Energy Policy ∎ (∎∎∎∎) ∎∎∎–∎∎∎

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

China's energy consumption change from 1987 to 2007: A multi-regional structural decomposition analysis

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HIGHLIGHTS

- Energy consumption in China grew faster in the last 5 years from 2002 to 2007.
- China increased its production of energy-intensive goods especially in hinterland.
- Capital investment is the largest final demand driver of intermediate energy use.
- Energy is flowing from hinterland China to the coast directly and indirectly.
- Energy utilization efficiency varies a lot among regions.

ARTICLE INFO

Article history:
Received 6 November 2012
Received in revised form
24 September 2013
Accepted 25 November 2013

Keywords:
Regional disparity
Energy consumption
Structural decomposition analysis
China

ABSTRACT

Increasing use of energy has helped to stimulate China's economy. Despite central planning, China has great differences in economic development, energy endowment and energy consumption across its regions. This paper uses the structural decomposition approach to uncover the regional disparities in energy consumption from 1987 to 2007. We also examine six possible key factors for the change in energy consumption by region. We find that final demand change outpaced efficiency improvements to drive up energy use in all regions between 1987 and 2007. More surprisingly, from 2002 to 2007, it appears that changes in production structure enhanced energy consumption in most regions. China produced more energy-intensive goods for capital investment and export. We contend that improving the energy efficiency of key energy-intensive sectors would lead a significant decline in energy intensity. Energy, directly or indirectly, is flowing from Northwest, Central and North China to coastal regions. Regional-specific policies should be designed to promote production structure change and curb energy demand.

1. Introduction

As the largest developing country in the world, China has enjoyed near double-digit annual economic growth in the past three decades. To support such economic growth, China's energy consumption has increased over five-folds from 603 million tons of standard coal equivalent (Mtce) in 1980 to 3,249 Mtce in 2010. In 2010, China accounted for 17.5% of world's total primary energy consumption and 24.1% of the world's total CO_2 emission (International Energy Agency, 2011; Guan et al., 2009). China's energy demand has increased rapidly. This trend will likely to continue for the next decade (Ma et al., 2009). As a net energy importer, imports accounted for 15.4% of total primary energy consumption in China in 2009. Rapidly rising energy demand not only placed significant pressures on China's energy security but also on the global energy market.

Improved energy efficiency is a critical component of China's energy policy. In the Twelfth Five Year Plan (FYP), China is committed to cut the 2010 level of energy use per unit of gross domestic product (GDP) by 16% before 2015 (National Development and Reform Commission, 2011). In addition to technological improvement, production and consumption structure, rapid urbanization, and industrialization all affect energy consumption change in China. Also, as a spatially large developing country, China not only has significant regional differences in climate and geography, but also has great differences in energy endowments, economic development patterns, and levels of household consumption. Because of this, it is important to identify the main driving forces of energy consumption growth for each region in China, so appropriate regional-specific energy conservation policies can be adopted.

Many studies on China use panel data or input–output data to investigate the changes of energy consumption, energy intensity (energy use per unit of GDP) and CO_2 emissions. Most are focused

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http://dx.doi.org/10.1016/j.enpol.2013.11.069

on a nationwide phenomenon. Research indicates that energy efficiency improvement has been the main contributor to energy intensity reduction in China in the 1980s and early 1990s (Lin and Polenske, 1995; Garbaccio et al., 1999; Huang, 1993; Sinton and Levine, 1994; Zhang, 2003). However, changes in energy efficiency may have caused energy intensity rises due to negative technological progress since 2000 (Ma and Stern, 2008; Xia et al., 2012). Peters et al. (2007) found that technology and efficiency improvements have only partially offset the impact of consumption growth from 1992 to 2002 and efficiency gain have little impact on China's CO_2 emission from 2002 to 2005. Final demand growth, which was driven by urbanization and lifestyle changes, led to growth in China's CO_2 emissions. Kahrl and Roland-Holst (2008) and Guan et al. (2009) have indicated that exports became the largest source of energy demand growth in China since the nation's accession to the World Trade Organization (WTO) in 2001. Minx et al. (2011) suggest that energy efficiency improvements largely offset the growth of CO_2 emission from 2002 to 2007. Rapidly rising CO_2 emissions mostly have been caused by structural changes led by capital investment. Karl and Chen (2010) confirmed that increased government spending on housing and infrastructure stimulates growth of resource-dependent heavy industries such as steel and cement, which caused the rise in energy intensity in China from 2002 to 2005. Andrews-Speed (2009) worries that the nation's economic stimulus package, which was announced in 2008, is likely to lead to another increase in energy intensity.

Regional-level analysis indicated that China's regional energy efficiency is unbalanced. Most of the nation's energy-efficient provinces are located on China's coast, while most of its least energy-efficient provinces are in its hinterland (Li and Hu, 2012; Wang et al., 2012; Yu, 2012; Wei et al., 2009; Hu and Wang, 2006). Wei et al. (2009) find that provincial energy efficiency is negatively associated with the share of secondary industry and state-owned economy in GDP while positively associated with the technological level and the share of non-coal use in the region's fuel mix. Most of these studies are based on provincial panel data and do not dig into the driving forces of energy consumption or CO_2 change and the impacts of inter-regional trade. A recent study by Feng et al. (2012) used 28 provincial I–O tables of China and structural decomposition analysis (SDA) to investigate drivers of regional CO_2 emission in China from 2002 to 2007. The study showed that there were significant gaps among eastern, central, and western China in CO_2 emission intensities. Capital investment, rapid urbanization, exports and inter-regional trade contributed a lot to changes in CO_2 emission. Feng et al.'s (2012) study only aggregated provincial results into three economic zones and did not provide region-specific policy suggestions.

In this paper we use SDA to identify the drivers of China's energy use at the regional level between 1987 and 2007, with special focus on the most recent decade. We analyze the drivers of regional energy use from both the production side and the final-demand side. From the production side, we analyze the impacts of changes in energy use efficiency, production structure, the role of imported inputs, and inter-regional trade of intermediate goods. In the final demand side, we analyze the impacts of changes in final-demand level, impacts of interregional trade of final goods and services, and final demand structure especially capital investment, export and household energy consumption of each region. This paper offers both historical and current view of contributors to changes in energy consumption in China. Also, it provides a new decomposition approach that can explore the impact of interregional trade and the substitution effect of imported inputs.

2. Regional disparity of economic development, energy endowment and usage

In our paper, China is divided into seven regions: Northeast China, North China, East China, South China, Central China, Northwest China, and Southwest China (shown in Fig. 1). As the major traditional industrial base of China, the heavy-industry based economy of Northeast China (NE) is facing issues of resource exhaustion and a need for upgrading its industrial structure. North China (NC) has a nice balance of light and heavy industry, with Beijing as the political center and transportation hub of China. East China (EC) covers the Yangtze Delta area of China, with Shanghai as its center. This region has the highest level of economic development

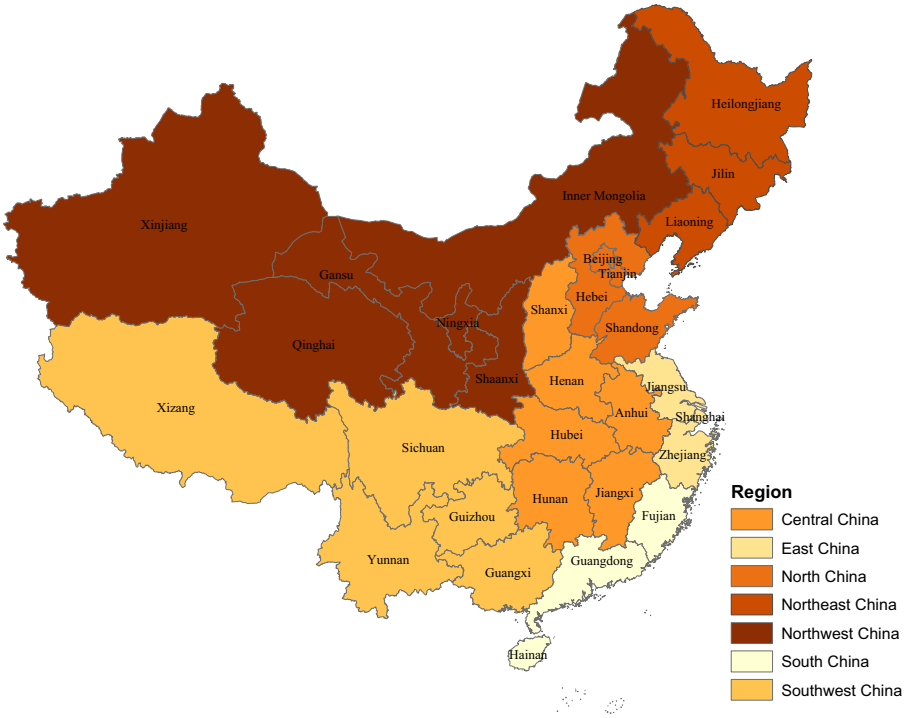

Fig. 1. The seven regions of China.

Please cite this article as: Zhang, H., Lahr, M.L., China's energy consumption change from 1987 to 2007: A multi-regional structural decomposition analysis. Energy Policy (2013), http://dx.doi.org/10.1016/j.enpol.2013.11.069