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Testing for Industrial Emission Convergence in Indonesia: Case in Java Island

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Abstract:
This main objective of this study is to test emissions convergence, absolute and conditional, of manufacturing industries among provinces in Java Island as an industrial base and economic growth in Indonesia. Data consist of six provinces during 2000-2009. Econometrics technique is applied to estimate dynamic model of the convergence. The result shows that the emissions convergence, both absolute and condition, is not confirmed. In other word, emission growth among the provinces tends to be divergent. Statistical test suggest that the emission growth is affected by economic growth and technique effect.

Keywords: emissions convergence, technique effect, manufacturing, Indonesia

I. Introduction

One of the environmental problems that have been getting serious attention from the world in the last few decades is global warming. Experts from the Intergovernmental Panel of Climate Change (IPCC, 2014) [1] agreed that the main cause of global warming is the increase of greenhouse gases (GHGs), especially carbon dioxide (CO_2) emissions. The impact of global warming which is most felt is climate change which has resulted in large economic losses [2]. The Global Commons Institute – GCI (2001) [3] mentions that economic losses from natural disasters (80% related to weather) increasing by around 12% per year. This growth is equivalent to four times that of global economic growth.

According to the IPCC (2014) [1] around 35% of total global GHGs in 2010 were generated by the energy sector, which consisted of electricity and heat production (25%) and other energy (9.6%). However, GHGs from the electricity sector and heat production relate to other sectors as final energy. Other sectors contributing GHGs based on the order of their contributions are agriculture, forests and other land uses or agriculture, forestry, and other land use - AFOLU (24%); industry (21%); transportation (14%); and buildings (6.4%). If GHGs from the electricity and heat production sectors are involved as indirect emissions, the contribution of the industrial sector becomes around 32% and 20% and makes it the largest GHG emitting sector. Therefore, the reduction of industrial emissions is a strategic step to mitigate climate change.

In the early 1990s GCI proposed an international GHGs control framework to mitigate the impact of climate change as quickly as possible. The framework is called "Construction and Convergence" (C&C), which contains a strategy to reduce GHG emissions to a safe level. The expected goal of the C&C is that each country can control emissions per capita to the same level. One of the requirements to achieve this goal is the stabilization of emissions level in the long run [4]. This means that the emission level for all countries must move at the same point or in a mathematical concept called as convergence.

The study of emissions convergence has been developing in recent decades [5]. Most of these studies use carbon dioxide emissions as an environmental indicator in response to the problem of global warming. At macro level, Aldy (2006) [6] and Kinda (2011) [7] examine convergence of emissions between countries. Li et al. (2017) [8] test emission convergence using a smaller scope between cities in China. Some recent studies examine emissions convergence between economic sectors such as [9] in Portugal. In their study in China, Wang and Zhang (2014) [10] tried to test emissions convergence, both between cities and between sectors. The results from these studies provide diverse conclusions. Ultimately, the results depend heavily on types of pollutants, model, and characteristics of a country or region studied. Meanwhile, the study of emission convergence in Indonesia so far not been carried out. This research is addressed to fill this gap.

The purpose of this study is to test the emission convergence between provinces in Java Island. The selection of Java Island as area of study is based on two following arguments. First, in the Master Plan for the Acceleration and Expansion of Indonesian Economic Development (MP3EI) it is stated that the industrial and service sectors are expected to be the drivers of national development and the regions designated as corridors for the development of the two sectors are Java Island [11]. Second, the socio-economic condition of Java Island is relatively more conducive compared to other islands in Indonesia. The 2009 data shows that around 82% of the national industries are in Java Island (3b) and Gross Regional Domestic Product (GRDP) of all provinces in Java account for more than 60% of Indonesian GDP (3a). In contrast to the previous studies, this study will examine emissions convergence using local emission consisting of air pollutants and water pollutants produced by the manufacturing industry sector.

II. Theoretical Framework and Methodology

Theoretically emissions convergence occurs if areas with high emission levels can reduce their emissions faster than areas with lower emissions level [12]. In other words, emissions convergence indicates a reduction in emissions disparity between regions so that in the long run emissions will lead to stable conditions. The concept is built from the income convergence theory based on the Barro and Sala-i-Martin Hypothesis (1992) [13] that assuming the same level of technology, poor countries tend to grow faster than rich countries, so that the level of prosperity experienced by developed and developing countries will someday converge. This phenomenon is known as the “cathcing up” effect when developing countries succeed in pursuing the economic progress of developed countries. Based on Neoclassical economic theory, Barro and Sala-i-Martin (1992) [13] state that developed countries will experience steady state conditions where investment can no longer increase output in the long run.

The basic principle of measurement of emissions convergence is the same as income convergence. The difference is only in the measured variable. Sigma convergence (σ-convergence) is the most conventional measure in measuring the level of disparity between regions in a given period. Referring to Barro and Sala-i-Martin (1992) [13] sigma convergence for emissions is measured by

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dispersion of per capita emissions between regions. If the dispersion of emissions per capita between regions decreases, convergence is occurred. Conversely, if the dispersion increases, divergence is occurred.

Another type of convergence is beta convergence (β-convergence). Unlike sigma convergence that uses static analysis, this convergence is dynamic because it uses several periods of observation. □-convergence occurs if there is a negative relationship between the growth of emissions per capita and the level of emissions per capita at the beginning of the period. This convergence consists of two hypotheses; they are absolute convergence and conditional convergence. Absolute convergence uses uni-variate analysis because it only involves emission variables in the form of per capita emission growth and per capita emission levels at the beginning of the period. Meanwhile, conditional convergence adds other variables to the model resulting multi-variate model. Through testing conditional convergence, the factors that influence the growth of emissions in the long run can be identified, so that the complexity of emissions problems can be accommodated in the model. Most studies of emissions convergence generally adopt the conditional convergence rather than the absolute convergence. The additional variables usually included in the model are economic growth, scale effect, emission intensity (defensive effect), technique effect, and others [4, 12].

This study examines β-convergence, both absolute and conditional. The convergence is tested quantitatively using the panel data econometric model. The absolute convergence model for emissions among provinces in Java is formulated in the form of double-log as follows:

$$LogE_{i,t} = \alpha_i + \beta logE_{i,t-1} + \varepsilon_{i,t} \qquad (1)$$

where $E_{i,t}$ provincial emissions i in year t; $E_{i,t-1}$ is *lag* of provincial emissions i in year t; α is intercept; β is coefficient of convergence; and $\varepsilon_{i,t}$ is *error term*. Convergence occurs if the value of β is less than zero (negative) and is statistically significant.

Meanwhile, conditional convergence tests include some variables that affect emissions, namely scale effect and technique effect adopted from the emission decomposition model [14]; and economic growth as in [4,12]. The conditional convergence model is formulated as follows

$$logE_{i,t} = \alpha_i + \beta logE_{i,t-1} + \gamma_1 GY_{i,t} + \gamma_2 logSCALE_{i,t} + \gamma_3 logTECH_{i,t} + \varepsilon_{i,t} \qquad (2)$$

where $GY_{i,t}$provincial economic growth i in year t; $SCALE_{i,t}$ is *scale effect* measured by the GRDP of the manufacturing sector in provinces i and years t; $TECH_{i,t}$ is *technique effect* proxied by the energy intensity of the manufacturing industry sector in provinces i and years t.

The econometric model used in this study is dynamic panel data regression with the argument that the relationships between economic variables are in fact dynamic in nature [15]. The advantage of dynamic models compared to static is that the dynamic model involves the dependent lag variable as the regression variable in the model, so that the process of dynamic adjustment can be analyzed. The estimation with the least square approach (as used in the static panel data model) becomes biased and inconsistent, even if it is not serially correlated. To avoid this problem, the method of moments approach is used. Arrelano and Bond (1991) in Baltagi (2005) [15] suggest a generalized method of moments (GMM) approach based on the following two reasons:

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(1) GMM is a common estimator and provides a framework for comparison and assessment; (2) GMM provides a simple alternative to other estimators, especially maximum likelihood.

There are two types of GMM estimation procedures used to estimate autoregressive linear models, namely: (1) first-difference GMM (FD-GMM or AB-GMM); and (2) System GMM (SYS-GMM) which can be used to estimate equations both first-difference and at the level [15]. With these advantages, the second procedure (SYS-GMM) was used in the study and most of the other studies also.

In estimating the dynamic panel data model several testing criteria validity and model specifications are needed to determine a better dynamic model. These criteria are [15]: (1) the consistency of the model using Arellano-Bond m1 and m2; (2) the validity of the instrument using the Citizen Test to determine whether there are serial residual correlations; and (3) parameter estimates using GMM should produce unbiased estimates. Based on these criteria, the best estimator must have consistent, valid, and unbiased criteria.

1. Variables and Data

Based on the model, the variables studied included industrial emissions, economic growth, scale effect, and technique effect. The following are operational definitions and measurements of the variables used in the model.

First are industrial emissions. Referring to Field and Olewiler (2002) [16] emissions are residuals from production activities in the manufacturing sector after going through the process of processing, storing or recycling. Emission volume measurement refers to World Bank (1994) [17] and Yusuf and Alisjahbana (2003) [18] with the following formula

$$Volume\ of\ Emissions = \sum_m \sum_n p_{mn} \cdot q_n \quad (3)$$

where p_{mn} is the volume of emissions m produced per unit of output produced by the manufacturing sector n or often referred to as the emission intensity, and q_n is the output of the manufacturing sector n. The types of emissions included in this study include air pollutants consisting of Nitrogen dioxide (NO_2), Sulfuroxide (SO_2), Carbon monoxide (CO), Volatile Organic Compound (VOC), Particulate, Fine particulate (PM_{10}), Toxic water, and water pollutants consisting of Biochemical Oxygen Demand (BOD), Total Suspended Solid (TSS), and Toxic water.

The emission intensity for each type of pollutant is based on [17]. Industrial sector activities are separated into two groups, namely processing and assembly (subscript n). The emission intensity of the two groups is different where the processing groups are relatively higher compared to the assembly group (Table 1).

Second, economic growth is an increase in economic activity as measured by changes in real GRDP or on the basis of constant prices in 2000 per province. Third, scale effect is the magnitude of industrial activity measured using the real GRDP of the manufacturing industry sector per province. Fourth, the technique effect shows the use of technology measured using industrial sector energy intensity that is defined as the amount of energy used to produce one unit of output (GRDP). Energy use is calculated from the total amount of fuel used by the company in the production process. Each type of fuel consumption is converted into Barrel of Oil Equivalent (BOE). The type of energy and its conversion factors refer to Kementerian Energi dan Sumberdaya Mineral [19] as presented in Table 2.

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The data used in this study consists of 6 provinces during the period 2000-2009 or as many as 60 observations. The provinces are DKI Jakarta, Banten, West Java, Central Java, DI Yogyakarta, and East Java. All data used are secondary data obtained from various publications from various agencies; they are the World Bank, BPS, ESDM, and other sources.

III. Results and Discussion

Statistical testing of the absolute convergence model concluded that there was no convergence of processing industry emissions between provinces in Java during the period 2000-2009. This conclusion can be seen from the emission lag coefficients that are positive and statistically significant at the level of confidence (α) of 5% (Table 3). The same results also occur in the conditional convergence model. Statistical tests conclude that there is no convergence of processing industry emissions between provinces in Java during the period 2000-2009, which is indicated by the emission lag coefficients that are positive and statistically significant with a level of confidence (α) of 10%. Another test result is that emissions growth is influenced by economic growth and the technique effect with a level of confidence (α) of 10% and 5%, respectively. The positive sign of the coefficients of the two variables shows that the increase in economic growth and the partial technique effect will be followed by an increase in emissions growth, vice versa. Meanwhile, the scale effect does not have a significant effect on the growth of these emissions (Table 4).

The results of dynamic panel data estimation must be consistent, valid and unbiased. Arellano-Bond (AB) testing is used to determine the consistency and Citizenship test to determine validity. Meanwhile, to determine the bias and bias in estimation of regression, a comparison between the regression coefficients of estimates using fixed effects and OLS (Ordinary Least Square) is compared. Estimation results and tests to evaluate the absolute and conditional convergence models are presented in Table 5 and Table 6.

The consistency test using the AB m1 and m2 methods of the two models shows consistent results. In the absolute convergence model, the AB test results show a significant value of m1 at the confidence level (α) of 10% and the m2 value is not significant. The same results occur in the conditional convergence model. The significance of the m2 value in both models indicates the lack of a second order serial correlation in the residual, so the estimator is said to be consistent. Meanwhile, the validity test using the Sargan method for both models yielded the same conclusion, which is statistically valid. This conclusion is shown by the insignificance of the Chi-Square statistics, which indicates that there is no correlation between the residuals in the model.

The estimation of the dynamic panel must also be unbiased. This condition is fulfilled if the emission lag coefficient value of the SYS-GMM estimation is above the estimated fixed effect and below the OLS estimate, assuming that all coefficients are statistically significant. In the absolute convergence model these assumptions are fulfilled, where the coefficient value (0.6193) is above the estimated fixed effect (0.2528) and below the OLS estimate (0.9411). Meanwhile, in the conditional convergence model this assumption is not fulfilled because the coefficient value of the fixed effect estimate is not statistically significant. Thus, it can be concluded that estimation is not biased for absolute convergence models but biases for conditional convergence.

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The GMM estimator can contain bias in a limited sample (small size). This condition occurs when the lag levels of the series are weakly correlated with the next first difference, so that the instruments available for the first-difference equation are weak. However, Alvarez and Arellano (2003) in Baltagi (2005) [15] show that the bias in GMM is always smaller than fixed effects and OLS.

The results showed that there was no convergence of industrial emissions between provinces in Java during the period 2000-2009, both in absolute and conditional terms, or in other words the dynamics of industrial emissions led to divergent conditions. This means that provinces with high emission levels cannot reduce emissions faster than provinces with lower emission levels, so there is no catching-up effect towards smaller emissions disparities. This result is a 'signal' that industrial emissions in the current period are proportional to industrial emissions in the previous period. If there is no policy that encourages convergence, then in the long run there will be no emission stabilization towards eco-industry and sustainable development.

The process towards emission convergence is closely related to reducing emission levels. Various countries have different experiences in applying emission reduction policies and strategies. In developed countries, emissions reductions are carried out through several instruments such as emission tax and subsidies, or transferable charge permits / marketable pollution permits which are better known as carbon trading [2, 20]. Meanwhile, in developing countries, the emission reduction strategy can be carried out through investments in environmentally friendly technology development, both in terms of supply and demand [21]. Referring to this experience, the reduction in processing industry emissions in Java can be directed towards environmental improvement investments and the Payment of Environmental Services (PES) system.

Emission divergence is a common phenomenon that is often found in developing countries such as the study of [6, 22]. In general, developing countries have socio-economic characteristics that inhibit the occurrence of emission convergence. The following is an explanation of the results of estimation and statistical testing of the effects of economic growth, the scale effect, and the technical effect on emissions growth between provinces in Java Island during the period 2000-2009.

The test results show that economic growth has a positive and significant effect on emissions growth, meaning that increasing economic growth will have an impact on increasing industrial emissions. This case generally occurs in developing countries such as Indonesia where the relationship between economic development and environmental preservation is still a trade-off, meaning that efforts to accelerate economic growth through industrialization will be followed by increased emissions. Conversely, reducing emissions will have consequences for the slow pace of economic growth.

The relationship between economic growth and emissions has long been a study of studies among academics. Most studies in this field aim to examine the existence of the Environmental Kuznets Curve Hypothesis (EKC) which states the 'U inverse' relationship between economic development and environmental degradation. Test results The EKC hypothesis does not produce general conclusions and is even 'ambiguous' [23]. However, in general EKC occurs in developed countries that have high income levels, while in NSB the relationship

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between the two variables is linearly positive [24]. The results of the Fauzi (2012) [20] study in Indonesia showed a positive linear relationship between income and CO2 emissions or in other words the existence of EKC was not found.

The test results concluded that the scale effect did not affect the growth of processing industry emissions between provinces in Java. These results are not in accordance with the theory which states that the scale effect that shows the output size of an industry is the main factor causing the increase in emissions [3, 25] . The anomaly is related to the calculation method where the emission intensity coefficients are distinguished according to the group processing and assembly. On the other hand, the scale effect represents the size of the output produced by the industrial sector without making a difference based on the group. Selden, et al. (1999) [21] provide confirmation that output does not contribute too much to the decomposition of emissions. In fact, the volume of emissions is more determined by shifting fuel use, energy intensity, and technological progress.

Empirical evidence proves that the technique effect has a positive and significant effect on the growth of emissions. Given that in this study the technique effect is proxied from energy intensity as measured by the ratio of fuel consumption to output, the high value of the technique effect indicates the low level of technology. Thus, the positive relationship between technique effect and emission growth implies that high energy intensity (low level of technology) contributes to the high growth of emissions. This finding is supported by the results of calculations showing energy intensity of more than 1 during the period 2000-2009. This means that to produce one rupiah the output requires more than one rupiah of energy, or in other words energy use in the processing industry is inefficient.

Some studies prove that technology has an important role in reducing emissions [22, 26, 27]. According to Karakaya and Ozcag (2005) [28] technology can reduce emissions through two ways, namely: (1) technology can reduce raw materials and energy used to produce output; and (2) technology is able to convert high-polluting energy into low pollution or from fossil energy to non-fossil. However, technological development requires enormous costs, so the high level of technology has a close relationship with the progress of a country. Kate (1993) [29] illustrates that manufacturing industries in advanced industrial countries that are members of the OECD (Organization for Economic Co-operation and Development) are able to reduce energy intensity by around 38%.

IV. Conclusion

The results of estimation and statistical testing using dynamic panel econometric data concluded that there was no convergence of emissions, both absolute and conditional, in the provincial pageanter industry in Java during the period 2000-2009. The dynamics (movement) of industrial emissions in Java Island tend to be diverging which indicates an increase in the disparity in emissions growth between provinces from year to year. Another finding is that the emission growth is influenced by economic growth and technique effects, but not influenced by the scale effect.

Based on these conclusions, this study proposes the following recommendations. First, industrial emission reductions (especially processing groups) can be done by: (1) reducing dependence on fossil energy, developing alternative energy, and creating technological

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progress; (2) applying policy instruments through emission tax or internalization of emissions costs that have been implemented in several countries. Second, to avoid the problem of bias in estimating models and explaining emissions growth better, further research is recommended by adding research data and variables.

Table 1 Emission Intensity: *Processing Vs Assembly*

(lbs. per million Rp - 1989)

Pollutants	*Assembly*	*Processing*	*Ratio Processing/Assembly*
"New" Pollutants			
Volatile Organic Compounds (Air)	9.609	9.495	1.0
Lead (Air)	0.00048	0.00289	6.0
Toxic Release (All Media)	4.806	13.085	2.7
Bio-accumulative Metal (All Media)	0.254	0.987	3.9
"Traditional" Air Pollutants	0.679	3.037	4.5
Fine Particulate (Air)	7.394	24.03	3.3
Sulfur Dioxide (Air)	2.518	15.39	6.1
Total Particulate (Air)	4.138	17.50	4.2
Nitrogen Dioxide (Air)	7.193	17.39	2.4
Carbon Monoxide (Air)			
"Traditional" Water Pollutants			
Biochemical Oxygen Demand (Water)	7.006	5.458	0.8
Suspended Solids (Water)	2.632	36.27	13.8

Source: World Bank (1994)

Table 2 Conversion of Energy Unit to BoE

Type of Energy	Unit	BOE's multiplier
Premium/Gasoline	Kilo Liter	5.8275
ADO/HSD/Diesel Fuel	Kilo Liter	6.6078
Kerosene	kilo Liter	5.9274
Coal	Tons	4.1998

Source: ESDM (2007)

Table 3 Regression Result of Absolute Convergence Using SYS-GMM *two step*

Parameter	Estimated Coefficients	Standard Error	P>|z|
SYS-GMM			
L.emission	0.6193251	0.195181	0.002
constanta	4.696555	2.414745	0.0052

Source: estimation result

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Table 4 Regression Result of Conditional Convergence Using SYS-GMM *two step*

Parameter	Estimated Coefficients	Standard Error	P>|z|
SYS-GMM			
logL.emission	0.3021407	0.168944	0.074
growth	0.4095109	0.214887	0.057
logscale	0.4827898	1.199889	0.687
logtechnique	0.350862	0.171654	0.041
constanta	6.039975	2.89197	0.037

Source: estimation result

Table 5 Model Evaluation of Absolute Convergence

Parameter		*Estimated Coefficients*	*Standard Error*	*t*	*P>|t|*
Pooled Least Square					
logL.emission		0.9411	0.0472	19.96	0.000
Fixed Effect					
logL.emission		0.2528	0.1423	1.78	0.082
AB Test		Z	Prob > z		
Arellano-Bond m1		-1.6503	0.0989		
Arellano-Bond m2		1.1175	0.2638		
Sargan Test	Chi (41)			3.7109	
	prob > chi			1.0000	

Source: estimation result

Table 6 Model Evaluation of Conditional Convergence

Parameter		Estimated Coefficients	Standard Error	t	P>|z|
Pooled Least Square					
logL.emission		0.5808	0.1217	4.77	0.000
Fixed Effect					
logL.emission		0.16670	0.1509	1.11	0.275
AB Test		Z	Prob > z		
Arellano-Bond m1		-1.6498	0.0990		
Arellano-Bond m2		0.7780	0.4365		
Sargan Test	chi (40)			1.8380	
	prob > chi			1.0000	

Source: estimation result

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