Advances in Economics, Business and Management Research, volume 101
1st International Conference on Islamic Economics and Business (ICONIES 2018)

Industrial Emissions in Java Island of Indonesia: A Convergence Analysis

1st Deni Kusumawardani
Department of Economics
Airlangga University
Surabaya, Indonesia

2nd Teuku Noerman
Department of Business Administration
Brawijaya University
Malang, Indonesia
tnoerman@ub.ac.id

3rd Mei Anggun Soraya
Department of Economics
Airlangga University
Surabaya, Indonesia

4th Feri Dwi Riyanto
Department of Management
State Islamic University of Maulana Malik Ibrahim
Malang, Indonesia
feri.riyan@uin-malang.ac.id

***Abstract* – This main objective of this study is to test emissions convergence, absolute and conditional, of manufacturing industry among provinces in Java Island as center of industrial activity and economic growth in Indonesia. Micro-data at firm-level of six provinces during 2000-2009 are employed and econometrics technique is applied to estimate dynamic model of the convergence. The statistical 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. Other findings conclude that the industrial emissions growth is affected by economic growth and technique effect.**

Keywords – emissions convergence, technique effect, manufacturing industry, 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. Some experts agreed that the main cause of global warming is the increase of greenhouse gases (GHGs), especially carbon dioxide (CO_2) emissions [1]. The impact of global warming that triggers climate change resulted large economic losses. It is mentioned 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 [2].

It is 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%) [1]. 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 Global Commons Institute (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 [3]. This means that the emission level for all countries must move at the same point or in a mathematical concept called as convergence.

The studies of emissions convergence have been developing in recent decades. Most of studies explored macro data level among countries [4,5], even though the emission convergence may be tested in a smaller scope among cities in certain countries [6]. Some recent studies [7,8,] tried to examine the emissions convergence among economic sectors. CO_2 is dominant used as an environmental indicator in response to the problem of global warming. These studies results provide diverse conclusions depending heavily on types of emissions and model used.

Meanwhile, the study of the 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 [9]. **Second**, the socio-economic condition of Java Island is relatively more conducive compared to other islands in Indonesia. It is around 82% of the national industries are in Java Island

[10] and Gross Regional Domestic Product (GRDP) of all provinces in Java account for more than 60% of Indonesian GDP [11]. In contrast to the previous studies, this study uses local emission consisting of air pollutants and water pollutants produced by the manufacturing industry sector.

II. THEORETICAL FRAMEWORK AND METHODOLOGY

Emissions convergence occurs if areas with high emission levels can reduce their emissions faster than areas with lower emissions level [13]. 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 Barro and Sala-i-Martin Hypothesis [14] 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 *"catching up"* effect when developing countries succeed in pursuing the economic progress of developed countries. Based on Neoclassical economic theory, developed countries will experience steady state conditions where investments can no longer increase output in the long run.

The basic principle of measurement of emissions convergence is the same as income convergence and 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. If the dispersion of emissions per capita between regions decreases, the convergence is occurred. Conversely if the dispersion increases, divergence is occurred.

Another type of convergence is beta convergence (β-convergence). Unlike σ-convergence that makes use of static analysis, the β-convergence is dynamical nature because it uses several periods of observation. The β-convergence occurs if there is a negative relationship between growth of emissions per capita and level of emissions per capita at the beginning of the period. The convergence consists of two hypotheses: absolute convergence and conditional convergence. The absolute convergence employs uni-variate analysis technique because it only involves emissions variable 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 so that results multi-variate form. Through testing conditional convergence, the factors affecting the emissions growth 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 adopted 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 [3,13].

A. Model Specification

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

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

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. The emission convergence occurs if the value of β is less than zero (negative) and is statistically significant.

Meanwhile, conditional convergence test include some variables that affect emissions; those are scale effect and technique effect [15] and economic growth [3,13]. The conditional convergence model is formulated as follows

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

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* measured by the energy intensity of the manufacturing industry sector in provinces i and years t.

The econometric model employed in this study is dynamic panel data regression with the argument that the relationships between economic variables are in fact dynamic in nature. 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 of least square approach used in the static model is bias and inconsistent, even if it is not serially correlated. To avoid this problem, generalized method of moments (GMM) approach is adopted based on following reasons: (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 [16].

There are two types of GMM estimation procedures to estimate autoregressive linear models: (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]. The second procedure will be applied in the study as used in the previous studies.

B. Variables and Data

Based on the model, the variables included in this study are industrial emissions, economic growth, scale effect, and technique effect. The operational definitions and measurements of these variables are explained as follows.

Table 1
Emission Intensity: *Processing Vs Assembly* (lbs. per million Rp - 1989)

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

Source: World Bank [18]

Industrial emissions (E) are residuals from production activities in the manufacturing sector after going through the process of processing, storing or recycling [17]. The Emissions measured using following formula [18,19]

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

where p_{mn} is the volume of emissions m produced by per unit of output of manufacturing sector n and it is called as emission intensity, and q_n is the output of the manufacturing sector n. The types of emissions 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 [18]. Industrial sector activities are separated into two groups; those are processing and assembly (subscript n). The emission intensity of the two groups is different where the processing are relatively higher compared to the assembly as presented in Table 1.

Economic growth (GY) is an increase in economic activity as measured by changes in real GRDP at 2000 constant prices per province. Scale effect (SCALE) is the magnitude of industrial activity measured using the real GRDP of the manufacturing industry sector per province. Technique effect (TECH) indicates technology level of industrial sector. This variable is commonly measured by energy intensity 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 a firm in the production process. Each type of fuel consumption is converted into Barrel of Oil Equivalent (BOE) unit [20] as presented in Table 2.

The data used in this study consists of 6 provinces during the period 2000-2009. Calculation and estimation employ micro-data at firm-level of 2-digit ISIC. The provinces included are DKI Jakarta, Banten, West Java, Central Java, DI Yogyakarta, and East Java. All data are secondary data obtained from publications from many institutions, particularly BPS, World Bank, and ESDM.

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 [19]

III. RESULTS AND DISCUSSION

The absolute convergence model concludes that there is no convergence in manufacturing industry emissions among provinces in Java Island of Indonesia. This finding can be seen from positive sign in the emission lag coefficients variable and statistically significant at 5% of level of significance (Table 3). The same result also occurs in the conditional convergence model at 10% of the level of significance. Statistical tests show that the emissions growth in Java Island is affected by economic growth and technique effect at 10% and 5% of level of significance, respectively. The positive sign of the two variable coefficients show that an increase in economic growth and technique effect will be followed by an increase in emissions growth. Meanwhile, the scale effect does not have a significant effect on the emissions growth.

The divergence of industrial emissions among provinces in Java Island indicates 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 move proportionally to industrial emissions in the previous period.

The emission divergence is a common phenomenon that is often found in developing countries [4,23]. In general developing countries have socio-economic characteristics that inhibit the occurrence of emission convergence. If there is no policy that encourages convergence condition, in the long run there will be no emission stabilization towards eco-industry and sustainable development.

Table 3
Regression Results Using SYS-GMM twostep

Variables	**Absolute Convergence**	**Conditional Convergence**
log $E_{i,t-1}$	0.619*** (0.195)	0.302* (0.169)
GY	-	0.410* (0.215)
logSCALE	-	0.483 (1.200)
logTECH	-	0.351** (0.172)
Constant	4.697*** (2.415)	6.040** (2.892)

Notes: ***, **, and * indicate 1%, 5%, and 10% significance levels. Standard errors in parentheses

Towards emission convergence many countries have different experiences in implementing emission reduction policies and strategies. In developed countries, emissions reductions are carried out through several instruments such as emission tax and transferable charge permits known as carbon trading [17,21]. Meanwhile, in developing countries the emission reduction strategy may be carried out through investments in friendly technology development [22]. Referring to this experience, the reduction of industrial emissions in Java Island of Indonesia can be directed towards environmental improvement investments and the Payment of Environmental Services (PES) system.

Statistical test results that the economic growth has a positive and significant effect on emissions growth in Java Islands of Indonesia. It means that increasing in the economic growth will have impact on increasing industrial emissions. This case generally occurs in developing countries where the relationship between economic development and environmental quality is still 'trade-off' condition. In consequence, efforts to accelerate economic growth through industrialization will be followed by increased emissions. Conversely, reducing emissions will have impact to slow pace of economic growth.

The relationship between economic growth and emissions has been one of debated topics in academic circle. Most studies focus on testing existence of the Environmental Kuznets Curve Hypothesis (EKC) which states the inverted-U shaped relationship between economic development and environmental degradation. The EKC hypothesis investigation does not produce a general conclusion and is even 'ambiguous' [24]. However, in general EKC found in developed countries that have high income levels. In developing countries, such as Indonesia, the common relationship is linearly positive or the EKC is not confirmed [25,26].

Scale effect does not affect statistically on the industrial emissions growth in Java Island of Indonesia. This result is not in accordance with the most of previous studies showing that the scale effect, measured by output size, is one of driving forces of emissions increase [15,27]. The anomaly is related to the calculation method where the emission intensity coefficients are distinguished according to processing and assembly whereas the scale effect represents the size of total output produced.

Empirical evidence proves that the technique effect has a positive and significant effect on the emissions growth in Java Island of Indonesia. It is mean that high energy intensity (low level of technology) contributes to the high growth of emissions. This finding that the energy use in Indonesia, particularly manufacturing industry, is inefficient as found in most of developing countries. Such condition differ from developed countries where technology can reduce emissions through two ways: (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 [28]. However, technological progress requires a lot of fund, so the high level of technology has a close relationship with economic progress and income level of a country.

IV. CONCLUSION

The results of estimation and statistical testing using dynamic panel econometric concluded that the emissions convergence, both absolute and conditional, in industrial sector in Java Island of Indonesia during the period 2000-2009. The movement of industrial emissions tends to be diverging which indicates an increase in the disparity in emissions growth among provinces. Other findings are that the emission growth is affected by economic growth and technique effects, but not by the scale effect.

According to these conclusions, this study recommends energy and environmental policies to reduce the industrial emissions. The energy policies may be implemented through reducing dependence on fossil energy, developing alternative energy, and creating technological progress while the environmental policies may be applied through emission tax.

REFERENCES

[1] Intergovernmental Panel on Climate Change – IPCC. 2014. *Climate Change 2014: Synthesis Report*. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Geneva, Switzerland: IPCC

[2] Global Commons Institute (GCI). 2001. "The Essentials of 'Contraction and Convergence' (C&C)". *UNEP Financial Institutions Position Paper at COP-7 UNFCCC - Dec 200.*

[3] Criado O. C., Valente S., and Stengos S. 2011. "Growth and Pollution Convergence: Theory and evidence". *Journal of Environmental Economics and Management,* 62 (2011) 199–214.

[4] Aldy, Joseph E. 2005. "Per Capita Carbon Dioxide Emissions: Convergence or Divergence?". *Discussion Papers,* DC 20036. Washington.

[5] Kinda, S. R. 2011. Education, Convergence and Carbon Dioxide Growth per Capita. *African Journal of Science, Technology, Innovation and Development,* Vol. 3 No. 1 (2011) 65-85.

[6] Li, J., Huang, X., Yang, H., Chuai, X., & Wu, C. 2017. Convergence of Carbon Intensity in the Yangtze River Delta, China. *Habitat International* 60 (2017) 58-68.

[7] Mountinho, V., Robaina-Alves, M., & Mota, J. 2014. Carbon Dioxide Emissions Intensity of Portuguese Industry and Energy Sectors: A Convergence Analysus and Econometric Approach. *Renewable and Sustainable Energy Reviews 40 (2014)* 438-449.

[8] Wang, J., & Zhang, K. 2014. Convergence of Carbon Dioxede Emissions in Different Sectors in China. *Energy 65 (2014)* 605-611.

[9] Kementerian Koordinator Bidang Ekonomi. 2011. *Masterplan Percepatan dan Perluaan Pembangunan Ekonomi Indonesia (MP3EI) 2011-2015*. Jakarta

[10] Badan Pusat Statistk (BPS). 2010b. *Jumlah Industri Pengolahan Besar dan Sedang, Jawa dan Luar Jawa*, 2001-2008. Jakarta.

[11] Badan Pusat Statistik.2010a. *Perkembangan Beberapa Indikator Utama Sosial-Ekonomi Indonesia*. Jakarta.

[12] Badan Pusat Statistik. 2000-2009. *Survey Tahunan Perusahaan Industri Pengolahan*. Terbitan tahun 2000-2009. Jakarta

[13] Alvarez F., Marrero G.A., dan Puch L.A. 2004. "Air Pollution Convergence and Economic Growth Across European Countries". Paper dipresentasikan pada *2nd Economic Dynamic and the Environment Workshop* pada Juli 2014 di Madrid.

[14] Barro, R.J., dan Sala-i-Martin, V. 1992. "Convergence". *Journal of Political Economy* Vol 100 No.2.

[15] Grossman, G.M. 1995. "Pollution and growth: what do we know?" *The economics of sustainable development*, Cambridge University Press.

[16] Baltagi, B.H. 2005. *Econometric Analysis of Panel Data*. *Third Edition*. England: John Wiley & Sons, Ltd.

[17] Field B. dan Olewiler N. 2002. *Environmental Economics*. *Second Canadian Edition*. USA: McGraw-Hill.

[18] World Bank. 1994."Indonesia Environment and Development". *A World Bank Country Study*. Washington.

[19] Yusuf A.A., dan Alisjahbana A. 2003. "Assessing Indonesia's Sustainable Development: Long-Run Trend, Impact of The Crisis, and Adjustment during The Recovery Period". *MPRA Paper,* No. 1736.

[20] Kementerian Energi dan Sumber Daya Mineral (ESDM). 2007. *Handbook of Energy & Economic Statistics Of Indonesia*. Accessed from www.esdm.go.id

[21] Pearce, W.P. & Turner R.K. 1990. *Economics of Natural Resources and the Enivronment*, Newyork: Harvester Wheatsheaf.

[22] Timilsina, R. G. 2012." Economic Implications of Moving Toward Global Convergence on Emission Intensities". *Working Paper of World Bank*, No.6115.

[23] Romuald. 2011." Education, Convergence and Carbon Dioxide Growth per Capita". *African Journal of Science, Technology, Innovation and Development,* Volume 3, Number 1 65-85.

[24] Egli, H. 2004. "The Environmental Kuznets Curve – Evidence from time series data for Germany", *Working paper 03/28,* Institute of Economic Research.

[25] Martinez-Zarzosso, Inmaculada, dan Bengochea-Morancho, A. 2003. "Testing for an Environmental Kuznets Curve in Latin". *Revista de Analisis Economico* Vol 18 No 1.

[26] Fauzi, D. A. 2012. "Pendapatan dan Emisi Karbon Dioksida (CO2) di Indonesia Tahun 1960-200: Uji Kausalitas dan Environmental Kuznets Curve". *Thesis*. Unpublished

[27] Grossman, G. M., dan Krueger, A.B. 1994. "Economic Growth and The Environment", *NBER Working Paper Series No.4634*.

[28] Karakaya E., dan Ozcag M. 2005. "Driving Forces of $C0_2$ Emission in Central Asia: A Decomposition Analysis of Air Pollution From Fossil Fuel Combustion", *Arid Ecosystems Journal* Vol. 11, No. 26-27, August 2005, Pages 49-57.