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A REVIEW OF INPUT OUTPUT RESEARCH AND ITS APPLICATION ON ENERGY STUDIES

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Abstract

Input-output analysis that is based on input-output theory has become an important research tool. It has been widely applied in areas such as international trade, environment, employment and specific sectoral economic performance. Globally, the increasing concern about depleting primary energy resources and environmental impact of energy use has resulted in overwhelming number of energy studies. As a result, input-output analysis has been applied extensively on energy studies as well. Out of the input-output analysis conducted, many policy implications had been highlighted in order to help countries in improving their existing energy-related policies. This study takes the initiative to review those researches that utilized input-output analysis in Malaysia and to look into its application on energy studies in the country. Thus, this study sheds lights on efforts undertaken by researchers that are interested in input-output analysis and gives ideas on the development of input-output research in the country especially those that are related to energy studies.

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1. Introduction

Input-output (I-O) theory is based on Leontief's work continued after the appearance of his first I-O study in 1936, which deals with the structure of functional relationships motivated by production analysis (Baumol & ten Raa, 2009). In this theory, all the intermediate goods are expressed as a set of equations, with sales and purchases of the intermediate industries founding the core of the system. Generally, I-O theory is constructed from observed economic data, which are concerned with the activity of a group of industries that both produce outputs and consume inputs from other industries in the process of producing each industry's own output. It also records the sales by each sector to final markets for their production, such as personal consumption purchases and sales to the government, which are categorised as final demand (Miller & Blair, 2009).

I-O theory offers a tool with a vast array of uses. Leontief has made the applications of I-O theory to international trade and environmental issues (Boumal & ten Raa, 2009). The contributions of many researchers have extended the application of the I-O theory on other areas, especially energy. I-O models that focused on energy use were developed extensively during the oil crises in the early 1970s (Miller & Blair, 2009). A variety of I-O analyses have been applied on energy studies such as those using the analyses known as backward and forward linkages analysis, multiplier analysis and structural decomposition analysis. I-O analysis enables researchers to study the interrelationship between economic activities and their energy use. It helps researchers to investigate direct and indirect energy use by producing sectors and final demand components. Economy-wide energy use changes as well as the impact of production structure change on energy use can also be investigated. In order to understand any type of I-O analysis, having the knowledge on basic structure of an I-O table is crucial. Figure 1.0 below demonstrates the general structure of an I-O table (refer Miller and Blaire (2009) for further explanation).

Figure 01. General Structure of an Input-Output Table

2. Problem Statement

The use of input-output data in conducting research in Malaysia had been very rare compared to those research using time-series data. Though it was firstly introduced in 1936, its application to Malaysian scenario had been slowly developed. Research based on I-O data have its own advantages. Thus, it is crucial to investigate its development in this country and its application on energy studies due to the overwhelming concerns of researchers on energy conservation and climate change mitigations.

3. Research Questions

The research questions for this study are as follows:

1. How is the development of I-O research in Malaysia?
2. To what extent is the application of I-O analysis in Malaysia's energy studies?

4. Purpose of the Study

The purpose of this study can be outlined as follows:

1. To discuss the development of I-O research in Malaysia.
2. To deliberate the application of I-O analysis on energy studies in Malaysia.

5. Research Methods

This study was accomplished based on the content analysis of each I-O research in Malaysia; observing the year of publications, areas of interest and the findings.

6. Findings

To the researchers' best knowledge, the revolution of I-O studies in Malaysia emerged from a thesis written by Bent (1970), which constructed the West Malaysian 1960 transaction table and estimated final demand projection for 1970. This was followed by several studies done in the 1980s by Rahman (1985a, 1985b, 1986, 1987a, 1987b, 1987c), which were more on determining sectoral linkages and key economic sectors. In the 1990s, though limited in numbers, the Malaysian I-O studies appeared to be conducted in a wider scope. At this period, apart from sectoral linkages studies, there were other new areas such as cost of production, labor productivity, sectoral price structure, and structural change, which also had been explored (for example, see Rashid, 1991, 1992a, 1992b; Rashid & Abdullah, 1993; Rashid et al., 1999; Rashid & Elameer, 1999).

A fascinating development in Malaysia's I-O research occurred in the year 2000 onward, indicated by the increasing number of I-O researchers with their respective field of interest. Studies on sectoral linkages and determining key economic sectors has continuously been the interest of many researchers (for instance, see Rashid & Soon, 2002; Kamaruddin et al., 2008; Kamaruddin & Masron, 2010; Bekhet, 2009a; Al-Amin et al., 2010; Shuja' et al., 2012; Saari et al., 2013a). Discussion on Malaysia's structural change also has attracted the attention of several researchers (for instance, see Kamaruddin, 2006; Kamaruddin & Rashid, 2007; Ismail, 2007; Bekhet, 2009b; Bekhet & Yasmin; 2015, 2017). Also, issues of labor and employment had been increasingly debated (for instance, see Saari & Rashid, 2007a; Hassan et al., 2010;

Bekhet, 2011; Saari & Pei, 2013; Sauian et al., 2013; Tin, 2014). Specific sector contribution to economic growth such as tourism also has been an important area of interest (for example, see Bashir et al., 2008; Mazumder et al., 2009; Mazumder et al., 2011). Correspondingly, environmental impact analysis has also received notable attention (for example, see Al-Amin et al., 2007b; Al-Amin et al., 2007a; Chik et al., 2013a). There are also other new areas of interest among Malaysia's I-O researchers such as income distribution (for example, see Saari et al., 2007a; Saari et al., 2008a) and efforts to update Malaysia's I-O tables (see Saari, 2014).

The increasing concern about depleting national primary energy resources and environmental impact of energy use has resulted in overwhelming numbers of energy studies in Malaysia. The concern of Malaysia's energy studies emerged since the early 1980s, in line with government's introduction of the Four Fuel Diversification Policy in 1981. Though the policy advocated the imperative use of coal, natural gas and hydropower for reducing the country's dependence on depleting national crude oil, several early studies found to have more inclination toward the importance of renewable energy use in the country (see Ong, 1980; Ismail, 1981; Keong, 1981; Chuah & Lee, 1981). Various aspects of Malaysia's energy issues have been investigated using ranges of methodologies. Unfortunately, they are rare in considering the I-O approach.

The concern on Malaysia's energy I-O analysis started from the work of Rashid and Othman (1994), which discussed the economic impact of oil trade in Malaysia due to the Gulf crisis. It was followed by the studies of Saari and Rashid (2006), Saari and Rashid (2007b), Saari et al. (2007b) and Saari et al. (2008b), which discussed the impact of an increase in petroleum prices on the costs of production by conducting simulations of different scenarios of the petroleum price changes on sectoral production costs. The authors found that sectors such as fisheries, forestry and logging, electricity and gas, cement, and transport were among the significantly affected sectors due to the increases in domestic petroleum prices. Saari et al. (2013b) extended the simulation study by investigating the impacts of two scenarios of price shocks: increase in electricity price and a simultaneous increase in petroleum and electricity prices. An increase in electricity price was found to have minimal impacts on the cost of production and household living expenses. However, the results indicated considerable impacts on production sectors and households if electricity and petroleum prices increased simultaneously. Moradkhani et al. (2010) also conducted an energy price impact study. A study by Bekhet and Yasmin (2014) assessed the impact of the global financial crisis (2007/2008) on Malaysia's energy consumption. Their results indicated that the drop in exports caused by the crisis led to a reduction in energy consumption.

Very few studies are found to focus on energy sector performance alone using I-O analysis. Abdullah (2013a) attempted to investigate the performance of Malaysia's energy-related sectors through their linkages analyses with other sectors. The petrol refinery sector has continuously been among the key sectors of the economy for the 1991–2005 period. In addition, the electricity and gas sector is also among the key sectors in 2005. Abdullah (2013b) also investigated the import requirements of Malaysia's energy sector. Findings reveal that, apart from relying highly on imports of primary energy and petrol refinery products, Malaysia's energy sector also is highly dependent on machinery products and business services from abroad. Studies on sectoral energy use also has attracted the attention of several researchers. Bekhet and Abdullah (2010, 2012) explored energy use in Malaysia's agricultural sector. The authors revealed that,

though linkages between the energy and agricultural sectors are weak, the relationship has gained strength over time, especially as indicated by increasing dependence of the agricultural sector on petrol refinery inputs. Energy use in the transportation sector also has been examined by Bekhet and Abdullah (2013), explaining that Malaysia's transportation's energy requirement has increased over time, especially in regards to the use of petrol refinery products. Abdullah (2016) investigated energy use in Malaysia's manufacturing sector and found that cement, basic metals, and industrial chemical industries had consistently become the most energy-intensive industries in the country. Abdullah (2017), examined energy use in Malaysia's services sector and found that health care and waterwork sectors as among the top services subsectors in terms of their energy use.

Other studies in Malaysia that also use I-O based analysis include the one authored by Chik et al. (2012) that examined household energy use changes. The study discovered that total household energy consumption has rapidly increased, both directly and indirectly, through expenditures such as on electrical and electronics products, construction, and private transportation. There are also studies that scrutinise sectoral energy use and its environmental impacts. Al-Amin et al. (2007c) investigated energy use in the transportation sector and its pollution implication using 1991 and 2000 I-O tables. The study indicates that energy intensities and energy multipliers in the transportation sector are higher in 1991 than in 2000. However, total emissions were proven to be higher in 2000 than in 1991. Environmental impact studies due to energy use in the electricity sector were also discovered. Generally, these studies conclude that the fuel mix envisioned by the Four-Fuel Diversification Policy and the Five-Fuel Diversification Policy designed to reduce Malaysia's dependence on fuel oil would increase undesired emissions (see Al-Amin et al., 2007d; Al-Amin et al., 2008; Al-Amin et al., 2009). Chik et al. (2013b) explored the impact of industrial energy use on CO_2 emissions in 2005. This study suggests that energy-intensive sectors, especially transportation, should reduce energy consumption by adopting energy-efficient technology that produces less CO_2. Further investigation on the same issue for the period of 1991–2005 was done by Chik and Rahim (2014). Lastly, Bekhet and Abdullah (2017) investigated the changes in Malaysia's energy intensity for the 2005-2010 period. They found that there was a decline in Malaysia's energy intensity and the reduction in final demand components of the country has become the major contributor for the energy intensity decline.

Almost all of the above studies have highlighted policy implications and give suggestions for improvement of the existing energy related policies, regulations and initiatives implemented so far in the country based on the research findings resulted from I-O analysis. It is expected that more research on energy utilizing I-O analysis will be implemented in the near future as the number of researchers interested in using the method is increasing.

7. Conclusion

Internationally, I-O analysis has become an increasingly important tool in conducting energy related studies. This study takes the initiative to discuss the development of research that are based on I-O analysis in Malaysia and review its application on energy studies in the country. Though it was firstly introduced in 1970, its application on energy studies in this country was started only in 1990s. Since then, the number of Malaysia's energy researchers interested in using I-O analysis as a tool for conducting their research is increasing. The results generated from any I-O analysis helps researchers to identify the weaknesses in the

existing policies such as the policies related to energy use of a country. Hence, using I-O analysis as a research tool for energy studies in this country is important, so that a better policy recommendations can be highlighted in order to help Malaysia achieve its energy sustainability target.

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