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# Energy market integration and equitable growth across countries

Yu Sheng [a], Xunpeng Shi [b,*]

[a] Crawford School of Public Policy, The Australian National University, Canberra, Australia
[b] Economic Research Institute for ASEAN and East Asia, Jakarta, Indonesia

## HIGHLIGHTS

- EMI not only advances economic development, but also facilitates equitable growth.
- Countries with higher EMI are more likely to catch up with rich countries.
- High capital-labor ratio and literacy proportion facilitate economic convergence.
- Competitive domestic energy market helps developing countries to catch up.

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## ABSTRACT

Energy Market Integration (EMI) has been a goal for many regions, including the European Union and East Asia, for quite a long time. How it could play a role in facilitating equitable economic growth among a group of countries remains an empirical question that this paper will attempt to answer. The paper uses 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 paths across countries. Its special interest lies in informing policy making related to promoting EMI. The results show that countries involved in a more integrated energy market are more likely to reduce their income disparity, suggesting that EMI may help the region to achieve equitable growth through the accelerated economic development of lagged economies.

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## 1. Introduction

Understanding the role of energy consumption in the pursuit of equitable growth across countries has emerged as a primary concern for policy makers in the past two decades. While the role of energy in promoting economic growth has been well addressed in the literature, little attention has been paid to the question of how institutional reforms in the energy sector, such as Energy Market Integration (EMI), can affect equitable growth among a group of countries. This is an important issue as it is often perceived that globalization, including economic integration, has widened the gap between rich and poor, and increased inequality [1].

Theoretically, EMI may promote regional economic development, but there are only a few empirical studies providing supportive evidence. Recent studies on EMI [2,3] have found that the benefits from EMI have generally outweighed its costs. More generally, Park [4], followed by Lee et al. [5], Lee and Plummer [6] and Velde [7], showed that free trade agreements (including for energy products) may bring positive economic impacts to the member countries.

However, there are many limitations in the above literature. First, most of these studies used computable general equilibrium models and did not indicate positive economic effects directly obtained from EMI for the region. Secondly, EMI has always been defined as "tariff cutting" in these studies, which understates EMI's benefits through the elimination of non-tariff barriers, improvements in market accessibility and market efficiency. Thirdly, all these studies focus on the net welfare improvement provided by EMI but ignore its re-distribution effects between countries. In particular, they cannot inform policy makers about whether EMI is able to narrow development gaps across countries, and thus to facilitate equitable growth within a region. The answer to this

*Abbreviations:* EAS, East Asia Summit; EMI, Energy Market Integration; EU, European Union; HCD, human capital development; NAFTA, North American Free Trade Area; PCA, Principle Component Analysis.

* Corresponding author. Address: ERIA Annex Office, Sentral Senayan II, JL. Asia Afrika No. 8, Senayan, Jakarta Pusat 10270, Indonesia. Tel.: +62 2157974460; fax: +62 2157974465.
*E-mail address:* xunpeng.shi@gmail.com (X. Shi).

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question is important in encouraging the participation of developing countries in EMI. Further empirical studies are thus required to address all three limitations.

This paper examines the impact of EMI on equitable economic growth, aiming to inform policy makers of the potential role of EMI in reducing income disparity. To do so, we use economic convergence analysis to examine the impact of EMI on equitable growth across countries, using two innovative indexes to measure the level of EMI. The research provides useful information on the dynamic path of income disparity across countries resulting from EMI, in particular the impact of EMI on the ability of developing countries to reduce the level of economic inequality between themselves and developed economies (hereafter shortened to "catch-up"). The empirical results show that EMI is likely to promote the economic growth of individual countries, as well as to facilitate equitable growth within a region. This finding supports the qualitative analysis that economic integration will generally benefit all participants in terms of economic growth and income disparity reduction [4,7,8]. The positive impact which regional integration has on equitable growth should also give policy makers more confidence in promoting EMI.

The remainder of the paper is arranged as follows. Section II presents the methodology, model specifications and data. Section III introduces the measurement of EMI. Section IV reports the estimation results. In the last section, we present concluding remarks.

## 2. Methodology, model specification and data

As argued in the case of East Asia [9], EMI may boost economic development and reduce disparity in economic growth through three channels: transforming undeveloped comparative advantages in developing countries into real economic benefits; improving domestic energy access and use efficiency in developing countries; and encouraging the free flow of foreign direct investment to the energy sector, thus providing more energy infrastructure to developing counties.To examine changes in cross-country income disparity and EMI, we adopt a convergence analysis based on panel data regressions (the so-called 'Barro regressions'). There are two concepts of convergence employed in the analysis, namely σ-convergence and β-convergence [10]. σ-convergence indicates that the dispersion of real per capita income across countries tends to fall over time. In analyzing σ-convergence, dispersion is measured by the variance of the logarithm of per capita income across regions. Let $\sigma^2$ be the cross-country variance of $\ln(y_{it})$ at time $t$. Eq. (1) shows the definition of $\sigma^2$ which is equal to the sample variance of logarithmic income at t.

$$\sigma_t^2 = (1/N)\sum_{1}^{N}[\ln(y_{it}) - \mu_t]^2 \tag{1}$$

where $\mu_t$ is the sample mean of logarithmic income, and the sample variance is close to the population variance when $N$ is large, which can be used for analyzing the evolution of $\sigma_t^2$. In practice, if there is a reduction in the dispersion of income levels ($\sigma_t^2$) across economies over time, it can be argued that there is σ-convergence, and vice versa.

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'.

$$\ln(y_{it}/y_{i,t-1}) = \alpha - \beta\ln(y_{i,t-1}) + u_{it} \tag{2}$$

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 a mean of zero and constant variance for all regions, and over time. $\beta$ is the convergence coefficient. It is to be noted that the intercept, $\alpha$, represents common factors across regions that can affect economic growth which are not captured elsewhere. Generally, a significantly positive $\alpha$ means higher balanced growth rates common to all countries [11]. If $\beta > 0$, then Eq. (2) implies that poor regions tend to grow faster than rich ones and convergence takes place. In contrast, a zero or negative value for $\beta$ means that no convergence takes place.

Although Eq. (2) is self explainable, it is too simple to be used as our baseline model for examining economic convergence across countries, since many major determinants affecting economic growth have not been considered. To stabilize the regression function form, two factors including the capital-labor ratio ($KL_{it}$) and the human capital development index ($HCD_{it}$) have been incorporated into the β-convergence analysis to account for their potential impact. Thus, Eq. (2) can be re-written as:

$$\ln(y_{it}/y_{i,t-1}) = \alpha - \beta\ln(y_{i,t-1}) + \gamma_1 KL_{it} + \gamma_2 HCD_{it} + u_{it} \tag{3}$$

The capital-labor ratio ($KL_{it}$) is defined as the ratio of gross capital formation to total population, an indicator of the level of capital equipment (or technology) in production. The human capital development index ($HCD_{it}$), representing the human capital development differences across countries, is approximated by the percentage of the total population aged 15 years and older who are able to read and write (the "literacy proportion"). The control of these two factors is relevant and consistent with previous literature since both the level of technology and the development of human capital are important for promoting economic growth [12]. To capture the lag effect, we define time indicator $t$ to be every 5 years.

Finally, the dummy for the EMI index and its interaction with the countries' initial income level have been added into Eq. (3) to examine the role of EMI in affecting the economic growth convergence process. Incorporating a dummy for EMI and its interaction term with countries' initial income levels into the economic convergence analysis is justifiable. This is because the treatment is similar as to splitting our sample into low EMI and high EMI subgroups and comparing the relative convergence speed across different subgroups. Since movement towards an integrated energy market by a country can be treated as an improvement in institutional arrangements, which may have a similar role to capital accumulation and technology progress in promoting economic growth, it is expected that the speed of economic convergence would be higher in high EMI countries than in low EMI countries.

$$\ln(y_{it}/y_{i,t-1}) = \alpha - \beta\ln(y_{i,t-1}) + \gamma_1 KL_{it} + \gamma_2 HCD_{it} + \gamma_3 DEMI_{it} + \gamma_4 DEMI_{it}\times\ln(y_{i,t-1}) + u_{it} \tag{4}$$

where $DEMI_{it}$ refers to the dummy variables for EMI, which takes a value of 0 if the corresponding EMI index of country $i$ at time period $t$ is lower than its sample mean across countries and time period, and 1 otherwise. The construction of the EMI index will be discussed in the next section. It is to be noted that omitting EMI in Eq. (3) does not invalidate the ordinary least square (OLS) estimation as long as variables in both Eqs. (3) and (4) can form co-integration relationships. The co-integration is a standard requirement for time series estimation [13].

We first run the conditional β-convergence regression with Eq. (3) (excluding the EMI index) to justify the function form, and then run the β-convergence regression with Eq. (4) (including the EMI index) to assess the impact of EMI. There are in general three

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