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Article

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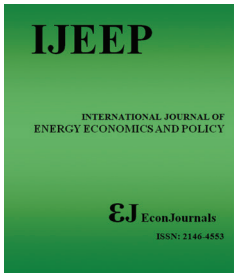

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Role of Innovation in Testing Environment Kuznets Curve: A Case of Indonesian Economy

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ABSTRACT

This present study examines the role of technology innovation in testing the environmental Kuznets Curve in Indonesia by taking the annual time series data over the time period of 1980-2017. The study used high technology exports as a proxy of technology innovation to examine the long run relationship between economic development, technology innovation and carbon dioxide emission in Indonesia. The author applied the advance econometrics to serve the purpose of investigation and therefore used the fully modified ordinary least square (FMOLS) and dynamic ordinary least square (DOLS) for assessing the presence of long-run relationship between the variables. Utilizing the framework of Kuznets Curve, the results of FMOLS and DOLS approaches confirm the valid long run relationship between technology innovation and environmental degradation in Indonesia. The empirical results indicate that technology innovation has negative and significant impact on carbon dioxide emission long run. Therefore, the findings of the study recommended that technology innovation does not only benefit for the economic development but also helps to reduce the environmental degradation in Indonesia.

Keywords: Environmental Kuznets Curve, Technology Innovation, Innovation, Indonesia
JEL Classifications: Q5, Q55, Q56,

1. INTRODUCTION

The World at present is witnessing severe adverse effects of deteriorating environmental condition (Kang and Hwang, 2016). The hostile impact of global warming has resulted into extreme weathers conditions, droughts, diminishing natural resources that ends up in creating unpredictable situations that bring negative effects to human and economic development (Baiardi, 2014) in addition to the global warming, the human impact on environmental degradation, as a result of harmful emissions from the industries and transportations, has also augmented the atmospheric burden.

Carbon emission is regarded as the most harmful form of emission that brings several adverse effects to environment (Kigpiboon, 2013; Kobayashi et al., 2013; Balin and Akan, 2015; Zomorrodi and Zhou, 2016; Zhang, 2017; Al-Fatlawi, 2018). In order to deal with the damaging impact of such emissions, the economies now a days is converting their focus towards innovative forms of business practices that can curtail not only the negative influence of environmental degradation but also brings the productivity and enhanced efficiency. In this context, the role of innovation is being highly appreciated by the financial experts, investors and policy makers, in inventing durable solutions to compliment not only the organizational visions but also to ensure environmental sustainability (Henry, 2014; Van der Bank and Van Der Bank, 2014; Danbaba et al., 2016; Kang and Hwang, 2016; Zomorrodi and Zhou, 2017; Luong et al., 2017; Baran and Yilmaz, 2018). In doing, the businesses in modern times are more focused in enhancing the capacity of the individual, organizations and countries to adapt, shape and accommodate the inventive ways of economic operations that corresponds to the goal of sustainable

development. For that purpose, the focus of nations is diverted towards utilizing progressive methods and consistent high-tech exertions to elevate the prospects of distinctiveness.

As the adversity in climate is increasing with greater pace, the objective of sustainability in such manner is considered urgent to address the issue of environmental degradation to minimize the negative impact on the earth. Furthermore, the policy makers and ecological experts have also stressed the role of innovation in resulting maintainable improvement by concentrating on the incentive ways through which the damaging impacts of business and financial activities can be reduced (Hofman, 2014; Gideon, 2014; Adebambo et al., 2014; Shahid et al., 2014; Ramos et al., 2018). In this regard, the contribution of high technology inventions are considered to create effective ways of combating business goals along with sustainable targets. In other words, the trend of high technology innovations are regarded as the successful antecedent of progressive commercial activities, unique philosophies, and redefined ecological goals.

The principle goal of the present examination is to find the impact of innovation in the theoretical background of Environmental Kuznets Curve (EKC) in Indonesia. For fulfilling our objective, the present research looks at the dynamic association between carbon emissions, economic growth and innovation. The innovation in the present study is measured by the value of high-tech exports of Indonesia and thus aims to offer the proficient insights to the policy makers in Indonesia. In compliance with the objective of the study, the authors employed the advanced econometrics of fully modified ordinary least square (FMOLS) and dynamic ordinary least square (DOLS) to ensure the reliability and trustworthiness of the empirical findings.

The present examination is hence inspired to contribute from several aspects. Initially, in analyzing the substantial inclusion of innovation in existing framework of EKC literature after considering its substantial importance in the recent literature (Fernández et al., 2018; Ramos et al., 2018; Balsalobre and Shahbaz, 2017). Second, retreating from the utilization of traditional knowledge-based measures of innovation such as, investments in Research and Development (Álvarez-Herránz et al., 2017; Kang and Hwang, 2016; Baiardi, 2014), the present study utilized the economically hands-on aspect of innovation in terms of high-tech exports. Furthermore, the uniqueness of the present study is also explained from the utilization of the multivariate approach to ensure larger explanation of the phenomenon and freedom from non-inclusion biasness, as opposed to the frequently applied bi-variate approach (Shahbaz et al., 2018; Balcilar et al., 2017). Also, the current investigation utilized the advanced approach in applying the DOLS and FMOLS as opposed to depending on the conventional procedures, such as the traditional OLS methodology.

The rest of the investigation is organized as follows: Sections two sheds lights on the literary examinations identified with the field of innovation and environmental degradation. Segment three displays the essential comprehension of the procedures associated in the present investigation. This is followed by section four that shows the empirical examination and outcomes of the analysis. In conclusion, segment five closes the exploration and proposes the basic ramifications of the relationship among environmental degradation and innovation for the case of Indonesia.

2. LITERATURE REVIEW

The debate on the connection between environmental degradation with economic activities has been frequently documented in the existing literature. In this context, the majority of the studies supported the view of negative association between environmental degradation and economic progress. However, investigating the role of innovation in the existing EKC framework is considered as a fresh inclusion.

In discussing the role of innovations associated with energy, Balsalobre and Shahbaz (2017) examine the contribution of energy innovations in influencing environmental degradation in the form of greenhouse gas emissions. In order to measure the energy innovation, the study utilized the public expenditures on research and development & demonstration in energy sector of twenty eight countries under the OECD. For fulfilling the purpose of exploratory the role of energy innovation in EKC, the authors utilized the data from the period of 1990-2014. The findings of the study suggested that energy innovation has a partial significant effect in influencing greenhouse gas emissions in the sampled countries. The study recommended that the policies of energy innovation are required government exclusive focus and time to enhance the positive effect of innovation in reducing environmental quality.

With the similar objective, Kang and Hwang (2016) reconnoitered the effect of technological innovations in EKC framework. Similar to Balsalobre and Shahbaz (2017), the study also measured environmental degradation from the emissions of greenhouse gases. Also the measure of technological innovations adopted by the authors represent the value of per capita research and development. For performing the empirical investigation, the authors applied the technique of Panel VAR to analyze the role of technological innovation in EKC hypothesis. The results of the analysis establish that technological innovation play a significant role in influencing environmental degradation. In other words, the outcomes suggested that research and development per capita tends to reduce the impact of greenhouse gas emissions in the sampled countries.

Balin and Akan (2015) explore the contribution of innovation in reducing environment degradation. For that purpose, the study analyzed the sample of twenty seven industrialized countries from the period of 1997-2009 utilizing the panel approach. Similar to several earlier studies, the authors measured innovation as the investments made by the countries in research and development, whereas, unlike Balsalobre and Shahbaz (2017) and Kang and Hwang (2016), the environmental degradation is measured as the emissions resulted from the carbon-di-oxide in the sampled countries. The results of the study revealed an N-shaped association between gross domestic product and environmental degradation. Furthermore, the findings also establish a significant negative association between innovation and environmental degradation. Similarly, Baiardi (2014) also examine the role of innovation in

influencing ecological deterioration. Similar to Balin and Akan (2015), the study also establish the substantial contribution of innovation in reducing the adverse effects of the harmful emissions on the environment.

Recently, Ramos et al. (2018) also examine the impact of innovation in affecting the environmental degradation of Portugal. The study utilized the investments in research and development as the measure of innovation and carbon emission as the measure of environmental degradation. The study utilized the panel data approach by analyzing the eleven diverse industries of Portugal between the periods of 1996-2013. The results of the study suggested the presence of both U-shaped and N-Shaped association among the variables. Performing the firm level analysis, Lee and Min (2015) investigated the role of technological innovation in improving environmental performance. In addition, the study also seek to find the association of green innovation with organizational performance. Collecting data from the manufacturing companies of Japan, the study examine the role of research and development investments in improving firm and environmental performance. For this purpose, the study utilized the data from the period of 2001-2010. The results of the study found that green investments tends to reduce the negative effects of carbon emission, Moreover, the findings also established that investments in green research and development enhances firm's value and improves financial performance.

Similarly, Álvarez-Herránz et al. (2017) also examined the effects of innovation in decreasing environmental degradation. The study adopted the panel approach in investigating the sample of twenty eight OECD countries from the period of 1990-2014. Utilizing the proxies of research and development investments and greenhouse gas emissions to measure innovation and environmental degradation, the findings of the panel investigation establish a significant relationship between energy innovation and greenhouse gas emissions. In other words, the outcome suggested that energy innovation has the tendency to decline the negative effects of greenhouse gases on the environment of panel countries.

In another panel investigation, Zhang et al. (2017) explore the impact of innovation in affecting environmental degradation. The study collected data from the period of 2000-2013 in thirty provinces of China. The authors applied SGMM methodology to investigate the impact of technological innovation in curtailing carbon emissions in the sampled provinces. The results of the study established that innovation does play critical role in reducing carbon emissions and should be considered as the efficient tool of minimizing environmental degradation. More recently, Fernández et al. (2018) also examine the effect of innovations in the form of research and development in influencing carbon emissions in a sample of seventeen countries from the period of 1990-2013. The empirical investigations of the study is carried out by applying the technique of ordinary least square in the panel estimation. The results of the study conclude that investments in research and development reduce the effects of carbon emission and is considered crucial for curtailing the adverse effects on the climate.

Hence the overview of the existing literature confirms the association of innovation with the degradation of environment, however, the majority of the existing studies focused on panel investigations. In this regard, the scarcity of time series analysis calls for the need of re-investigate the association of innovation with environmental deterioration in the existing EKC Framework by applying the unique measure of the value of high-technology exports as the indicator of technological innovation. Also the adoption of refined methodologies will be fruitful in analyzing the relationship between innovation and environmental degradation.

3. METHODOLOGY

3.1. Data

The present employs the annual observations of carbon dioxide emission as a proxy of environmental degradation, gross domestic product as a proxy of economic growth and high technology exports as a proxy of technology innovation. All the data is gathered from World Bank for the period of 1980-2017. Furthermore, the data is converted in per capita form by dividing all the variables by the total population of Indonesia. After critically examine the earlier studies framework, we investigate the nexus of economic growth, carbon dioxide emission and exports of goods and services in the current study which are as follows:

$$CE_t = \alpha_0 + \beta_1 Y + \beta_2 Y^2 + \beta_3 INO + \varepsilon_t \quad (1)$$

In the above mode, *CE* represents per capita of carbon dioxide emission, *Y* is the economic growth of Indonesia which is a proxy and calculated by the per capita of gross domestic product, Y^2 is the square of economic growth, *INO* is measured as per capita of high technology exports which is the proxy of technology innovation. ε is the error term and *t* represents the number of observations in the time.

3.2. The Cointegration Test

To examine the existence of long run or co-integrating relation of innovation under the EKC framework, the paper employs Johansen and Juselius (1990) Cointegration tests. To inspect the presence of long run association among the studied variables, we employ Johansen and Juselius (1990) Cointegration technique. The Johansen-Juselius Cointegration technique is based upon trace statistics (λ_{trace}) and maximum Eigen value statistic (λ_{max}) which decide the total cointegrating vectors (Brooks, 2008). The test statistics i.e., λ_{trace} and λ_{max} can be expressed as follows.

$$\lambda_{trace}(r) = -T\sum_{i=r+1}^{g} \ln(1-\hat{\lambda}_i) \quad (2)$$

And

$$\lambda_{\max}(r, r+1) = -T\ln(1-\hat{\lambda}_{i+1}) \quad (3)$$

Where r in equation 2 denotes the total cointegrating vectors in null hypothesis and represents the expected significance amount for the i^{th} ordered Eigen value from the Π matrix. The different co integrating vectors termed as Eigen vectors will be associated with Eigen value.

3.3. FMOLS

The FMOLS approach introduced by Phillips and Hansen (1990) is also utilized to examine the robustness of our basic outcomes

which attain from OLS focused coefficients framework. *FMOLS* gives the maximum coefficients of the Cointegration equation (An and Jeon, 2006; Sharif et al., 2018; Sharif and Afshan, 2018). The FMOLS alters the OLS to overcome the issues of endogeneity and serial-correlation in the variables that results from the presence of a cointegrating association (Philips and Hansen, 1990).

3.4. DOLS

The current study also used DOLS method to check the robustness of the connection between criterion variable and predictor variables. DOLS technique is introduced by Stock and Watson (1993). This approach includes assessing the criterion variable on predictor variable by utilizing the levels, leads and lags of the predictor variable. This approach solves the problem of lesser sample bias, serial-correlation and endogeneity issues by accumulating the leads and lags effect of predictors (Stock and Watson, 1993).

3.5. Granger Causality Analysis

In order to identify the causal linkages between the specified variables, the present study intended to apply the Granger causality technique. The method of Granger causality entails numerous benefits in contrast to other causal estimation particularly in the time-series estimations. This endorses that the decision of applying the said analysis for identifying the causal connection between environmental degradation, economic growth and technology innovation in Indonesia are trustworthy and more dependable in comparison to the earlier studies.

4. DATA ANALYSIS AND DISCUSSION

The main focus of the current study is to test the EKC framework in Indonesia with the inclusion of innovation. Table 1 provides the results of the descriptive statistics analysis of carbon dioxide emission, economic growth and innovation. The average values for all the considered variables are positive. Carbon dioxide emission a mean value of (158.4677) which varies from 143.641 to 167.181. Economic growth has an average value of (0.061) which fluctuates from 0.052 to 0.069 and finally, innovation has a mean value of (12.475) which differs from 8.374 to 15.556. Furthermore, the outcomes of the Jarque-Bera test are significant at the 1% level, which shows that carbon dioxide emission, technology innovation and economic growth are not normally distributed in the case of Indonesia. Moreover, the coefficient of correlation is also positive and strong for the variables. The maximum correlation is found between carbon dioxide emission and economic growth the coefficient value of 0.988. The correlation between carbon emission and technology innovation is also positive and high with the coefficient value of 0.957. The P-values of the correlation coefficients are highly significant as those values are statistically significant at the 1% level.

Table 2 displayed the outcome of stationary test utilized in the current study. For fulfilling the purpose of checking the data Stationarity, the authors have applied the tests of Augmented Dickey Fuller and Phillip Perron tests. The tests of unit root therefore consider the outcomes initially at level of variables but later on apply the tests on their first difference.

The findings of Table 2 established that both carbon emission and technology innovation are stationary & integrated at their first difference. The results of both tests confirm the robustness of results suggesting that all variables are co-integrated at I(1) and we can use these variables for further long run estimation procedures. In other words, from the outcomes of unit root test, we can apprehend that series of both the variables reflect the stationary properties and allow for proceeding towards the long run estimations. Furthermore, in order to find the long run relationship between environmental degradation and innovation, the authors have applied the technique of Johansen and Juselius Cointegration. In the process, the first stage is to identify the trace statistics and then maximum Eigen value. Therefore, the outcome of the Johansen and Juselius Cointegration are displayed in Table 3.

Table 3 indicates the rejection of null hypothesis of no long run relationship among considered variable at 1% significance level in approval of other hypothesis that is the presence of long-run connection among variables with one cointegrating equation. The outcomes confirm the existence of long-run association between carbon dioxide emission, economic growth and innovation in Indonesia.

Table 4 explains the results of FMOLS and DOLS which indicate the rejection of null hypothesis and acceptance of alternate hypothesis for

Table 1: Results of descriptive statistics

Variables	Mean	Minimum	Maximum	SD	Jarque-Bera	Correlation
CE	157.467	143.641	167.181	6.213	11.310***	-
Y	0.061	0.052	0.069	0.052	11.039***	0.988***
INO	12.475	8.374	15.556	0.054	12.391***	0.957***

*** Represents the values are significant at 1%. Source: Authors estimation

Table 2: Results of unit root test

Variables	ADF unit root test				PP unit root test			
	I (0)		I (1)		I (0)		I (1)	
	C	C and T	C	C and T	C	C and T	C	C and T
CE	2.120	1.733	−4.845	−4.827	2.927	1.530	−4.862	−4.136
Y	−0.141	−0.263	−5.329	−5.120	−0.157	−0.533	−5.199	−5.302
INO	−1.121	−1.805	−6.167	−6.365	−1.374	−1.778	−6.405	−6.418

The critical values for ADF and PP tests with constant (c) and with constant and trend (C and T) 1%, 5% and 10% level of significance are −3.711, −2.981, −2.629 and −4.394, −3.612, −3.243 respectively

Table 3: J. J. cointegration test

Null hypothesis number of CS (s)	Trace statistics	5% critical values	Max. Eigen value statistics	5% critical values
None*	62.328	57.856	48.455	37.584
At most 1	21.872	28.797	16.403	19.132
At most 2	5.470	12.495	5.264	12.265

*1% level of significant. Source: Authors estimation

Table 4: Results of long run coefficients

Variables	FMOLS			DOLS		
	Coeff.	t-stats	P	Coeff.	t-stats	P
C	−4.126	−4.133	0.000	−1.378	−4.867	0.000
Y	0.474	2.058	0.047	0.499	2.314	0.027
Y^2	−0.639	−9.384	0.000	−0.794	−5.890	0.000
INO	−0.252	−5.824	0.000	−0.229	−2.922	0.008
Adj. R^2	0.962			0.941		
D.W stats	1.991			2.08		

Source: Authors estimation

Table 5: Results of Granger causality test

Variables	F-stats	P
CE dos not Granger cause Y	14.000	0.000
Y does not Granger cause CE	5.392	0.011
CE does not Granger cause	17.026	0.000
Y^2 does not Granger cause CE	9.780	0.004
CE does not Granger cause CE	1.318	0.294
INO does not Granger cause CE	14.932	0.000

Source: Authors estimation

all considered variables. The results suggest that economic progress has a positive and significant impact of environmental degradation in Indonesia. Also, the square of economic progress and technology innovation have a negative and significant impact on environmental degradation. Results of FMOLS further explain that a per unit increase in economic progress caused 0.474 unit increase in environmental degradation. Similarly, the results of DOLS also confirm the robustness of the results and explain the same relationship between economic progress and environmental degradation in Indonesia with different magnitude. On the other hand, the results of square of economic progress show a negative and significant impact on environmental degradation. The results show a 1 unit increase in square of economic progress decreases 0.639 unit of CO_2 emission in Indonesia. The results of DOLS also confirm the effect and direction of square of economic progress on CO_2 emission. The outcomes of FOMLS and DOLS further explain that technology innovation also the major contributor to reduce environmental degradation in Indonesia with an increase of 1 unit in technology innovation decreases (0.252 and 0.229) unit of carbon dioxide emission respectively.

In general, the results confirm that economic progress has a positive and significant impact on environmental degradation in Indonesia which means if economic progress of Indonesia increases then it will also increase the carbon dioxide emission in Indonesia whereas, the square of economic progress has a negative and significant impact on carbon dioxide emission which means there is a non-linear relationship present when consider as a whole. The results further confirm that there is an inverted U-Shape connection present between these two variables and it supports the EKC hypothesis in Indonesia. The relationship between square of economic progress and carbon dioxide emission identifies that carbon emission enhance with economic development but after reaching the sustainable growth if starts decline. The outcomes of the present study are in line with the earlier studies of Jebli et al. (2016) and Farhani et al. (2014).

The results of Table 5 displays the outcomes of Granger (1969) causality analysis. In Indonesia, the outcomes clarify the bidirectional causal relationship between economic growth and carbon dioxide emission, while the causality is running in both directions. Similarly, the results also confirm the existence of bidirectional causality between square of economic growth and carbon dioxide emission in Indonesia. Furthermore, the outcomes of causality later suggest that technology innovation reflected by high technology exports has uni-directional causal effects on the carbon dioxide emission in Indonesia. In addition, the direction of causality in the results suggest that technology innovation brings significant causal effects on the environmental degradation in Indonesia.

5. DISCUSSION AND CONCLUSION

This present study examines the role of technology innovation in testing the EKC in Indonesia by taking the annual time series data over the time period of 1980–2017. The study use high technology exports as a proxy of technology innovation to examine the long run relationship between economic development, technology innovation and carbon dioxide emission in Indonesia. The author applied the advance econometrics to serve the purpose of investigation and therefore used the FMOLS and DOLS for assessing the presence of long-run relationship between the variables. Utilizing the framework of Kuznets Curve, the results of FMOLS and DOLS approaches confirm the valid long run relationship between technology innovation and environmental degradation in Indonesia. The empirical results indicate that technology innovation has negative and significant impact on carbon dioxide emission long run.

The results also confirm that economic growth has a positive and significant impact on environmental degradation in Indonesia whereas, the square of economic growth has a negative and significant impact on carbon dioxide emission which means there is a non-linear relationship present. The results further confirm that there is an inverted U-Shape connection present between these two variables and it supports the EKC hypothesis in Indonesia. For estimating the causal effects of the variables, the study used Granger Causality approach. The outcomes of causality suggest that technology innovation reflected by high technology exports has uni-directional causal effects on the carbon dioxide emission in Indonesia. In addition, the direction of causality in the results suggest that technology innovation brings significant causal effects on the environmental degradation in Indonesia. Furthermore, the findings of the study suggest that technology innovation does not

only benefit the economic development by curtailing the income gaps and improving standard of livings but entail the potential of augmenting economic growth of the country by creating job opportunities and micro-finance investments and the significant reason to reduce environmental degradation in Indonesia.

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