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Sources of energy productivity growth and its distribution dynamics in China☆

Chunhua Wang [a,b,*]

[a] School of International Trade and Economics, University of International Business and Economics, Beijing 100029, China
[b] Department of Geography and Earth Sciences, University of North Carolina at Charlotte, 9201 University City Blvd., Charlotte, NC 28223, United States

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ABSTRACT

The purposes of this paper are to determine the sources of energy productivity growth at the provincial level in China and to examine the relative contributions of the sources and their impacts on regional inequality. Energy productivity change is first decomposed into five components attributable to changes in capital–energy ratio, labor–energy ratio, output structure, and technical efficiency change and technological change. Then a nonparametric analysis is implemented to statistically test the relative contributions of the components and their roles in the distribution dynamics of energy productivity. It is found that (1) changes in capital–energy ratio, output structure, and technological change contribute to energy productivity growth in China, (2) increase in capital–energy ratio caused by capital accumulation is the primary driving force for energy productivity growth, and (3) capital accumulation contributes to energy productivity convergence between Chinese provinces over the time period of 1990–2005.

1. Introduction

China is the world's most populous country and has a rapidly growing economy with an average annual growth rate of 9.5% in the past decades since 1978 when China initiated its economic reforms.

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* Tel.: +1 704 687 5921; fax: +1 704 687 5966.
E-mail addresses: Chunhua.Wang@uncc.edu, chunhua.wang@rocketmail.com.

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As China's economy continues to grow, so does its energy demand. In 1993, China became a net importing country of crude oil. Energy productivity (i.e., the inverse of energy intensity) is a key indicator for discussions on maintaining energy supply security and controlling climate change. Two stylized facts are widely observed and analyzed by many previous studies in the literature. First, China's energy productivity is relatively low and far below than that in industrialized countries. Second, a positive signal is that it has risen significantly since 1978.

It is of theoretical and practical importance to explain the contributors to the increases in energy productivity, especially for a giant energy consumer like China. Many previous studies made efforts to do so, but the findings are far fr om conclusive. A majority of the studies find that technical change within sectors accounted for most of increase in energy productivity in China (Garbaccio et al., 1999; Lin and Polenske, 1995; Sinton and Levine, 1994), while several others conclude that structural change in energy use is the major contributor (World Bank, 1994). The third explanation for the growth is that it is based on reported data that are inaccurate (Fisher-Vanden et al., 2004; Sinton and Fridley, 2000).

The purposes of the present paper are to determine the sources of energy productivity growth at the provincial level in China and to examine the relative contributions of the sources to growth and their impacts on energy productivity disparities across provinces. To accomplish the purposes, we implement two different but related nonparametric methods. The first method allows one to model energy as an input factor in the process of producing outputs along with other input factors such as capital and labor, and then decompose energy productivity change between two time periods into five components attributable to changes in capital–energy ratio, labor–energy ratio, output structure, and technical efficiency change and technological change. The second nonparametric method is implemented to statistically test the relative contributions of the components and their roles in the distribution dynamics of energy productivity between the two time periods, not just compare the means or variances of each contributor. In addition, there are two other major innovations of this paper. First, we use cross-region data observed at the level of province in China, which complements the existing literature in which most studies rely on sector data. Second, we also investigate convergence trend in energy productivity across provinces in China, then we can understand more about the evolution of energy productivity in this country.

Major findings of the paper can be summarized as follows. First, changes in capital–energy ratio, output structure, and technological change contribute to energy productivity growth at the national level in China. Second, increase in capital–energy ratio caused by capital accumulation is the primary driving force for energy productivity growth. Third, capital accumulation also contributes to energy productivity convergence between Chinese provinces over the time period of 1990–2005.

The remainder of the paper is organized as follows. Section 2 briefly develops the basic framework for decomposing energy productivity change to provide the foundation for our empirical analyses. Section 3 describes data and reports preliminary results of the decomposition exercise. Section 4 is an analysis of energy productivity distribution dynamics. The final section concludes.

2. A decomposition framework

Following Wang (2007), we decompose energy productivity change by using Shephard output distance functions.[1] For each time period $t = 1, 2\ldots, T$, the production technology is given by the set

$$S^t = \{(K_t, L_t, E_t, Y_t) : (K_t, L_t, E_t) \text{ can produce } Y_t\}, \tag{1}$$

where the variables are capital K_t, labor L_t, energy E_t, and outputs (from three sectors)[2] $Y_t = (Y_{1,t}, Y_{2,t}, Y_{3,t}) \in \Re^3_+$. Standard conditions which suffice to define output distance functions are imposed on the production set S^t, e.g., S^t is a closed set and inputs and outputs are freely disposable.[3]

[1] This approach to decomposing productivity growth was started by Färe et al. (1994), and it has been used by Kumar and Russell (2002), Henderson and Russell (2005), and Henderson et al. (2007) to study labor productivity growth. Wang (2007) also compared the decomposition framework of this paper to those reviewed by Ang and Zhang (2000) and found the decomposition indexes pass major tests for desirable properties of decomposition analysis—time-reversal, factor-reversal, zerovalue robust.

[2] The three sectors are agriculture, industry, and services in our data source, *China Statistical Yearbook*.

[3] For more details on those conditions and properties of the distance functions, see Färe (1988) and Shephard (1970).