Energy Market Integration and Economic Convergence: Implications for East Asia*

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Abstract: Energy Market Integration (EMI) has been pursued by East Asian countries in recent years, but how it could play a role in facilitating economic growth of countries in the region remains to be an empirical question. This paper uses the economic convergence analysis (including both the σ-convergence and β-convergence approaches) to examine the impact of EMI — measured by two newly constructed indexes (namely, the energy trade index and the energy market competition index) — at the country level, on dynamic economic growth path across countries, with a special interest to inform policy makings related to promoting EMI among East Asian countries. The result shows that a more integrated energy market may significantly reduce income disparity across countries and thus help poor countries to catch up with rich countries in economic development. Moreover, a comparison among the three regions including EU, NAFTA and EAS shows that EAS countries are more likely to achieve economic convergence along with the construction of EMI process. An important policy implication is that less developed countries in the EAS region can increase benefits from actively participating into the EMI process.

***Keywords*:** Economic convergence, energy market integration, principle component analysis, East Asia

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1. Introduction

East Asia has pursued a policy of economic integration, starting with formation of the Association of Southeast Asian Nations (ASEAN) in the 1960s. As a further extension of the integration policy, the Association of Southeast Asian Nations (ASEAN) has recently initiated a dialogue with its partners including Japan, South Korea, China, India, Australia and New Zealand3 (Shi and Kimura, 2010), for energy market integration (EMI). Although significant progress along EMI has been made, little has been know about its pattern in the region and associated economic impacts.

It is in no doubt from a theoretical perspective that EMI may promote regional economic development, but there are only a few empirical studies providing supportive evidence. Bhattacharya and Kojima (2008, 2010) find the benefits from EMI have generally outweighed costs. More generally, Park (2000), followed by Lee *et al.* (2009) and Lee and Plummer (2010) showed that free trade agreement (including energy products) may bring positive economic impact to member countries within the region. Three limitations have restricted the wide spread of the above literature. First, most of these studies used computable general equilibrium (CGE) models, neglecting how EMI can generate positive economic effects in the region. Second, EMI has always been defined as tariff cutting in these studies, which underestimates EMI's benefits through non-tariff barrier elimination, improvements in market accessibility and market deregulation. Third, all these studies focus on the net welfare of EMI but ignore its re-distribution effects across countries. In particular, they cannot inform policy makers on whether EMI may narrow development gaps (NDG) across countries and thus facilitate economic integration within a region. Thus, further empirical studies are required to address all three limitations.

The past three decades have witnessed rapid economic growth, as well as the enlarging income gap, across countries in the east Asian submit (EAS) region, with the Cambodia, Laos, Myanmar and Vietnam (CLMV) countries at the bottom (Sheng and Shi, 2011). Since NDGs across countries is a pre-requisite condition for complete regional integration, it is therefore important to know how the disparity in economic development across EAS countries is determined. Given the positive relationship between EMI and economic growth, one may expect that EMI will help to facilitate the economic convergence. Yet, the empirical relationship between EMI and income disparity across countries is still be examined before any conclusive policy implications can be drawn. If there is significant impact on NDGs, EMI will be further justified and the policy makers can more confidently promote EMI. If there is significant loss, policy measures should be proposed to avoid such kinds of negative impacts. It is only through this way that a better EMI for the EAS countries can proceed.

This paper aims to inform policy makers of the potential benefits of EMI from reducing income disparity within the East Asian region. To do so, we use economic convergence analysis to examine the impact of EMI on economic convergence across countries between 1960 and 2008. Contributing to previous literature, we construct two new indexes: the energy trade index and the energy market competition index, to analyze multiple aspects of the EMI process and directly link EMI to regional economic growth. We aggregate bilateral trade flow of energy products adjusted with trade distance to construct the energy trade index and use the Principle Component Analysis (PCA) approach to extract information from a group of different variables to construct the energy market competition index. The research provides useful information on the dynamic path of income disparity across countries resulting from EMI, in particular, the impact of EMI on LDCs' catch-up.

The remainder of the paper is arranged as follows. Section II presents the methodology, empirical specifications and data. Section III describes measurement of EMI and two indexes have been created to represent EMI from trade facilitation and energy consumption perspectives. Section IV reports the regression results and is followed by discussions and policy implications. In the last section, we make the conclusion.

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[3] The 10 ASEAN member countries, i.e. Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, Vietnam, and 6 ASEAN dialogue partner countries, i.e. Australia, China, India, Japan, Republic of Korea and New Zealand are collectively group as East Asia Summit (EAS), which was established in 2005. The US and Russia will join the EAS in 2011. For the current paper, we are still focusing on the 16 countries. In this paper, EAS and East Asia are interchangeable.

2. Methodology, Model Specification and Data

To examine changes in cross-country income disparity and EMI, we adopt convergence analysis based on the panel data regressions (the so-called 'Barro regressions')[4]. There are two concepts of convergence employed in the analysis, namely σ-convergence and β-convergence (Barro and Sala-i-Martin, 1995).

σ-convergence indicates that the dispersion of real per capita income across countries tends to fall over time. Dispersion is measured by the variance of the logarithm of per capita income or product across regions. Let σ^2 be the cross-country variance of log (y_{it}) at time t. Equation (1) and the assumed properties of u_{it} imply that σ^2 evolves over time in accordance with the first-order difference equation.

$$\delta_t^2 = e^{-2}\beta\delta_{t-1}^2 + \delta_{ut}^2 \qquad (1)$$

where it is assumed that the cross-section is large enough so that the sample variance of log(y_{it}) corresponds to the population variance. If the variance of the disturbance, σ_{ut}^2, is constant over time such that $\sigma = \sigma_u^2$ for all t, then the solution of the first-order difference equation (1) is

$$\sigma_t^2 = \left(\frac{\sigma_t^2}{1-e^{-2}\beta}\right) + [\sigma_0^2 - \left(\frac{\sigma_u^2}{1-e^{-2}\beta}\right)] \qquad (2)$$

Equation (2) implies that income per capita (σ_t^2) monotonically approaches its steady-state value, $\sigma^2 = \left(\frac{\sigma_u^2}{1-e^{1}-\beta}\right)$, which rises with σ_u^2 but declines with the convergence speed.

β-convergence applies if a poor country or region tends to grow faster than a rich one. Under such a context, the poor country or region will 'catch up' with the rich one in terms of per capita income. This phenomenon is often described as 'regression towards the mean'.

$$\ln\left({}^{y_{i,t}}/{}_{y_{i,t-1}}\right) = \alpha - (1 - e^{-\beta}) \times \ln(y_{i,t-1}) + u_{it} \qquad (3)$$

where y_{it} is the real per capita income, the subscript t denotes the year, and i denotes the country or region. The left-hand side of the equation is the logarithm of the annual growth rate of the real per capita income. The disturbance term (u_{it}) is assumed to have zero mean, the same variance σ_{ut}^2 for all regions, and is independent over time and across regions. β is the convergence coefficient. If the intercept, a, is the same in all regions and β>0, then the equation (3) implies that poor regions tend to growth faster than rich ones and convergence takes place. In contrast, a 0 or negative value for β means that no convergence takes place. β can be calculated based on the coefficient estimation of $\ln(y_{i,t-1})$.

σ-convergence is designed to examine the absolute convergence of income level while β-convergence examines relative convergence of income level. More importantly, the former approach is a more strict condition than the latter. Over time, income per capita of a country (σ_t^2) falls (or rises) if its initial value σ_0^2 is greater than (or less than) the steady-state value, σ^2 . However, a positive coefficient β (β-convergence) does not imply a falling σ_t^2 (σ-convergence). Thus, β-convergence is a necessary but not a sufficient condition for σ-convergence (Barro and Sala-i-Martin, 1995).

Both measures provide useful indications as to whether economic convergence (or divergence) has taken place over time, but they do not reveal why convergence or divergence has occurred. To find out the major determinants of changing economic growth across countries and the role that EMI has played in affecting the process, a series of factors such as the use of capital per worker, the technology progress index and the index for EMI have been incorporated into β-convergence analysis to test how important they are in contributing to the convergence process across countries. Thus, Equation (3) can be re-written as

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[4] Incorporating EMI into the economic convergence analysis as a controlled condition is justifiable since moving towards an integrated energy market by a country can be treated as improvement in institutional arrangement, which may have a similar role as capital accumulation and technology progress in promoting economic growth.

$$\ln\left({y_{i,t}}/{y_{i,t-1}}\right) = \alpha - \left(1 - e^{-\beta}\right) \times \ln\left(y_{i,t-1}\right) + \gamma_1 KL_{it} + \gamma_2 TEC_{it} + u_{it} \quad (4)$$

$$\ln\left({y_{i,t}}/{y_{i,t-1}}\right) = \alpha - \left(1 - e^{-\beta'}\right) \times \ln\left(y_{i,t-1}\right) + \gamma_1 KL_{it} + \gamma_2 TEC_{it} + \gamma_3 EMI_{it} + u_{it} \quad (5)$$

where $y_{i,t}$ and $y_{i,t-1}$ are real per capita income of country i at time t and t-1. To capture the lag effect, we use a 5-year span to estimate equations (4) and (5). KL_{it}, TEC_{it} and EMI_{it} are the per capita use of capital, technology progress index and the EMI index respectively. The use of per capita capital (KL) and technology progress index (TEC) here, is relevant since both the effectiveness of labour and technology progress (or human capital) are important for promoting economic growth (Romer, 2001).

Based on Equations (4) and (5), a two-step procedure is to be used to examine the contribution of EMI to economic convergence in the East Asia region. Specifically, we first run the β-convergence regression with Equation (4) (excluding the EMI index), and then run the β-convergence regression with Equation (5) (including the EMI index). There are in general three situations that may occur, each of which corresponding to a specific result. First, if γ3 is positive and significant and β'>β, we have evidence that EMI contributes to economic converge across countries. Second, if γ3 is negative and significant and β'<β, we have evidence that EMI contributes to economic divergence across countries. Third, if γ_3 is insignificant and β' are similar as β, we have no evidence that EMI has an impact on dynamic path of economic growth across countries.

Finally, as a robustness check, the similar regression procedure has been carried out with data for different regions (or country groups) including the 12 old EU countries[5], NAFTA countries (USA, Canada and Mexico) and over a different time period.

Data used in this study come from four major sources including the World Development Indicator (WDI) Database, the cross-country historical adoption of technology (CHAT) dataset, the UN Comtrade Database and Subramanian and Wei (2007). The dependent variable, income per capita for each country, is defined as GDP per capita at the constant price of 2000 US dollars. The use of capital per capita, as a controlled variable for capital-labour ratio, is defined as the ratio of gross capital formation to total population. Data used for constructing the two variables are extracted from the WDI Database. As another controlled variable representing technology difference across countries, a technological progress index is also used in our regression. The index is defined as the percentage of population with age being 15 years and older who are able to read and write in the total population and comes from the CHAT database (Comin and Hobijn, 2009).

Based on the above discussion on variable definition and data collection, the total sample used in this paper covers 49 countries in 1960, 118 countries in 2008 and we have 1017 total observations. Between 1960 and 2008, the average GDP per capita across countries has been increasing with the annual growth rate of 2.1 per cent a year. Yet, the variance of GDP per capita also increased suggesting that economic growth has been achieved unevenly across countries with different capital accumulation process and technology progress.

3. Measurement of Energy Market Integration

As for the measure of EMI within the neighborhood, we define two types of indexes in this paper: one for energy trade and the other for domestic energy market competition.

It is widely argued that bilateral trade of fossil fuel may provide useful information on EMI. There are two arguments for this belief. Firstly, bilateral trade in fossil fuel products and transnational investment in energy production sectors is more likely to take place between countries with more integrated energy market if the initial endowment difference in endowments can be well controlled. Secondly, bilateral trade not only reflects the degree of resistance between countries

[5] Due to data constraints, this study used the 12 old EU countries (that is, UK, Germany, France, Spain, Portugal, Italy, Turkey, Ireland, Iceland, Austria, Hungary and Greek) rather than 27 EU countries as a subset for the regression. Since the 12 old EU countries accounted for most EU production and trade, the results from this subset would not be significantly different from that with 27 EU countries.

for free flow of energy products across countries but also implies their mutual demand for energy from (or dependency on) each other.

In this paper, we construct an EMI index for energy trade by using bilateral trade of fossil fuel products, geographical distance between each trading partners and each country's production of fossil fuel products. The index (as is shown in Equation (6)) is defined as the relative imports of fossil fuel products, which is equal to the average imports of a country's fossil fuel products from its trading partner over domestic production. To account for the impact of geographical vicinity, we define the average imports of a country's fossil fuel products as the weighted average of the country's import of fossil fuel products from each trading partner with the weights being geographical distance between the two countries (obtained from Subramanian and Wei (2007)). Since the index generally increases as the country imports more fossil fuel from neighborhood countries and deceases as domestic production (consumption) of fossil fuel products increase (decrease), it can be used to reflect the extent to which the country is integrated in neighborhood EMI.[6]

$$EMI\_TRADE_{it} = sum_j (energy\_trade_{ijt} / distance_{ij}) / n_j \times 1 / PROD_{it} \qquad (6)$$

where EMI_TRADE_{it} is the energy trade index, $energy\_trade_{ijt}$ is the imports of fossil fuel in country *i* from country *j*, $distance_{ij}$ is the economic distance between country *i* and *j* and $PROD_{it}$ is the total amount of consumption of fossil fuels in country *i*. The index has been calculated for each country in each specific year.

We also measure the progress of energy market competition in each country. In addition to trade and investment liberalization, EMI is also expected to be associated with energy market liberalization and thus competition (Shi and Kimura, 2010). Therefore, an energy market competition index was proposed to capture this domestic effect of EMI. Three indicators have been employed in this paper including energy productivity (defined as millions of 2000 US dollar GDP generated per unit of energy consumption), the share of electricity consumption in total energy consumption. Finally, we also use a measure of road sector energy use efficiency, which is defined as the thousand tones of energy use in the road sector for a given amount of CO2 emissions.

These three indicators are all expected to be positive correlated with the level of market competition. Energy productivity will be increased in a more competitive market according to standard economic theory. The share of electricity consumption in total energy consumption represents the quality of life resulting from using the clean energy. The higher the quality of life within a country, the higher the demand of competition, as it has been shown that developed countries generally have more competitive markets than less developed ones. The supply of petrol oil, the dominant energy product used in the road sector, is usually subject to global market forces. Therefore, the efficiency of domestic consumption is determined by the competitiveness level of domestic oil market. Generally, the more efficient the energy used in road sector (fewer CO2 emissions), the more competitive the domestic energy market would be.

We combine all these factors using PCA approach to construct our measurement for energy market competition. We use the first component (around 50 per cent of information) as an index in the regression (See Sheng and Shi (2011) for more detailed discussion on the PCA method).

$$EMI\_MKT_{it} = PCA(Energy\_\mathrm{int}_{it}, Electricity\_cons_{it}, Energy\_road_{it}) \qquad (7)$$

where $Energy\_\mathrm{int}_{it}$ is the energy productivity, $Electricity\_cons_{it}$ the share of electricity consumption in total energy consumption and $Energy\_road_{it}$ the energy use for road sector per tonne of CO2 emission.

As for the EMI indexes, the average trade index for EMI across all countries has increased from 3.89 in 1960 to 5.44 in 2008, showing that bilateral trade in energy products among countries in neighborhood has been strengthened due to regional integration over time. The low value of EMI indices in 2000 for most countries can be explained by the fact that

[6] Although oil is often imported from non-neighbor countries such as Middle East countries, the index for energy trade is still valid since the weighting system used here has accounted for each bilateral trading pair in fossil fuel and thus filter the potential bias due to resource abundance.

Asian Financial Crisis (AFC) in 1997 significantly damaged global trade flow and thus imposed a negative impact on our estimation for 2000.

Across the three regions, the average index for the EAS countries has increased from 4.33 in 1960 to 6.22 in 2008 with the annual growth rate of 0.8 per cent a year, which is much higher than those for EU countries (0.6 per cent a year) and the NAFTA countries (0.4 per cent a year). This result suggests that energy market in the EAS region has integrated more quickly than that in the EU and the NAFTA regions in recent years. Similar trends are also found from the energy market competition index (Table 1).

Table 1. The Estimation of Energy Market Integration Index for EAS Countries: 1960-2008

	Energy Trade Index						Energy Competition Index					
Country Name	1960	1970	1980	1990	2000	2008	1960	1970	1980	1990	2000	2008
Australia	4.15	4.22	6.56	5.61	4.65	6.95	1.16	2.12	2.26	2.76	2.84	2.90
New Zealand	-	3.93	5.52	4.46	3.48	4.48	1.10	2.26	3.36	2.87	3.11	3.99
Japan	4.71	5.08	7.80	7.71	7.35	8.65	1.08	1.68	2.26	2.83	2.86	2.95
South Korea	-	-	6.54	7.21	7.14	7.03	-	1.05	1.37	2.01	2.63	2.61
Singapore	4.62	4.72	7.04	7.81	6.95	7.26	1.15	1.98	2.16	2.59	2.87	2.80
Brunei	-	-	-	-	-	-	-	-	-	-	-	-
Malaysia	-	4.32	6.16	5.12	5.36	5.22			0.24	0.41	0.69	0.83
China, P.R.	-	-	-	5.97	7.53	8.59	-	-	-	0.21	0.54	0.93
Thailand	3.93	4. 77	6.84	5.55	5.40	6.59	0.31	0.47	0.59	1.46	1.42	1.27
Philippines	4.23	5.23	6.96	6.14	6.09	5.76	0.60	0.70	0.65	0.75	1.14	1.39
Indonesia	3.26	4.20	5.04	5.56	4.66	5.68	-	-	-	-	-	-
Vietnam	-	-	4.66	7.52	-	-	-	-	-	-	0.64	0.74
India	4.27	5.53	7.75	6.29	5.53	8.23	0.04	0.05	0.06	0.47	0.66	0.86
Lao	-	-	-	-	-	-	-	-	-	-	-	-
Cambodia	-	-	-	-	3.81	5.01	-	0.03	0.06	0.19	0.31	0.34
Myanmar	-	4.70	-	-	-	-	-	-	-	-	-	-
EAS	4.33	4.51	6.44	6.25	5.66	6.62	1.08	1.22	1.30	1.50	1.64	1.80
EU-15	5.41	5.90	8.02	7.54	7.05	7.40	1.32	2.17	2.46	3.03	3.53	3.73
NAFTA	4.61	4.79	6.53	6.14	5.91	5.49	2.83	3.88	4.17	1.73	1.91	2.09
All World	3.89	4.19	5.50	5.50	4.80	5.44	1.52	1.71	1.87	1.96	1.96	2.34

Note: For simplicity, the estimation of energy trade index reported here only covers the EAS countries and major regions between 1960 and 2008. The estimated index for other countries is available upon request.

Source: Authors' own estimation.

4. Estimation Results

Based on the methodology and data mentioned above, this section presents empirical findings on the relationship between EMI (measured by using the trade index and the energy market competition index) and economic convergence across countries (in particular, for countries in the EAS region) between 1960 and 2008.

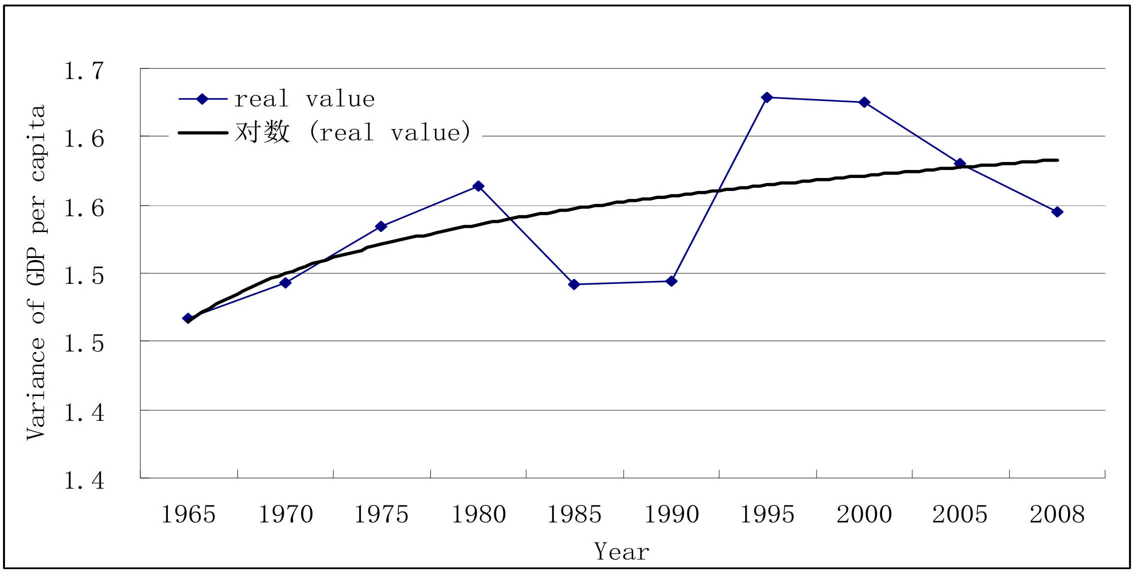
5.1. Economic Convergence and its Conditions: a Baseline Model

To better understand cross-country disparity in economic development and its changing trend over time, we first use σ-convergence analysis to examine the variance of real income per capita across countries. Figure 1 shows the logarithm of the standard deviation of GDP per capita of all countries in our sample over the period of 1960 to 2008. Although there were significant fluctuations, the time trend of the variable has been increasing.[7] A further regression of the logged variance of real GDP per capita on the time tend (based on Equations (1) and (2)) showed that the estimated coefficient

[7] Between 1960 and 2008, the standard deviation of real GDP per capita in logarithm across 114 countries has increased from 1.37 to 1.54, with the annual growth rate of 0.24 per cent a year.

(0.004) in front of time trend was positive and significant at 1 per cent level.[8] Both the regression and the trend change analysis suggest that the disparity in real income per capita across countries has been enlarging over time throughout the world during the past four decades. This finding is consistent with our expectation that unbalanced economic growth has taken place in different countries, in particular in the EAS region.

Figure 1. Variance of Real GDP across Countries throughout the World: 1960-2008



Source: Authors' own calculation.

Although σ-convergence analysis has shown income per capita diverged across countries, it could not tell whether it is possible for poor countries to catch up with rich countries in terms of economic growth and the factors affecting the catch-up if it could. To solve this problem, we further use the β-convergence analysis to re-examine cross-country economic growth and its determinants. Table 2 shows the regression results based on Equations (3) and (4) by using both Pooled ordinary least square (OLS) and controlling for country-fixed effects (FE). In particular, columns (1) and (2) shows the unconditional convergence results and columns (3) and (4) shows the conditional convergence results when the capital-labor ratio and the technical progress index has been well controlled.

Without controlling for any other variables, the OLS regression (in Column (1)) may be biased due to the potential endogeneity problem. This would occur where there are unobserved country-specific factors in the residual that are correlated to the lagged income per capita, which is likely. This source of endogeneity can be removed by controlling for country fixed effects. Column (2) presents these results, which shows that the negative relationship between changes in logarithm of income per capita and the lagged logarithm of income per capita became more significant (with the estimated coefficient being -0.022 and significant at 1 per cent level). The result suggests that levels of economic growth across countries are likely to converge unconditionally despite of the enlarging disparity in income per capita level. In other words, poor countries are catching up with rich countries in terms of economic growth, reducing the income gap in the long run.

Moreover, we added two controlled variables, the capital-labor ratio (for investment per capita) and literacy proportion (for technical progress), into the β-convergence analysis to identify whether those factors may contribute to economic convergence across countries. As is shown in Columns (3) and (4) of Table 3, the estimated coefficients in front of lagged logarithm of income per capita obtained from the new regressions were -0.096 (for the OLS regression) and -0.074 (for the panel data regression) and significant at 5 per cent and 1 per cent level respectively. Comparing with those obtained from the unconditional analysis, the newly estimated coefficients were more negative. This finding, combined with the positive and significant coefficients in front of capital-labor ratio and literacy proportion, suggests that

[8] The Durbin-Watson statistics is 1.44, which is far less than 2.00, suggests that the regression results may not suffer from the time-series problem.

increasing capital-labor ratio and literacy proportion may help to facilitate the catch-up of poor countries with rich countries in economic growth and promote economic convergence across countries (Barro and Sala-i-Martin, 1995).

Table 2. The Regression Result **from** the β-convergence Analysis

	Model I		Model II	
	OLS	Panel (FE)	OLS	Panel (FE)
Dependent variable: Difference in Logged GDP (constant 2000 USD) (dlncgdp2000)				
Lagged Logged GDP (constant 2000 USD) (lncgdp2000)	-0.008*	-0.022***	-0.096***	-0.074**
	(0.004)	(0.007)	(0.029)	(0.032)
Lagged capital-labor ratio	-	-	0.059**	0.026***
	-	-	(0.027)	(0.009)
Lagged literacy proportion	-	-	0.001***	0.001***
	-	-	(0.000)	(0.000)
Constant	0.181***	0.308***	0.301***	0.323***
	(0.040)	(0.061)	(0.059)	(0.070)
Number of observations	264	264	264	264
Adjusted R-squared	0.005	0.009	0.108	0.107

Note: For the OLS regression, country-specific effects have been controlled. In this paper, "***", "**" and "*" represent the estimated coefficients are significant at 1 percent, 5 percent and 10 percent level.

Source: Authors' own estimation.

5.2. *Energy Market Integration and Economic Convergence*

Based on the baseline model for economic convergence, the next step is to examine the impact of EMI on the path and speed of economic convergence across countries. We use Equation (5) as a benchmark model and incorporate two indexes for EMI, including the energy trade index and the energy market competition index, into the regression. Each index is designed to capture EMI from a different perspective: the energy trade index is used to capture relative importance of energy trade within neighborhood and the energy market competition index is used to capture the domestic market distortion. The results are shown in Table 3, where Columns (1) and (3) presents the results by using pooled OLS and Columns (2) and (4) presents the results using country fixed effects. Compared between Tables 2 and 3, there are two findings that we wish to highlight.

First, when we control for EMI, the estimated elasticities of economic growth of a country to its initial economic development level are more negative than those obtained from the baseline model. On one hand, when the energy trade index is controlled, the estimated coefficients in front of the lagged logarithm of real GDP per capita (from the panel data regression with the fixed effects) become -0.084. On the other hand, when the energy market competition index is controlled, the estimated coefficients in front of the lagged logarithm of real GDP per capita (from the panel data regression with the fixed effects) become -0.252. Both estimated elasticities are significantly smaller than that obtained from the regression without control of energy trade index (-0.074). This is strong evidence that EMI within a country's neighborhood, either through promoting trade facilitation or promoting competition in the domestic energy market, may help to improve the ability of poor countries to catch up with and overtake rich countries in economic growth. In other words, poor countries tend to grow faster than rich countries with EMI.

Moreover, when the related coefficients obtained from the regressions are translated into the convergence ratios following the equation of $r = -1/\ln(1-\beta)$, it is estimated to take approximately 55 years (convergence rate 8.7 per cent) and 13 years (convergence rate 37.3 per cent) for the poor countries to catch up with rich countries in half of their income per capita when EMI has been implemented and the investment and technology progress are well controlled. The time line is shorter than that based on the baseline model without the consideration of EMI, where it may take more than 65 years for poor countries to catch up with their rich counterparts in half of their income per capita (convergence ratio

7.7 per cent). This suggests that EMI has significantly contributed to poor countries economic growth and can help to reduce the development gaps across countries.

Table 3. Economic Convergence: 1960-2008

	EMI Model I		EMI Model II	
	OLS	Panel (FE)	OLS	Panel (FE)
Dependent variable: dlncgdp2000				
Lagged lncgdp2000	-0.103***	-0.084**	-0.098***	-0.252***
	(0.030)	(0.033)	(0.033)	(0.101)
Lagged capital-labor ratio	0.061**	0.030***	0.059*	0.053*
	(0.027)	(0.003)	(0.033)	(0.033)
Lagged literacy proportion	0.001***	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
Lagged energy trade index	0.017***	0.018***	-	-
	(0.001)	(0.002)	-	-
Lagged energy market competition index	-	-	0.026***	0.051**
	-	-	(0.001)	(0.022)
Constant	0.277***	0.298***	0.208***	1.207***
	(0.059)	(0.072)	(0.073)	(0.524)
Number of observations	264	264	193	193
Adjusted R-squared	0.110	0.113	0.193	0.09

Note: For the OLS regression, country-specific effects have been controlled.

Source: Authors' own estimation.

Second, although EMI in general may help to reduce the economic development gap across countries, different policy instruments of EMI may play different roles. When the energy trade index and the energy market competition index are separately used in the β-convergence analysis (in different regressions) as controlled conditions, the role they each play in affecting economic convergence across countries are significantly different from each other. Table 4 shows the higher the energy trade index, the more likely economic convergence can be achieved across countries. The energy trade index's elasticity is positive, suggesting that trade policies aiming to further facilitate free movement of energy products within the region may help to narrow the development gap. Similarly, the higher the energy market competition index, the more likely economic convergence would be across countries. The elasticity of energy market competition is much larger, implying that eliminating obstacles and monopoly in domestic energy market seems to be a more important factor contributing to poor countries' catch-up with rich countries.

The above findings are based on the assumption that the energy trade index and the energy market competition index are good indicators for EMI within a country's neighborhood, from different perspectives. When more data becomes available, more accurate estimates could be made though the general finding would be similar.

5.3. Asymmetric Impact of EMI on Economic Convergence across Regions

How does EMI impose different impacts on economic convergence across countries in different regions? To answer this question, we split our sample into three country groups: namely, the EAS region, the European Union region (EU) and the North American Free Trade Area (NAFTA) and use a dummy variable for each region and its interaction term with the lagged real GDP per capita to account for regional specific effect in the β-convergence analysis. Based on Equation (5), three regressions thus have been made for the EAS region, the EU region and the NAFTA region respectively. The comparison of results obtained from different model specifications can be used to distinguish the asymmetric impact of EMI in different regions. Due to data constraint, only the energy trade index has been used for this exercise and the results are shown in Table 4.

When the capital-labor ratio and the literacy proportion are controlled, EAS countries have shown more rapid economic growth rates than the rest of the world and they are more likely to achieve economic convergence within the region. As is shown in Column (1) of Table 5, the coefficient in front of the EAS dummy is positive (0.268) and significant at 5 per cent level. This result suggests that: economic growth of EAS countries are on average stronger than rest of the world by 0.268 per cent over the period of 1960 to 2008. Moreover, the coefficient in front of the interaction term between the dummy for EAS countries and the lagged real GDP per capita is negative (-0.029) and significant at 5 per cent level.

This result implies that the elasticity of economic growth to initial real GDP per capita for the EAS countries are -0.094 (which is equal to -0.065+(-0.029)), which are much more smaller than that for the rest of the world (-0.065), suggesting that income per capita among EAS countries are more likely to converge to each other.

Table 4. Different Impact of EMI on Economic Convergence across Regions: 1960-2008

	EAS	EU	NAFTA	All Countries
Dependent variable: dlncgdp2000				
lagged lncgdp2000	-0.065*	-0.093***	-0.084**	-0.077**
	(0.034)	(0.032)	(0.034)	(0.036)
lagged capital-labor ratio	0.020	0.029	0.030	0.017
	(0.029)	(0.028)	(0.029)	(0.029)
lagged literacy proportion	0.001***	0.001***	0.001***	0.001**
	(0.000)	(0.000)	(0.000)	(0.000)
lagged energy trade index	0.019*	0.022*	0.016*	0.021
	(0.010)	(0.012)	(0.011)	(0.014)
D_EAS	0.268**	-	-	0.191
	(0.125)	-	-	(0.146)
D_EAS X lagged lncgdp2000	-0.029**	-	-	-0.017
	(0.015)	-	-	(0.018)
D_EU	-	0.150	-	0.198
	-	(0.189)	-	(0.209)
D_EU X lagged lncgdp2000	-	-0.010	-	-0.014
	-	(0.020)	-	(0.023)
D_NAFTA	-	-	0.340	0.286
	-	-	(0.277)	(0.279)
D_NAFTA X lagged lncgdp2000	-	-	-0.034	-0.025
	-	-	(0.029)	(0.030)
Constant	0.220***	0.343***	0.303***	0.297***
	(0.082)	(0.080)	(0.075)	(0.111)
Number of observations	264	264	264	264
Adjusted R-squared	0.154	0.134	0.113	0.178

Note: The results are based on the panel data regression with the fixed effects.

Source: Authors' own estimation.

As a comparison, when the dummy variables for the EU and NAFTA countries are incorporated into the β-convergence analysis, similar results have not been found. As is shown in Columns (2) and (3) of Table 5, the coefficients in front of the dummy variables are positive and the coefficients in front of interaction terms between the dummy variables and the real GDP per capita are negative. This result is consistent with the estimation (in sign) obtained for the EAS countries. However, since all the coefficients are insignificant at 10 per cent level, this suggests that the EU countries and the NAFTA countries do not show different economic growth trend and convergence pattern comparing with the rest of the world over the past four decades.

As for the impact of EMI from trade, the coefficients for the energy trade index throughout all regressions with the dummies for EAS, EU and NAFTA are all positive and significant at 10 per cent level. This suggests that EMI has played an important role in promoting economic convergence in all the three regions. Yet, the relative impact of EMI on economic convergence in the three regions is different from each other. As is shown in Table 5, the elasticity of the energy trade index for EAS, EU and NAFTA are 0.019, 0.022 and 0.016 respectively, implying that (after accounting for regional specific effects) a more integrated energy market within neighborhood is associated with a greater reduction in the development gap among EU countries than among EAS countries or NAFTA countries. Economic convergence took place more quickly among EU countries with the elasticity of real GDP per capita being -0.093 than those for the NAFTA countries (-0.084) and for the EAS countries (-0.065). This is partly because that the integrated market and international cooperation mechanism in EU helped enlarge the positive impact of EMI on balancing regional development gap across countries, setting a good example for EAS countries to follow.

5. Discussion and Policy Implications

Although EMI is shown to be beneficial to all countries in the region (Bhattacharya and Kojima, 2008, 2010), LDCs are often reluctant to play an active role in promoting the market integration process. For example, the CLMV countries often delayed their enforcement of existing trade and investment agreements. As a consequence, the ASEAN- China Free Trade Area gave five additional years preparation time to CLMV countries. Similarly, the ASEAN-Korea Free Trade Area also allowed six additional years to CLMV countries for preparation and the ASEAN-Australian-New Zealand Free Trade Area excluded Cambodia and Laos from their enforcement timetable (Shi and Kimura, 2010). Although these consensuses have been agreed by both developed countries and LDCs, the delayed participation of LDCs may do harm to further EMI process and its related effects on growth in the EAS region.

Since EMI appears to facilitate NDGs across countries and thus bring more benefits to member countries in particular to LDCs, it should be treated more confidently and positively in practice, which is consistent with findings from the previous study (Bhattacharya and Kojima, 2010). Considering the huge disparity in income per capita across EAS countries, the positive impact of EMI on economic convergence suggests that East Asia should promote EMI to achieve both sustainable and equal growth.

The comparison of EMI and economic convergence among the three regions shows that the deeper market integration can facilitate the faster economic convergence. Consequently, international cooperation towards a deeper integration of energy market should be advocated. In terms of economic convergence, EAS has overtaken NAFTA but still lags behind EU and thus there is still potential for further improvement.

Furthermore, greater participation of LDCs should be promoted. This analysis provides strong evidence of a positive impact on regional economic convergence, which implies that LDC would gain from active participation in EMI. From our calculations, participating in EMI on average may help to shorten the time period for LDCs catch-up with developed countries in economic growth by 50-75 years. Being aware of this potential benefit of EMI, LDCs in the EAS region should have more incentive to participate into regional cooperation and be actively involved into the construction of an integrated regional energy market.

Even though LDCs may need more preparation time, a workable roadmap toward EMI should be considered ahead of time to achieve the catch-up in economic development. The benefits of EMI to LDCs in terms of reducing economic development gaps across countries may only be achieved in the long run. However, as long as benefits to LDCs can be realized through the participation, more involvement from LDCs would come out and become the continuing driver of sustainable economic development and regional integration.

Developed countries can also play an important role in helping LDCs to build capacities in maintaining sustainable development when they pursue long-term goals for regional EMI. Since the study shows that increasing capital-labor ratio and literacy proportion may help to facilitate the catch-up of poorer countries with richer countries, investment and capacity building including for technology progress should be considered as a priority for LDCs since they are much weaker than developed countries in this field. This could involve providing development assistance and technology support to facilitate LDCs' participation into the construction of a unified energy market and eliminating domestic distortion. Currently, most EAS developed economies, including Australia, Japan, South Korea and New Zealand, are allocating a significant amount of official aid to ASEAN countries. The aim of this aid is to assist ASEAN nations economically integrate more fully in the region and EMI could be incorporated into these aid programs.

6. Concluding remarks

By using economic convergence analysis (including the σ-convergence and the β-convergence), this paper examines the impact of EMI on economic convergence across countries, with a particular focus on the EAS region, between 1960 and 2008.

The results show that in addition to trade, an integrated energy market may help to reduce economic development gaps among countries and accelerate the catch-up of LDCs' income per capita. In particular, the positive impact of energy trade facilitation may play a more important role for the EU countries and the NAFTA countries than for the EAS countries. The study also finds that investment and capacity building may help to facilitate the catch-up and promote economic convergence across countries.

This paper suggests that EMI should be promoted more confidently and positively, not only among developed countries but also involving LDCs. Even though LDCs may need more time to make preparation, a workable roadmap toward EMI is valuable. Developed countries can also play an important role by helping LDCs to overcome the difficulty through capacity building programs.

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