Energy Economics 30 (2008) 3063–3076

Contents lists available at ScienceDirect

Energy Economics

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

Economic growth and energy consumption revisited — Evidence from linear and nonlinear Granger causality

Song Zan Chiou-Wei [a,1], Ching-Fu Chen [b,*], Zhen Zhu [c]

[a] Department of Managerial Economics, Nan-Hua University, Chia-Yi, Taiwan
[b] Department of Transportation and Communication Management Science, National Cheng Kung University, 1, Ta-Hsueh Road, Tainan, 701, Taiwan
[c] Department of Economics, College of Business, University of Central Oklahoma, Edmon, OK, 43034, United States

ARTICLE INFO

Article history:
Received 7 September 2007
Received in revised form 17 February 2008
Accepted 17 February 2008
Available online 26 February 2008

Keywords:
Nonlinear causality test
Neutrality hypothesis
Energy consumption
Economic growth

ABSTRACT

The relationship between energy consumption and economic growth is considered as an imperative issue in energy economics. Previous studies have ignored the nonlinear behavior which could be caused by structural breaks. In this study, both linear and nonlinear Granger causality tests are applied to examine the causal relationship between energy consumption and economic growth for a sample of Asian newly industrialized countries as well as the U.S. This study finds evidence supporting a neutrality hypothesis for the United States, Thailand, and South Korea. However, empirical evidence on Philippines and Singapore reveals a unidirectional causality running from economic growth to energy consumption while energy consumption may have affected economic growth for Taiwan, Hong Kong, Malaysia and Indonesia. Policy implications are also discussed.

1. Introduction

Economists have been debating about the issues related to global warming and policies have been designed and implemented to address the global warming issue. For this purpose, the Kyoto Protocol has been enacted in 2005. According to the Protocol, 39 developed and developing countries in the world have to reduce their CO_2 emission to 5% of their 1999 levels by 2012. To protect economic development, no CO_2 reduction promise is required for the first commitment period of 2005–2012 for other developing countries. Some of these countries produce a considerably large share of the world's total emission due to high level of industrial development. For example, South Korea, Taiwan and Singapore rank high on the list

* Corresponding author. Tel.: +886 6 2757575x53230; fax: +886 5 2753882.
E-mail addresses: chiouwei@mail.nhu.edu.tw (S.Z. Chiou-Wei), cfchen99@mail.ncku.edu.tw (C.-F. Chen).
[1] Tel.: +886 5 2721001.

0140-9883/$ – see front matter
doi:10.1016/j.eneco.2008.02.002

of CO_2 emission: 9th, 22nd and 39th, respectively. Therefore, these countries are considered to be the candidates to reduce their CO_2 emissions in the following period.

The issue of the possible impact of emission reduction on economic growth inevitably arises due to the possible connection between emission and energy consumption, and energy consumption and economic growth. Due to the importance of the possible connection between energy consumption and economic growth, there is a growing literature in this area. In general, studies find evidence of correlation between these two variables for countries with different economic structure and at different stages of economic development.

Studies on the bi-directional relationships can be traced back to Kraft and Kraft (1978). They applied the Granger causality test to U.S. data for the period of 1947–1974, and found that a unidirectional causality runs from economic growth to energy consumption, thus suggesting that an energy conservation policy is feasible. Since Kraft and Kraft (1978), there has been a vast body of studies contributing to this literature. Table 1 summarizes related studies. One observation from the table is that these studies yield mixed and often conflicting results for both developed and developing countries due to different methods, sample periods, and model specifications being employed. Furthermore, it is worth noting that most previous studies are limited in scope to the applications of linear models. However, economic events and regime changes such as changes in economic environment, changes in energy policy and fluctuations in energy price can cause structure changes in the pattern of energy consumption for a given time period under study. This creates a room for a nonlinear rather than linear relationship between energy consumption and economic growth (Lee and Chang, 2005).

Looking at the time trends of energy consumption for sampled Asian developing countries as in Fig. 1, one can observe one or more possible breaks. Some studies considered these possible structure changes in the time series. For example, Lee and Chang (2005) used the cointegration test to examine the structural breaks in the Taiwanese energy consumption for the period of 1954–2003, and identified the points of structure

Table 1
Overview of previous studies

Authors	Empirical method	Period	Subject	Results
Kraft and Kraft (1978)	Standard Granger test	1947–1974	USA	Energy←GDP
Yu and Hwang (1984)	Standard Granger test	1947–1979	USA	No causality
Yu and Choi (1985)	Standard Granger test	1954–1976	Korea	Energy←GDP
			Philippines	Energy→GDP
			USA, UK, Poland	No causality
Cheng (1997)	Standard Granger test	1963–1993	Brazil	Energy→GDP
		1949–1993	Mexico	No causality
		1952–1993	Venezuela	No causality
Yu and Jin (1992)	Error-correction model	1974–1990	USA	Non-cointegrated
Masih and Masih (1996)	Error-correction model	1955–1990	Malaysia, Singapore, Philippines	Non-cointegrated
			India	Energy→GDP
			Indonesia	Energy←GDP
			Pakistan	Energy←→GDP
Masih and Masih (1997)	Error-correction model	1955–1991	Korea	Energy→GDP
		1952–1992	Taiwan	Energy←→GDP
Asafu-Adjaye (2000)	Error-correction model	1973–1995	India, Indonesia, Turkey	Energy→GDP
			Thailand, Philippines	Energy←→GDP
Glasure (2002)	Error-correction model	1961–1990	Korea	Energy←→GDP
Hondroyiannis et al. (2002)	Error-correction model	1960–1996	Greece	Energy←→GDP
Soytas and Sari (2003)	Error-correction model	1950–1992	Argentina	Energy←→GDP
			Korea	Energy←GDP
			Turkey	Energy→GDP
			Indonesia, Poland	Non-cointegrated
Yemane (2004)	Standard Granger test	1952–1999	Shanghai	Energy→GDP
Oh and Lee (2004)	Error-correction model	1970–1999	Korea	Energy←→GDP
Lee (2005)	Panel VECM	1975–2001	18 developing countries	Energy→GDP
Lee (2006)	Granger noncausality test	1960–2001	11 developed countries	Mixed
Hwang and Gum (1992)	Standard Granger test	1955–1993	Taiwan	Energy←→GDP
Cheng and Lai (1997)	Hsiao's Granger causality test	1955–1993	Taiwan	Energy←GDP
Yang (2000)	Hsiao's Granger causality test	1954–1997	Taiwan	Energy←→GDP

Notes: Energy→GDP denotes causality runs from energy consumption to GDP. Energy←GDP denotes causality runs from GDP to energy consumption. Energy←→GDP denotes bi-directional causality between GDP and energy consumption.