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## **CARBON DIOXIDE EMISSION AND STAGE OF ECONOMIC DEVELOPMENT : A CROSS COUNTRY ANALYSIS**

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### **1. Introduction**

Economic activities are causing the release of certain pollutant atmospheric trace gases such as carbon dioxide, methane, nitrous oxide and chlorofluorocarbons (CFSs) which tend to block the emission of heat from the earth's surface. If these gases are increasingly concentrated in the atmosphere, this will cause the earth's surface and lower atmosphere to become warm like a greenhouse. Although the relationship between temperature trends and greenhouse effects is not clear, observed evidence on warming suggests that there is a positive relation between temperature trends and greenhouse effects.<sup>1</sup> Among the gases the Carbon Dioxide is considered to be responsible for around 60% of human induced greenhouse effect.<sup>2</sup> The emission of such greenhouse gas is also largely responsible for potential changes in climate. Concentration of carbon dioxide in the atmosphere has risen by 25% over the last

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<sup>1</sup>. David W. Pearce and Kerry R. Turner, *Economics of Natural Resources and The Environment*, The Johns Hopkins University Press, Maryland, USA, 1990.

<sup>2</sup>. Kerry R. Tumer, David W. Pearce, and Ian Bateman, *Environmental Economics: An Elementary Introduction*, The Johns Hopkins University Press, USA, 1990.

two hundred years and the trend is continuing upwards. The fossil fuel burning is still principal means of energy production in both developed and developing countries, and this accounts for 81% of annual carbon dioxide emissions, with deforestation, particularly tropical forests loss, also playing an important part in the emissions of carbon dioxide gas. The country which produces and consumes more energy for economic activities has the higher probability of carbon dioxide emissions. Until recently, the growing economies have significant carbon dioxide emissions as they attempt to foster increased rates of economic growth, thereby increasing their demand for energy. The present paper aims at making an econometric analysis between the carbon dioxide emission and the stage of economic development using data of both developed and developing countries. The per capita GDP is a measure of stage of economic development. Higher per capita income usually represents higher level of development while low per capita indicates low level of development. Another indicator is the state of industrial structure. At the initial stage of development, the tertiary sector dominates industrial sector while in the process of development the manufacturing sector gains ground. In a highly developed country the service sector dominates the scenario.<sup>3</sup>

In this paper, it is hypothesized that the carbon dioxide emission is directly related with per capita GDP. Per capita GDP also measures the size of the economy and as the economy expands the need for energy consumption increases.<sup>4</sup> It is also hypothesized that carbon dioxide emission is positively correlated with concentration of manufacturing industry in a country and negatively correlated with the concentration of service sector. The manufacturing sector is assumed to consume more energy than the service sector or tertiary

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<sup>3</sup>. G.M. Mier, *Leading Issues in Economic Development*, Fifth Edition, Cambridge University Press, 1995.

<sup>4</sup>. Jose Goldemberg, Thomas B. Johnson, Amulya K. N. Reddy and Robert H. Williams, *Basic Needs and Much with One Kilowatt*, University of Oslo, Norway.

sector. So, as manufacturing sector expands with expansion of economy, it is expected that carbon dioxide emission will increase while the expansion of service sector is assumed to reduce the need of energy consumption which results in the fall of Carbon dioxide emission.

The paper is organized into five sections. Section 2 deals with the methodology and the model of the study, section 3, with representation and interpretation of the estimated results. Section 4 deals with policy option to reduce CO<sub>2</sub>. Section 5 is the summary and conclusion.

## 2. Methodology and the Model of the Study

The study is based on secondary data of 55 countries which includes 19 developed industrialized countries and 36 developing countries and the data is for 1990. The carbon dioxide and the industrial sector data are taken from United Nations Statistical Yearbook 1992 and data for per capita GDP are obtained from the UNDP *Human Development Report, 1993*. The functional form of the Model is as follows:

$$C = f(\text{GDP}, \text{MN}, \text{SS})$$

and assumptions are :

$$\frac{\partial C}{\partial \text{GDP}} > 0, \frac{\partial C}{\partial \text{MN}} > 0, \frac{\partial C}{\partial \text{SS}} < 0$$

The model has an attempt to estimate the following linear regression by Ordinary Least Square (OLS) method by a standard econometrics package *Shazam*<sup>5</sup> :

$$C = \alpha + \beta \text{GDP} + \phi \text{MN} + \sigma \text{SS} + \varepsilon$$

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<sup>5</sup> Shazam, The Econometrics Computer Program, *User's Reference Manual*, Version 7, McGraw-Hill Book Company, NY, USA.

where,

C = Carbon dioxide emission

GDP = per capita GDP

MN = concentration of manufacturing industry

SS = concentration of service sector

$\epsilon$  = the disturbance term

The resulting regression did not produce significant results due to the problem of heteroscedasticity. In order to remove the heteroscedasticity problem the regression was run in log linear form which produced expected results. The log linear form of equation is as follows:

$$\ln C = \ln \alpha + \beta \ln GDP + \phi MN + \sigma \ln SS + \epsilon$$

Similar form of regressions were run for both developed and developing countries separately. The estimated equations give significant results for the developing countries but for developed countries the result is not meaningful. There may be some other factors beyond GDP and industrial sector which are more relevant for carbon dioxide emission in developed countries. The paper did not analyze that part due to the shortage of data and a proper econometric package. However, the regression run according to the model developed before for both developed and developing countries in general and results of the estimated equation are given in the following section.

### 3. Representation and Interpretation of Result

The estimated equation is the following :

$$\ln C = 3.28 + .815 \ln GDP + 1.28 \ln MN - 2.42 \ln SS$$

$$(2.694) \quad (.2251) \quad (.5393) \quad (1.280)$$

$$R^2 = .359 \quad R^2 (\text{Adj}) = .321 \quad F = 43.60$$

The figures in the parentheses are the standard deviation of respective coefficients. The results of the above estimated equation show that all the coefficients have expected signs and the coefficients are significant. The  $R^2$  and  $R^2(\text{adj})$  are .359 and .321 respectively, which are quite significant for cross section analysis. Moreover, the F value of the model indicates the overall significance of the model. The results indicate that the emission of carbon dioxide is positively related with per capita GDP and share of manufacturing sector in industrial activities, and it is negatively related with the share of service sector in industrial activities. Careful calculation of the data<sup>6</sup> suggests that in the developed countries the service sector accounts for 68% of total industrial activities, and the manufacturing sector encompasses 24% of industrial sector. On the other hand, the corresponding figures for the developing countries are 50% and 19% respectively. As a country moves from developing to developed stage, the manufacturing sector's contribution to national economy becomes higher than the service sector contribution. At this stage, the size of service sector is small and, contribution is also tiny. But once the economy reaches certain stage of development, the service sector contribution to national economy increases. This implies that at this stage, less energy is required for industrial activities. Moreover, at this stage of development, due to technological development, the developed country uses efficient and environment friendly technology for industrial activities which really need less energy and accordingly, the emission of carbon dioxide is also less. But still a developed country produces huge amount of carbon dioxide compared to developing countries due to large size of their economy. So in line with econometric results, it can be said that emissions of carbon dioxide will increase in both developed and developing countries.

#### **4. Policy Options to Reduce CO<sub>2</sub> Emission**

Various ways can be adopted to check the emission of CO<sub>2</sub>. Some of them are outlined here :

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<sup>6</sup> United Nations (UN), *United Nations Statistical Yearbook, 1992*.

(a) *Industrial Emissions Abatement Policies*: There are some policy tools available to the governments which can be used to limit the industrial emissions. These include the taxation of emissions, tradable permits, quotas and, standards. The first two policies are market based and economists are of view that these two policies are more effective since they tend to reward the more efficient producers, allow greater flexibility for firms and they are generally easier to enforce. Government can also provide additional incentives by giving option of tax credit and subsidies to the producers who adopt pollution abatement technologies.

(b) *Proper Resource Pricing*: Energy pricing policies of governments have significant implication for fuel use. Most developing countries use carbon intensive fuels such as coal and oil for their economic activities. In order to reduce CO<sub>2</sub> emissions, government energy policies should discourage people to use coal and oil for economic activities. Government policies should be directed to use alternative energy use which have less CO<sub>2</sub> emission. In many developing countries governments provide subsidies to various types of fuels. However, such subsidies often lead to unsustainable methods of production. Environmental issue should be taken into serious consideration during the energy price formulation period.

(c) *Research and Development*: Technological improvement which enhances energy efficiency is a very effective way to reduce industrial emission of CO<sub>2</sub> gas. However, such researches are too expensive to be undertaken by the developing countries. In this regard the role of developed countries is highly emphasized. Many clean technologies are being used in developed countries. But these are prohibitively expensive and as a result developing countries can not adopt such technologies. By making these technologies cheaper through further research and development, the developed countries can make them accessible to the developing countries.

(d) *Preserving Rain Forest*: Deforestation has significant contribution to the global concentration of greenhouse gases. Several

steps can be taken to preserve the tropical rain forests. The developing countries have many scopes to increase the efficiency of their economic use of rain forests. It is estimated that insignificant percentage of rain forests are replanted or cut in a sustainable manner. In this regard massive tree plantation programme can help to increase environments absorptive capacity for CO<sub>2</sub>.

The developed countries can provide fund for preservation and maintenance of rain forests. Many developing countries export timber to earn foreign exchange. By reducing trade barriers to alternative export from developing countries and also by reducing import of timber and other forest products the developed countries can assist in forest preservation.

(e) *International Cooperation* : Most of the developing countries are ridden with huge debt burden and as a result every year these countries pay substantial sum of foreign currency to service their debt. Because of debt burden these countries can not make investment to reduce environmental degradation. Forgiving debt and debt for nature swaps can help the developing countries to preserve forest resource and also to invest in environment preservation programmes.

## 5. Summary and Conclusion

The paper uses econometric method to analyze the relationship between carbon dioxide emission and stage of economic development. The study found the carbon dioxide emission is positively related with per capita GDP, share of manufacturing sector in industrial activities and negatively correlated with share of service sector in industrial activities. The implication is that as countries move toward development, the emission of carbon dioxide gas will increase because of increased share of manufacturing sector in the industrial sector of the country concerned. On the other hand, in developed countries as service sector dominates over manufacturing

sector the emission of carbon dioxide gas due to industrial activities should fall. But because of enormity of economy these countries will still produce huge amount of carbon dioxide gas.

Recent study by Holtz-Eakin and Selden<sup>7</sup> also supports the above contentions. They studied data on per capita emissions of CO<sub>2</sub> from fossil fuel consumption and cement manufacturing in 130 countries and estimated the relationship in both quadratic and cubic functions between per capita emissions and both the level and the log of per capita income. The study observed considerable evidence of decreasing marginal propensity to emit CO<sub>2</sub> with increase economic activity but very little evidence that CO<sub>2</sub> will fall when incomes grow higher even in the richest countries. The study also concluded that estimated emissions will continue to rise until a country's per capita income reaches more than US \$ 35000 in 1985 constant prices.

The prime drawback of this study is that it did not consider the impact of technology. The technological development already increased the efficiency of energy uses and it is expected that such progress will continue. So in the future industrialized countries are expected to reduce the fossil fuel consumption and the emission of CO<sub>2</sub>. But how far the developing countries will be able to practice such conservation procedure is a matter of question. Because much efforts and energy are needed for technological development which the developing economies hardly can provide. Until now most of the advanced technologies in this area are invented in developed countries which have clear bias toward capital intensive nature. But still the concerted efforts by both developed and developing countries may ease the problems.

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<sup>7</sup>. Holtz-Eakin and Selden, *Stoking the Fires? CO<sub>2</sub> Emissions and Economic Growth*, NBER, Working Paper 4248, Cambridge MA, 1992.

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