Applied Energy 104 (2013) 297–305

Contents lists available at SciVerse ScienceDirect

Applied Energy

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

Exploring the nexus of electricity consumption, economic growth, energy prices and technology innovation in Malaysia

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HIGHLIGHTS

- The electricity-economic growth nexus in Malaysia is examined.
- Enhanced technology innovation could reduce electricity consumption.
- Technology innovation Granger-causes electricity consumption and economic growth.
- Technology innovation could curb wastage of electricity.
- Technology innovation could also stimulate Malaysia's long-term economic growth.

ARTICLE INFO

Article history:
Received 22 December 2011
Received in revised form 8 September 2012
Accepted 28 October 2012
Available online 17 December 2012

Keywords:
Causality
Cointegration
Electricity-growth
Malaysia
Technology innovation

ABSTRACT

This study principally attempts to investigate the relationship between electricity consumption on the one hand and economic growth, energy prices and technology innovation in Malaysia on the other over the period, 1970–2009. The results of this study indicate that electricity consumption and its determinants are cointegrated. Specifically, the empirical results show that income positively affects electricity consumption, while energy prices and technology innovation negatively affect it in Malaysia over a long run. The Granger causality results reveal that technology innovation Granger-cause economic growth and electricity consumption in Malaysia. Moreover, we find that electricity consumption and economic growth Granger-cause each other both in the short and in the long run. Therefore, policymakers should increase investment in electricity infrastructure to ensure that electricity supply is sufficient for economic growth and development and at the same time encourage technology innovation to minimise the usage of fossil fuels. This could strike a balance between environmental quality and economic growth in Malaysia.

1. Introduction

Over the past decades, many empirical studies on energy-growth nexus have been published. Generally, they all involved the use of conventional variables with mere changes in the data span. Karanfil [1] emphasised that changing the data span is an insufficient contribution to literatures and effective policymaking. Ozturk [2] and Payne [3] highlighted that omission of relevant variable(s) and methodological flaws are two major factors that cause conflicting estimation results. Instead of using a bi-variate model, research on the energy-growth nexus should consider other potential variable(s) that affect energy consumption and economic growth. In addition, more robust econometric approaches should be employed to reduce the possibility of producing inaccurate results. Karanfil [1] and Ozturk [2] suggested that the fairly new bounds testing approach to cointegration should be used to avoid conflicting and unrealistic results for policymaking.

Motivated by the above studies, the goal of this study is to re-investigate the electricity-growth nexus in Malaysia by accommodating technology innovation as a new control variable. To the best of our knowledge, technology innovation has not been considered by other electricity-growth studies, particularly in the case of Malaysia. Technology innovation could stimulate long-term economic growth as emphasised by the neoclassical and the endogenous growth theories [4,5]. More green energy and energy savings products could also be created through technology innovation. Greater technology innovation could reduce fossil fuel consumption which in turn leads to a better quality of the environment and economic growth. In this context, technology innovation is considered a very important variable affecting energy consumption and its relationship with economic growth.

Malaysia is the choice of this study because of its impressive economic growth record, with rapid development in the informa-

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http://dx.doi.org/10.1016/j.apenergy.2012.10.061

tion and communication technologies (ICTs) and other infrastructures that require large inputs of electricity [6,7]. Since 1980s, Malaysia has been one of the popular destinations of foreign direct investment (FDI). Such influx of FDI has brought about large volumes of technology transfer to Malaysia because FDI is a main channel of foreign technology transfer. Therefore, it is important to investigate the relationship between electricity consumption, economic growth, energy prices, and technology innovation in Malaysia.

This study employs a set of econometric techniques to achieve the objective of this study. First, apart from using the standard Phillips–Perron (PP) and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) unit root tests, we also apply the Zivot and Andrews [8] and Narayan and Popp [9] unit root tests with one and two structural breaks to verify the order of integration of each series. This is because according to Perron [10], standard unit root tests have low power when there are structural breaks in the data series. On the basis of Monte Carlo experiments, Narayan and Popp [11] found that the two-break unit root test proposed by Narayan and Popp [9] has better size and power than the other unit root tests (e.g. [12,13]). Second, we follow the recommendations of Karanfil [1] and Ozturk [2] in using the bounds testing approach to cointegration to examine the presence of a long run equilibrium relationship between electricity consumption and its determinants in Malaysia. This approach is superior for small samples and is able to handle variables with mixed orders of integration. Finally, the Granger causality test will be conducted within an error-correction model (ECM) to ascertain the direction of causality among electricity consumption, economic growth, energy prices, and technology innovation in Malaysia to yield valuable lessons for future policy direction. One of the advantages of using the ECM-based Granger causality test is that it allows us to differentiate between short and long run causal relationships, if any.

The rest of this paper will be organised as follows. A concise review of the power sector in Malaysia is presented in the next section. Section 3 then discusses the past empirical studies on Malaysia and Section 4 will describe the methodology used in this study. The empirical results will be discussed in Section 5. Finally, Section 6 will present the conclusion and policy recommendations.

2. An overview of power sector in Malaysia

Malaysia which gained independence from Britain in 1957 is one of the more advanced developing countries in the Association of Southeast Asia Nation (ASEAN). As a result of rapid development, there was a sharp increase in energy consumption. For example, electricity sold in 1955 was only 919 million kilowatt per hour (kWh), and it increased markedly to 21,889 million kWh in 1989 and to more than 89,000 million kWh in 2007 [14].

Historically, the main power supply in Malaysia was managed by the Central Electricity Broad (CEB) which was renamed as the National Electricity Broad (NEB) in June 1965. However, in the mid-1980s, the privatisation policy has been implemented to improve the power sector's efficiency and productivity. Under the Privatisation Master Plan [15], Tenaga National Berhad (TNB) was established on 1st September 1990 to replace the NEB. Currently, electricity in Malaysia is supplied, transmitted and distributed by three main utility companies namely, TNB, Sabah Electricity Private Limited (SESB), and Sarawak Electricity Supply Corporation (SESCO). TNB remains the largest power supply utility company in Malaysia and Southeast Asia. It is responsible for supplying electricity throughout Peninsula Malaysia and Sabah while SESB and SESCO are responsible for supplies to East Malaysia.

Fig. 1 shows that oil was previously the main resources used for generating electricity in Malaysia. However, it was gradually replaced by natural gas and coal due to the implementation of the Four-Fuel Diversification Policy in 1981. Following that, electricity in Malaysia was generated by four main resources such as oil, natural gas, hydropower, and coal. Before 1980, nearly 90% of the electricity in Malaysia was generated by oil, while hydropower supplied the remainder (see Fig. 1). In 1990, the contribution of natural gas to electricity generation in Malaysia was approximately 20% compared to approximately 51% contribution from oil. Nevertheless, the contribution of natural gas grew tremendously to approximately 70% in 2005, while the contribution of oil dropped to approximately 5%. Apart from natural gas, another important fossil fuel for generating electricity in Malaysia is coal and it becomes more prominent after 2000. In 1990, coal contributed 4.7% of total electricity generation in Malaysia and this has increased to 28% in 2007. According to Energy Information Administration [16], coal accounted for 42% of world electricity generation in 2007. It is expected to continue contributing to a large portion of worldwide electricity generation until 2035 as it is the world's most abundant fossil fuel and is cheaper compared with the other fossil fuel.

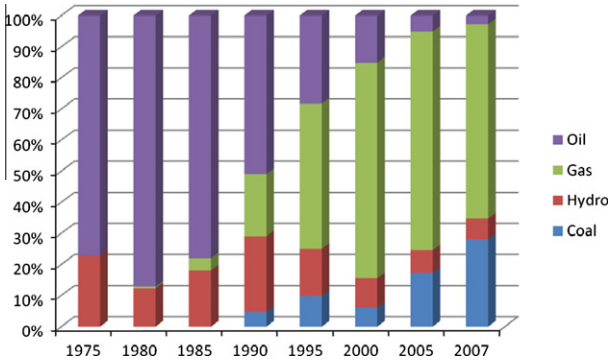

Fig. 1. The sources of electricity in Malaysia. Source: World Development Indicators (WDI).

3. Review of studies on Malaysia

Economists and environmentalists have been investigating the nexus between energy consumption and economic growth because it has important policy implications. Basically, they attempt to determine whether energy consumption Granger-causes economic growth or economic growth Granger-causes energy consumption or both. Understanding the direction of causality is very important for policymakers to formulate appropriate energy and economic growth and development policies to ensure sustainable economic development. Thus, knowing the direction of causal relationship between energy consumption and economic growth is needed even though it is not a new area of exploration. There are many existing studies on this topic were published using either a bi-variate or a multivariate framework. A major limitation of bi-variate studies is that they are prone to suffer from the omitted variable bias problem. In other words, biased estimates of the actual causal relationship between two variables of interest could result from a bi-variate model. Recently, Ozturk [2] and Payne [3] have published two comprehensive literature surveys on the energy-growth nexus. To conserve space, our literature review only focuses on the empirical studies related to Malaysia (see Table 1). Generally, the Malaysian empirical studies can be divided into two major groups. The first group involved bi-variate framework, while the second involved multivariate framework.

We begin our discussion with the findings of the bi-variate framework studies. Masih and Masih [17] used annual data from