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How much have electricity shortages hampered China's GDP growth?

Y.S. Cheng [a], W.K. Wong [a], C.K. Woo [b,c,*]

[a] Department of Economics, Hong Kong Baptist University, Hong Kong
[b] Energy and Environmental Economics, Inc., 101 Montgomery Street, Suite 1600, San Francisco, CA 94104, USA
[c] Hong Kong Energy Studies Centre, Hong Kong Baptist University, Hong Kong

HIGHLIGHTS

- China's electricity generation growth is found to Granger cause GDP growth, but not vice versa.
- The estimate of the GDP elasticity of electricity generation is about 0.6.
- A 1% increase in China's electricity generation growth would increase GDP growth by 0.6%.

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ABSTRACT

Based on an econometric analysis of the annual growth data for China's GDP and electricity generation from 1953 to 2010, we find that electricity generation growth Granger causes GDP growth, but not vice versa. We also find that the GDP elasticity of electricity generation is about 0.6, implying that a 1% increase in China's electricity generation growth would increase GDP growth by 0.6%. While Deng's reform raised China's GDP growth rate by about 5% per year, it did not alter the GDP elasticity of electricity generation. Hence, an obvious strategy to promote China's economic growth would be accelerating electricity generation expansion. Rapidly adding thermal generation units, however, could have large-scale, adverse environmental impacts. We therefore support China's 2011 five-year plan, which calls for expanding investments in renewable energy, conservation and energy efficiency as well as improving China's integrated electricity planning and cost-based pricing decisions.

1. Introduction

China is now the second-largest economy in the world, behind the US but ahead of Japan and Germany. Since 1979, China has been growing at an average annual rate of approximately 10%, doubling its gross domestic product (GDP) every eight years. If China's unsurpassed economic growth was to continue, it would become the world's largest economy in about a decade.[1]

Despite China's rapid expansion of electricity infrastructure, electricity shortages remain common (Yang et al., 2007; Tsai, 2011). This raises an immediate and substantive policy question: have electricity shortages hampered China's GDP growth?

Two pieces of empirical evidence suggest "yes". First, estimates of electricity outage cost suggest that electricity shortages can cause large economic losses (e.g., Munasinghe et al., 1988; Woo and Pupp, 1992; LaCommare and Eto, 2006; van der Welle and van der Zwaan, 2007; Sun et al., 2009). Second, the unidirectional causal relationship between electricity consumption and GDP in China indicates that rising electricity consumption tends to increase GDP (Shiu and Lam, 2004; Ho and Siu, 2007; Ozturk, 2010; Ozturk et al., 2010; Yuan et al., 2007, 2008).[2] This evidence affirms that electricity shortages hampered China's GDP growth, demonstrating that electricity is a non-storable but critical input for economic growth.

The next question is: how much? Using the most recently available annual growth data for 1953–2010, this paper finds that China's electricity generation growth Granger causes GDP growth, but not vice versa. It also finds that a 1% increase in electricity generation growth would raise China's GDP growth by about 0.6%.

Since China's total electricity generation in 2010 was 4206.54 TW h, a 1% increase in electricity generation is about 42 TW h per year, translating into 4795 MW of capacity addition

* Corresponding author at: Energy and Environmental Economics, Inc., 101 Montgomery Street, Suite 1600, San Francisco, California 94104, United States. Tel.: +1 415 391 5100; fax: +1 415 391 6500.
E-mail address: ck@ethree.com (C.K. Woo).

[1] http://www.bbc.co.uk/news/business-12427321

[2] There is limited evidence for the absence of a causal relationship between China's electricity consumption and GDP (Chen et al., 2007). Moreover, China's energy consumption and GDP nexus is unclear. It may be from energy consumption to GDP, GDP to energy consumption, or bi-directional (Ma et al., 2010). The preponderance of evidence, however, supports the unidirectional causal relationship between China's electricity consumption and GDP.

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[$=(42\times10^{12}$ W h per year/8760 h per year)/10^{7} W per MW]. Our estimate of a 0.6% GDP increase due to a 4795 MW growth corroborates that a 3790 MW electricity shortage in 2004 "is estimated to have caused China's GDP growth rate to decrease by 0.64%…" (Yang et al., 2007, p. 349).

Given China's past and current shortages, however, a 1% increase in electricity generation will not, in the next few years, achieve the generation reliability target typically used in OECD countries.[3] Thus, attaining electricity adequacy will likely require expanding China's demand-side management, including demand response, energy efficiency and conservation.

The paper's main contribution is its analysis of long (58-year) growth data series unseen in prior studies, thereby enriching the recent literature on China's energy-growth nexus (e.g., Apergis and Payne, 2011; Ozturk, 2010; Ozturk et al., 2010; Yuan et al., 2007, 2008, 2010). We find a Granger causal relationship that runs from China's electricity *generation* growth to GDP growth, corroborating prior studies that focus on the causal relationship between electricity *consumption* and GDP (e.g., Shiu and Lam, 2004; Ho and Siu, 2007; Ozturk et al., 2010). This is expected because there has been very little import or export of electricity in China, implying that China's electricity generation is highly correlated to electricity consumption ($r=0.99$).[4] Finally, we econometrically affirm the GDP effect of electricity shortages reported by Yang et al. (2007).

The policy implication of our findings is that sustaining GDP growth in China would require continuous development of its electricity sector. To address environmental concerns, however, conventional generation capacity expansion should be accompanied by renewable energy development, increased conservation, and energy efficiency improvement (Huang and Yan, 2009; Bing et al., 2010; Woo and Greening, 2010; Woo et al., 2011; Zhang et al., 2010). Thus, we support China's 12th five-year plan of 2011, which has already adopted such a strategy and actions to improve China's integrated electricity planning and cost-based pricing decisions (Kahrl et al., 2010).

2. China's economic development and electricity shortages

China's economic development over the past six decades can be divided into two distinct periods: before and after 1979, the year that marks the beginning of China's economic reform.

In the early 1950s, the Chinese government adopted a Soviet-type economic planning system, with state-owned enterprises dominating the economy. While China had a respectable annual GDP growth rate of about 6% from 1953 to 1978, its allocative and technical efficiencies were notoriously low (Wu, 2010). From 1979 to 2010, China's reform efforts resulted in an impressive annual growth rate of over 9%. To explore China's GDP-electricity nexus, consider Fig. 1 that portrays China's real GDP level and electricity generation data series obtained from National Bureau of Statistics (2010, 2011). While China's electricity generation closely tracked GDP before 1979, it did not sufficiently outpace GDP to achieve consistent supply adequacy in the post-reform period, as evidenced by China's past and current shortages.

This figure also indicates three major events in the post-1978 period. The first is the 1979 launch of gradualisitic economic reform, under which decision-making power was decentralized to local governments and enterprises. After Deng Xiaoping's famous tour to South China in 1992, the Chinese Communist Party committed to establishing a market economy, further opening up to foreign trade and investment. At the end of 2001, China successfully entered the World Trade Organization (WTO). Since then, China has increased its integration into the world economy and experienced even higher growth rates. According to the National Bureau of Statistics (2010), the annual GDP growth rates in these three sub-periods were similar, equal to 9.1% (1979–1991), 9.9% (1992–2001), and 10.4% (2002–2010), respectively.

The electricity sector was subject to entirely different market regimes in the pre- and post-reform periods. Before 1979, investment, generation, transmission, and distribution of electricity were under government control. Considered to be strategically important to industrialization, the electricity sector received heavy investment during the era of central planning. Electricity output grew from 1.96 TW h in 1952 to 57.12 TW h in 1978, implying an annual growth rate of about 14% (Zhang, 1994). Electricity rates were artificially suppressed and electricity was often in short supply (Bai and Qian, 2010).

As economic growth accelerated after 1979, electricity shortages worsened at an alarming pace. The central government lacked sufficient funds to expand power generation capacity to meet rapidly growing demand.

In 1985, the central government allowed local governments as well as foreign and domestic private companies to invest in constructing electricity generation stations. The electricity prices charged by these stations were set to recover competitive returns on investment. As a result of increased supply, electricity shortages sharply diminished by 1997 (Feng, 2008).

However, as economic growth spiked in the early 2000s, a nationwide electricity shortage broke out in 2003–2004. In response, the central government adopted a multipronged approach. Besides increasing supply, it discouraged high energy-consumption industries via investment restrictions and electricity rate increases (Chen, 2011). Furthermore, it encouraged renewable energy development (Zhang, et al., 2010;Howell et al., 2010). Despite these developments, electricity shortages remain frequent and common in China.[5]

The central government's electricity market reform efforts did not relieve China's electricity shortages, due in large part to (a) the conflicts between the coal and electricity sectors and between regions (Feng, 2008; Ma and Oxley, 2011; Tsai, 2011; Zhang and Chen, 2011) and (b) problems in market entries, supply contract enforcement, and irregular charges for inter-provincial transmission (State Electricity Regulatory Commission, 2011b).[6] This is not unexpected, in light of the international experience of electricity market reforms that have largely failed to achieve reliable supply at reasonable costs and rates (Woo et al., 2003, 2006).

To presage our regression analysis, Table 1 presents the descriptive statistics for China's GDP growth and electricity

[3] A commonly used reliability target is one day in 10 years (or 2.4 unserved hours per year), implying a reserve margin of 15–25% of system peak demand (Keane and Woo, 1992). In contrast, areas around Shenzhen in the Guangdong province of South China had, in the summer of 2011, planned outages of one day per week for industrial users.

[4] To the best of our knowledge, China has not published a long and consistent data series on electricity consumption. The reported correlation is based on the electricity generation and consumption data consumption jointly available for the period of 1980–2009 in National Bureau of Statistics (2010, 2011).

[5] See, for instance, *China Daily*'s report on 8 September 2011, available at www.chinadaily.com.cn/business/2011-09/08/content_13649351.htm. In addition, China's system average interruption duration index (SAIDI) in 2010 is 6.7 h/customer (State Electricity Regulatory Commission, 2011a, p.19), higher than the SAIDI of 0.3 h/customer for Hong Kong and 1–2 h/customer for OECD countries (Woo et al., 2009).

[6] In 1997, the central governments established the State Power Corporation (SPC) to help commercialize the electricity sector—which was supposed to run profit-driven business operations—under the watchful eyes of regulatory agencies. To introduce generation market competition, the SPC was divested in 2002, resulting in two grid companies, five big power producers, and four auxiliary power corporations (Ma and He, 2008).