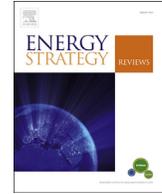


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## CASE STUDY

# Economic development, energy market integration and energy demand: Implications for East Asia

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## ABSTRACT

This paper uses a general method of moment regression technique to estimate an energy demand function with a dataset covering 71 countries between 1965 and 2010. The estimated results show that countries undergoing rapid economic growth may show relatively higher income and price elasticities in the long run. The higher income elasticities and lower price elasticity in the short run of rapid growing countries may impose pressure on energy demand in the domestic and international markets. Energy market integration can help to reduce such pressure by smoothing energy demand through lowering its income elasticity and creating a flexible energy market through increasing its price elasticity. These findings have important implications for forecasting energy demand and promoting international cooperation in East Asia.

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## 1. Introduction

Price and income are two primary factors shaping the energy consumption of a country, and estimation of the elasticities of these two factors is thus essential for defining the energy demand function. In previous empirical studies [1–5], the income and price elasticities of energy products have been widely estimated with either single-country time-series data or cross-country data. However, there is no general agreement on representative values of the income and price elasticities, and in particular it is still not clear why the magnitude of these elasticities may differ across countries with disparate

economic development levels and institutional arrangements.

Using a comprehensive survey of quantitative studies on country-specific energy consumption, Dahl [6] shows that the demand for energy is price inelastic and slightly income elastic at the national level but there is no clear evidence that the developing world should be less price elastic or more income elastic than the industrialized world. In contrast, Brenton [5] and Ferguson et al. [2], when using cross-country energy consumption data to estimate different energy demand functions, find that the price elasticity for energy is usually higher in the poor countries than in the rich countries, and that the income elasticity for energy declines with rising income.

To explain the above inconsistent findings on the estimated energy demand elasticities, many studies including Maddala et al. [7], Garcia-Cerrutti [8], Lowe [9], Bernstein & Griffin [10], and Yoo [11] attempt to incorporate regional characteristics, such as

country-specific energy consumption preferences and different energy-usage technology in production, into the estimation of the energy consumption function. These studies provided some interesting results with respect to the relationship between economic growth, policy making and energy consumption by providing new estimates of the cross-country income and price elasticities for energy. However, they could not explain two important phenomena [10]: (1) estimated energy consumptions using the cross-country data generally lack price elasticity, and they are significantly different from those in country-specific studies; (2) estimated energy consumptions using the single-country data usually show different trends over different time periods.

These two phenomena raise the interesting question of whether economic development and the institutional arrangements associated with the energy market, which are the two important features associated with the different phases of economic development

*Abbreviations:* ASEAN, association of Southeast Asian nations; EAS, East Asia summit; EMI, energy market integration; GMM, general method of moment; NIEs, new industrialized economies.

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and income levels of a country, can be identified as affecting the income- or price-energy consumption relationships.

This paper attempts to measure the income and price elasticities of energy consumption in a country and to link these elasticities to the country's economic development and institutional arrangements related to Energy Market Integration (EMI). Contributing to the previous literature examining the relationship between energy consumption and income, such as Asafu-Adjaye [12] and Lee and Chang [13], our study is the first to highlight that the economic development stage and its related industrialization and urbanization may reshape the energy consumption behavior of a country by affecting its income and price elasticities. In addition, we also demonstrate the role that EMI may play in changing a country's energy demand when the country passes through different economic development stages.

Implications from this study shed light on two policy issues in the East Asian Summit (EAS) region. The first policy issue is that since many EAS countries are less developed and will industrialize in the future, a projection of the relationship between energy demand and industrialization is critical in choosing how to deal with the potential energy supply challenge. The second policy issue is that the study provides the method for valuing the costs of, and benefits from, participating in EMI. An incentive for EAS countries to participate in EMI is that regional integration may help to secure the energy supply for sustainable economic growth whilst reducing income disparity in the region. However, to what extent this goal can be achieved and how much benefits each country can obtain from participating in EMI depend on the impact of regional integration on the income and price elasticities of energy demand.

The paper is organized as follows. Section 2 summarizes the structural change in energy demand of some major countries. The analysis shows that there are often significant structural changes in energy demand when a country moves from a lower economic-development stage to a higher one, and different institutional arrangements associated with the energy market may impose different impacts on such structural changes in energy demand. Section 3 develops a dynamic panel data model, which incorporates economic growth stages and EMI into the estimation of the energy demand function. Section 4 presents the estimated results which show that countries in different stages of economic development, and with different involvement in EMI, would demonstrate different levels of demand for energy consumption. Section 5 presents conclusions and policy implications for East Asia.

## 2. Changing world energy demand and its determinants

The world's demand for energy has experienced rapid growth over the past five decades, despite a slight drop due to two supply shocks in 1973 and 1979. Up to 2010, the total world energy demand had reached 12.0 billion tonnes of oil equivalent (toe) which is 3.2 times the level in 1965 (3.8 billion toe) [14]. Behind the steadily increasing trend of world energy demand, countries with different levels of economic development have demonstrated different energy demand patterns. Three characteristics of cross-country energy consumption trends throughout the world can be summarized as follows [15]. First, the energy demand in developed countries is still dominant in total world energy consumption, though increasing only slowly over time. Second, the energy demand in developing countries, in particular the newly industrialized economies (NIEs) in East Asia, is increasing rapidly and has become the new engine of total world energy consumption growth. Third, the growth in world energy demand comes in a wave pattern, with each wave dominated by the countries with rapid economic growth.

Between 1965 and 2010, the rate of growth of energy demand from the United States, the European Union (EU) and Japan was on average 1.5 per cent, which was far lower than that from developing economies in East Asia, such as South Korea, Taiwan, ASEAN, China and India, which averaged around 5.8 per cent. This implies that developing economies are increasingly becoming the major driving force of world demand for energy.

Moreover, the driver behind world energy demand seems to change from one group of countries/economies to another over different time periods. World energy demand had been driven by the EU and Japan over the period of 1965–1970, but the driver shifted to the NIEs, such as South Korea, Taiwan and the ASEAN countries over the period 1980–1990. In recent years, the growth in world energy demand has mainly been coming from China, followed by India, in particular after 1990 [16]. This implies that the world's energy demand increases in a wave pattern, as more countries/economies enter into a rapid economic growth stage with consequent industrialization and urbanization.

The above phenomena raise a number of questions:

- why has East Asia, rather than other parts of the world, become the new engine of world primary energy demand?
- what are the underlying factors affecting world energy demand trends?

- how have changing world income and fluctuations in the price of energy products affected world energy consumption?

To answer these questions, a number of previous studies, such as IEA [15], Karki et al. [17] and Yoo [11] argue that the rapid increase in the world income level and the rapidly fluctuating oil price in the international market have changed the pattern of world energy consumption, and that institutional arrangements associated with the energy market can play an important role in reshaping the income and price elasticities of energy demand across countries.

Fig. 1 shows the relationship between energy consumption per capita and GDP per capita in major Asia-Pacific countries between 1965 and 2010. Over the past four decades, there have been significant increases in the energy consumption of countries experiencing rapid economic growth. As the change in energy consumption is always associated with a specific income level (say, US\$ 5000–US\$ 10,000), this suggests that the GDP per capita range rather than the GDP per capita level play a more important role in affecting the energy demand across countries and over time, which provides us with a new perspective for empirical work.

Moreover, as countries are re-categorized into two groups according to the level of their involvement into EMI, it is easy to see that countries with different EMI level may have different energy consumption per capita. Fig. 2 shows that countries with relatively higher EMI indices have, on average, higher energy consumptions per capita compared with countries with relatively lower EMI levels. This implies that EMI (or its represented institutional arrangements) is an important factor affecting the relationship between energy consumption, income level and the price of energy products.

## 3. Methodology and data

As shown in Section 2, it is necessary to incorporate economic development stages and EMI into the estimation of the energy consumption function. Based on a standard consumption function, we assume that the energy demand is determined not only by changes in income and price but that it also varies with different economic development stages and institutional arrangements with which a particular country is associated. The energy demand function in double-log form for panel data regression can thus be written as:

$$\ln C_{it} = \beta_0 + \beta_1 \ln P_{it} + \beta_2 \ln Y_{it} + \gamma S_{it} + u_i + \varepsilon_{it} \quad (1)$$

where  $C_{it}$  is the aggregated demand for all energy products in country  $i$  at time  $t$  which is

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