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Impact Of Economic Growth And Energy Consumption In Asian Countries Using Panel Data

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Abstract:
Energy consumption and Economic growth nexus performs a key for economic development because it plays a vital role in economic and social development. Hence, many studies have tried to identify the direction of causality among energy consumption, economic growth, and CO_2 emissions. In order to investigate the relationship among energy consumption, economic growth and CO_2 emissions, the country level data for selected four south Asian countries viz India, China, Bangladesh, and Pakistan for the period 1980-2011 formed a panel data for the study. The empirical results of the Granger Causality indicate that the causality is running from the economic growth and energy consumption to CO_2 emissions. To economise the space, the empirical results of tests of stationarity, cointegraion and casuality are not reported in the study. Based on the identified direction of causality, the impact of economic growth and energy consumption on CO_2 emission level, the pooled OLS, fixed and random effect models are used. The estimates of fixed and random effect models indicate that the energy consumption has a significant positive impact and per capita GDP has negative impact on CO_2 emission per capita. The empirical results have revealed that the CO_2 emission is found to be more elastic in response to energy consumption per capita and the reduction of CO_2 emission in relation to income per capita is less elastic. The contribution of energy consumption to CO_2 emission and the growth of income significantly reduces CO_2 emission in the panel of developing countries indicates that there is a change in the attitudes of people to reduce the pollution level over the years. It is also observed that the China is relatively a predominant contributor in CO2 emission level among the nations accounted for the empirical examination of the study. Hausman's test indicates that the fixed effect model is more appropriate over the random effect model.

Keywords: Energy consumption, Economic growth, CO_2 emissions, Panel data

1. Introduction

The economists and the policy makers worldwide have taken a serious view on fossil fuel use and its impact on carbon dioxide (CO_2) emission level in the earth atmosphere (Stern et al; 2006, Apergis et al; 2010 and Li et al; 2011,). Of late, the level of growth of Greenhouse Gas (GHG) emission, more specifically composed of carbon dioxide (CO_2), is reported to have contributed to 'global warming'. It implies that there is a rapid rise in average temperature globally accounting 2 per cent every year. If it is unchecked, there is greater than 50 per cent chance that the rise in temperature would exceed 5^0 C in the long run (Tiwari, 2011: 86). This finding has prompted the world economies to contain the level of emission by reaching a consensus among them in containing the emission level. Two so called 'Earth Summits' were held respectively in Rio de Janeiro (1992) and New York (1997) in order to have sustained development without compromising future wellbeing of the people. In consequence to this development, 39 developed countries signed Kyoto Protocol in December, 1997 and in which, the members had agreed to curb the emission of greenhouse gases in the near future (Bengochea-Morancho, 2001). Most likely, the poor and more populous countries would be hit

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hard even though they have contributed little to the growth of greenhouse gas emission (Tiwari, 2011*)*.The happening of events has prompted the economists to find out an appropriate solution to the increased use of fossil fuels and the environmental degradation by CO_2 emission. Therefore, we wish to examine the impact of economic growth and energy consumption on CO_2 emission level in this paper.

The Figure 1 explains the trend of growth of CO_2 emission in the selected Asian countries. For all the countries, which are included in the study, has shown an increasing trend of CO_2 emission. The Figures 2 and 3 also present the general trends of growth of per capita income and energy consumption per capita for the panel of select Asian countries for the period 1980-2011. The figures evidences that the per capita energy consumption and income have shared a common trend.

Figure 1: The Trend of CO_2 Emission for Selected Asian Countries, 1980-2011

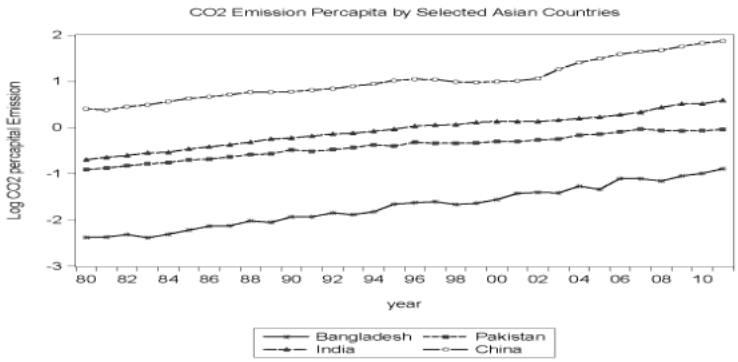


Figure 2: The Trend of Growth of Energy Consumption Percapita for Selected Asian Countries, 1980 - 2011

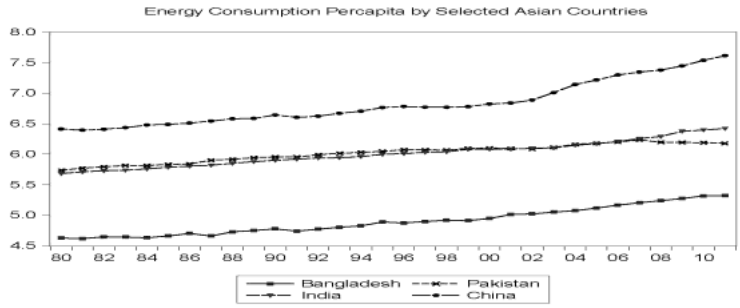
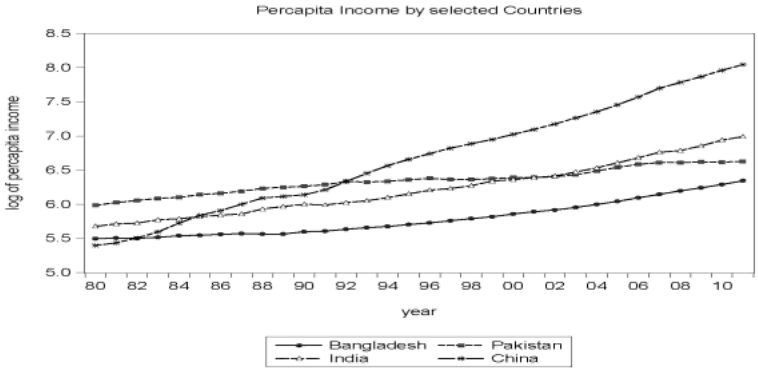


Figure 3: The Trend of Growth of Per Capita Income of Selected Asian Countries: 1980 - 2011



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This study examines relationship between energy consumption and economic growth after accounting gross fixed capital formation and labour force for a panel of selected four Asian countries viz., India, China, Bangladesh and Pakistan and for the period 1980- 2011. The application of stationarity tests, cointegration tests and Granger causality tests indicate that the causality runs from economic growth and energy consumption to CO_2 emission level. However the empirical results of these tests are not presented in this study. Hence to study the relationship between carbon dioxide emission and economic growth over the years, fixed and random effect models are used to examine the response of CO_2 emission to economic growth and energy consumption. [Bengochea-Morancho, (2001); Selden and Song, (1994)]. This paper has made an attempt to study the impact of economic growth and energy consumption on carbon dioxide emission in selected Asian countries using pooled ordinary least squares, fixed and random effect models.

2. Data, Model and Methodology

2.1. Definition of Dependent and Independent variables

Natural logarithm of percapita CO_2 emission level is used as a dependent variable and natural logarithms of percapita gross domestic product and percapita energy consumption are used as independent variables. The detailed definition of these variables is discussed below.

2.2. CO_2 Emission level per capita

Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring. This variable is measured as metric tons per capita and the natural logarithm of this variable is used as dependent variable.

2.3. Gross Domestic Product per capita

GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. GDP is measured in constant U.S. dollars.

2.4. Energy Consumption per capita

Energy use refers to use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport. This variable is measured as kg of oil equivalent per capita.

2.5. Database

This study has formed a panel data for the variables of CO_2 emission, energy consumption and economic growth for four select Asian countries viz. India, China, Bangladesh, Pakistan for a period from 1980 to 2011. The annual data of 32 years from 1980 to 2011 for the above four nations forms a panel data of 128 observations as a database for the empirical study. Based on the earlier studies (Bruyan et al, 1998; Kaufmann et al, 1998; Seldom and Song, 1994 and Bengochea-Morancho et al, 2001), this study adopts the following specification to analyse the panel data of selected Asian countries including China, India, Pakistan and Bangladesh. We used the following specification to estimate the CO_2 emission function:

$$LnCO_{it} = \alpha_0 + \alpha_1 LnEU_{it} + \alpha_2 LnPC_{it} + \sum \beta_i D_i + \delta_i + \varepsilon_{it}$$

Where LnCO is natural log of CO_2 emission per capita, LnPC is natural log of per capita income, LnEU denotes energy use per capita, D_i's are dummies for various countries. δ_i refers to

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unobserved individual effects and ε_{it} is the error term. 'i' refers to country included in the panel, and 't' denotes different years, Fixed effect model is based on two assumptions. There is correlation between error term and predictor or independent variables which are to be controlled and another assumption is that the error term and entity's intercept (or constant which captures individual characteristics of entities) should not be correlated. On the other hand, the random effect model depends upon the variation across entities which are assumed to be random and uncorrelated with the predictor variables. To find out appropriateness of the model for this panel data, we use fixed effect or random effect model and apply Housman's test to choose one of them. We compute the estimates of fixed effect, random effect and pooled OLS models in order to facilitate a comparison among the various models.

3. Empirical Results

The study has extracted aggregate variables like energy consumption, per capita income in constant US dollars, and CO_2 emission per capita from online data base of the World Bank official website. Table 1 provides descriptive statistics of CO_2 emission, per capita income and energy consumption per capita for four countries chosen.

Table -1: Descriptive Statistics of Dependent and Independent Variables

Variables	Description of variables	Mean	SD
$LnCO_2$	Natural log of per capita CO_2 emission	- 0.289	1.049
LnEU	Natural log of per capita energy consumption	5.938	0.7305
LnPC	Natural log of per capita income	6.258	0.566
D_P	Dummy for Pakistan	0.25	0.435
D_I	Dummy for India	0.25	0.435
D_C	Dummy for China	0.25	0.435
	No. of Observations	128	128

Table 2 presents the estimates of fixed, random, OLS and fixed effect by intercepts (constants representing individual differences) for the panel of countries viz., China, India, Pakistan and Bangladesh. In which, Bangladesh is used as reference category in the estimates of fixed and random effects. In fixed effect model, energy consumption per capita increases the CO_2 emission level through years. i.e., a one per cent increases in energy use causes CO_2 emission level to rise by 1.99 per cent. It is inferred that the coefficient of CO_2 emission is found to be elastic in response to energy consumption per capita. On the other hand, 1 per cent increase income per capita reduces CO_2 emission per capita by 0.27 per cent. The reduction of CO_2 emission in relation to income per capita is less elastic. The findings are in conformity with the findings of Aurelia Bengochea-Morancho et al, (2001) which examined income – CO_2emission relationship for a panel of countries in European Union. In which, coefficient of income is found highly significant in reducing CO_2 emission. Similarly, the estimates of random effect have shown similar direction of impact by income per capita and per capita energy consumption on CO_2 emission per capita as that of the estimates of the fixed effect model.

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Table -2: Fixed and Random Estimates of CO_2 Emission Functions for Selected Asian Countries, 1980-2011

Dependent Variable: Natural Log of Co_2 Emission

Independent Variables	Pooled OLS	Fixed Effects	Fixed Effects	Random Effects
LEU	1.438*** (41.45)	1.991*** (19.02)	-	1.797*** (20.14)
LPC	-0.0352 (0.79)	-0.2705*** (4.96)	-	-0.1789*** (3.70)
Dummy for Pakistan	-	-	1.293*** (13.50)	-
Dummy for India	-	-	1.651*** (17.21)	-
Dummy for China	-	-	2.729*** (28.44)	-
Constant	-8.604*** (49.36)	-10.414*** (32.62)	-1.7073*** (25.16)	-9.839*** (34.18)
Significance of FE Model	-	F(2,122) = 969.17***	-	-
Hausman's Test	-	Chi square = 12.50***	-	-
R^2	0.972	0.969	0.869	0.971
No of Observations	128	128	128	128

NOTES: 1.'t' - values are given in brackets
2. *** - denotes significant at 1 percent level.

In OLS equation, except the coefficient of per capita income, the coefficient of energy consumption is found to be highly significant. The estimates of intercept dummies (country specific intercepts referring to heterogeneous characteristics) are given for comparison. The coefficients of China, India and Pakistan are significantly positive, in which, China appears to be the highest contributor of CO_2 emission over India and Pakistan. In regard to fixed and random effects are concerned, fixed effect is found to be perfectly fitting for the data. Energy contributes to more CO_2 emission in the panel of developing countries. However, the growth of income significantly reduces CO_2 emission and shows that there is a change in the attitudes of people to reduce the pollution level over the years. Besides, it is reasonable to presume that the pollution control laws are strictly implementing pollution abatement technologies in these countries.

Hausman's test is applied to determine whether fixed or random effect model is found appropriate in explaining the suitability of the models for given panel data. The Hausman's test rejects the null hypothesis of random effect model and accepts the suitability of fixed effect

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model in explaining the impact on CO_2 by income per capita and energy use per capita through years. Besides, the F statistics also confirms that the fixed effect model is found fitting well.

4. Summary and Conclusion

This paper has attempted to examine the impact of economic growth and energy consumption on carbon dioxide emission. It is estimated using fixed, random, pooled OLS and fixed effect intercepts (dummies) for China, India, Pakistan and Bangladesh. The Hausman's test rejects null hypothesis of random effect model and accepts fixed effect model is appropriate in explaining the impact on CO_2 emission by income per capita and energy use per capita through years. In fixed effect model, Energy consumption increases CO_2 emission through years. i.e., one per cent increases in energy use causes CO_2 emission to rise by 1.99 per cent. It is inferred that the coefficient of CO_2 emission is found to be elastic in response to energy consumption per capita. But, an increase in 1 per cent income per capita reduces CO_2 emission per capita by 0.27 per cent. The reduction of CO_2 emission in relation to income per capita is less elastic. It is also in agreement with the findings of Aurelia Bengochea-Morancho et al, (2001) which examined income-emission relationship for a panel of countries in European Union, in which, coefficient of income is found highly significant in reducing CO_2 emission. The estimates of random effect have shown similar direction of impact by income per capita and per capita energy consumption on CO_2 emission per capita as that of the estimates computed for fixed effect model.

The estimates of intercept dummies (country specific intercepts referring heterogeneous characteristics) are given for comparison. The coefficients of China, India and Pakistan are significantly positive, in which, China appears to be the highest contributor of CO_2 emission over India and Pakistan. In regard to CO_2 emission and per capita income are concerned, per capita income reduces CO_2 emission for the panel of countries. This shows that these countries have been taking series steps in reducing the environmental pollution. Any energy conservation will seriously impair the economic growth of the panel of countries. The panel of countries under the study is small and can have alternative sources of renewable energies like wind, solar, biogas, hydro electric power in order to reduce the fossil fuel use.

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