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Abstract

Energy is the most essential tool for production and distribution of economic goods. It is also considered as crucial input of economic development. The World Energy Committee states that there are several environmental risks linked to energy production from non-renewable sources such as coal, gas, and petroleum etc. One of the associated risks is high per capita carbon emissions. To reduce such risk economy should switch to the renewable energy sources that characterize less or no carbon emission. This paper investigated the dynamics of coal, gas and hydroelectric energy within the framework of the environmental Kuznets curve. The study used the Arellano and Bond (1991) dynamic panel model using the GMM framework developed by the Hansen (1982). The empirical results of the study confirm the environmental Kuznets curve (EKC) hypothesis and that coal and gas are significant contributors to carbon. Results suggest that the hydel energy can play an essential role in mitigating the carbon emissions and improving climate emissions in case of South and East Asian Countries.

Keywords: *Environmental Kuznets curve; Renewable energy; Non-renewable energy; CO2 emissions; Arellano-Bond dynamic panel-data.*

JEL Classifications: *O44; P1814; Q42; Q43*

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Introduction

Energy is the backbone of the economic development which promoted the notion of the industrialization, create employment opportunities, the eliminate poverty in the country. The economic activities directly associated environmental cost. The greater economic activities, greater demand for energy that lead to greater ecological collapse. The higher energy consumption caused higher environmental degradation and accelerated the carbon dioxide emissions which affect the environmental quality (Sasana et al. 2017). While the environmental Kuznets curve hypothesized the quadratic behavior of environmental cost and economic activities. EKC states, at early stages of economic growth increase the environmental cost and increase pollution in the country. Beyond some level of economic development the trend reverses, the consequences of economic outcome improved the environmental quality.

The cost and benefits of the economic activities associated with the environmental quality depend upon the technology and economic structure of the country (Grossman and Krueger, 1991) and (Shafik, 1994). The country used modern technology and increased the productivity growth which enhanced economic growth with low environmental pollution. The people of the country increase their incomes share to improving the environmental quality through the use of the cleaning water. So, the economy should focus on its economic activities and environmental cost reduces automatically as a consequence of economic growth after a certain level of economic development. The early studies like Selden and Song (1994), Shafik (1994), Holtz-Eakin and Selden (1995) and Cole, Rayner, and Bates (1997) were generally examined the scope of economic growth to eliminate the environmental issues.

The literature to explain the nexus of environment-growth-energy can be famed into three wide sorts. First sort emphases on the analysis of association carbon emissions causing pollution and economic growth which is known as Environmental Kuznets Curve (EKC) as introduced by Simon Kuznets (1955). The Simon's EKC describes the inverted U-shaped relationship between pollution and economic growth and further studies York et al. (2003); Roca et al. (2001); Galeotti et al. (2006); Azomahou et al. (2006); Coondoo and Dinda (2008); Managi and Jena (2008); Melenberg and Dijkgraaf (2009); Carson (2010); Wagner (2008 provided the work on sideways-mirrored S-shaped or N-shaped and linear relationships. The second sort establishes the association between energy and economic growth and explores the one or two-way causation. The empirical studies like Kraft and Kraft (1978); Narayan and Sing (2007); Narayan et al. (2008) and Wolde-Rufael (2009) evaluate the uni or bi-variate dynamics of more energy consumption on economic growth. The recent literature has probed the practicability of assessing the EKC by employing time series properties of emissions per capita and of income per capita such as, Sari et al. (2008), Payne (2009), Kouakou, (2011), Shahbaz and Lean (2012), Shahbaz et al. (2012), Shahbaz et al. (2013b), Yildirim et al. (2012), Yildirim and Aslan (2012) and Pao and Fu (2013). Perman and Stern (2003) argued that traditional specification of EKC is quite general for co-integration analysis.

Figure 1.2 depicted the relationship between ecological factor (Corban dioxide and per capita real income in selected six Southeast Countries. The selected South Asian countries (Pakistan, India and Bangladesh) lower per capita income with lower environmental quality degradation than selected East Asian countries (China, Japan, and Indonesia).

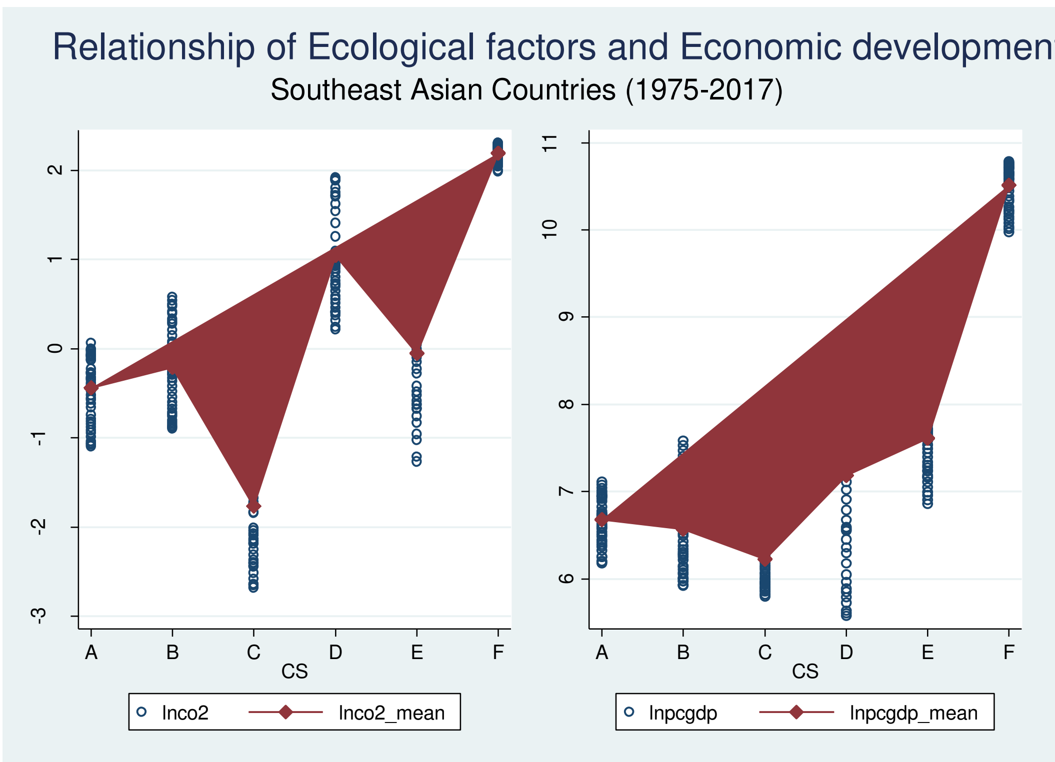

Figure 2: A=Pakistan, B=India, C=Bangladesh, D=China, E=Indonesia, and F=Japan

The following study estimated the nexus of the environment, economic growth and energy within the framework of Environmental Kuznets curve in case of selected Southeast Asian countries (Pakistan, India, Bangladesh, China, Japan, and Indonesia) and confirmed the hypothesis of Environmental Kuznets curve.

Methodology Framework

The debate of the EKC started since the 1990s that postulated U-shaped relationship between ecological factors and economic development. The cost and benefits of the economic activities associated with the environmental quality depend upon the technology and economic structure of the country. According to (Grossman and Krueger, 1991) and (Shafik, 1994) the greater economic activities, greater demand for energy that lead to greater ecological collapse. But beyond some level of economic development the trend reverses, the consequences of economic outcome improved the environmental quality. The country used modern technology and increased the productivity growth which enhanced economic growth with low environmental pollution. The people of the country increase their incomes share to improving the environmental quality through the use of the cleaning water as depicted in figure 1. So, the economy should focus on its economic activities and environmental degradation problem will be automatically eliminated as a consequence of economic growth after a certain level of economic development.

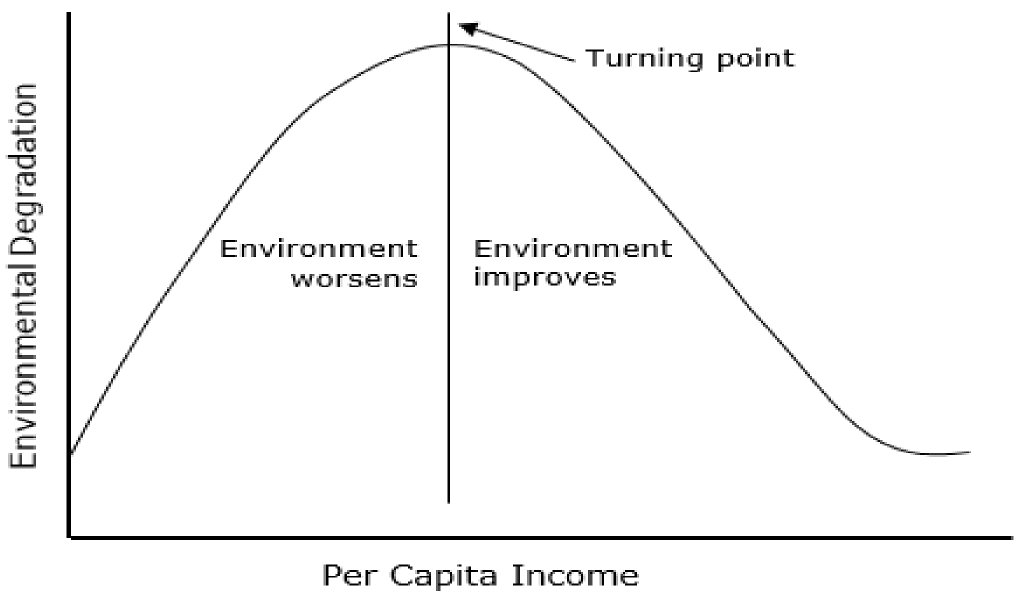

Figure 1: The environmental Kuznets curve

The study extended the Stokey (1998) optimum growth model to explain the economic activities cause environmental degradation. To figure the model we assumed the Cobb-Douglas production function with the environmental factor and exogenous technological progress:

$$Y_t = Ae^{mt} K_t^{\theta} L_t^{1-\theta} z_t \quad (1)$$

Y is the productivity, depend upon labor, technology, Capital and environmental technology index.

Zt = 0: Cleanest production technology with zero pollution to produce the good and services.

Zt = 1: Maximum pollutant emissions technology

The pollution emission function is:

$$x_t = Ae^{mt} K_t^{\theta} L_t^{1-\theta} z_t^{\beta} \tag{2}$$

Where β shows the relationship between the environmental technology and pollution flow.

Utility function:

$$u_t = \frac{c_t^{1-\sigma} - 1}{1-\sigma} - \frac{B}{\gamma} X_t^{\gamma} \tag{3}$$

Where u_t is the utility function and σ is represents the parameter of intertemporal elasticity of substitution of individual consumption. The γ represents the inverse relationship between utility and pollution and B shows the level of stock of pollution in the economy.

The equation of the pollution accumulation is:

$$X_t^0 = x_t - \eta X_t \tag{4}$$

The parameter η shows the degree of purification capacity of pollution in the economy.

$$K_t^0 = Ae^{mt} K_t^{\theta} L_t^{1-\theta} z_t - \delta K_t - C_t \tag{5}$$

The above equation shows the capital accumulation equation with pollution

$$k_t^0 = Ae^{mt} k_t^{\theta} l_t^{1-\theta} z_t - \delta k_t - c_t \tag{6}$$

$$\int_0^{\infty} e^{-\rho t}(u_t = \frac{c_t^{1-\sigma}-1}{1-\sigma} - \frac{B}{\gamma} X_t^{\gamma})dt \qquad (7)$$

Subject to

$$k_t^0 = Ae^{mt}k_t^{\theta} z_t - \delta k_t - c_t \qquad (8)$$

$$X_t^0 = Ae^{mt}k_t^{\theta} L_t z_t^{\beta} - \eta X_t \qquad (9)$$

Where $K(0) = k_0$ and $X(0) = X_0$

$$z_t = \begin{cases} 1 \\ (\frac{\lambda_t}{\mu_t \beta L})^{\frac{1}{\beta-1}} \end{cases} \qquad (10)$$

$$\frac{\lambda_t^0}{\lambda_t} = \begin{cases} \rho + \delta - (\theta 1 - \frac{\mu_t L}{\lambda_t})\frac{y_t}{k_t} \\ \rho + \delta - \theta(1 - \frac{1}{\beta})\frac{y_t}{k_t} \end{cases} \qquad (11)$$

$$\frac{\mu_t^0}{\mu_t} = \rho + \eta - \frac{BX_t^{\gamma-1}}{\mu_t} \qquad (12)$$

$$m_y = \frac{\gamma(\beta-1)m}{(1-\theta)\gamma(\beta-1)+(\gamma+\sigma-1)} \qquad (13)$$

$$m_X = m_x = \frac{1-\sigma}{\gamma} m_y \qquad (14)$$

The value of the σ shows that at $\sigma < 1$ economic activities leads to environmental degradation and $\sigma > 1$ shows positive relationship between economic activities leads to environmental quality.

To empirically estimate the relationship between economic activities and environmental factors with energy, study used the dynamic Generalized Method of Moment (GMM) presented by Arellano and Bond in (1991). The GMM model further extended by the Arellano and Bover, 1995; Blundell and Bond, 1998). The Generalized Method of Moment (GMM) was the extension of the method of moment. So, in order to apply Generalized Method of Moment (GMM), first we need moment conditions to know a vector-valued function $g(CO_2, \lambda)$.

$$m(\lambda_0) \cong E[g(CO_{2,t}, \lambda_0)] = 0 \qquad (15)$$

Where CO_2 is a dependent variable and $\lambda \neq \lambda_0$, otherwise the parameter λ will not be identified.

The basic idea is the simple average, and

$$\hat{m}(\lambda) \cong \frac{1}{n}\sum_{n=1}^{n} g(Y_t, \lambda) \qquad (16)$$

The Generalized Method of Moment (GMM) minimize the expression with respect to λ and λ is the estimate for λ_0. The resulting estimator will depend on the particular choice of the norm function, defined as

$$\left\|\hat{m}(\lambda)\right\|_W^2 = \hat{m}(\lambda)^n W \hat{m}(\lambda) \qquad (17)$$

Where W is the weighting matrix and estimate on the bases of available data set. So, Generalized Method of Moment (GMM) estimator can be written as:

$$\hat{\lambda} = \underset{\lambda \varepsilon \Theta}{\arg\min} \left(\frac{1}{n}\sum_{n=1}^{n} g(Y_t, \lambda)\right)^n \hat{W} \left(\frac{1}{n}\sum_{n=1}^{n} g(Y_t, \lambda)\right) \qquad (18)$$

Under the properties that, GMM estimator are consistent, asymptotically normal, and asymptotically efficient.

To investigate the hypothesis of environmental Kuznets curve and energy the study used the annual frequency data from 1975 to 2017. Table 1 presented the description of all variables and source of the data used to estimate the nexus of the environment, energy and per capita income of the selected Southeast Asian countries (Pakistan, India, Bangladesh, China, Japan, and Indonesia) for the period 1975 to 2017.

Table 1

Sr.	Variables	Unit	Data Source
1	Corban Dixids emission (CO2)	Million tonnes	BP Statistics Review of World Energy 2017
2	Per capita GDP (PCGDP)	Dollar	WDI
3	Coal consumption energy (CCE),	Million tonnes oil equivalent	BP Statistics Review of World Energy 2017
4	Gas consumption energy (GCE)	Million tonnes oil equivalent	BP Statistics Review of World Energy 2017
5	Hydel consumption energy (HYE).	Million tonnes oil equivalent	BP Statistics Review of World Energy 2017

Econometric Model

The study designated the following model on the bases of cited literature (Ozokcu and Ozdemirb, 2017), (Lorente and Álvarez-Herranz, 2016), (Iddrisu and Bhattacharyya, 2015) and (Shahbaz *et. al.* 2012).

$$\ln CO_2 = \alpha + \beta_1 \ln PCRGDP_{ij} + \beta_2 \ln PCRGDP_{ij}^{\ 2} + \beta_3 \ln CCE_{ij} + \beta_4 \ln GCE_{ij} + \beta_5 \ln HYE_{ij} + \varepsilon$$

Empirical Results

Table 2

Arellano-Bond dynamic panel-data estimation

Variables	Model 1	Model 2
$LnCO2_{t-1}$	0.965***	0.877***
LnPCGDP	0.146**	0.282***

$LnPCGDP^2$	-0.008*	-.0158***
LnCCE	----------	0.027***
LnGCE	----------	0.0236**
LnHYE	----------	-0.028***
Constant	-0.566**	-1.119***
N	246	246

legend: * p<0.05; ** p<0.01; *** p<0.001

Sargan test of Over-Identifying Restrictions			
H0: over-Identifying restrictions are valid			
Model 1		**Model 2**	
chi2(230)	268.5147	chi2(230)	299.206
Prob > chi2	0.0414**	Prob > chi2	0.0014***

legend: * p<0.05; ** p<0.01; *** p<0.001

The results of the study estimated by using the system dynamic panel data estimation method which is also called Arellano and Bover/Blundell and Bond system estimator. The Arellano-Bond dynamic panel-data estimation model used the lag of the dependent variable as the instrument: the study estimated two models: the first model investigated the hypothesis of the environmental Kuznets curve, and 2nd model analysis the phenomena of the environmental Kuznets curve and impact of the energy consumption on the quality of the environment. Figure 3 presented the coefficient plot of model 1 and figure 4 presented the coefficient plot of model 2. The estimated results of the System dynamic panel data estimation confirmed the hypothesis of the environmental Kuznets curve and parameters are statistically significant in both models. The empirical results showed the statistically significant and inverted U-shaped relationship between CO2 and the per capita income in case of the selected Asian countries as suggested by the (Shahbaz, Lean, & Shabbir, 2012); and (Tiwari, Shahbaz, & Adnan Hye, 2013). The results of table 1 show the significant degree of persistence in CO2 emissions with its lag value. The finding of the study shows the one percent change in the lag value of the CO2 lead to increase the 96 percent in the

CO_2. The one percent change in the per capita income lead to increase the 0.146 percent in the CO_2. The Sargan test of over-identifying restrictions check the model dependent variables which are used as the instruments are valid instruments or not. The instrumental variable should be uncorrelated with the error term. The estimated results of the Sargan test shows that we can reject the null hypothesis which states that over-identification restrictions are valid. So, the empirical results reported that instrumental variables correctly specified and uncorrelated with the error term. One of the interesting results of the study which postulated in table 1 shows that coal and gas consumption is the major contributor to ecological degradation while hydel consumption positively affects the environment.

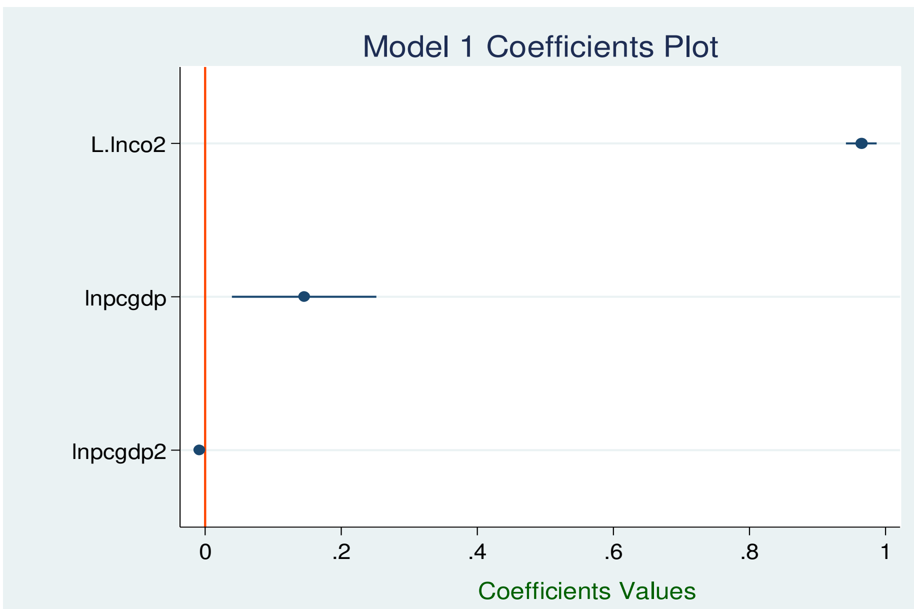

Figure 3: Coefficient plot

The depicted parametric values of table 1 show that coal consumption energy emits more CO_2 as compared to the gas consumption energy. One percent change in the coal consumption energy contributed 2.7 percent reduction in the environmental quality and one percent in the change in the gas consumption energy lead to increase the 2.36 percent in CO_2. The coal consumption energy more polluted the environment as compared to the other indicators and finding of the study supported the viewpoint of the Wolde-Rufael (2010); and (Tiwari, Shahbaz, and Hye, 2013). The hydel consumption energy mitigates the effect of environmental degradation. The estimated results of table 1 show that one percent change in the Hydel consumption energy lead decreases the -2.8 percent in the CO_2. Thus, to tackle the problem of ecological degradation, more emphasis should place on the clean energy sources like hydel energy. The empirical results of the Sargan test of model 2 depicted that we can reject the null hypothesis we state that instrumental variables not correctly specified and correlated with the error term.

Figure 4: Coefficient plot

Conclusion

The study test the environmental Kuznets curve (EKC) hypothesis, the relationship between coal, gas, and hydel energy consumption and environmental quality in case of selected Southeast Asian countries (Pakistan, India, Bangladesh, China, Japan, Indonesia). The results of the research study estimated by using the system dynamic panel data estimation technique to estimate the dynamics of environmental quality, economic growth, and energy consumption.

The empirical results presented in table 1 confirm the existence of the environmental Kuznets curve (EKC) and the relationship between environment and energy consumption in the selected Asian countries for the period 1957 to 2017. The nonrenewable (gas and Coal) energy consumption positively contributed to environmental degradation in the selected panel countries. However renewable energy (hydel) reduce the emission of corban dioxide and positively affect environmental quality. So, it’s time to switch toward Hydropower (renewable) energy to achieve the economic goals and find substitutable energy sources in the form of solar and wind energy to reduce the air pollution and emission of greenhouse gasses such as Corban dioxide. The following selected Asian countries produce hydropower energy much lower than its potential capacity.

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