# Chapter 2

# Economic Development, Energy Market Integration and Energy Demand: Implication for East Asia

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*This paper uses the General Method of Moment (GMM) regression technique to estimate an cross-country energy demand function with a data set covering 71 countries over the period of 1965-2010. The estimated results show that rapid economic growth due to industrialization and urbanization tends to increase the energy consumption per capita, which in turn may generate a surge in the overall demand for energy. As is shown in the econometric results, an increase in economic growth (i.e. the dummy of GDP level) may increase 0.6 per cent of energy consumption per capita. Moreover, economic growth also leads to lower price and income elasticities (in absolute terms). However, energy market integration can help to reduce the energy demand pressure and to smooth the demand shock through decreasing the income elasticity and increasing the price elasticity in particular in the long run. This finding can be used to explain how cross-country institutional arrangement related to energy market may affect regional energy consumption patterns over the period of rapid economic growth and offer policy implications for East Asia, which is diversified in terms of development level.*

# 1. Introduction

Price and income are two primary factors shaping energy demand, and thus the elasticities to price and income are leading factors for understanding energy demand. It is widely believed that the income and own-price elasticities of energy products found in previous studies (Dahl & Sterner, 1991, Ferguson, *et al*., 2000, Bohi & Zimmerman, 1984, Taylor, 1975, Brenton, 1997) are two important indicators for measuring the response of a country's energy consumption to national income and international market price. However, there appears to be lack of a general agreement on representative values for these energy consumption elasticities, and in particular on why the magnitude of the elasticities may differ across countries with disparate development level and institutional arrangements.

For example, in a comprehensive survey of quantitative studies on country-specific energy consumption, Dahl (1992) showed that the demand for energy was price inelastic and slightly income elastic at the aggregate level but there were no clear cut evidence that the developing world's energy demand is less price elastic or more income elastic than for the industrial world, while Brenton (1997) and Ferguson, *et al*. (2000) used some cross-country energy consumption data to estimate different energy demand equations respectively and found that the own-price elasticity for energy is higher in the poor than in the rich countries and income elasticity for energy declines with the rising of income.

To explain the above phenomenon, many studies including Maddala, *et al*. (1997), Garcia-Cerrutti (2000), Lowe (2003), Bernstein & Griffin (2005), and Yoo (2006) attempted to incorporate some regional specific characteristics, such as different consumption preferences and different energy-usage techniques in production across countries, into the estimation of the cross-country energy consumption function. Those studies provided some interesting results with respect to the relationship between economic growth, policy making and energy consumption through improving the accuracy of estimating the income and price elasticities of energy products. However, they could not explain two important phenomena (Bernstein & Griffin, 2005): (1) estimated energy consumptions in cross-

country studies generally lack price elasticity, which is significantly different from those in country-specific studies; (2) estimated energy consumptions in country-specific studies usually show different trends over different time periods, which is probably due to the differences in country-specific characteristics.

The above two phenomena raise an interesting question as to whether "Economic Development and Institutional Arrangements associated with Energy Market" — the two most important features specific to countries at different phases of development and income levels — can be identified as affecting the income- or own-price- energy consumption relationship and changing the related elasticity estimation across countries over time.

The attempt to link economic development and institutional arrangements associated with energy market to energy demand is of interest to academics and policy makers. On one hand, the contradictive findings from the previous literature ask for further studies from the academic perspective to fuel the debate in public. On the other hand, policy makers need to know energy demand in the future and its resistance to price volatility in the energy market in order to assist decision making. In practice, an accurate projection on energy demand is important for policy makers to secure energy supply, while understanding the response of energy demand to price is essential for reducing market uncertainty.

This study attempts to measure the income and price elasticities of energy consumption and link them to a country's economic development and institutional arrangements related to Energy Market Integration (EMI), aiming to inform policy makers on the different roles EMI may play in changing a country's energy demand when the country stays at different economic development stages. Implications from this study can be shed light on two policy issues in the East Asian Summit (EAS) region. The first policy issue is that many EAS countries are less developed and will industrialize in the future, thus the projection on the relationship between energy-demand and industrialization is critical to inform the potential energy supply challenge. The second policy issue is about how to value the impact of 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 and to reduce income disparity in the region. However, to what extent this goal can be achieved

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and how much benefit each country can obtain from regional integration depend on the impact of regional integration on the income and own-price elasticities of energy products.

The paper is organized as follows. Section 2 summarizes the structural change in energy demand of some major countries. The experience of development shows that there are often significant structural changes in energy demand when a country moves from the lower economic-growth stage to the higher one, and different institutional arrangements associated with energy market may impose different impacts on such structural changes. Section 3 develops a dynamic panel data model, which incorporates the impact of different economic-growth stages and different institutional arrangements associated with energy market into the estimation of energy demand function. Section 4 presents the estimated results which show that countries in different stages of economic development, and with different involvement in energy market integration, would demonstrate different levels of demand for energy consumption in response to changes in price and income. Section 5 applies the empirical results for analysing the economic development, changes in institutional arrangements and energy demand in the EAS region. Some policy implications are drawn concerning energy market integration and its impact on the future demand and international trade in the world energy market. Section 6 concludes.

## 2. Changing World Energy Demand and Its Determinants

The world primary energy demand has experienced rapid growth over the past five decades, despite a slight drop due to the supply shock in the late 1970s. Up to 2010, the total world primary energy demand had reached 12.0 billion ton of oil equivalent which is 3.2 times of that (3.8 billion ton of oil equivalent) in 1965. Behind the steady increasing trend of world primary energy demand, countries with different levels of development have demonstrated different energy demand patterns. Three characteristics of cross-country primary energy consumption trends in the world can be summarized as follows (IEA, 2011). First, the primary energy demand

in developed countries is still dominant in the total world primary energy consumption, though they increased slowly.  Second, the primary energy demand in developing countries, in particular the new industrialized economies (NIEs) in East Asia, increased rapidly and became a new engine of the total world energy consumption growth.  Third, the newly increased part of the world primary energy demand came in a wave by wave pattern and has been dominated by different countries with different stages of development over time.

Figure 1 shows the world primary energy consumption and the components of its growth across countries and economies during the period 1965-2010.  As shown in Figure 1 (a), from 1965 to 2010, the annual growth rate of primary energy demand from the United States, the European Union and Japan is on average 1.5 per cent which is far lower than that from developing economies in East Asia, such as South Korea, Taiwan, ASEAN, China and India, which is around 5.8 per cent on average.  As a consequence, the share of the primary energy demand from the US, EU and Japan over the total demand of the world, declined from 79.3 per cent to 53.1 per cent (but is still dominant in world primary energy consumption) while that from South Korea, Taiwan, ASEAN, China and India increased from 6.9 per cent to 24.7 per cent over this period.  This implies that developing economies are increasingly becoming a major driving force of the primary energy demand in the world.

Moreover, as shown in Figure 1 (b), the driving force for the primary energy demand seemed to come from different counties/economies over different time periods.  The newly increased primary energy demand mainly came from the EU and Japan during the period of 1965-1970, the major driving force for the primary energy demand came from the new industrialized economies, such as South Korea, Taiwan and ASEAN, during the period of 1980-1990, and the major driving force for the primary energy demand came from China, followed by India, after 1990-2010.  This implies that the newly increased world primary energy demands have been waved up and increased as more and more countries/economies have entered the process of industrialization.

**Figure 1: World Primary Energy Consumption and Its Structural Distribution by Countries**

(a) World primary energy consumption by countries (oil equivalent: million ton): 1965-2010
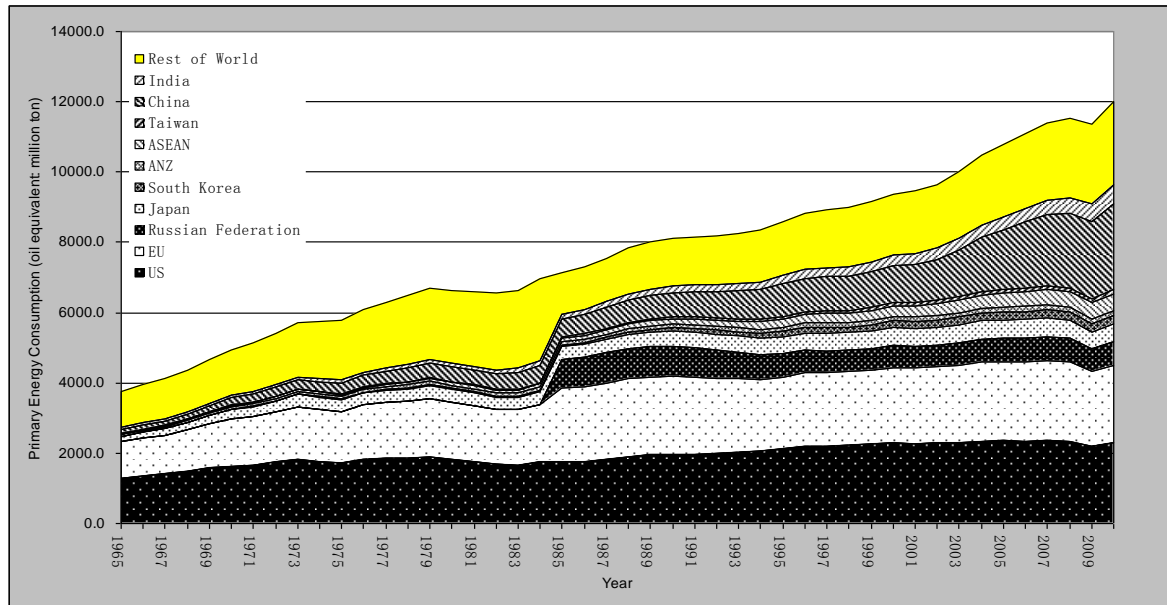


(b) Share of world primary energy consumption growth by countries: 1965-2010
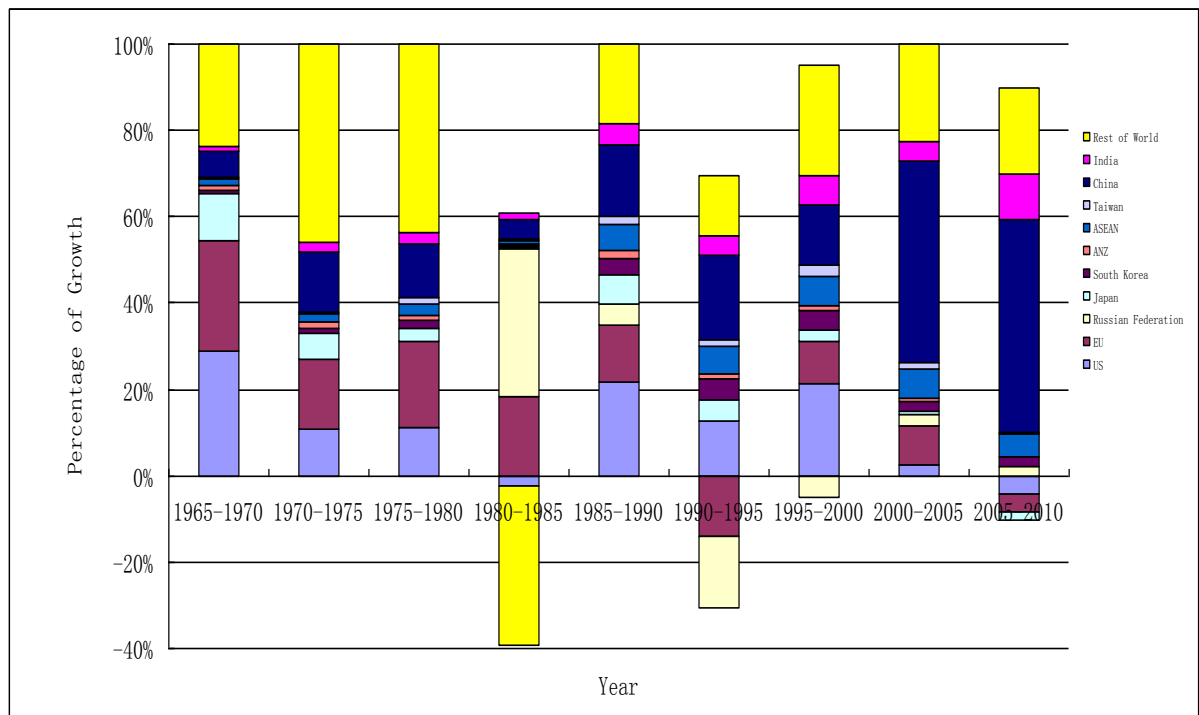


*Source*: BP Statistical Review of World Energy (BP, 2011).

The above phenomena raised a number of questions: why could East Asia, rather than any other parts of the world, has become the new engine of world primary

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energy demand?  What are the underlying factors which can be used to explain the changing trend in the world primary energy demand?  How has the changing world income and price of energy price affected world energy consumption?  To answer those questions, a number of previous studies, such as IEA (2011), Karki, *et al.* (2005) and Yoo (2006) argued that the rapid increased world income and the vibrating oil price in the international market changed the demand pattern of world energy consumption, and the adjustment of institutional arrangements associated with energy market had played an important role in affecting the energy income and price elasticities.

Figure 2 shows the relationship between energy consumption per capita and GDP per capita in major Asia-Pacific countries during the period 1965-2010.  As it is shown, there are significant increases in primary energy consumption in most countries when they experience rapid economic growth.  This suggests that it was GDP per capita range rather than GDP per capita level seemed to play a more important role in affecting the primary energy demand both across different countries and over different periods of time.  This observation provided us with a perspective for carrying out our empirical work.

**Figure 2: Relationship between Energy Consumption per Capita and GDP per Capita: 1965-2010**
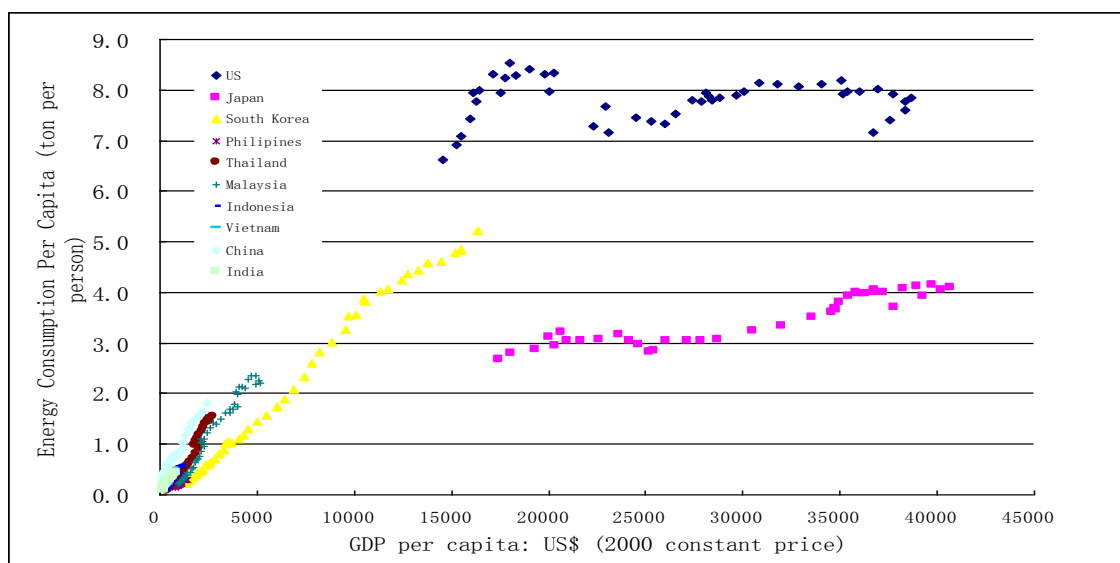


*Source*: Authors' calculation with the data from World Development Indicator (World Bank, 2012).

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Moreover, as countries are re-categorized into two groups according to the level of their involvement into the energy market integration, it is easily to find that countries with different energy market integration level may have different energy consumption per capita. For the measurement of institutional arrangement, the paper follows Sheng & Shi (2011) to construct an energy market integration index by using bilateral trade of fossil fuel products, geographical distance between each trading partners and each country's population. As shown in Figure 3, countries with relatively higher energy market integration level have, on average, a higher energy consumption per capita compared with countries with relatively lower energy market integration level. This implies that EMI (or its representing institutional arrangement) is an important factor affecting the relationship between energy consumption and income and price.

**Figure 3: Energy Consumption per Capita by EMI level: 1965-2010**
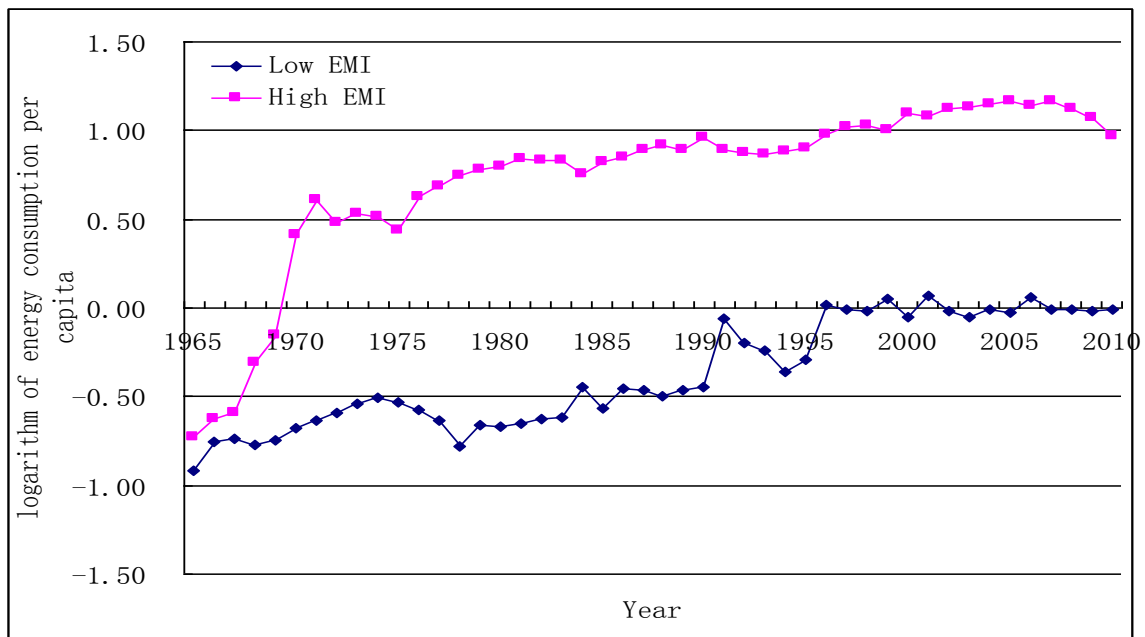


*Source*: Authors' calculation with the data from World Development Indicator (World Bank, 2012)

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## 3. Theory, Methodology and Data

Following the classical development theory (i.e. Chenery, *et al*. (1986)), the economic development of a country usually consists of four stages: agricultural economic stage, industrialization economic stage, commercialization economic stage and advanced economic stage. Each stage of economic development has its own significant features. More specifically, the agricultural economic stage is the initial development stage of an economy, which is characterized by the relatively large proportion of agricultural population and the relatively low level of industrialization. In this stage, the core of the economic development is to overcome the "dual economy". When economic growth moves on and the national income increases to some extent, the economy may enter into the second and the third development stages sequentially — that is, the industrialization and the commercialization economic stages. At these stages of development, the core of economic development is industrialization and urbanization and as a consequence, the economy will experience dramatic changes in industrial structure. Finally, after both secondary and tertiary industries are mature and primary industry declines below 10 % of total output, the economy can achieve the integration and step into the advanced economic stage. From then on, the economy growth will be mainly driven by technological progress and population growth. In each of the economic development stage, the disparity in institutional arrangements across countries may significantly promote or hamper the structure adjustment and its related resource consumption.

Applying the structural economic development theory with the changing pattern of energy consumption associated with economic development, one can easily find that: since different economic development stages are corresponding to different industrial structures and institutional arrangements associated with energy market, the relationship between economic growth of a country and her primary energy demand would vary along the economic development path. Thus, it is necessary to incorporate the economic development stages and institutional arrangements into the estimation of energy consumption function so that the impact of economic structural change on the fall and rise of energy consumption along the economic growth path can be examined.

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Based on the standard consumption function with utility maximization theory, we assume that the demand for energy products is determined not only by changes in income and price but also varies with different economic development stages and institutional arrangements with which a particular country is associated. Thus, the demand function for energy products in double-log form for panel data regression can be written as:

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

where $C_{it}$ is the aggregated demand for all energy products in country $i$ at time $t$ which is measured with tons of oil equivalent and $Y_{it}$ is the national income of country which is measured with US dollar at the 2000 current price and adjusted by purchasing power parity across countries. Both of those variables are measured on a per capita basis so as to control for any variation in population growth. Data for the price variable $P_{it}$ is the real price of crude oil in the world market adjusted with country-specific factors (such as transportation costs and individual country's market condition), which is calculated using the spot price in the international market adjusted by the consumer price index in each country.[1] $S_{it}$ is a group of variables representing structural change. In addition, $u_i$ is defined as the country specific effect which does not change over time, and $\varepsilon_{it}$ is defined as the random effect.

A key assumption of Equation (1) is that the income and price elasticities of each country for energy products are independent of their development stages or stable over time and thus all the effects associated with economic development can be squeezed into the coefficients of $S_{it}$. Moreover, as Equation (1) can be regressed with sample countries involving into different levels of institutional arrangements, the comparison of these regression results can also be used to examine the potential impact of institutional arrangements associated with energy market on various energy consumption elasticity and its relationship with economic development.

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[1] Based on the BP Statistical Review of World Energy (2006), the spot price of crude oil before 1984 is set as the price of Arabian Light posted at Ras Tanura and that after 1984 is set as Brent dated price.

The appropriate measure of different economic development stages of a country has been a controversial topic in the literature on economic development. Many authors prefer to the use of trend proxies, such as the industrialization rate (or the share of secondary and tertiary industrial output over the total GDP), the urbanization rate (the share of the number of urban population over that of the total) and the industrial structural index of workforce, for this variable. Although those proxies reflect some characteristics of different stages of economic development, they may be generally biased when being incorporated into the estimation of energy consumption function since energy consumption is usually related to changes of the whole economy. For this reason, we use different ranges of GDP per capita (measured with 1984 constant price and adjusted with the purchasing power parity across countries) to generate a dummy variable (d_dgp) designed to capture the characteristics associated with industrialization along with economic development (with GDP per capita more than USD 5000 and less than USD 10,000 at the 1984 price taking the value of 1, otherwise 0) and its interaction term with price and income variables are included into the regression. Such design is consistent with Chenery, *et al*. (1986).

$$\gamma S_{it} = \gamma_1 \times d\_gdp + \gamma_2 \times d\_gdp \times P_{it} + \gamma_3 \times d\_gdp \times Y_{it} \qquad (2)$$

Where $\gamma$ is a vector of coefficients and the interaction terms between the dummy for economic development (d_gdp) and income and energy price are included.

The EMI index (as is shown in Equation (3)) is defined as the relative import of fossil fuel products, which is equal to the average import of a country's fossil fuel products from its trading partner over its population (Sheng & Shi, 2011). To account for the impact of geographical vicinity and country-specific scale effects, the average import of a country's fossil fuel products is defined as the weighted average of the $i$ country's import of fossil fuel products ($energy\_trade_{ijt}$) from each if its $n$ trading partner ($j$) with the weights being geographical distance between the two countries ($dis \tan ce_{ij}$) (obtained from Subramanian & Wei (2007)) and their population. Since the index generally increases as the country imports more fossil fuel from the neighborhood countries and deceases as domestic consumption) of

fossil fuel products increase (or decrease), it can be used to reflect the extent to which the country is involved in neighborhood energy market integration.

$$EMI\_TRADE_{it} = \frac{1}{n}\sum_n (energy\_trade_{ijt} / dis\tan ce_{ij}) \times 1 / Population_{it} \quad (3)$$

Estimation of our general model would seem to be quite simple using the standard ordinary least squares (OLS) method. However, this would be misleading with respect to its estimation due to the fact that most economic variables are non-stationary in their level form and this high auto-correlation may generate in-consistent estimators and inaccurate hypothesis tests (Granger & Newbold, 1974). To deal with this econometric problem, we use the dynamic panel data (DPD) regression technique developed by Arellano & Band (1991), Arellano & Bover (1995) and Blundell & Bond (1998) in this study. The advantage of the method is that it can make full use of the combinations of different variables to eliminate the endogeneity between independent variables and the residuals (or the co-integration of the non-stationary series) and as a result, both the long-term and short-term elasticities of energy consumption can be specified.

For a group of non-stationary series, Equation (1) can be re-arranged in a structural form to detail the long-run and short-run dynamics of a group of integrated variables:

$$\Delta Z_{it} = \eta + \sum_{j=1}^{n} \Gamma_j \Delta Z_{jt-ji} + \pi Z_{it-1} + \gamma S_{it} + u_i + \varepsilon_{it} \quad (4)$$

where $Z_{it}$ is a vector of $I(d)$ variables, $\varepsilon_{it}$ is a vector of white noise residuals, and $\eta$ is a constant vector (representing the time trend). The adjustments to disequilibrium are captured over $n$ lagged periods in the coefficient matrix $\Gamma_j$.

Following Roodman (2006), we can specify suitable instrumental variables from the lagged or differentiated dependent and independent variables and use the difference and system GMM methods to investigate the relationship between integrated series with dynamic panel data.[2] Obviously, for a long-run relationship to

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[2] The Johansen (1991) test orders linear combinations of the different variables using eigen values, and then sequentially tests whether the columns of the $\alpha$ matrix are jointly zeros.

exist, at least the first column must contain non-zero elements. Thus, this co-integrating relationship specified in Equation (4) represents the foundation of a complete dynamic panel model and the regression which allows us to compare the immediate and overall average elasticities of energy demand across countries.

Finally, the data used in the above regression covered 71 countries and regions for the period 1965-2010. The data for energy consumption in each country and that for the real price of crude oil come from BP Statistical Review of World Energy (BP, 2011). The data for population and GDP (calculated with the constant price and adjusted for purchasing power parity) come from the World Development Indicators (World Bank, 2012).

## 4. Empirical Results

### 4.1. Model Selection and Benchmark Results

Before estimating any relationship between energy consumption and its explanatory variables, one may need some identification strategy either from economic or statistical perspectives. Specifically, it is assumed that all lagged independent variables on the RHS of Equation (4) are exogenous so that their further lagged or differentiated items can be used as the instrument variables for GMM estimation.[3] Based on Roodman (2006), we first differentiate the regression function (say, Equation (4)) to remove country specific effect ($u_i$) and thereafter produce an equation that is estimable by instrumental variables and use a Generalised Method of Moments estimator for coefficients using lagged levels of the dependent variable and the predetermined variables and differences of the strictly exogenous variables. The results from both a difference GMM and system-GMM estimation are compared to examine the autocorrelation of the logged energy consumption (with Equation (5)).

$$\ln C_{it} = \theta \ln C_{it-1} + \sum_{t=1}^{T} D_{it} + u_i + \varepsilon_{it} \qquad (5)$$

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[3] This assumption is only made for simplicity, and the results from the endogenous independent variables are shown in Appendix A.

where $D_{it}$ is a group of lagged independent variables.  The results show that the coefficient of $\ln(C_{t-1})$ is 0.95 and the significance level is ($Z = 58.45$) close to 1 per cent ($m_1 = 0.002$, $m_2 = 0.026$, Sargan-Hassen test=1).  According to Blundell & Bond (1998), this suggests that a system GMM estimate will be more suitable than the difference GMM estimation.  Furthermore, we use the Arellano-Bond test for AR(1) and AR(2) in first differences to choose the suitable lagged periods for dependent and independent variables and the Sargan-Hassen test to specify the combination of instrumental variables for the system GMM estimation.  Finally, we eliminate the insignificant independent variables from the regressions with no dummy for economic development, with only intercept for economic development and with intercept and interaction terms, and the results are shown in Table 1.  A further split of the sample into countries with high and low EMI indexes are also used to examine the impact of different institutional arrangements associated with energy market on the estimated energy income and price elasticities, and results are shown in Table 2.  There are two interesting findings shown below.

## 4.2. Impact of Economic Development on Energy Consumption

First, there exist some significant income and price elasticities for energy demand with the cross-country data over time and in particular there are significant time structures for these income and price elasticities for energy demand which is different from the results obtained from the previous studies on cross-country studies (Dahl, 1992).  From column 1 of Table 1, we have the estimated energy demand function as below:

$$d\ln C_t = -0.241 + 0.555 d\ln Y_t - d\ln P_t - 0.081[\ln C_{t-1} - 0.407\ln\ln Y_{t-1} + 0.012\ln P_{t-1}] \quad (6)$$

from which both the short-run and long-run income and price elasticities can be calculated.

**Table 1: The GMM Estimations of Price and Income Elasticity of Energy**

|  | No Dummy | With Dummy | With Interaction |
|---|---|---|---|
| Dependent variable: lnenergy_consumption_per capita |  |  |  |
| lnenergy_consumption_per capita (t-1) | 0.919*** | 0.918*** | 0.908*** |
|  | (0.007) | (0.007) | (0.007) |
| lnprice (t) | -0.008*** | -0.008*** | -0.007*** |
|  | (0.003) | (0.003) | (0.000) |
| lnprice (t-1) | 0.007*** | 0.007*** | 0.006*** |
|  | (0.003) | (0.003) | (0.002) |
| d_gdpXlnprice(t) | - | - | 0.006*** |
|  | - | - | (0.006) |
| d_gdpXlnprice(t-1) | - | - | -0.008* |
|  | - | - | (0.006) |
| lngdp_percapia (t) | 0.555*** | 0.555*** | 0.582*** |
|  | (0.027) | (0.027) | (0.032) |
| lngdp_percapita (t-1) | -0.522*** | -0.523*** | -0.538*** |
|  | (0.027) | (0.027) | (0.033) |
| d_gdpXlngdp_percapita(t) | - | - | 0.257*** |
|  | - | - | (0.065) |
| d_gdpXlngdp_percapita(t-1) | - | - | -0.235*** |
|  | - | - | (0.064) |
| d_gdp | - | 0.006*** | 0.283*** |
|  | - | (0.001) | (0.096) |
| Constant | -0.241*** | -0.237*** | -0.332*** |
|  | (0.056) | (0.056) | (0.068) |
| Number of observations | 2,272 | 2,272 | 2,272 |
| Wald Test | 50,539 | 50,546 | 50,790 |

*Note*: the numbers in brackets are the standard errors. "*", "**" and "***" represent the coefficients are significant at 10 per cent, 5 per cent and 1 per cent level respectively. Source: Authors' own estimations. Year dummies have been included to control for the year-specific effects.

The short-run and the long-run price elasticities are -0.008 and -0.012 respectively. The finding that elasticities are less than one is expected since energy is a necessity. The finding that the absolute value of the short-run own price elasticity is lower than the long-run one is also expected. A feasible explanation is that energy products lack substitutes especially in the short run but in the long run exploration of new technology and energy products may reduce the energy demand. For example, when there is a hike of oil prices, customers can reduce their vehicle

use immediately and later, in the long run, they can also use more energy efficient vehicles.

Equation (6) also shows that the short-run and the long-run income elasticities are 0.555 and 0.407 respectively. That is, the absolute value of the short-run income elasticity is higher than the long-run elasticity. The relatively low income elasticity in the long run could be explained that as time goes on, there is a shift away from traditional energy consumption technology towards new energy consumption technology; and improved energy usage efficiency. In addition, income growth leads to exploration of new substitute for energy products in production and consumption (Jones, 1991), and thus the income elasticity will be lower in the short run as compared to the long run.

The above finding of different long-term vs. short-term price and income elasticity also helps to explain the inconsistency between the cross-country and country specific estimates on energy demand. Unlike this present study, previous studies on cross countries samples show no significant price elasticity, which is inconsistent with the impact of international oil price on demand, see IEA (2011). The reason is likely that the analytical approach adopted in the previous study only allows them to show the short-run effects. As there is no substitute for energy products in production and consumption for the short term, it is of no surprise that there is no significant price elasticity.

Second, the different stages of economic development play an important role in affecting the energy demand in addition to the income and price effects. To illustrate this point, we make use of the dummy for economic development level (as shown in column 2) and their interaction terms with price and income (as shown in column 3) and the related lags to estimate the income elasticity of energy consumption for different stages of a country's development.

The estimated results obtained from the regression incorporating the interaction terms between dummy for economic development level and price and income variables and its lags show that countries at different economic development stages may have different price and income elasticities. Compared to other countries, countries when coming to the stage of industrialization and urbanization process may tend to have relatively lower price and income elasticities in both the short and long

run. Estimated price and income elasticities for countries expiring rapid economic growth is around -0.016 and 0.475, which are lower than the coefficients for countries at lower development stage, say -0.042 and 0.712. This suggests that as economies are experiencing industrialization and urbanization processes, their energy consumption is less likely to respond to the price and income level. Observation that fast growing regions have lower price elasticity is demonstrated at least in the case of oil (Dargaya & Gately, 2010).

Moreover, in both cases, the estimated coefficients of the dummy for economic development level are positive and significant at 1% level. This suggests that an economy when coming to the stage of industrialization and urbanization process may consume more primary energy products than countries in other economic development stages. In other words, as GDP per capita increased from USD 5,000 to USD 10,000 (1984 constant US dollars) (or at the industrialization stage), there will be a significant increase in energy demand in addition to the income effects. An explanation for this phenomenon is that: when an economy undergoes transformation from an agricultural society to an industrialized society the more capital- and energy-intensive sectors will substitute the labor-intensive sectors in dominating the production (Humphrey & Stanislaw, 1979). This could also be the case in the advanced development stage where services, while not high energy-intensive industrial goods, are the driver of economic growth. Another explanation is that associated urbanization will drive more energy demand than the agricultural society through food delivery, infrastructure development and maintenance, changing domestic activity (Jones, 1991). In other words, the relationship between economic growth and energy demand will be changed when a country starts and finishes industrialization. Therefore, those energy outlooks that did not take consideration of such structural changes would be questionable.

Combining the above two points, Figure 4 provides the simulated relationship between energy consumption per capita and stages of economic development, which shows that the marginal contribution of industrialization towards percentage changes in energy consumption won't reach the peak until the per capita income level reaches USD 10,000. These findings can be used to explain the pattern of wave-by-wave increases in energy demand from East Asia following the development process of

different countries in this region during the past four decades, even if the price elasticity is assumed to be constant across countries. This also helps us to identify the future trend of changing world energy demand as some new industrialized countries such as China and India move along the path characterized with the "continuous change and breaking-points". This also means that we should expect more energy demand from China and India in the past decade when industrialization and urbanization is at a historic high speed.

**Figure 4: Simulated Relationship between Energy Consumption and Changes in Income**
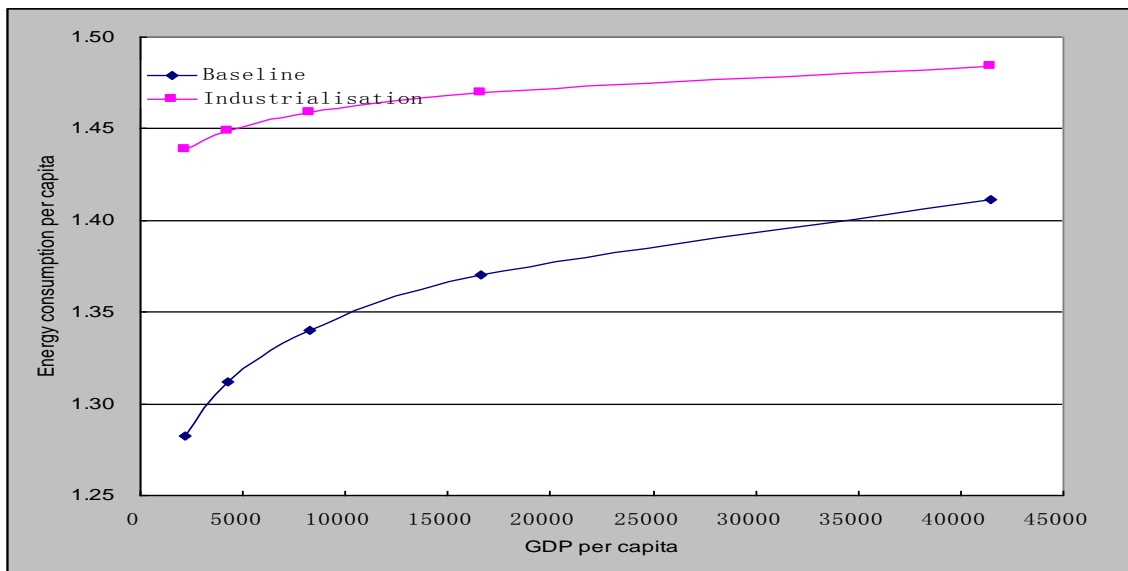


*Source*: Authors' own calculation.

## 4.3. Role of Energy Market Integration in Affecting Energy Consumption

How do different institutional arrangements associated with energy market may affect energy demand of countries at different economic development stages? To answer this question, we adopt a regression (similar as that for economic development) to re-estimating the price and income elasticity of energy consumption with the control of the dummy for energy market integration and its interaction with price and income included separately. The dummy for EMI is evaluated against the average EMI index: countries with high EMI indexes taking 1 and countries with low EMI indexes taking 0. The regressions have been made for all samples and countries with high economic growth as a robustness check. For simplicity, there is no

distinction between the long-term and short-term effects in this exercise, and the estimation results are shown in Table 2.

**Table 2: Impact of EMI on Energy Consumption Elasticities**

| | All Sample | | High Growth/Industrialization Countries | |
|---|---|---|---|---|
| | With Development Dummy | With Interaction Term | With Development Dummy | With Interaction Term |
| Dependent variable: lnenergy_consumption_per capita | | | | |
| lnenergy_consumption_percapita (t-1) | 0.966*** | 0.958*** | 0.897*** | 0.900*** |
| | (0.007) | (0.008) | (0.013) | (0.014) |
| lnprice (t) | -0.008*** | -0.010*** | -0.009** | -0.027*** |
| | (0.003) | (0.003) | (0.004) | (0.010) |
| lnprice (t-1) | 0.007*** | 0.010*** | -0.002 | 0.012 |
| | (0.003) | (0.003) | (0.004) | (0.009) |
| EMI_DummyXlnprice(t) | | 0.002 | | 0.021** |
| | | (0.004) | | (0.010) |
| EMI_DummyXlnprice(t-1) | | -0.006* | | -0.016* |
| | | (0.004) | | (0.009) |
| lngdp_percapia (t) | 0.523*** | 0.521*** | 0.386*** | 0.421*** |
| | (0.028) | (0.028) | (0.046) | (0.051) |
| lngdp_percapita (t-1) | -0.516*** | -0.516*** | -0.360*** | -0.368*** |
| | (0.028) | (0.028) | (0.045) | (0.046) |
| EMI_DummyXlngdp_percapita(t) | | 0.010** | | -0.032* |
| | | (0.005) | | (0.019) |
| EMI_DummyXlngdp_percapita(t-1) | | 0.001 | | 0.005 |
| | | (0.002) | | (0.004) |
| EMI_Dummy | 0.012*** | -0.070* | 0.043*** | 0.276 |
| | (0.006) | (0.037) | (0.008) | (0.179) |
| Constant | -0.037*** | -0.028 | -0.103 | -0.337* |
| | (0.058) | (0.063) | (0.068) | (0.189) |
| Number of observations | 2,272 | 2,272 | 955 | 955 |
| Wald Test | 48,177 | 48,533 | 15,035 | 14,902 |

*Source*: Authors' own estimation.

Given the same condition, energy consumption per capita in countries with higher level of involvement in energy market integration are significantly higher when the price and income elasticities are assumed to be same. The estimated

coefficients in front of the dummy for energy market integration from both regressions are positive and significant at 1% level (shown in columns (1) and (3) of Table 2). However, when the interaction terms between the dummy for energy market integration and price and income variables (as a substitute for the dummy for energy market integration itself) are added into the regression, the estimation result shows that the coefficients in front of the dummy variable of energy market integration become less significant. This suggests that the difference in energy demand among countries with different levels of involvement energy market integration comes from their different price and income elasticities.

Furthermore, to understand the impact of EMI on the energy consumption behaviors of countries at different economic development stages, we convert the estimated coefficients obtained from the regression into the corresponding price and income elasticities shown in Table 3.

On average, the countries with a higher level of involvement in energy market integration tend to have no significant difference in energy consumption level but do have a relatively lower income elasticity and higher own-price elasticity. In other words, policy towards energy market integration tends to improve the flexibility of a country in meeting its energy demand through the international market.

**Table 3: The Impact of EMI on the Price and Income Elasticities**

|  | All samples | | High income country | |
|---|---|---|---|---|
|  | emi | base | emi | base |
| Price Elasticity: long term | -0.15 | 0.00 | -0.22 | -0.15 |
| Price Elasticity: short term | -0.01 | -0.01 | -0.01 | -0.03 |
|  |  |  |  |  |
| Income Elasticity: long term | 0.35 | 0.32 | 0.20 | 0.52 |
| Income Elasticity: short term | 0.53 | 0.52 | 0.39 | 0.42 |

*Source*: authors' own estimation.


## 5. Policy Implications


As argued in the previous section, the results show that EMI does help to strengthen the energy supply to the region as a whole so as to increase the income

elasticity of energy consumption of countries with rapid economic growth driven by factors such as industrialization and urbanization, whose further economic development may be restricted by high energy price and low-linkage between energy consumption and income. In addition, we also show that the future energy demand of the whole region can be better projected when accounting for country-specific characteristics related to economic growth and institutional arrangements.

The study may also offer policy makers a chance to understand countries' future paths of energy demand. Current energy outlooks, such as Kimura (2011), often assume liner relationship between economic growth and energy demand and reply on history trend. This will create at least two problems: countries with low/high history data will stay low/high, which are unrealistic. For example, the path of Cambodia and China in Figure 5. The likely difference for the forecasting between China and Cambodia is that Cambodia is on a long energy intensity path due to agriculture dominated economy which China is on a rapid growing energy intensity path due to industrialization and urbanization.

**Figure 5: Economic Development and Energy Demand in Selected Countries, 1990-2005**
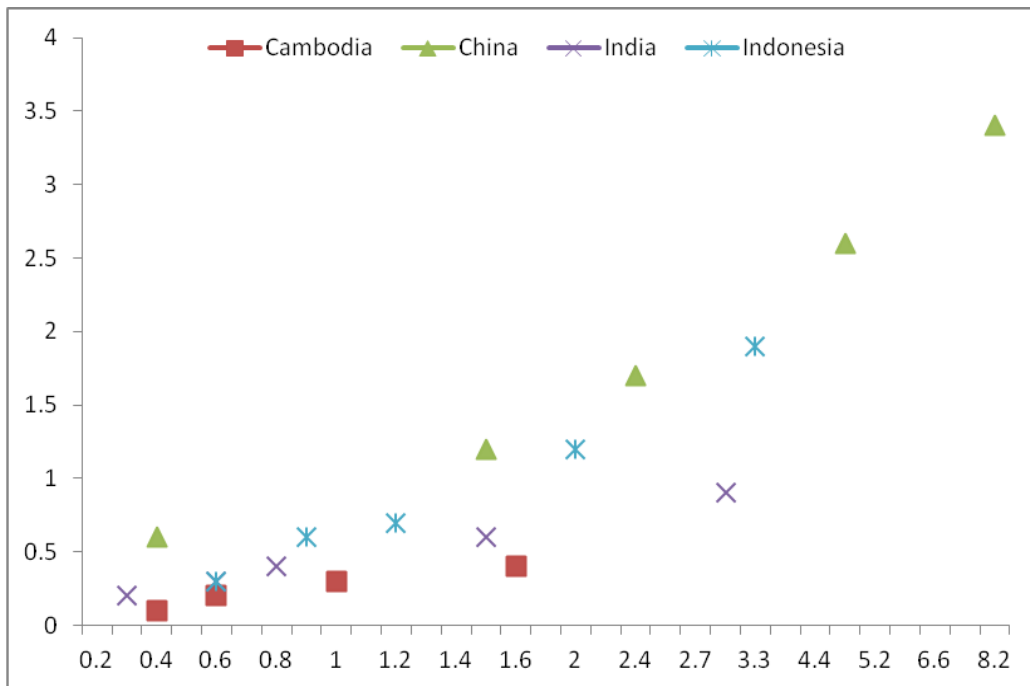


*Source*: Kimura (2011).

However, if we consider the structure change in the relationship between economic growth and energy demand, the future scenarios would be different. As has been shown in Figure 4, in the advanced stage of development, the growth of energy demand would slow down. The change of relationship will change the regional energy outlooks significantly. Earlier developing countries, like China may demand less energy in the future while later developing countries, like Cambodia, may demand more. The changes in policy implications could be: the region could be relatively easy about the demand from China; instead, it needs to pay more attention to later developing countries; the later developing countries need to prepare for their booming demand of energy and consequent environmental impact. Improvement of supply capacity in those later developing countries thus should be a policy priority; In contrast, earlier developing countries should switch focus from the supply side to the demand side, such as energy saving and energy productivity.

Clearer understanding of energy trend, in particular, structure change, also helps energy modelers to improve their forecasting. Structural changes were deliberately omitted by energy modelers in predicting long run energy outlooks, which, however, play an important role in shaping future energy policy, and technical development. However, there is a general trend that the outlook of energy demand tends to extend recent trend to the future, whilst avoiding structure change. One of the reasons for this trend is that modelers themselves are not sure about the structure changes and thus tend to minimize their risks of predictions by not proposing scenarios that will significantly increase the level of acceptance of their outlooks (Matsui, 2011). Considering the fact that EMI has been implementing in many regions, EMI structural change would be popular and have impacts on a large scale. Therefore, a deep understanding of its impacts on energy trend is beneficial and necessary for future policy making.

Another policy implication is that EMI can smooth the fluctuation of energy demand, which will improve energy security and thus should be firmly promoted. In particular, economies that are undergoing industrialization and commercialization should adopt EMI, which can increase price elasticity of energy demand. With increased elasticity, the economy will be more resilient to price volatility.

## 6. Conclusion

This study uses a dynamic panel regression technique to estimate a cross-country demand equation for energy products with 71-country and 45-year long data and examines the cross-country income and price elasticities of energy consumption during the period of 1965-2010.

The results show that countries in different stages of economic development and institutional arrangement associated with energy market would demonstrate different levels of demand for energy consumption and thus the energy consumption related to price and income elasticities.  In particular, we found that countries at specific economic development stages may have relatively higher income elasticity or relatively lower price elasticities due to economic structural changes, which in turn may impose additional pressure on the demand side of the international energy market.

Energy market integration can help to reduce such a pressure by improving the domestic energy supply and thus reduce the price elasticity.  This finding can be used to shed light on explaining the recent boom in China's and India's ever increasing demand for energy products in the East Asian Submit region, which has important policy implication for assessing the role of EMI in the region to maintain sustainable regional economic development.

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