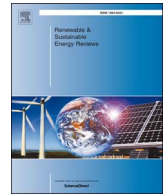




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# Electricity consumption and economic growth nexus in Beijing: A causal analysis of quarterly sectoral data

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## ABSTRACT

Traditional energy-economy nexus analysis is limited to aggregated and annual data because more detailed energy consumption data are usually not available. However, probing the disaggregated sectoral data usually provides a deep insight of energy-economy nexus at sectoral level, which is vital for governments to make proper policies in a timely manner. This paper developed a deep research to find detailed quarterly and sectoral nexus between electricity consumption and economic growth. Sectoral data of electricity consumption and economic growth from 2005Q1 to 2016Q3 in Beijing were exploited to model with Granger causality analysis.

The results show that at the aggregated level there is a unidirectional causality running from economic growth to electricity consumption. At sectoral level, for the primary sector the electricity consumption impacts its added value with two quarter lagged; for the secondary sector and the tertiary sector, there is a unidirectional causality running from economic growth to electricity consumption. At cross-sector level, the economic growth of the secondary sector has no impact on that of the tertiary sector, while the economic growth of the tertiary sector strongly affects that of the secondary sector.

In terms of energy saving and emission reduction, different policies should be employed in the three sectors. Beijing should encourage the electrification of the primary sector to stimulate its development; Beijing should make more efforts on tertiary sector to reduce electricity consumption however these policies should be more prudent. While for the secondary sector, improving energy efficiency and technological innovation should be paid more attention to.

## 1. Introduction

Increasing energy supply issues followed by environmental deterioration and massive health problems have drawn great attention around the world. Governments keep on trying search for more reliable ways to sustain the development of the economy and society in accordance with energy savings and emissions reduction. It has been proved that a close relationship usually exists between energy consumption and economic growth, and an analysis of such relationship reveals their dependence on each other. Therefore with an observation of one variable's fluctuations, we can figure out the future trend of another variable. Such observations and predictions will contribute to develop appropriate policy making [1].

In 1978, Kraft and Kraft [2] originally validated the causality between energy and economy, and then the causality analysis has been a popular topic. The empirical studies on energy-economy nexus have drawn great attention in recent years [3–9]. The nexus was further

probed in more detail with disaggregated data at sectoral level, indicating that specific energy-economy nexus information between sectors were complex and inconsistent [10,11]. Such information is more helpful and specific for governments to develop effective policy than at aggregated level.

However annual data, the most popular temporal data, are not sensitive enough to reflect the fluctuation of causality for a timely policy making. Quarterly sectoral data thus will contribute more to making sector policies, especially with respect to developing reasonable and practical energy savings and emission reduction policies. Most of the energy consumption data are usually published lagged behind, while electric power, as an important terminal energy, is real-time measured and monthly publicly reported. So it is easier to obtain than other energy data. And electricity accounts for an increasingly greater proportion of energy consumption thus analyzing the electricity consumption helps to estimate total energy consumption timely. In fact valuable proposals for policy making were proposed with the

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electricity-economy nexus validation [12–31]. While these studies were conducted with annual data and the advantage that electricity can be obtained in a narrower time frame was neglected.

As a fast-growing megacity, Beijing, the capital of China has been suffering bad air quality in recent years. Beijing keeps on struggling to eliminate the PM 2.5 by making rigid energy saving and emission reduction policies and speeding its sector restructuring. Revealing the nexus between electricity consumption and economic growth would help to enact right sector policy.

In recent years, there are increasing energy-economy nexus study of Beijing. In [32] it was proved that there was a long-term equilibrium relationship between electricity consumption and economic growth. Beijing was used as a case in [33] to depict a specific urban economy's overall energy consumption impacted by local direct energy use, domestic and foreign trade. Energy-related carbon emissions from Beijing's production and household sectors were calculated [34]. The effects of different development alternatives on future energy consumption and carbon emission was predicted in [35]. In [36] a multivariate generalized Fisher index decomposition model was built to measure the impacts of economic growth, population size, energy intensity and energy structure on energy-related carbon emissions in Beijing.

The above studies used the overall data and external factors to analyze the relationship between energy and economy. Such results are not enough to help to make industry restructuring and sectoral regulation policies for Beijing. Based on the above analysis, this paper aims to reveal the short-term sector relationship between electricity and economy using the quarterly sectoral data for more detailed policy recommendations. Such experiments would benefit other regions in China as well as other countries facing the similar situations.

The rest of paper is organized as follows. In the following section, we give a brief depiction of the case background, data and methods. Section 3 presents the empirical results of the electricity-economy nexus in Beijing and the discussion. In Section 4, we present the conclusions and the corresponding policy implications.

## 2. Research background, data and methods

### 2.1. Electricity consumption and economic growth in Beijing

Beijing experienced extraordinary economy boom and suffered with hazy weather and energy pressure in the past years. The economic growth and energy consumption of Beijing is presented in Fig. 1.

It shows that high economic growth is accompanied by intensive energy consumption, especially with high electricity consumption. And the electricity consumption is highly related to the energy consumption. Electricity dominates energy consumption in Beijing, accounting more than 35% (See Fig. 2) of total end-use energy consumption. It is critical that the government resolves the energy, environment and sustainable develop problems by establishing effective energy policies after a deep probe of the nexus between electricity and economy.

To welcome 2008 Olympic Games, Beijing made great effort to

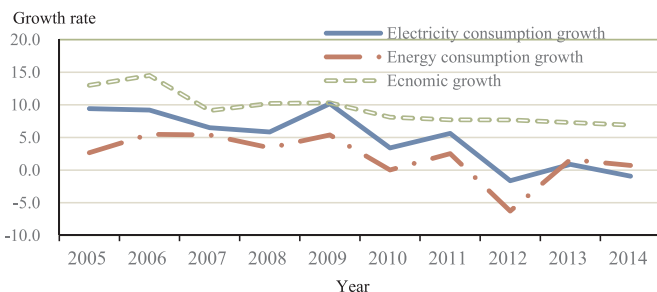


Fig. 1. Energy and electricity consumption growth, and economic growth of Beijing. (Source: Beijing Statistical Yearbook)

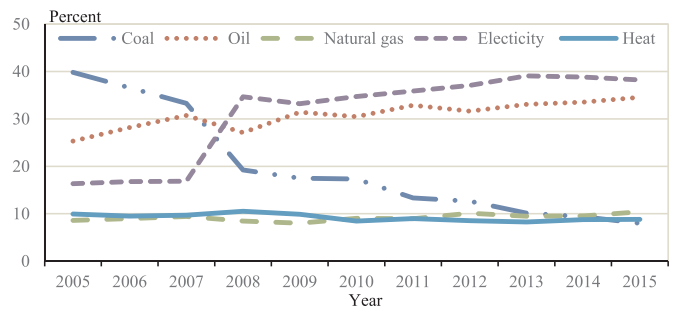


Fig. 2. Proportion of end-used energy consumption in Beijing (excluding residents' consumption). (Source: Beijing Statistical Yearbook)

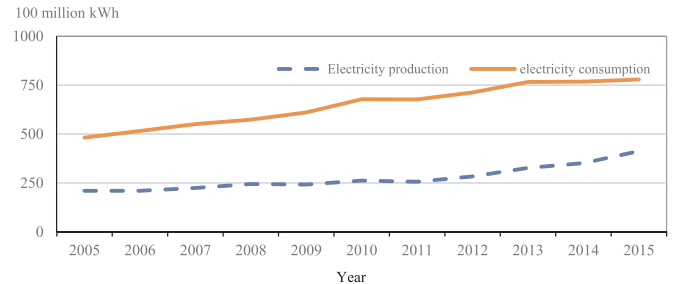


Fig. 3. Electricity production and consumption of Beijing. (Source: Beijing Statistical Yearbook)

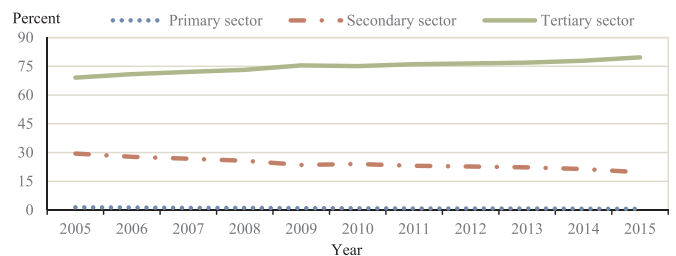


Fig. 4. Proportion of economic added value in the three sectors. (Source: Beijing Statistical Yearbook)

improve its air quality by replacing coal with cleaner energy, especially promoting the electricity utilization. Thus the electricity consumption rose sharply since 2007, and since then it became the major energy in Beijing.

Electricity production and consumption of Beijing is shown in Fig. 3.

We can see that electricity production and electricity consumption grew steadily from 2005 to 2015, and most of the time the consumption was about 2 times the production. It means that Beijing produced less than half of the electricity it consumed, the gap was filled by importing from neighbor regions.

The economic structure and electricity consumption structure are shown in Fig. 4 and Fig. 5. We can see that the tertiary sector is the major contributor of Beijing's economic growth and energy consumption in recent years. As evidenced from Fig. 4, economic portion of the tertiary sector is keeping on rising, while the secondary sector continues to decrease. To build an environment-friendly and sustainable city, Beijing aims to develop high-tech manufacturing sector and improve the service sector in the coming years according to the 12th Five Year Plan.

### 2.2. Data source and variables

Quarterly sectoral data of Beijing's electricity and economy from 2005Q1 to 2016Q3 are selected for our experimental study. These data

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