

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

Song Zan Chiou-Wei<sup>1</sup>, Ching-Fu Chen<sup>2,\*</sup>, Zhen Zhu<sup>3</sup>

<sup>1</sup>Department of Managerial Economics, Nan-Hua University

<sup>2</sup>Department of Transportation and Communication Management Science, National Cheng Kung University

<sup>3</sup>Department of Economics, University of Central Oklahoma

cfchen99@mail.ncku.edu.tw

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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<sub>2</sub> emission to 5% of their 1999 levels by 2012. To protect economic development, no CO<sub>2</sub> 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 of CO<sub>2</sub> emission: 9<sup>th</sup>, 22<sup>nd</sup> and 39<sup>th</sup>, respectively. Therefore, these countries are considered to be the candidates to reduce their CO<sub>2</sub> 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.



Past studies on the bi-directional relationships 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).

In this study, we adopt a nonparametric statistical method based on the correlation integral to detect nonlinear causal relations between time series proposed by Hiemstra and Jones (1994) to explore the nonlinearity in the relation between economic growth and energy consumption. Our study centers on developing countries in Asia, including Taiwan, South Korea, Singapore, Hong Kong, Indonesia, Malaysia, Philippines and Thailand. The United States, as a developed economy, is also examined in order to compare with the Asian countries under study. Yearly data from 1954 to 2006 of total energy consumption and real GDP for all countries are used and obtained

from the databanks of World Development Indicators and AREMOS. Some differences in data periods between research subjects exist due to data availability.

Table 1 reports our results. The results reveal that five countries (Taiwan, Hong Kong, Singapore, Indonesia and Philippines) had nonlinear causal relations between energy consumption and economic growth. The existence of nonlinearity might owe to the structural breaks caused by some significant economic events such as the Asian financial crisis or oil crisis etc. Ignoring the nonlinearity, therefore, the linear model cannot fully explore all information.

The neutrality hypothesis, i.e. no causal relation between energy consumption and economic growth, is supported by both the linear and nonlinear tests for the United States, South Korea and Thailand. However, the unidirectional nonlinear Granger causality running from economic growth to energy is evident for Philippines and Singapore. In term of policy implication, due to the neutrality or unidirectional causality for above countries, implementing energy conservation policies and strategies to mitigate global warming in the Kyoto protocol such as reducing CO<sub>2</sub> emissions would not significantly impact economic growth in these countries. On the other hand, the causality running from energy consumption to economic growth is found evident for Taiwan, Hong Kong, Malaysia and Indonesia. More specifically, the bi-directional causality exists for Malaysia and Indonesia, while unidirectional causality exists for Taiwan and Hong Kong. For these countries, therefore, implementing energy conservation policy might lead to a significantly negative impact on economic growth. Facing continuously rising oil price and coping with the pressure of environmental protection, the above countries should actively seek other energy-related strategies such as enhancing efficiency of energy consumption and developing alternative energy resources to sustain economic growth.

Table 1 Overview of causality test results

		EC=>GDP	GDP=>EC
Taiwan	Linear Granger causality	X	✓
	Nonlinear Granger causality	✓	X
Hong Kong	Linear Granger causality	✓	X
	Nonlinear Granger causality	✓	X
Singapore	Linear Granger causality	✓	✓
	Nonlinear Granger causality	X	✓
Korea	Linear Granger causality	X	X
	Nonlinear Granger causality	X	X
Malaysia	Linear Granger causality	✓	✓
	Nonlinear Granger causality	X	X
Indonesia	Linear Granger causality	✓	X
	Nonlinear Granger causality	✓	✓
Philippines	Linear Granger causality	X	✓
	Nonlinear Granger causality	X	✓
Thailand	Linear Granger causality	X	X
	Nonlinear Granger causality	X	X
USA	Linear Granger causality	X	X
	Nonlinear Granger causality	X	X

Notes: ✓ is causal relation supported; X otherwise.

## References:

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