Applied Energy xxx (2013) xxx–xxx

Contents lists available at SciVerse ScienceDirect

Applied Energy

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

Short- and long-run causality between energy consumption and economic growth: Evidence across regions in China

M.J. Herrerias [a], R. Joyeux [b,*], E. Girardin [c]

[a] School of Contemporary Chinese Studies, The University of Nottingham, Nottingham, UK
[b] Macquarie University, Sydney 2109, Australia
[c] Aix-Marseille University, Aix-Marseille School of Economics, CNRS, EHESS, France

HIGHLIGHTS

- We investigate the relationship between energy and economic growth across Chinese regions.
- We examine short- and long-run causality.
- We use panel cointegration techniques.
- We find that causality runs in the long-run from economic growth to energy consumption from 1999 to 2009.
- We conclude that policies for conserving energy can be adopted without interrupting the path of growth.

ARTICLE INFO

Article history:
Received 3 October 2012
Received in revised form 4 March 2013
Accepted 15 April 2013
Available online xxxx

Keywords:
Granger causality
Energy consumption
Regional growth
China

ABSTRACT

The relationship between energy consumption and economic growth has created a large body of research in the energy-economics literature. In this paper, we investigate such a relation in the case of Chinese regions from 1995 to 2009. The majority of previous studies have ignored the regional dimension and the cross-sectional dependence of provinces. Besides, different energy policies adopted by the government have influenced energy intensity over time, showing improvement in the 1990s and deterioration from 2000 onwards. Thus, it is necessary to examine these two periods separately. Moreover, a detailed disaggregation of total energy consumption into electricity, coal, coke, and crude oil consumption and its linkage with economic growth may provide new insights for the design of energy policy across Chinese regions. We use panel techniques to test the direction of the causality in the long- and short-run between these different types of energy consumption and economic growth. Our results are mixed from 1995 to 2009 due the aforementioned break around 1999. However, in all cases our estimations provide empirical evidence that from 1999 to 2009 there is unidirectional causation from economic growth to energy consumption in the long-run. Therefore, energy-saving policies can be adopted without interrupting the path of growth.

1. Introduction

The reduction of greenhouse gas emissions is one of the most important concerns across countries. However, there is little consensus among developed economies on the way to meet international commitments until developing countries such as India and China commit themselves to alleviate climate change [1]. This is relevant due to the rising importance of these countries in the contribution to global warming given their fast economic growth and increasing demand for energy resources. As is well-known one way to reduce emissions is to cut energy consumption. However, in the case of developing countries this aim is conditioned by economic development. Often these economies face the dilemma of promoting energy-saving measures at the expense of economic growth. Thus, an essential empirical investigation is whether energy consumption is a consequence or a cause of economic growth. Conclusions of such analysis are relevant not only for the design of energy policies to mitigate global warming, but also to link these policies with economic development and the welfare of the whole population. In addition, investigating the direction of the causality between energy consumption and economic growth may help to clarify the economic model that prevails in this relationship. In other words, whether energy consumption is seen as an input – and in this case, energy influences economic growth – and therefore a production model is supported by the data, or by contrast

* Corresponding author. Tel.: +61 2 9850 8487; fax: +61 2 9850 6069.
E-mail addresses: Maria.jesus_Herrerias@nottingham.ac.uk (M.J. Herrerias), roselyne.joyeux@mq.edu.au (R. Joyeux), eric.girardin@univ-amu.fr (E. Girardin).

0306-2619/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.apenergy.2013.04.054

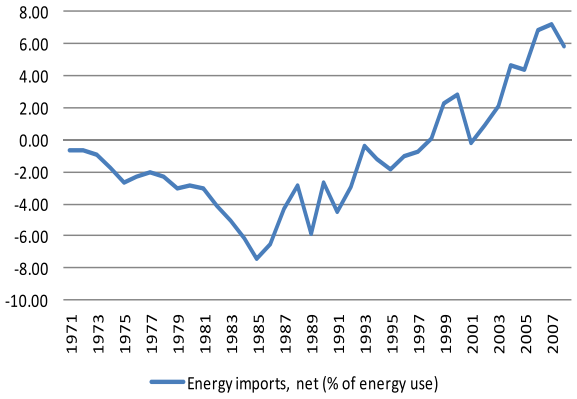

Fig. 1. Energy imports, China. *Source*: World Bank and own elaboration.

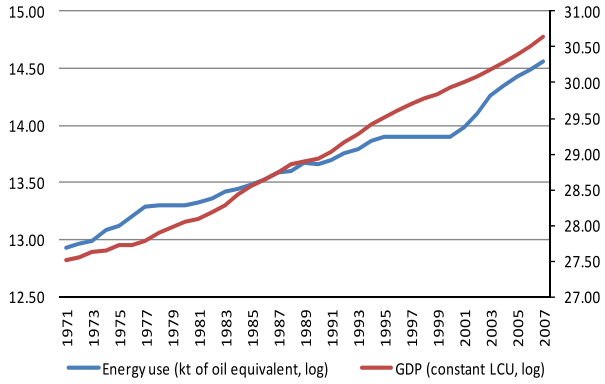

Fig. 2. Energy use (right) and GDP (left). *Source*: World Bank and own elaboration.

is considered a good – and economic growth causes energy consumption following a demand model.

Among developing countries, China is probably one of the most interesting cases for several reasons. First, the Chinese economy has undergone an exceptional performance over the past three decades switching from a central planned to a more market-oriented economy. Besides, by the year 2009 this country became the most important consumer and producer of energy in the world overtaking the United States. However, even the largest power producer, China, was pursed to participate in the international market to import energy from the mid-1990s onwards as seen in Fig. 1. Given its sheer size, any domestic shock not only affects its economy, but also international markets. The Chinese government, aware of how essential is energy consumption for its economy and of its role in generating environmental damage, established in the mid-nineties a series of measures to cut energy consumption. As shown in Fig. 2, energy consumption remained steady between 1995 and 2000, leading to physical shortages of electricity in the first half of the 2000s [2].[1] Energy consumption increased rapidly thereafter. The current trend of China in terms of increasing energy consumption and carbon dioxide emissions, growing on average around 10% per year, makes necessary corrective actions to protect the environment. The Eleventh Five-year plan aimed at achieving energy and environmental goals, but such targets were not met.

Analyzing the economy as a whole may provide interesting insights on the current debate concerning the relationship between energy consumption and economic growth. However, this economy has singular characteristics that makes imperative to investigate that nexus across regions. First, preferential policies have encouraged economic growth in coastal areas at the expense of the central and western ones, creating a significant unbalanced growth with a high degree of inequalities.[2]

In addition, energy resources are unevenly distributed across the vast territory. Coal, the most important source of energy, is mainly produced in Shanxi and Inner Mongolia, while the generation of electricity is located in the South, Sichuan and its neighbors, and crude oil is mainly concentrated in the North-Western provinces. This dispersion of energy resources forced the government to put as first priority the guarantee of energy supply to meet a growing demand for energy, especially in the Eastern regions that require large amounts of energy linked to economic growth. In a second stage, the increasing level of pollution in both producing and consuming regions and the growing demand for energy have revealed that active environmental policies also need to be implemented. Thus, the agglomeration of economic activities around the coast and the unbalanced growth between regions with this marked heterogeneity justify the need to analyze the causal relationship between energy consumption and growth at the regional level. Although we do not have enough time series observations to study each region individually or to break up our regional panel in sub panels, we use panel techniques, which allow as much heterogeneity as possible. Longer time series would be necessary to establish the target of regional energy conservation for environment protection or promotion of regional development.

To the best of our knowledge the majority of previous works examine the causal relationship at the national level, generating biases through aggregation and yielding contradictory results ([7,8]). Only a few studies investigate this issue across Chinese regions following [9]s lead work. Thus, over the 1985–2008 period [10] find bidirectional causality between coal consumption and GDP growth, while, by using panel cointegration techniques, [11] document a bidirectional causal relationship between energy consumption and economic growth from 1995 to 2007, and [12] apply short-run panel causality tests to study the relationship between energy consumption and GDP over the 1986–2008 period. This paper is based on the same approach but differs from the previous ones in many significant ways.

First, we use panel cointegration techniques to study the Chinese regions. We consider that this methodology is appropriate since as pointed out by [13] short-time spans will weaken the power of unit root, cointegration and causality tests in time series data, thereby giving rise to distorted and mixed results. The use of panel data with a higher number of observations may overcome this problem, see [14]. Besides, previous work assumes that cross-sectional units are independently distributed. This assumption is rather restrictive and is likely to be violated for the GDP variable in regional panels. Following [15,16], we relax this hypothesis by the introduction of the cross-sectional dependence across different regions in China, when unit root and cointegration tests are carried out respectively. This provides more reliable tests on the nature of the relationship between energy consumption and economic growth.

Second, we follow Canning and Pedroni's approach [17] to test for long-run causation in a cointegrated panel framework. Their test gives information about the incidence of a long-run effect rather than just about whether there is at least one such long-run causality in at least one region. It also allows for heterogeneity of the dynamic models for all the regions in the sample. This is important since, as pointed out in the introduction, the regions included in our study are very diverse. Furthermore, we estimate the long-run elasticities using group-mean Panel Dynamic Ordinary Least Squares (Panel DOLS) proposed by [18].

Third, we test the short-run causality in the panel following [19], which takes into account the heterogeneity of the causal relationships and the heterogeneity of the data generating process.

[1] See [3,4].
[2] See [5,6].

Please cite this article in press as: Herrerias MJ et al. Short- and long-run causality between energy consumption and economic growth: Evidence across regions in China. Appl Energy (2013), http://dx.doi.org/10.1016/j.apenergy.2013.04.054