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# Energy consumption, economic growth and prices: A reassessment using panel VECM for developed and developing countries

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**Abstract**

This paper reinvestigates the energy consumption–GDP growth nexus in a panel error correction model using data on 20 net energy importers and exporters from 1971 to 2002. Among the energy exporters, there was bidirectional causality between economic growth and energy consumption in the developed countries in both the short and long run, while in the developing countries energy consumption stimulates growth only in the short run. The former result is also found for energy importers and the latter result exists only for the developed countries within this category. In addition, compared to the developing countries, the developed countries' elasticity response in terms of economic growth from an increase in energy consumption is larger although its income elasticity is lower and less than unitary. Lastly, the implications for energy policy calling for a more holistic approach are discussed.


*Keywords:* Energy consumption; Energy prices; Economic growth

## 1. Introduction

The recent unprecedented increases in crude petroleum prices due to the Iraq war and the 2005 hurricanes in the US have again raised questions about their detrimental effects on economic growth in oil-importing countries in particular. The price hikes have also brought the issue of energy conservation and efficiency back on the policy agenda, that is, whether the adoption of energy saving policies inhibits or stimulates economic growth. This matter has been debated at length in the energy economics literature and often rests on the direction of causality between energy consumption and economic growth.

For example, if it is found that unidirectional causality runs from energy consumption to economic growth, then conserving (or reducing) energy could reduce economic growth. On the other hand, if unidirectional causality runs from economic growth to energy consumption, then energy conservation measures may be implemented with little or no adverse impacts on economic growth. The finding of a lack of causality in either direction implies that increasing energy consumption does not have any effect on economic growth. Some studies (Yoo, 2006; Jumbe, 2004; Shiu and Lam, 2004) have used electricity consumption which although a narrow definition,[1] may be appropriate for certain economies which are heavily reliant on electricity for energy.

So far, the empirical findings on the causal relationship between energy consumption and economic growth have been mixed. The seminal paper on this topic was by Kraft and Kraft (1978) who used bivariate causality procedures and found evidence of causality running from GNP to energy consumption for the US. Since then there has been a proliferation of such studies using different techniques, time periods and different sample of countries as seen in Table 1.

In this study, we make a contribution to the debate on the relationship between energy consumption and economic growth in three ways. First, we employ recently developed panel methods to test for unit roots, cointegration and Granger causality. This method avoids problems

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[1]Energy is obtainable from many sources such as coal, crude petroleum, natural gas, hydropower, geothermal energy, and nuclear energy.

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Table 1
Overview of selected studies

| Study | Estimation method | Period | Countries | Results |
|---|---|---|---|---|
| Kraft and Kraft (1978) | Bivariate Sims causality test | 1947–1974 | USA | Income→energy |
| Yu and Choi (1985) | Bivariate Granger test | 1954–1976 | South Korea | Income→energy |
| | | | Philippines | Energy→income |
| Erol and Yu, 1987 | Bivariate Granger test | | USA | Energy∼income |
| Yu and Jin (1992) | Bivariate Engle & Granger test | 1974–1989 | USA | Energy∼income |
| Stern (1993) | Multivariate VAR | 1947–1990 | USA | Energy→income |
| Masih and Masih (1996) | Trivariate VECM | 1955–1990 | Malaysia, Singapore, & Philippines | Energy∼income |
| | | | India | Energy→income |
| | | | Indonesia | Income→energy |
| | | | Pakistan | Energy↔income |
| Glasure and Lee (1997) | Bivariate VECM | 1961–1990 | South Korea & Singapore | Energy↔income |
| Masih and Masih (1998) | Trivariate VECM | 1955–1991 | Sri Lanka & Thailand | Energy→income |
| Asafu-Adjaye (2000) | Trivariate VECM | 1973–1995 | India & Indonesia, | Energy→income |
| | | | Thailand & Philippines | Energy↔income |
| Hondroyiannis et al. (2002) | Trivariate VECM | 1960–1996 | Greece | Energy↔income |
| Soytas and Sari (2003) | Bivariate VECM | 1950–1992 | Argentina | Energy↔income |
| | | | South Korea | Income→energy |
| | | | Turkey | Energy→income |
| | | | Indonesia & Poland | Energy∼income |
| | | | Canada, USA, & UK | Energy∼income |
| Fatai et al. (2004) | Bivariate Toda and Yamamoto (1995) | 1960–1999 | Indonesia & India | Energy→income |
| | | | Thailand & Philippines | Energy↔income |
| Oh and Lee (2004) | Trivariate VECM | 1970–1999 | South Korea | Energy↔income |
| Wolde-Rufael (2004) | Bivariate Toda and Yamamoto (1995) | 1952–1999 | Shanghai | Energy→income |
| Lee (2005) | Trivariate Panel VECM | 1975–2001 | 18 developing countries | Energy→income |
| Al-Iriani (2006) | Bivariate Panel VECM | 1971–2002 | Gulf Cooperation Countries | Income→energy |

*Notes*: → means variable *x* Granger causes variable *y*; ↔ means bidirectional causality; ∼means no causality in any direction. VAR means vector autoregression and VECM means vector error-correction model.

of low power associated with the traditional unit root and cointegration tests. Pooling increases the sample size considerably, allowing for higher degrees of freedom and hence more accurate and reliable statistical tests. It also reduces collinearity between regressors. Another advantage of using panel cointegration is that it allows for heterogeneity among the countries.

To the best of our knowledge, only Lee (2005) and Al-Iriani (2006) have used the panel causality tests but our study differs from theirs in more ways than one. While the latter study uses a bivariate model (and only reports long run results) for six countries in the Gulf Cooperation Council, the former uses a trivariate model with capital stock[2] for 18 developing countries. The trivariate model allows an additional channel of causality to be investigated. Thus similar to the Lee study, we consider a trivariate model but one that proxies energy prices. This is because price responses have been argued to have a crucial role in affecting income and energy consumption directly (Dunkerley, 1982; Hoa, 1993). Although data on energy prices would be ideal to use, given the multicountry nature in a panel estimation framework, it is not possible to obtain a comparable series on energy prices for all 20 countries over 1971–2002.[3] The information-intensive difficulty of this exercise is compounded by the fact that the use of energy sources (such as use of coal, oil, etc.) vary in these economies and different prices exist for residents and industries. Furthermore, industries that are energy-intensive may well be subsidised by the government and therefore face different prices. Hence the consumer price index is used instead as energy prices are expected to be sufficiently reflected in this index.

The second contribution of the study is in the check for robustness of the empirical outcome by a comparison of the panel causality results (both short and long run) with those from the separate estimation of a vector error correction model (VECM) for each country. In addition, the impact on elasticity with respect to changes in GDP growth and energy consumption are also discussed using both pooled and individual estimations.

The third contribution lies in the sample that considers a mix of countries comprising both net energy producers and consumers, as well as developing and developed countries. Most previous studies have either focussed on single countries or groups of countries of a similar level of economic development. Here, we examine countries at two different stages of development within the group of energy

[2]Although capital formation is a relevant variable, it reflects an investment decision for energy production which may not directly affect household energy consumption. The latter is determined more by prices.

[3]This is clearly too tedious a task even for the *World Development Indicators* to compile!