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Electricity consumption and metropolitan economic performance in Guangzhou: 1950–2013

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ABSTRACT

This study analyzes the relationship between electricity consumption and metropolitan economic growth for Guangzhou, China using 64 years of annual-frequency data. The capital stock is used as a control variable because of its role in mediating the relationship between energy utilization and economic output. Empirical results indicate unidirectional Granger causality from electricity consumption to metropolitan economic performance in the short run. This is consistent with the argument that dependable electricity infrastructure and service can play a vital role in facilitating economic growth. Implications for conservation efforts and regional development are discussed.

1. Introduction

Substantial effort has been devoted to empirical analysis of electricity consumption and economic performance at the national level. Research in this area has yielded differing conclusions regarding the existence and direction of causality between electricity usage and GDP growth for various countries and time periods (Ozturk, 2010). To date, the energy-growth nexus at the sub-national level has received far less attention. Given the diversity of empirical results documented in national-level studies, it would not be surprising if directions of causality also differ between regional economies. The objective of this study is to analyze the interaction between electricity usage and economic performance in Guangzhou, China.

With more than a 2100 year history, Guangzhou is a major commercial center in south China. The capital of Canton Province, it is located within 120 km of both Hong Kong and Macau. From 1949 to 1977 collectivist policies abolished many of the trade and commercial activities long associated with Guangzhou. The major breakthrough for the repositioning of Guangzhou as a regional hub was the open-door policy introduced in 1978 (Bercht, 2013). Since then, Guangzhou has experienced rapid urbanization accompanied by strong economic growth and greater electricity consumption. Trailing only Beijing and Shanghai, Guangzhou is the third largest city in China with the highest level of per capita disposable income among all urban areas in the country (Yang, 2004). Due to its historic role as a key port city and a testing ground for export-oriented industrialization policies, the experience of Guangzhou may serve as a bellwether for other regions of China that are undergoing similar transformations.

Metropolitan economic growth is affected by standard factors of production and may also be influenced by the coverage and reliability of local energy supply networks. As a preliminary step in the empirical analysis, a production function including electricity usage is estimated within the framework of a vector autoregressive (VAR) model. The data sample employed spans 64 years from 1950 through 2013. Potential causal relations between electricity consumption and output are examined using Granger causality tests. The direction of causality between these two variables has important implications for environmental conservation and economic development strategies. As an expanding urban economy where linkages between electricity consumption and economic performance have not been analyzed very extensively, a study of this nature for Guangzhou may yield interesting insights that are useful to analysts and decision makers.

The next section provides a brief overview of prior studies that analyze the relationship between electricity consumption and economic growth. Those studies cover various sample periods and geographical regions, and employ several different empirical methodologies. Section 3

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describes the theoretical framework and the data structure used to complete the econometric analysis. Section 4 summarizes empirical results obtained. Section 5 concludes.

2. Literature review

Prior literature on this topic identifies four possible hypotheses regarding the nature of the nexus between electricity consumption and economic performance (Wolde-Rufael, 2014). The first of these is the conservation hypothesis implying unidirectional causality running from economic growth to electricity consumption. In contrast, the growth hypothesis postulates unidirectional Granger causality running from electricity consumption to economic growth. The feedback hypothesis contemplates bidirectional causality such that electricity consumption and economic growth mutually influence each other. The fourth view is the neutrality hypothesis of no direct causal links between electricity consumption and economic performance.

Among the studies that test the conservation hypothesis, Ghosh (2002) documents unidirectional Granger causality from economic growth to electricity consumption using annual data covering the period from 1950 to 1997 in India. Jumbe (2004) detects unidirectional causality running from GDP to electricity consumption with data from 1970 to 1999 for Malawi. Mehrara (2007) reports strong unidirectional causality from economic growth to energy consumption for oil exporting countries between 1971 and 2002. Jamil and Ahmad (2010) find the presence of unidirectional causality from real economic activity to electricity consumption by using annual data for the period 1960–2008 in Pakistan.

Other studies report evidence in favor of the growth hypothesis. Narayan and Prasad (2008) use a bootstrapped causality testing approach to show the evidence in favor of electricity consumption causing real GDP in Australia, Iceland, Italy, the Slovak Republic, the Czech Republic, Korea, Portugal, and the UK for the four decade period between 1960 and 2002. Shahbaz et al. (2011) report similar results for Portugal using sample data from 1971 to 2009. Additional evidence in favor of the growth hypothesis is documented in a number of other efforts (Shiu and Lam, 2004; Altinay and Karagol, 2005; Yuan et al., 2007; Akinlo, 2009; Ciarreta and Zarraga, 2010; Bildirici and Kayıkçı, 2012; Al-Mulali et al., 2014). Those studies include data from many different regions and are not consequences of specialized geographic factors.

Evidence in favor of the feedback hypothesis has also been documented in a variety of studies using data for several different countries. Yoo (2005) reports bi-directional causality between electricity consumption and economic growth between 1970 and 2002 in Korea. Yoo (2006) chronicles similar bi-directional causality between electricity consumption and economic growth for Malaysia and Singapore during the same three decade period, as does Tang (2008) for Malaysia. Odhiambo (2009) finds a causal feedback loop between electricity consumption and economic growth in South Africa for the period from 1971 to 2006. Cheng-Lang et al. (2010) uncover a comparable pattern for Taiwan between 1982 and 2008. Shahbaz and Lean (2012) obtain similar evidence for Pakistan, as does Ouédraogo (2010) for Burkina Faso, and Hamdi et al. (2014) for Bahrain.

A smaller number of studies also report evidence in favor of the neutrality hypothesis. Huang et al. (2008) uncover no causal relationship between energy consumption and economic growth from 1972 to 2002 in a sample of low income economies. Ozturk and Acaravci (2011) indicate that there is no relationship between electricity consumption and economic expansion in eleven Middle Eastern and North African countries over a slightly longer time period from 1971 to 2006. Dogan (2015) reports evidence of neutrality between electricity consumption from renewable sources and economic growth, as well as between electricity consumption from non-renewable sources and economic growth, in Turkey for the years of 1990 through 2012.

The literature to date, thus does not provide definitive corroboration of any of the four major hypotheses regarding the relation between electricity consumption and economic growth. The majority of the research on this topic, however, relies on national-level data. To at least partially fill that gap in the energy and regional economics literatures, the study at hand employs data from a major metropolitan economy in China. At present, there are relatively few efforts that examine regional energy consumption patterns in China (Haitao Yin, 2015) and none that consider the specific case of Guangzhou. The analysis examines whether electricity consumption promotes, retards, or is neutral to economic performance.

3. Data and methodology

Some prior research employs bivariate models to study the direction of causality between energy consumption and economic growth (Ghosh, 2002; Shiu and Lam, 2004; Altinay and Karagol, 2005; Yoo, 2006; Narayan and Prasad, 2008). Ozturk (2010) points out that other variables may impinge upon this relationship and not accounting for such factors may invalidate the results of causality testing. To aid in properly identifying causal relationships between energy and economic growth, several prior studies utilize factors of production as control variables (Ghali and El-Sakka, 2004; Oh and Lee, 2004; Soytas and Sari, 2006; Lee et al., 2008; Yuan et al., 2008; Hamdi et al., 2014). This analysis follows the same general approach to examine the nexus between electricity consumption and gross metropolitan product (GMP) in Guangzhou.

Electric energy is a vital ingredient for various types of production processes. In the case of Guangzhou, it is also the energy source with the most extensive documented history and data availability with information going back to 1949. Based on the example of Ghali and El-Sakka (2004), electricity consumption is included as a key input in the aggregate production function shown in Eq. (1),

$$Y_t = f(EC_t, K_t, L_t) \tag{1}$$

where Y is real output, EC is electricity consumption, K is capital and L is labor. Following Hamdi et al. (2014), both sides of the aggregate production function are divided by population so that output, electricity consumption, and the capital stock are expressed in per capita terms while the impact of labor on output is held constant. Eq. (2) shows the basic model that informs the choice of variables included in this analysis,

$$y_t = b_0 + b_1 ec_t + b_2 k_t + v_t \tag{2}$$

where y_t represents the natural logarithm of real per capita GMP, ec_t is the logarithm of total electricity consumption in per capita terms, k_t is the logarithm of the real per capita capital stock, and v_t is a random error term. Lee et al. (2008) find bi-directional causality between the capital stock and electricity utilization, suggesting that these variables may affect each other while also potentially affecting output. Thus, there are theoretical and empirical grounds for suspecting that multiple causal relationships may exist between the variables identified in Eq. (2).

Standard Granger causality tests are conducted on stationary time series (Granger, 1969). To determine whether the variables are stationary, two unit root tests are conducted. The first of these is the Augmented Dickey-Fuller (ADF) test. When there are structural breaks in the data, the ADF test is biased towards a spurious acceptance of non-stationarity (Enders, 2010). As a result, a second unit root test is also conducted, which allows for a one-time structural break occurring at time TB ($1 < TB < T$), where T is the number of observations (Perron, 1989). It is important to allow for the possibility of breakpoints due to the numerous important institutional changes that affected China's national and regional economies between 1950 and 2013 plus additional periodic regulatory shocks. In particular, various changes in electricity regulation have been introduced during the past two decades (PRC,