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The Relationship between Economic Growth and Environmental Pollution in China: An Arellano–Bond Linear Dynamic Panel-Data Based Approach

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ABSTRACT: The mandate and duty of policy makers is to implement policies that are supposed to ensure that the needs its citizens are meet. This could be in the form of infrastructural development, economic growth, job creation etc. However, in the process of meeting these needs in the form of economic growth, the quality of the environment could be compromised and hence the need for environmental depletion to be considered an important issue in the process of economic growth. Therefore, this process of development has to be carefully achieved with the thoughts of protecting the interest of the people and environment. This paper is aimed at investigating the relationship between economic growth and environmental pollution in china. The Arellano–Bond linear dynamic panel-data estimation model was used to examine the influence of economic growth environmental pollution in China from 1996 to 2016. The results indicated that presence of Sulphur dioxide emission which has a negative impact on the health status of the population in the long-run.

KEYWORD:*Environmental Pollution; Economic Growth, Gross Domestic Product; Foreign Direct Investment; China*

I. INTRODUCTION

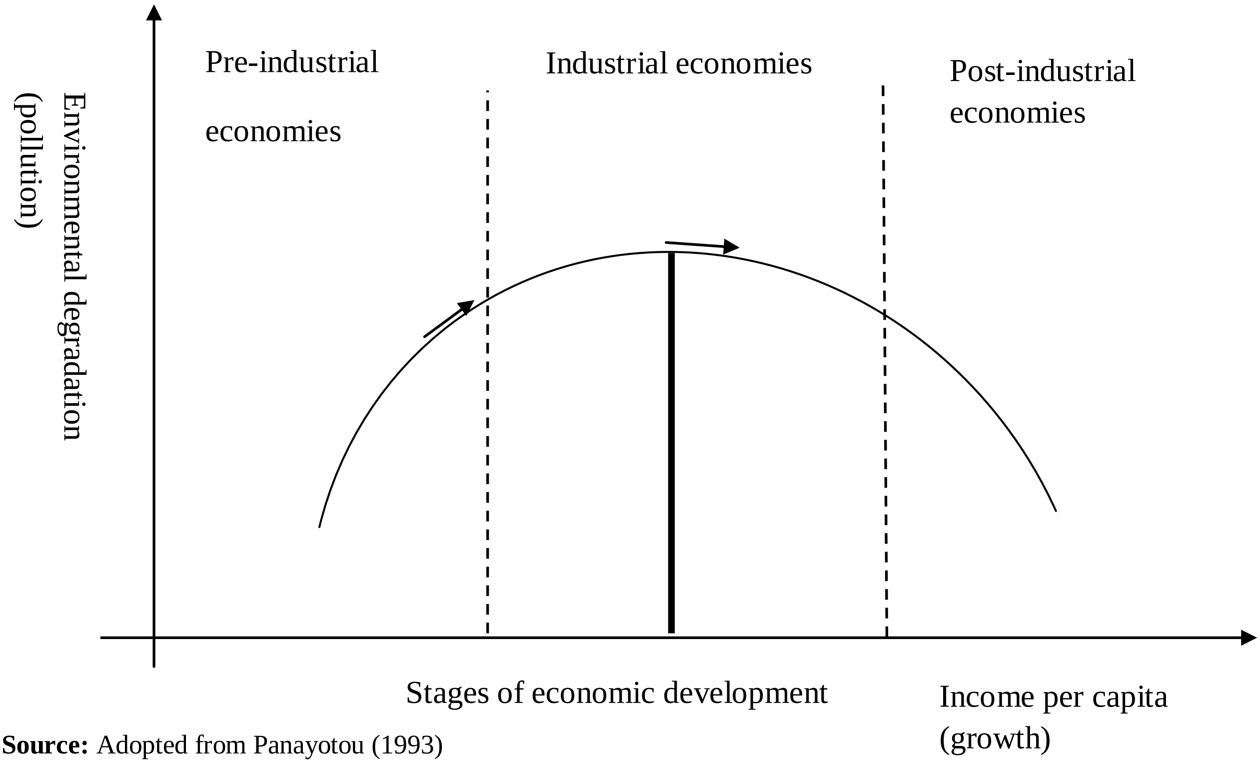
The past three decades has been marked as a period of tremendous economic transition for the Chinese economy. The open up and economic reform policies adapted by the Chinese government in the late 1970's has been very beneficial to the economic evolution of the country. Over the said period, there has been an upsurge in the amount of foreign direct investment (FDI) into China. As a result, China became the second world leader of FDI inflows, (Alam and Kabir, 2013). This translated into a rapid economic transition of the Chinese economy leading to increased employment, improved and better living conditions, increased per capita income, infrastructural development, transfer of technology and knowledge, (Alam and Kabir, 2017). It is however, worth noting that the influx of the foreign investment and its associated economic growth also comes with its corresponding costs to the environment in the form of pollution, (Asghari, 2012). During the production process, pollutants such as Sulphur dioxide are emitted to the air thereby polluting it and making it unhealthy for inhalation, (Al-mulali, 2012).

It is important to state that the debate on the relationship between economic growth and environmental pollution has been ongoing and recently its intensity has heaped up which seeks the attention from researchers and policy makers worldwide. No doubt there is the very need for economic transformation to enhance positive social and economic activities, at the same time it is also important to maintain the environmental quality as it is now proven that the economic growth and environmental quality are intricately interrelated to each other over time (Schumacher, 2016). However, it is not that straightforward to regard this inter-connection as either positive or negative, as the existing literature is divided in their opinions by supporting either of the two directions and thus, the issue still remains controversial, (Bakare, 2011).

II. REVIEW OF LITERATURE

The world over, increased FDI inflows is seen as a panacea to rapid economic growth. The challenge here is its accompanying cost to the society, economy and environment. This there calls the attention of scholars and policy makers on the relationship between economic growth and the environment. This phenomenon has been broadly and still being discussed in literature. There have been several deliberations surrounding this phenomenon and known as the Environmental Kuznets Curve (EKC). The EKC explains an inverted U-shaped linkage between environmental quality and per capita income, (Chen and Ku, 2000).

Figure 1: Environmental Kuznets Curve



Source: Adopted from Panayotou (1993)

The logic behind the EKC hypothesis attempts to elucidate how increased economic activities generates higher incomes levels of the citizens which eventually results in a depletion of the environment which will need the intervention of the governments to institute policies that helps to curb this phenomenon. On the other hand, in the long run the citizens who tends to have higher per capita income will be willing to pay for environmentally friendly products which therefore forces the producers to use advanced technology in the production process. This analogy explains the environment income inverted U-shape in literature, (Hitam and Borhan, 2012).

As stated earlier, there are diverging views from various researchers for and against the presence of environmental pollution being generated from increased economic activities. According to Kostakis et al. (2016), in their research which attempts to measure the role of foreign direct investment (FDI) inflows on environmental quality, they noticed that pollution emission as a result of economic activities. It was also realized in a research on the determining link between CO2, energy consumption, growth of economy and FDI in Sub Saharan African revealed the presence of the EKC philosophy (Kivyiro and Arminen, 2014). In addition, Cole et al. (2011), also encountered the presence of EKC relationship between water pollution and economic growth at current income levels. Implying when income levels rises to a point there will be the demand for efficient waste disposal and consumption of green products leading to the usage of more sophisticated technologies, (Chiwira and Kambeu, 2016, Cole et al., 2011, Dong et al., 2012).

On the flip side some scholars hold diverging views an=bout the presence of EKC in their research outcomes. According to Elliott and Zhou (2013), Everett et al. (2010) and Fodha and Zaghdoud (2010) they investigated the rate of economic growth and its impact on environmental pollution while testing the EKC phenomenon and the results did not confirm the presence of EKC hypothesis. Their findings rather implied that there was a positive impact of economic growth on the environment since in the production process advanced machines were used. Accordingly, He and Richard (2010), and Grossman and Krueger (1995) also indicated that the relationship between the EKC hypothesis and CO2 was positive implying the absence of the environment being polluted as a result of economic growth (Baek, 2015).

On the contrary, a there is an emerging opinion that propounds the ideology that environmental pollution could emanate from various sources other than economic growth. These could be through the scale, composition (structural) and technique effects (Xuemei et al., 2011, Baojuan et al., 2011, Adu and Denkyirah, 2018). The scale effect refers to the scale of economic activity and relates to the use of natural resources in production and the pollution impacts of production. If production of goods and services consumes natural resources and produces pollution as a negative side effect of it, then increasing the scale of the economy will – everything else equal – increase resource depletion and pollution (Hadjimichael et al., 2014). Economic growth facilitates technological progress in production of goods and services. This technique effect implies cuts in emissions per produced unit as well as reduced natural resource (and energy) use per output unit. Also, increased abatement creates a technique effect in terms of lowering emissions per unit of output, but may also lower pollution by lowering the growth rate of output, (Higgins, 2013). Industrial development across time shows that growing economies specialize in less pollution intensive goods and services and/or relatively less natural resource intensive industrial production. Combined with the development of more pollution intensive production of goods and services in developing countries this has fueled research and debate on the "export of dirty production" from rich to poorer countries. Combined with relatively less strict pollution regulation in developing countries it has also triggered research on the so called pollution-haven hypothesis, (Helpman, 2009).

III. THE MEASUREMENT MODEL AND METHODOLOGY

For the purpose of this empirical work the, the following methodology will be adopted. The vector error correction model is adopted with six variables (Sulphur dioxide, GDP, Population density, Trade openness, gross fixed capital formation and research and development).

$$\Delta Y_t = \alpha\beta_1 Y_{t-1} + \sum_{i=1}^{k-1} \delta_i \, \Delta Y_{t-1} + \varepsilon_t \qquad (1)$$

Explanation of model above:

Y_t is a vector of variables comprising of policy, economic and pollution variables.

β_1 Is a vector of parameters for the error correction term.

α is a vector of long run adjustments.

δ_t the number of cointegrating equations

ε_t vector of error terms

3.1 The Data

A panel dataset of secondary data of 31 Chinese provinces was gathered and used in the empirical analysis covering a duration of 21 years from the Urban Statistical Yearbook of China and China Economics Information and Statistics (National Bureau of Statistics, PRC, 1995-2016 editions). The selection and calculation methods of each variable are described in detail below.

1. Environmental pollution data. To fully reflect the environmental pollution situation, we used three indicators of industrial solid waste, industrial sulfur dioxide and industrial smoke and dust. According to the practice of the previous literature, all three indicators in the measurement estimate are measured by per capita emissions, which are obtained by dividing the total pollution indicators by the population.
2. The intensity of R&D investment in curbing pollution. According to the statistical data of the China Statistical Yearbook, and multiplied by the intermediate exchange rate of RMB against the US dollar.
3. Per capita output data. The per capita output is measured by the per capita GDP of each city (per capita GDP) in China.
4. Physical capital stock data. Due to the lack of relevant data, it is not directly calculated. According to the perpetual inventory method, the physical capital stock is calculated according to the annual capital depreciation rate of 5%, and the price factor is eliminated by the GDP deflator. This estimate is also divided by the population to obtain a per capita physical capital stock.
5. Trade openness is calculated by adding imports and exports and divide it by the GDP of each city
6. Population is calculated by the number of people per square kilometer of land area

The following is a tabular description of variables considered for our empirical analysis and their source.

Table 1. Theoretical Concepts and Their Indicators

Concept	Indicators	Data source
Environmental quality	Natural log of SO2 emissions per capita	China Statistical Yearbooks
GDP per capita	Natural log of GDP per capita	China Statistical Yearbooks
Population density	Natural log of population density	China Statistical Yearbooks
Technology	Natural log of R&D	China Statistical Yearbooks
Trade openness	Natural log of (import + export/ GDP)	China Statistical Yearbooks
Physical capital	Natural log of gross fixed capital formation	China Statistical Yearbooks

Table 2 Descriptive Statics

Variable		Mean	Std. Dev.	Min	Max	Observations
lngdp	overall	8.45116	1.304206	4.024994	11.19564	N = 657
	between		.8666189	7.099305	9.91055	n = 30
	within		.9872028	5.132079	10.34808	T-bar = 21.9
lntrdopn	overall	7.809022	2.972877	1.196948	14.04939	N = 645
	between		2.53392	4.840137	11.34862	n = 30
	within		1.624793	2.149167	12.85038	T-bar = 21.5
lnrd	overall	12.47087	1.929023	2.302585	16.53717	N = 654
	between		1.049396	10.66196	14.46168	n = 30
	within		1.627597	2.947196	15.97919	T-bar = 21.8
lngfcf	overall	7.694539	1.480839	3.540959	10.78544	N = 657
	between		1.198322	5.891003	9.592752	n = 30
	within		.8972045	4.796363	9.551059	T-bar = 21.9
lnsul	overall	6.882281	4.327343	-2.542371	14.38086	N = 656
	between		4.053243	3.38853	12.99139	n = 30
	within		1.668445	.7631924	15.13899	T-bar = 21.8667
lnpop	overall	8.047239	.8745084	5.480639	9.334768	N = 658
	between		.2006229	7.770837	8.406585	n = 30
	within		.8519085	5.354062	9.598118	T-bar = 21.9333

3.2 Unit Root Test

The Fisher-type test is undertaken to better understand the stationarity elements. This test combines the evidence on the unit-root hypothesis from the N unit-root tests performed on the N cross-section units as indicated by (Maddala and Wu, 1999). To compute the test statistics, we fit the Fisher-type regression.

$$\pi = -2\sum_{i=1}^{N} ln\,(\pi_i) \qquad (2)$$

where π_i is the p-value from ith cross-section. The test statistics is x^2 distributed with 2N degrees of freedom.

DECISION RULE:

$$H_O: \beta = 1; There\ exist\ unit\ root$$
$$H_A: \beta = 1; There\ is\ no\ unit\ root$$

Table 3: Fisher-Type Test

Dependent Variable	Statistics Without Trend (pm)	Prob	Statistics With trend and intercept (pm)	Prob
lntrdopn	15.8866	0.0000	19.9571	0.0000
lngdp	12.1642	0.0000	15.7612	0.0000
lnrd	16.1876	0.0000	17.7017	0.0000
lngfcf	16.9111	0.0004	19.4036	0.0000
lnsul	28.6673	0.0001	25.6785	0.0000
lnpop	20.4779	0.0000	26.5492	0.0000

DECISION RULE on unit root testing: Reject the Null hypothesis when p-value is less than or equal to 0.05 (5%) significance level or $|t_s| > |t_T|$.

Unit root analysis is conducted on the coefficient of π in the above regression. If the coefficient, $\pi\ is \neq 0$, then the null hypothesis is rejected, meaning the variable contains no unit root problem. The optimal lag length is also determined in the Fisher-type test and is selected using Schwarz information criterion (SIC). Using the 95% confidence interval, we tested for the presence of unit root in the panel data and found all variables do not have unit root. Which means the null hypothesis will be rejected for all the variables thereby making them stationary I(0), (see table 3).

3.3 Pedroni Cointegration test

The Pedroni cointegration test is used because it is more generally applicable and so permits more than one cointegrating relationships. It therefore allows long-run relationships among the variables to be examined. The general regression equation to test for the cointegration models is:

$$y_{i,t} = \alpha_i + \delta_i t + \beta_{1i}x_{1i,t} + \beta_{2i}x_{2i,t} + \cdots + \beta_{Mi}x_{Mi,t} + \varepsilon_{i,t} \quad t = 1,..T; i = 1,...N \qquad (2)$$

where T refers to the number of observations over time, N refers to the number of the individual members in the panel, and M refers to the number of regression variables. Here x and y are assumed to be integrated of order one. The slope coefficients $\beta_{1i}, \beta_{2i}, ..., \beta_{Mi}$ and specific intercept α_i vary across individual member of the panel.

Table 4 Pedroni test for cointegration

	Statistic	p-value
Modified Phillips-Perron t	1.7235	0.0424
Phillips-Perron t	-8.0837	0.0000
Augmented Dickey-Fuller t	-9.1141	0.0000

Ho: No cointegration — Number of panels = 30
Ha: All panels are cointegrated — Avg. number of periods = 19.867
Cointegrating vector: Panel specific
Panel means: Not included — Kernel: Bartlett
Time trend: Not included — Lags: 2.00 (Newey-West)
AR parameter: Panel specific — Augmented lags: 2

The results from the Pedroni cointegration test indicates that all the test statistics reject the null hypothesis of no cointegration in favor of the alternative hypothesis that gross domestic product, trade openness, research and development, gross fixed capital formation, Sulphur dioxide and population density are cointegrated in all panels with a panel-specific cointegrating vector. The model underlying the reported statistics includes panel-specific means and panel-specific AR parameters and does include a time trend. The Bartlett kernel was used to test for the long-run variance among the six statistics with two lags, as well as the Newey–West methods, to adjust for serial correlation.

Table 5 Arellano–Bond linear dynamic panel-data estimation

gdp	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
L1.	.0545901	.0193536	2.82	0.005	.0166578	.0925224
L1.	-.0335586	.0184306	-1.82	0.069	-.069682	.0025647
trdopn	.0028153	.0012587	2.24	0.025	.0003484	.0052823
rd	.0032042	.0001406	22.80	0.000	.0029288	.0034797
gfcf	.5957793	.0475847	12.52	0.000	.5025151	.6890436
sul	.0008374	.0012746	0.66	0.511	-.0016608	.0033355
pop	-.0605473	.0852799	-0.71	0.478	-.2276929	.1065983
_cons	2603.791	492.3824	5.29	0.000	1638.74	3568.843

Number of obs= 535 — Wald chi2(8) = 2196.22
Prob> chi2 = 0.0000

The Arellano–Bond linear dynamic panel-data estimation seeks to explain the long-term impact between and among the variables. It is observed from the results that there was a two-year lag period in the analysis. The findings indicate that trade openness, research and development and gross fixed capital formation are positive and significant. This implies that there is a direct relationship between GDP and these three variables in the long run. That is, as GDP is increasing, favourable open up policies are implemented, the usage of advance technology is encouraged and capital formation is also increasing. From (table 5) it is noticed that a 1 % increase in GDP leads to about 0.29 % increase in trade openness, 0.32% increase in R&D and 60% increase in capital formation respectively. On the other hand, it is observed that the findings for Sulphur dioxide is positive but not significant whereas that of population density is negative and not significant. This implies that the production process generates some amount of Sulphur dioxide that pollutes the environment and this pollution emission has a negative consequence on the health status of the citizens. This means that as the GDP of the Chinese economy increases the emission rate also goes up thereby having a health implication on the populace.

IV. CONCLUSION

The outcome of the analysis implied that the GDP of the Chinese economy is increasing as a result of the open up policies being implemented. As a result of the stable and ready market prevailing in China, it seems to be the breeding ground for most foreign investors to produce their goods and services. This definitely has resulted in the desire of to make use of most recent and state of the art technology in the production process which invariably leads to economic transformation of the economy, creation of more jobs and an increased capital formation. However, there was the emission of Sulphur dioxide which polluted the environment causing health problems for the populace. It is however important to acknowledge tremendous efforts by the Chinese government to resolve the pollution problem through advanced technology usage as is shown in the findings. Thus, stricter implementation of environmental friendly policies is encouraged to help curb the pollution menace.

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