007, nearly 80% of which was from coal, [3]. By implementing advanced coal technology since the 1990s, the Chinese government has been very active in curbing CO_2 emissions per unit electricity from coal-fired power plants.

Our study is unique in detailing specifications by incorporating a coal-to-electricity efficiency indicator into the demand–supply framework to explain a neo-classical growth model. This coal-to-electricity efficiency indicator captures the role of coal technology in reducing CO_2 emissions per unit of electricity for China relative to that in Japan, a frontier country in reducing emissions-intensity from coal [4][3]. To our knowledge, there is no study in empirical energy research capturing this effect in the growth model. In absence of the overall effects of advanced coal technology that China has introduced since the 1990s, we believe this indirect measure will capture the technological development in generating electricity from coal in reducing CO_2 emissions.

The paper is organised as follows. Section 2 provides an overview of the coal-related empirical research in energy economics, with a brief discussion on coal and related technological improvements in reducing emission intensity since the 1990s. In Section 3, we describe our models and the data. Section 4 details our econometrics approach with empirical findings. In the final section, we discuss the policy implications of our findings with some indications of future research.

2. An overview of the literature with a brief on coal technology in China

2.1. Coal-related literature in energy economics: an overview

Applied research on the economic growth-energy consumption nexus is voluminous and establishes integration and causality among energy-related variables with growth process. Since the seminal research by Kraft and Kraft [5], studies have covered different time periods with panel and time series data using various econometric techniques both from the developed and developing world with different stages of development. Among others, [6–8] provide excellent surveys on this literature.

Here, we focus on coal-related studies on empirical energy research based on the growth literature, which has been scant until recently. A bi-directional causality between economic growth and coal consumption is established in the case of Pakistan in [9], where coal has been identified as an alternative source of energy for sustaining growth and capital formation for the country. In [10], a relationship between CO_2 emissions, economic growth and coal consumption is examined in case of China and India. Long-run causality is established among these variables in the case of China only. In the policy context, their findings suggest any conservation policies in China will reduce CO_2 emissions, but at the cost of economic growth. Improvement in coal utilisation efficiency and the use of renewables are among other measures to be identified as policy options for China.

Both supply and demand-side models are considered in [11] to explain coal consumption and economic growth in China. On the supply side, a unidirectional causality is established from coal consumption to economic growth. On the demand side, bi-directional causality is established between aggregate output and coal consumption. Reducing the subsidy on coal has been suggested as an alternative approach in curbing coal consumption and CO_2 emissions. In [12], considering province level data, coal consumption-real GDP nexus has been analysed. A feedback effect exists between these two variables for coastal and central provinces; real GDP Granger causes coal consumption in their study for western provinces. In [13], the authors suggest energy conservation measures will adversely affect coastal and central provinces in China where coal intensive industrialisation is expanding. In a multivariate framework, with a panel of 15 emerging market economies a bi-directional causality between coal consumption and economic growth is established in [13].

In [14], the coal consumption-GDP nexus is revisited for six major coal-producing countries. A unidirectional causality is established between coal consumption and economic growth in the case of India and Japan, whereas a reverse causality is found for China and South Korea. For South Africa and Korea, a feedback effect is revealed for these variables. In contrast to the findings from [10,11,14] suggest conservation policy measures can be implemented without restricting the growth process in the case of China. In [15], the authors find GDP Granger causes coal consumption in the case of Japan and China, and no causality exists between coal consumption and GDP for India, South Korea and South Africa. Their findings suggest that CO_2 emissions should be reduced with coal consumption for sustainable development in the case of most OECD and non-OECD countries. In the case of Korea, [16] establishes a feedback effect running from economic growth to coal consumption.[4] In case of the U.S., [18] establishes that the causal relationship between coal consumption and industrial production changes over time. Using non-parametric bootstrap approach, [19] finds a unidirectional causality from coal consumption to GDP growth but not for overall energy consumption in case of India.[5] In case of Turkey, [21] confirm decrease in coal consumption and increase in coal efficiency can be implemented without reducing growth.[6]

We emphasise that none of these studies have incorporated the role of coal technology in inducing the growth process.

[2] Coal is cheaper compared to oil and natural gas, as China does not have a large reserve of natural gas or oil like the U.S. does.

[3] Japan is in the forefront in overall energy technology innovation and in raising the efficiency of coal-fired power plants; see [4] http://www.iea.org/publications/freepublications/publication/fossil_fuel_fired.pdf.

[4] An excellent summary can be found in [17].

[5] A study based on energy consumption viz, [20] reports mutual dependence between economic growth and energy consumption in case of India; we emphasise here coal related studies only.

[6] [22] has a detailed summary Table on studies with coal (Table 1, pp. 3899).