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Multivariate Granger causality between electricity generation, exports, prices and GDP in Malaysia

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ABSTRACT

This paper employs annual data for Malaysia from 1970 to 2008 to examine the causal relationship between economic growth, electricity generation, exports and prices in a multivariate model. We find that there is unidirectional Granger causality running from economic growth to electricity generation. However, neither the export-led nor handmaiden theories of trade are supported and there is no causal relationship between prices and economic growth. The policy implication of this result is that electricity conservation policies, including efficiency improvement measures and demand management policies, which are designed to reduce the wastage of electricity and curtail generation can be implemented without having an adverse effect on Malaysia's economic growth.

1. Introduction

The relationship between energy consumption and economic growth has been much studied using the concept of Granger causality. Granger causality does not imply that '*X* causes *Y*' in the conventional sense. Instead, as Diebold [1] put it, '*X* causes *Y*' in the Granger sense means that '*X* contains useful information for predicting *Y*'. To this point, there is a lack of consensus in the literature. A major reason for the lack of consensus is that many Granger causality studies suffer from omitted variables bias. Studies which conduct Granger causality tests in a bivariate framework are likely to be biased due to the omission of relevant variables affecting energy consumption and economic growth [2]. For this reason, some Granger causality studies examining the relationship between energy consumption and economic growth have started to include other relevant variables such as capital and/or labour [3], employment [4], exports [5], pollutant emissions [6], prices [7] or urbanization [8]. Most studies for Malaysia on this topic suffer from omitted variables bias because they only consider the energy-GDP nexus in a bivariate setting (see [9–11]). Tellingly, most existing Granger causality studies of the energy-GDP nexus for Malaysia, which employ a bivariate framework, have failed to find evidence of cointegration and long-run causality, reflecting the use of a bivariate model [12]. In light of this methodological limitation, it is important to reexamine the relationship between energy and economic growth in Malaysia including other relevant variables in the Granger causality framework given its implications for energy conservation.

Few studies of the energy-GDP nexus for Malaysia use a multivariate framework. Govindaraju et al [13] include prices in addition to electricity consumption and economic growth, Ang [6] includes pollution emissions in addition to energy consumption and economic growth, while Lean and Smyth [58] include capital, labour and exports in addition to electricity consumption and economic growth. This study extends this literature to examine the relationship between electricity generation, economic growth, prices and exports in Malaysia. In doing so, it adds to a series of studies that have been published on the energy consumption-GDP nexus in this journal (see eg. [74–76]). A four VAR case incorporates more information than the bivariate case, making the causal inference drawn more reliable [14,15]. We use electricity generation rather than electricity consumption. This follows the approach in Yoo & Kim [16] (for Indonesia) and Ghosh [17] (for India). In developing countries non-technical transmission and distribution (T&D) losses are often high. The World Bank [18] reported that T&D losses in developing countries are two to four times higher than in OECD countries. In 1997, Malaysia's T&D losses were 9 per cent compared with 4 per cent in Japan and Singapore [19]. Thus, electricity consumption figures are underestimated. However, except for technical losses, all electricity generated contributes to GDP. Thus, it makes more sense to employ electricity generation as

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the appropriate proxy for electricity. We include prices because of their importance in influencing electricity consumption and income. There is no time series data available for Malaysia on electricity prices. Hence, we follow the normal practice of including the consumer price index (CPI) as a proxy for prices (see eg. [13]). Mahadevan and Asafu-Adjaye, [20] provide a detailed justification of the rationale for using the CPI as a proxy for energy prices in this context.

Including electricity generation, exports, economic growth and prices in the one model effectively marries the Granger causality literatures on the energy-GDP nexus and exports-GDP nexus. This follows the approach in Narayan & Smyth [5] which is a panel data study for the Middle East. In that study, those authors suggested a natural extension of their work was to look at the relationship between energy, exports and GDP in the export-oriented high growth Asian economies. Among South-east Asian countries that have successfully utilized export promotion strategies as a means to realize a high rate of growth, Malaysia is a prime candidate for such a study [21]. Lean and Smyth [58] consider Granger causality between economic growth, exports and electricity consumption for Malaysia; however, they use electricity consumption, rather than electricity generation, which we have argued is less appropriate for a developing country.

The methodological approach in this paper is to combine the Autoregressive Distributed Lag (ARDL) bounds test for cointegration, proposed by Pesaran et al. [27] with the modified version of the Granger causality test proposed independently by Toda and Yamamoto [28] and Dolado and Lutkepohl [29] – hereafter TYDL. There are advantages of using the ARDL bounds test over alternative approaches to cointegration such as those proposed by Johansen [30]. First, the ARDL bounds test can be applied irrespective of whether the variables are integrated of order zero (I(0)) or integrated of order one (I(1)). Second, the ARDL bounds test has good statistical properties for small sample sizes of 30–40 observations, which is common in single country studies such as ours with annual time series. The TYDL approach to Granger causality has the advantage is that it can be used irrespective of the order of integration of the variables and whether or not the variables are cointegrated.

2. Malaysian context

Malaysia is one of the most developed countries in ASEAN. From 1970 to 1980 economic growth averaged over 8 per cent, from 1980 to 1990 economic growth was 5.2 per cent and between 1990 and 2005 economic growth averaged above 6 per cent. It was higher than 9 per cent, prior to the Asian financial crisis in 1997 [22,23]. The only slumps in economic growth since the mid-1980s were in 1998, when Malaysia was severely affected by the Asian financial crisis [24] and the global financial crisis in 2008–2009.

Malaysia was among the most active among the ASEAN countries in liberalizing its investment regime in the manufacturing sector during the 1980s and 1990s. This policy offered many incentives including pioneer status tax holidays, expanded investment tax allowances, tax deductions for export promotions and the establishment of free trade zones [83]. More generally, during the 1990s the Malaysian economy was characterized by a trend towards increased liberalization, greater openness to world trade, a higher degree of financial integration and greater financial development [81]. Malaysia has also experienced declining tariffs over time [83]. In response to the Asian financial crisis, the Malaysian government imposed capital controls with the objective of reducing short-term capital flows [82]. Nevertheless, compared with other ASEAN economies, the Malaysia has progressed reasonably well with its outward-oriented strategies [83].

Malaysia's rapid economic growth and outward-oriented policies have been accompanied by steady export growth. Exports as a percentage of GDP in Malaysia have increased from 41 per cent in 1970–110 per cent in 2007 [25]. Compared with economic growth there have been more fluctuations in exports. In particular, Malaysia has experienced export slumps associated with the first oil price shock in 1975, second oil price shock in 1981, the Asian financial crisis in 1997, the collapse of the IT bubble in 2001 and the global financial crisis in 2008–2009 [26]. The manufacturing sector is regarded as the main driver for export performance as well as economic growth. In 2006, strong growth in manufacturing output (7.1 per cent) contributed 31.3 per cent of GDP [83].

Similar to many developing countries, energy has been a prime contributor towards rapid growth of the Malaysian economy [78]. According to Malaysia's Ninth Five Year Plan energy demand was expected to increase at an annual average rate of 6% between 2006 and 2010 [79]. According to Gan and Li [23] total primary energy consumption is expected to triple by 2030. This is consistent with Malaysia's vision to become a developed country by 2020. Electricity consumption in ASEAN is the second highest among the five founding economies [10]. Electricity consumption per capita has been increasing rapidly since the early 1970s [10]. Sales of electricity in Peninsular Malaysia have recorded double-digit annual growth rates [91]. In Malaysia, economic growth and export growth have been accompanied by a sharp rise in the use of information and communication technologies (ICTs) that require substantial electricity input. Malaysia's rapid industrialization over the last three decades has also resulted in the development of infrastructure and managerial processes that consume a lot of electricity.

The industrial sector in Malaysia is the major consumer of electricity and its share has increased over time with industrialization. Since, the beginning of the 1980s energy demand of the industrial sector has increased at 6.9 per cent per annum [80]. In 2007 the industrial sector accounted for 48 per cent of total energy use [77]. The industrial and transportation sectors together account for 80 per cent of total energy use [80]. Saidur et al. [78] conducted an energy audit of 11 industrial sectors, comprising 91 factories, on the east coast of Malaysia for 2006. Their main conclusion was that among a wide variety of end-use electricity-consuming equipment, electric motors were the main consumers of electricity, followed by pumps and air compressors. That study also found that the majority of the factories surveyed are still using old equipment, which are not efficient and waste large amounts of energy. Because of inefficient electricity use, it is expected that Peninsular Malaysia, which represents the hub of Malaysia's economic activities, will become a net importer of fossil fuels (coal, gas and oil) in the near future [78]. To summarize, over the period studied electricity consumption (and electricity generation) per capita has showed an upward trend, as have real exports per capita and real GDP per capita. The fact that these variables have moved together, and that all three are major economic indicators, suggests that there may be a causal relationship between them.

3. Existing literature

There is a sizeable literature on Granger causality between GDP and energy use for a range of countries using various methodologies. This literature has tested four competing hypotheses. These hypotheses are that there is unidirectional Granger causality running from electricity generation to GDP (growth hypothesis); unidirectional Granger causality running from GDP to electricity generation (conservation hypothesis); bidirectional Granger causality between these variables (feedback hypothesis) or no Granger causality in either direction (neutrality hypothesis). Several studies have applied the ARDL bounds test in the energy-GDP