Chapter 10

Economic Growth, Regional Disparities and Energy Demand in China: Implication for Energy Market Integration in East Asia

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CHAPTER 10

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East Asia is actively promoting Energy Market Integration (EMI). The integration process, however, takes a long time and there is no clear picture of its future. This paper attempts to explore a possible scenario for an integrated energy market in East Asia by analysing China's cross-province energy demand, which demonstrates a impeccable integrated energy market. The panel data of 30 provinces from between 1978 and 2008 indicates that economic development tends to increase the energy demand, while EMI will generally reduce the response of energy consumption prices to energy demand and production through cross-province trade of energy products. In addition, the effects can be reduced through reducing transportation costs and improving marketisation levels. This finding has important policy implications since it suggests that EMI is beneficial to the region by facilitating the diversified energy demand pattern across countries.

Keywords: economic growth, regional disparities, energy demand, energy market integration, China
JEL Classification: O13, O53, F15

1. Introduction

There has been rapid economic growth in China over the past three decades driven primarily by two important factors, industrialisation and urbanisation. As one of the major inputs into these twin processes, China's energy demand has been strong during that period, outstripping domestic production and making the country a net importer of crude oil since 1993 and coal since 2009. These changes in energy demand, due to economic growth, is reshaping the pattern of energy trade in the East Asian Summit (EAS) region and throughout the world. This makes understanding the future trends in China's energy demand a matter of both national and global importance (Lee, 2005; Lee and Chang, 2008).

Examining the relationship between economic growth and energy demand in China is a challenging task from an empirical perspective. Although there is evidence regarding to the relationship between economic growth, its drivers, and energy demand for a number of large advanced economies (e.g., the United States and the European Union), it is unclear which of these relationships are relevant to understanding how economic growth and its drivers affect the total energy demand and distribution in China. In particular, it is likely that China's energy demand will be unique, because of significant regional disparities in industrialisation and urbanisation that are not replicated elsewhere.

Using time series and cross-province data, this paper analyses the changes in provincial-level energy demand due to industrialisation and urbanisation, two important drivers behind economic growth. It also examines their impact on the market price of energy products between 1979 and 2008. The purpose is to clarify the role of a unified energy market to deal with the gap between energy demand and supply, which is the result of imbalanced cross-regional economic development. Three questions will be answered in sequence: (1) how to reduce the provincial-level energy demand from total energy consumption given the absence of accurate available data; (2) the impact of energy demand on energy consumption prices at the provincial level in China where there is already an integrated energy market; and (3) other factors such as cross-province disparities in transportation costs and market monopoly, which affect energy prices variation across regions.

The results show that economic growth and its drivers are the most important factors affecting energy demand and its distribution across regions in China in recent years and raising the market price of energy products. Moreover, in an integrated energy market, price effects of the increased energy demand have been significantly reduced. This suggests that market integration helps alleviate the impact of economic growth on energy demand in specific regions. In addition to market integration, some regional specific factors, such as transportation costs and market structure, can also affect energy consumption prices. Consequently, public policies need to be carried out with market integration in order to minimise the negative impact of increased energy demands due to economic growth.

Contributing to the previous literature, this paper explores the empirical relationship between the market price and energy demand by using cross-provincial data in China in an integrated market. This provides insights into the role of international market integration policies in solving the imbalance between energy demand and supply due to the imbalance of economic growth within the EAS region. The results will inform EAS policy makers on the possible scenarios of achieving a fully EMI.

The case study on China is also expected to have important policy implications for Energy Market Integration (EMI) in the EAS region. East Asia is actively promoting EMI but the integration process takes time and there is no clear picture of its future. Using China's case, this paper attempts to provide a possible scenario of an integrated market by analysing the cross-province energy demand in China.

Rapid economic growth has taken place in the major East Asian countries over the past few decades and has significantly increased the energy consumption in those countries. It is, however, still unknown how the increased energy demand is linked to economic growth in the region and whether market integration will help to alleviate the impact. In addition, there are huge disparities among the EAS countries such as difference in income level, which was about 60 times in 2010 (World Bank, 2012). Such similarity encouraged us to study the future of EAS' EMI using China's provincial data. Although the GDP per capita among the provinces is only 5 time more[1] and the average size of the economy of each province is larger than many EAS countries.

The remainder of this paper is arranged as below. Section 2 discusses the relationship between economic growth and energy demand from a theoretical perspective. Urbanisation and industrialisation are identified as the two important factors driving energy demand across regions in China. Section 3 develops the empirical method. In particular, economic development induced energy consumption is split from total energy demand at the provincial level by using information on urbanisation and industrialisation, so that its impact on energy consumption prices in an integrated market can be examined. Sections 4 and 5 analyses the empirical results. As expected, economic growth is a major driver of energy demand and leads to a regional disparity in consumption price, while integrated market arrangement tends to be a remedy. Section 6 extends the discussion to the international market and produces policy implications for energy market integration in the EAS region and section 7 makes the conclusions.

1 http://news.xinhuanet.com/local/2012-02/07/c_122667889.htm

2. Economic Growth and Energy Consumption: Implications for Regional Analysis

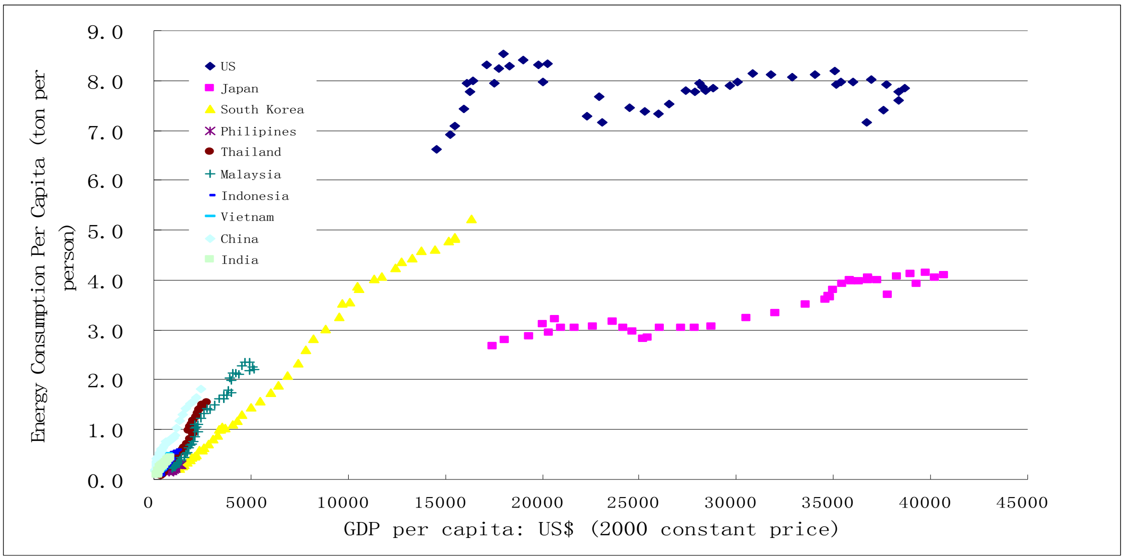
How economic growth can affect energy demand and its distribution across regions is an on-going debate in the literature. Theoretically, stable economic growth was considered a sufficient condition for stable energy consumption growth by its on-going impact on energy-intensive sectors, such as capital equipment, transport, and consumer durables. In practice, however, many developed economies experienced a slowdown in energy consumption growth, despite continued economic growth overall (Crompton and Wu, 2005). This gave rise to the concept of an inverted U-shaped long-term relationship between GDP growth and energy consumption growth, or equivalently between per capita GDP and per capita energy consumption.

The asymmetric relationship between GDP and energy consumption is a consequence of economic growth and development. The two major components of which are industrialisation and urbanisation (Sheng, *et al.*, forthcoming). At low levels of per capita GDP—in the pre-industrialisation stage described above—the national output is concentrated mainly in the primary industry, which is characterised by a relatively low per capita energy consumption. As the per capita GDP rises and the economy enters the industrialisation stage, changing preferences in production and consumption produce a gradual shift towards more energy-intensive products, including infrastructure and housing construction, investment in capital equipment, and the energy intensive manufacturing industry. Urbanisation rates rise significantly during this stage as well, underpinning much of the change in consumer preferences and industrial structure. During this stage, energy consumption growth exceeds GDP growth and per capita energy consumption increases considerably. In the post-industrialisation stage, while per capita income continues to rise, urbanisation rates tend to plateau and this, combined with the on-going shift towards services and high technology products, drives the growth of per capita energy consumption down.

Historical data for the early industrialisers illustrates the idea of a relationship between per capita energy consumption growth and per capita income growth, although it is clear that the relationship varies over time and place. In 1973 the United States reached peak energy consumption per capita of 8.5 tons of oil equivalent with a GDP per capita of $180,000.[2] Energy consumption per capita remained above 8.0 tons of oil equivalent until 1980 and fell as low as 7.1 tons of oil equivalent in 1983, fluctuating between 7.1 to 7.9 tons of oil equivalent since that time. Japan peaked later than the US with a lower per capita energy consumption of 4.1 tons of oil equivalents and a higher GDP per capita of $36,700. In 1970, Britain reached its peak energy consumption at a lower per capita energy consumption than the US with a lower per capita income, while Germany's peak energy consumption was higher and occurred at a lower per capita income level. In contrast, energy consumption per capita in South Korea and Brazil, recent industrialising economies, has not yet revealed any downturn. By 2010, South Korea's energy consumption per capita reached 5.2 tons of oil equivalents, which was around 10 times the level in 1974. During this period per capita income increased five-fold to reach $16,373, close to the turning point for the United States but well below Japan's. By 2010, Singapore's per capita energy consumption of 13.8 tons of oil equivalents was higher than any of the early industrialisers' peak levels, as was its per capita income of $32,538 (BP, 2011; World Bank, 2012).

[2] Data used here is drawn from World Bank Development Indicators and BP Energy Statistics 2012. All per capita income reported in 2000 prices.

Figure 1: Relationship between Energy Consumption per capita and GDP per capita: 1965-2010



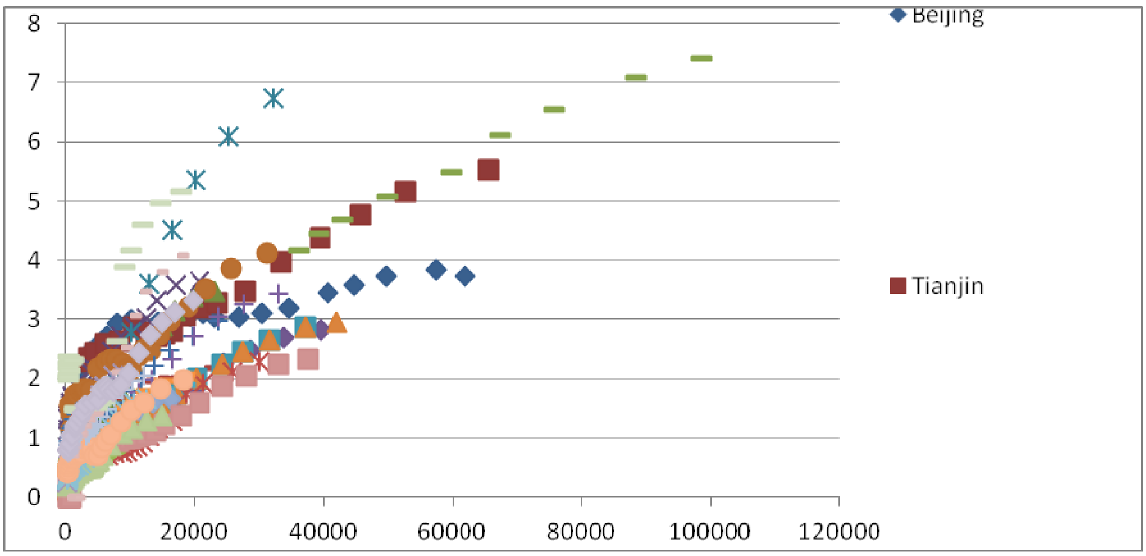
Source: World Development Indicator Database, World Bank (World Bank, 2012).

Although cross-country case studies provide some useful information, it is still unclear whether it is relevant to understanding how economic growth and its drivers may affect the total energy demand and its distribution in China.

As an alternative to using the experiences of other countries to understand the present and future trajectory of China's energy demand, regional-level (particularly provincial level) analysis offers a productive line of research. While there are certainly some regional specific characteristics that are likely to make energy demands differ across provinces, as they do across countries, it seems reasonable to assume that China's less-developed regions are likely to replicate the past trends of its leading provinces than that of other countries (Demurger, 2001). In the case of energy, a catching up period might be expected between poor and rich regions (Crompton and Wu, 2005). This is because all regions within China (under the direction of a unique central government) share the same development strategy and build their energy demand in an integrated energy market. Therefore, the disparity in economic growth can be used to derive the variation in the induced energy demand across regions, such as the role of market integration in reducing the gap between energy demand and supply, and should be thoroughly examined.

In line with the substantial differences in terms of economic development among China's provinces, there are also substantial differences in energy consumption per capita. As illustrated in Figure 1, Shanghai's energy consumption per capita of 7.4 tons of oil equivalents in 2008 was 6.2 times higher than Jiangxi's, which was only 1.2 tons of oil equivalents per capita. Shanghai's GDP per capita is 6.7 times higher than Jiangxi. Although both Shanghai and Jiangxi's energy consumption per capita are still increasing on account of their relative lower income per capita (relative to industrialised countries), the potential for further increase in Shanghai's energy consumption per capita would be less than Jiangxi, since its per capita energy consumption is past the peak of both Britain and Japan. A similar pattern can also been observed for the trans-temporal changes in energy consumption in the same province where energy consumption per capita is increasing with their GDP per capita.

Figure 2: Relationship between Energy Demand and Income per Capita across Regions in China



Source: China Energy Statistical Yearbook, various years.

The above theoretical analysis of the inversed U-shaped relationship between energy consumption and income per capita provides useful insights to explain the interaction between economic development, regional disparity, and energy consumption across regions. Generally, an economy experiencing an industrialisation stage may consume more energy products than their counterparts in the pre and post-industrialisation stages. Since such increased energy demand is a temporary phenomenon, it could be satisfied by re-allocating the resources to more efficient users. As a consequence, the aggregate energy demand would be more stable in an integrated market as long as there is an efficient re-allocation mechanism and all participants could overcome the bottleneck of energy consumption for industrialisation.

Although the logic is coherent, testing it empirically is still a challenge. On the one hand, the statistics for total energy demand contain many regional specific factors beyond economic development, including consumption preference changes and production technology differences among others. On the other hand, although the GDP per capita is a good measurement of economic development, the variable is highly correlated to the energy consumption income effects and thus could not be directly used. To deal with these two problems, the following proposes an instrumental method to reduce the total energy demand into economic development related demand and other energy demand by using the Chinese provincial level data. A further regression of energy consumption price in the integrated energy market on economic development, induced energy demand may provide implications on how market integration can alleviate the demand shocks.

3. Methodology and Data

To identify the energy demand related to economic development, it is essential to identify the factors that characterise economic development stages driving the energy demand. Based on the work of Chenery, *et al*. (1986),we choose three main factors characterising economic development which affect energy demand in China, these include industrialisation, urbanisation, and the fixed asset investments. While other factors, such as consumer preferences and energy saving technology progresses play a role in determining energy demand, the above three factors determine a significant proportion of energy consumption in China at the regional level (Golley, *et al*., 2013). These factors are representative of the demand-side perspective, which is the primary interest here. The importance of the last item stems from the observation that levels of investment will increase as the industrial structure becomes more capital intensive and as the demand for infrastructure associated with urbanisation rises (Kuznets, 1965).

Using the information from province-level industrialisation, urbanisation, and fixed asset investments, a dynamic panel data regression (Arellano and Bond, 1991) can be used to reduce total energy demand to specify the impact of economic growth on energy demand. Specifically, we regressed the total energy consumption on measures of industrialisation, urbanisation and fixed assets investment per capita, and use the coefficients of these three variables to predict energy demand associated with economic development. To make the regression immune to potential endogeneity/simultaneity problems due to the omitted variables, we adopted the General Method of Moment (GMM) for the estimation.[3] The difference between the total energy demand and the predicted energy demand associated with economic

[3] A similar method has been used by Castro, *et al*. (2012) for splitting the firms' sunk costs from total costs.

develop is defined as the energy consumption due to other factors (including regional specific effects).

Equation (1) specifies the regression model that is used for such estimation:

$$\ln(Energy_{it}) = \beta_0 + \beta_1 Industrialization_{it} + \beta_2 Urbanization_{it} + \beta_3 \ln(FixedAssetInv_{it}) + u_i + \varepsilon_{it} \quad (1)$$

Where $\ln(Energy_{it})$ is the apparent energy consumption per capita in province i at time t, $Industrialization_{it}$, $Urbanization_{it}$ and $FixedAssetInv_{it}$ are an industrialisation index (the share of secondary and tertiary industry in total output value), the urban share of the population and the amount of fixed asset investment per capita at 2000 constant prices. u_i represents the time invariant specific effects of each province. It is to be noted that Equation (1) is not a specification based on the demand function. Instead, it is derived from the major components of energy demand at the aggregate level.

Data used for reducing energy demands are drawn from a variety of sources. The data for the consumption of energy products by provinces is available for 30 provinces between 1978 and 2008 in various issues of the China Energy Statistical Yearbook.[4] The industrialisation index, urban population shares, and fixed asset investment ratios are also available for the same 30 provinces and the same time period in China's Comprehensive Data Collection 60 Years: 1949-2008 (NBS, 2010).

After reducing the provincial energy demand per capita, we can further analyse the impact of energy demand per capita on equilibrium prices in market at a steady state. The basic model is an empirical function linking the equilibrium energy consumption price to demand, supply, and other policy instruments. The function is

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[4] Sichuan (because Chongqing start to split since 1995), Fujian, Hainan, Tibet (the latter three have no complete datasets).

derived by equalising a standard energy demand, a standard energy supply function, the detailed derivation and is shown in Appendix A.

In this function, energy consumption prices in equilibrium are determined by energy demand due to different drivers, energy production, and other factors X_{it} (or W_{it} and Z_{it} in Appendix A), as shown in Equation (2). These factors affecting shift of demand and supply curves include preference/technology changes and other policy instruments such as public infrastructure, market arrangements, and so forth.

$$\ln(Price_{it}) = \gamma_0 + \gamma_1 \ln(\hat{Energy}_{it}) + \gamma_2 \ln(Prod_{it}) + \gamma_3 Tra_{it} + \gamma_4 Mkt_{it} + v_i + u_{it} \qquad (2)$$

Where $\ln(Price_{it})$ is the logarithm of energy consumption price, $\ln(\hat{Energy}_{it})$ is the logarithm of various energy demand per capita, which can take the value of total energy demand, energy demand due to economic development, energy demand due to other drivers, and $\ln(Prod_{it})$ the energy production representing the possible impact of factors from energy production perspective.

To identify the potential simultaneity relationship between energy consumption and local production, the local production of energy products determination is introduced, including labour and capital or the production function.

$$\ln(Prod_{it}) = \gamma_0 + \gamma_1 \ln(Labor_{it}) + \gamma_2 \ln(Capital_{it}) + v_i + u_{it} \qquad (3)$$

It is to be noted that in the controlled factors in Equation (2), we have also added two additional variables, Tra_{it} (transportation costs) and Mkt_{it} (marketization levels), in order to account for the cross-province flow of energy products. We can do so because: (1) after accounting for the demand and supply factors, energy prices are mainly determined by the cross-province energy flow, which is not directly observed; and (2) there are no barriers related to institutional arrangements within the same country, since there is an integrated energy market. Thus, the impact of transportation costs due to public infrastructure and market structure on the cross-province energy allocation can be examined.

Based on Equations (2) and (3), the effects of various energy demands on market prices across provinces can be estimated when different energy demands are used. The comparison of coefficients in front of various energy demands can be used to distinguish the effects of different energy demands. In particular, the effects of transportation costs and marketisation indexes can also be specified.

Data used to identify the impact of energy demand on market prices were obtained from the CEIC database. Specifically, the indicator for transportation costs is defined as the within-province freights per capita. The higher the indicator is, the lower the transportation costs are and more energy products can flow in and out of the province. For the indicator of marketisation we used the output value of non state-owned enterprises and non-collective enterprises dividing the total output value of all enterprises. The argument is that in China, the production of state-owned enterprises and collective enterprises are sourcing energy products (as intermediate inputs) from the monopoly market. Thus, it is expected that the higher the marketisation ratio is, the higher the market monopoly power is and the more flexible the market is. As for the capital and labour used for energy production in each province, we aggregated the number of employed workers, the account value of capital stock (derived from fixed asset investment), and the capital services in several sectors including; coal mining, petrol extraction, petrol refining, coal, gas/steam, water/electricity generation, hot water, and gas supply by province for approximation.

Finally, we used the instrumental regression technique to estimate the panel data, which helps to improve the efficiency of the two-step regression procedure. A simultaneous regression using Equations (2) and (3) was also utilised with the control of cross-equation residual correlations for a robustness check.

4. Estimating the Provincial-level Demand for Energy Products, 1979-2008

It is widely believed that there are three main factors affecting energy demand in China, industrialisation, urbanisation, and fixed asset investments that results from the two processes. While other factors such as consumer preferences and energy-saving technology progress play a role in determining energy demand, the above three factors are highly related to economic development and are of primary interest.

Although total energy demand can reflect the impact of economic development on energy consumption at the national level, it cannot be used to capture the effect at the province level. The problems associated with using total energy demand are at least two-fold. First, the official statistics on energy demand are problematic in reflecting economic growth and its impact, as it is the balanced results from both the supply and demand sides. Without accounting for the supply-side factor, total energy consumption at the province level is likely to be biased towards provinces with more energy production. Second, and more crucial is that the total energy demand for each province is not only affected by economic development but it's also heavily influenced by other factors specific to individual regions. These factors typically consist of technology progress, consumption preferences, and historical traditions. For example, the total energy consumption per capita in Shanxi is higher than that in Guangdong due to its abundant resources in coal. Shanxi's economic development, however, is far behind that of Guangdong. Failure to deal with this problem may lead to inaccurate estimations of energy demand, thus making the wrong judgment on changes in energy consumption.

In order to deal with these problems, we used Equation (1) to build the relationship between energy demand and economic development. In particular, economic development is defined by three factor, industrialisation, urbanisation, and fixed asset investment. Moreover, to eliminate provincial and time specific effects, we adopted the system general method of moment technique for the estimations.[5] The estimation results are shown in Table 1. From this table, it is evident that industrialisation, urbanisation, and fixed assets investments play an important role in affecting the demand for energy, since their coefficients are all positive and significant at the one per cent level.

Table 1: Identification of Energy Demand due to Economic Growth: 1979-2008

	Energy Demand: Economic growth identified
Dependent variable: ln_energy_demand	
Industrialisation	0.459***
	(0.061)
Urbanisation	0.070*
	(0.039)
Fixed asset investment	0.208***
	(0.033)
Other control variables	Yes
	Significant
Year	0.009
	(0.007)
Constant	-21.017*
	(12.967)
Number of observations	421
R-squared	0.4431
F-statistics	482.13

Note: Authors' estimation.

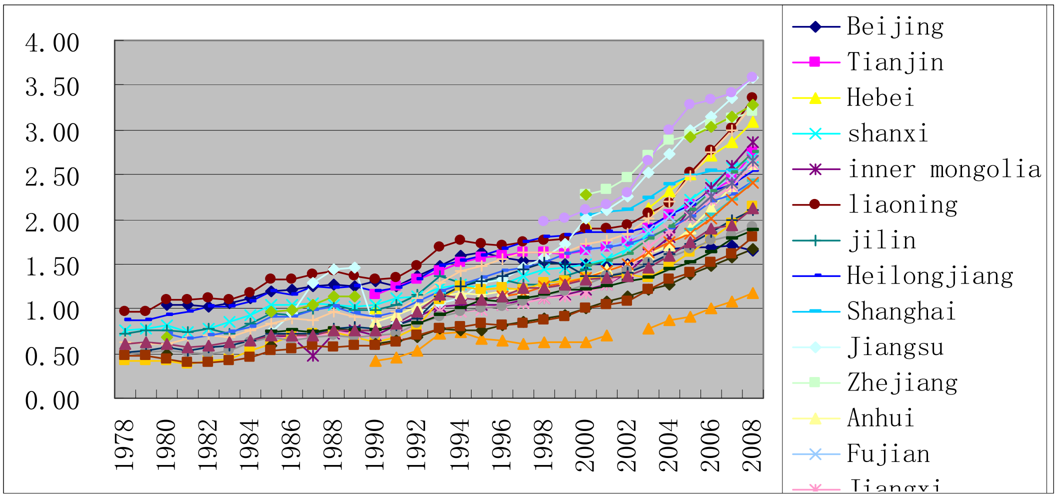
Using the estimated coefficients of industrialisation, urbanisation, and fixed assets investments, we can derive energy demand due to economic development by adding up their effects and the difference between total energy demand and energy demand due to economic development, which is defined as other energy demands.

[5] The choice between the system GMM and the difference GMM method is based on the Arellano-Bond test (Arellano and Bond, 1991).

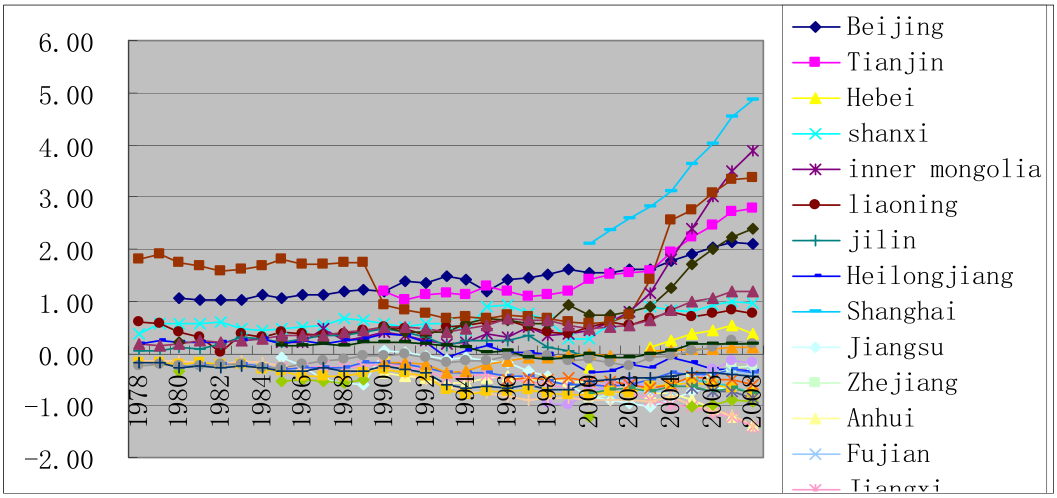
In Figures 3, we compared the estimated energy demand due to economic development and other energy demands between 1979 and 2008. As the two figures show, the two data series are quite different. There are numerous reasons for this divergence.

Figure 3: Comparison of Energy Demand due to Economic Development and other factors: 1978-2008

(a) Energy demand due to economic development



(b) Energy demand due to other factors



Note: Authors' estimation.

First, the estimated energy demand due to economic development has on average been increasing significantly compared to energy demand due to other factors.

Between 1978 and 2008, the average annual growth rate of energy demand due to economic development is 7.7 per cent a year, which is more than energy demand due to other factors at less than 1 per cent a year. Second, the estimated energy demand due to economic development excludes the information from the production perspective, including provincial and time specific supply-side factors captured by u_i, thus, the pattern of energy demand across provinces is likely to reflect the demand-side factors. Third, energy demand due to other factors (captured by the residuals) fluctuated over time, reflecting changes in factors specific to each province over time and macroeconomic shocks.

Critically, however, the difference between the two types of energy demand provides an opportunity to examine how different energy demand may affect market prices or the energy security. Moreover, it is expected that energy demand due to economic development is more likely to affect the equilibrium market price of energy products.

5. Market Price and Various Energy Demands in an Integrated Market

With the reduction of total energy demand by region, a further analysis examines the impact of different energy demands on market prices. In doing so, we needed to repeatedly use Equations (2) and (3) for regressing the market price of energy products on various energy demands with the control of local production and its impact on market prices. In addition, two supplementary variables, transportation costs and marketization index, are incorporated into the regression to examine the role of institutional arrangements. The comparison of the regression results can be used to improve the understanding of the interactive relationship between economic development and energy demand in an integrated market.

Considering that province specific unobservable factors such as provincially specific government policies, history, industrial structures, and production technology will affect energy prices, we adopted the panel data instrumental variable regression with fixed effects. In dealing with the provincial specific effects, the panel data regression with fixed effects is expected to be more appropriate in this case rather than other alternative methods such as first difference, given that demand function for energy products usually takes effect in the long term. In addition, it was also confirmed that this is the case using appropriate statistical tests[6] and therefore opted for the panel data regression with fixed effects.

Table 2: Impact of Energy Demand on Market Prices

	Total Energy Demand *Model 1*	**Growth Energy Demand** *Model 2*	**Remained Energy Demand** *Model 3*
Dependent variable: ln_market_price			
Energy_Demand	0.033***	0.080***	-0.005
	(0.013)	(0.020)	(0.014)
Local_Production	-0.004	-0.032	-0.073*
	(0.045)	(0.036)	(0.041)
Transportation Cost Index	0.070***	0.074***	0.084***
	(0.021)	(0.022)	(0.023)
Marketisation Index	-0.188***	-0.179***	-0.182***
	(0.046)	(0.046)	(0.047)
Year (Technological Progress)	-0.021***	-0.024***	-0.019***
	(0.003)	(0.003)	(0.002)
Constant	45.940***	51.736***	42.284***
	(5.296)	(5.458)	(4.954)
Number of observations	458	392	392
R2	0.221	0.178	0.103

Note: *** p<0.01, ** p<0.05, * p<0.1

6 In particular, the Hausman test and Breusch-Pagan test.

The estimates for the panel data instrumental variable regression with fixed effects are presented in Table 2. Columns (1), (2), and (3) provide the estimated results for total energy demand, energy demand due to economic development, and other energy demands adjusted for heteroscedasticity and time trends to account for time changing effects. The comparison of the estimation results from the three regressions can be used to provide several useful implications.

Table 3: First-stage Regression to Identify Local Production

	Total Energy Demand *Model 1*	**Growth Energy Demand** *Model 2*	**Remained Energy Demand** *Model 3*
Dependant variable: ln_local_production			
Energy_Demand	0.156***	0.070	0.211***
	(0.024)	(0.056)	(0.024)
Local_Production	0.260***	0.352***	0.309***
	(0.044)	(0.050)	(0.043)
Transportation Cost Index	-0.390***	-0.412***	-0.332***
	(0.117)	(0.128)	(0.116)
Marketisation Index	-0.054***	-0.055***	-0.042***
	(0.008)	(0.009)	(0.008)
Labour Used for Energy Production	0.066***	0.123***	0.122***
	(0.022)	(0.028)	(0.025)
Capital Used for Energy Production	0.202***	0.237***	0.201***
	(0.028)	(0.030)	(0.027)
Constant	104.404***	104.657***	78.799***
	(15.150)	(17.098)	(15.613)
Number of observations	458	392	392
R-squared	0.211	0.180	0.301

Note: the F-statistics for over-identification tests in the first stage regressions are 196.9, 197.9 and 164.7. Also, *** $p<0.01$, ** $p<0.05$, * $p<0.1$

In an integrated market, the equilibrium prices of energy products are not subject to the local energy production in each province when they are identified by using the production function. As shown in Table 2, the coefficients in front of the control variable representing local energy production are all negative, but insignificant at the 5 per cent level. This suggests that an increase in local production at the province level may not change the consumption prices of individual provinces. A possible explanation is that the integrated market will promote the free flow of energy products across provinces so that the equilibrium consumption price of energy products is not sensitive to province specific production. In other words, market integration may help to lessen the impact of supply shocks.

From the demand side, different types of energy demand may impose different impacts on the equilibrium prices of energy products. Although the coefficients in front of both total energy demand and energy demand due to economic growth are positive and significant at the 1 per cent level, the magnitude of coefficient in front of energy demand due to economic development is larger than that in front of total energy demand. In contrast, the coefficient in front of other energy demand, as shown in Column (3), is negative but not significant at a 10 per cent level.[7] This finding implies that energy demand due to economic development differs from other energy demands and will increase energy consumption prices even in an integrated market, though market integration can alleviate the demand shock due to other energy demand. The reason is that rapid economic development may create high marginal productivity of energy and thus influence its price, which may overwhelm the adjustment capacity of an integrated market.

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[7] The negative relationship between other energy demands and energy consumption prices deserve some explanation. A possible explanation is that energy demand independent of economic growth (or income) is necessity (or "Giffin good") such that its demand may decline as the price increases.

In addition to energy demand and production, there are also other factors affecting the market price of energy consumption. Throughout all three regressions, the coefficients in front of transportation costs are negative and significant at the 1 per cent level and the coefficients in front of marketisation index are positive and significant at the 1 per cent level. This implies that a decrease in transportation costs, or increased per capita freights, will tend to lower the market price of energy consumption and furthers the marketisation process or increased non-SOEs share in production. Both of these findings suggest that improving market institutional arrangements may reduce energy consumption prices. A policy implication is that transportation costs can be reduced or marketisation increased to alleviate the negative impact of economic development on local energy price.

In summation, economic development tends to increase energy demand more than other factors and is likely to raise market consumption, even in an integrated market. Market integration will in general reduce the response of energy consumption prices to energy demand and production by the cross-province trade of energy products. Along with market integration, improvement in market institutional arrangement will help to alleviate the negative impact of economic development. In particular, reducing transportation costs and improving the marketisation process will tend to reduce energy consumption prices.

To test the validity of these regression results, we used the simultaneous regression techniques to replicate the above exercises with local energy production to be identified by a simultaneous equation. The results obtained from this exercise are similar to the instrumental variable regressions, suggesting that these findings are not sensitive to the specific regression method.

6. Policy Implications to EMI in the EAS region

Although this study focuses on energy demand, supply, and trade across regions in China, it will have important policy implications for promoting EMI in the EAS region. It is believed that the EMI in the EAS region involves five types of activities: (1) trade liberalization; (2) investment liberalization; (3) development of regional energy infrastructure and associated institutions; (4) liberalisation of domestic energy markets; and (5) energy pricing reform, in particular, the removal of fossil fuel subsidies (Shi and Kimura, 2010; Wu, 2012). This paper will contribute to the provision of policy implications on the EAS EMI in at least three perspectives.

First, the energy trade pattern in the EAS region may be reversed by the involvement of development patterns. It is widely agreed that energy demand and its change over time is determined by country specific characteristics and thus energy market integration policies are always designed to facilitate trade to eliminate country specific disparities. This, however, is not the case in the EAS region. Using China's case study of cross-province energy demand, we demonstrated a direct and positive linkage between energy demand and economic development. It was also pointed out that a better design of energy market integration policies in the EAS region (as in China) is to fuel economic growth in a sequential process, irrespective of where it occurred. From a dynamic perspective, this implies that energy trade in the region can be reversed depending on the relative economic developments across regions, because in the EAS region, the significant change in energy demand and cross-country disparity are mainly derived from their different economic growth patterns.

Second, we examined the impact of market competition on energy consumption prices and split it from the cross-country institutional arrangement differences by using cross-provincial data in China. This helps to quantify the impact of non-policy factors on the imbalance between energy demand and supply and highlights the significant issues that future EMI policies need to focus on when dealing with domestic market distortions, which can be achieved by promoting competition and increasing investment in public infrastructures. These findings lead to the second policy impaction on infrastructure and the third policy implication on domestic market liberalisation.

Third, this study demonstrated that transportation costs (public infrastructure) play an important role in determining the energy prices in each region or country. Lower transportation costs within a region or country will reduce the energy price, given other factors are identical. This implies that EAS member countries may be able to have a favourable energy market by reducing transportation costs through measures such as infrastructure development and trade facilitation.

The results suggesting that a competitive market within a region will reduce prices indicates that it is in a region or country's own interest to liberalise its domestic market, including the removal of market distortions; such as fuel subsides, trade and non-trade barriers, and limitation of energy investment.

7. Conclusions

Using the panel data from 30 provinces between 1978 and 2008, this paper examined the relationship between economic growth, regional disparity, and energy demand in China. In so doing, we reduced the total energy demand into energy demand due to economic development and other remainders and linked them to the equilibrium energy consumption prices. The results reveal that economic development tends to increase energy demand. Market integration will generally reduce the response of energy consumption prices to energy demand and production through cross-province trade of energy products. In addition, the effects can be alleviated by reducing transportation costs and improving the marketisation level.

The findings from this paper have important policy implications on energy market integration in the EAS region. In particular, it provides further clarification on the possible trade patterns in the EAS region, supports the argument for a more liberalised trade regime, and calls for a more developed energy infrastructure and associate institutional arrangements.

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Appendix A: Mathematical derivation of the basic model

Assuming that the demand function for energy products takes the linear form of:

$$Energy\_Demand_{it} = a * P_{it} + b * Incomc_{it} + c * W_{it} \quad \text{(A1)}$$

Where $Energy\_Demand_{it}$ is energy demand and $Incomc_{it}$ income the related to driver. X_{it} represents other demand-side factors (i.e., preferences).

Similarly, the supply function for energy products takes the linear form of:

$$Energy\_Supply_{it} = m * P_{it} + n * Prodc_{it} + l * Z_{it} \quad \text{(A2)}$$

Where $Energy\_Supply_{it}$ is energy supply and $Prodc_{it}$ the production costs related to driver. Z_{it} represents other supply-side factors (i.e., technological progress).

In equilibrium, the demand and supply of energy products should be equalised so that Equations (A1) and (A2) are combined to derive the determination of equilibrium energy consumption price.

$$P_{it} = \frac{-b}{a-m} * Incomc_{it} + \frac{n}{a-m} * Prodc_{it} - \frac{c}{a-m} * W_{it} + \frac{l}{a-m} * Z_{it} \quad \text{(A3)}$$

Equation (A3) provides a theoretical relationship between equilibrium market price of energy prices and its determinants from consumption and production perspectives, as well as other market mechanisms (incorporated in W_{it} and Z_{it}). This helps to set up the empirical specification that is to be used. It also notes that since the relative magnitude of demand elasticity and supply elasticity are uncertain, the sign of coefficients in front of $Incomc_{it}$ and $Prodc_{it}$ are subject to empirical tests. The above derivation is not constrained by the assumption of linear function form and can be easily extended to a more general case.