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Re-examining Economic Growth-Environment Relationship: Evidence from High-, Medium- And Low-Income Countries

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Re-examining Economic Growth-Environment Relationship: Evidence from High-, Medium- And Low-Income Countries

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ABSTRACT

There is said to be an inverted U shaped relationship between economic growth and the environment, named environmental Kuznets curve (EKC). But why such relationship exists and what are the mechanisms by which economic development improves environment are not well known. Studies are generally based on reduced form single equation model of this relationship, which could not explain much insight into its underlying causes. To overcome these limitations, we develop a structural model for analysing economic growth-environment linkages. Using panel data from a cross-section of countries widely dispersed on economic growth scale, this study finds that the scale of economic activities deteriorates environmental quality during the earlier stage of economic growth, whereas structural economic changes and abatement activities offset this effect and thus improves environmental quality during the later stage. It is also found that these effects differ widely across high-, medium- and low-income countries and, therefore, a global aggregation is certainly a misspecification of the EKC relationship.

CONTENTS		PAGE

1. Introduction

The Environmental Kuznets Curve (EKC) debate has recently developed a large literature contributed by many authors[1] across disciplines. Studies have mostly examined net effect of changes in per capita gross domestic product (GDP) on the environmental quality, although some have examined the relationship adding variables, such as population density, per capita GDP growth rate, average per capita GDP of a number of years, etc. Panayotou (1997) and few other authors have used policy variables, such as 'contract enforceability', as an underlying factor behind the EKC relationship. But the empirical results of the EKC relationship in the existing studies are not always unequivocal, nor there a consensus on the underlying explanations (Barbier, 1997: 370; de Bruyn and Heintz, 1999: 665).

Existing studies are generally based on reduced form single equation model of the EKC relationship, which has its inherent limitations. It masks socio-political diversities and cannot explain much insight into the underlying structural causes of relation between economic growth and environmental quality. The mechanism by which economic growth first aggravates the environmental quality and then renders improvement is not yet well explained. Therefore, existing studies based on reduced form single equation model seem to have very little scope for policy prescription for the environmental improvement. Some authors, such as Arrow *et al.* (1995), Grossman and Krueger (1995), Kaufman *et al.* (1995), Ekins (1997), Stern (1998), de Bruyn and Heintz (1999) and others have suggested formulation of structural model of the EKC relationship in order to obtain more insight of the underlying interacting forces.

We develop a structural model for analyzing economy-environment relationship to overcome the above limitations. In the following section, we decompose the EKC relationship by breaking down net environmental effect of economic activities into three major determinants: *scale*, *composition* and *abatement* effects. Using the above decomposition, a structural model is developed in section 3. It seems that important socio-political variables, such as democratic and political rights, that may have strong impact on environmental quality, have been omitted in the existing studies. We incorporate additional socio-political variables, such as *adult literacy rate, popular democratic rights*, to explain the underlying causes of the relationship. Description of data and their sources are presented in section 4. We apply our model for empirical testing of the relationship in high-, medium-, and low-income countries and then present comparative results in section 5. The section 6 provides with a conclusion.

2. Decomposition of EKC

In absence of much insight behind the EKC relationship, various authors, following either theory, intuition or empirical results, identified several forces that seem to be acting behind the EKC relationship. de Bruyn and Heintz (1999) summarized these forces in terms of : peoples' behavioral changes and preferences, society's structural, institutional, technological and organizational changes at different levels, and international relocations of consumption and production. Using the above explanations, a few authors decomposed EKC relationship by breaking down net effects of economic growth into its *scale*, *composition* and *abatement* effects in order to explicitly identify the underlying determinants of the economy-environment relationship. Ekins (1997) theoretically derived scale, composition and abatement effects from economy-environment relationship. Later, Panayotou (1997) and others identified and analyzed the following three major determinants of environmental impact resulting from economic activities.

Scale effect,
Structural or composition effect, and
Abatement effect

Scale effect

Economic growth results in increased levels of resource use, waste generation, and pollution emissions unless appropriate abatement

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[1] Grossman and Krueger (1991), (1995), Selden (1994), Selden and Song (1994), Cole *et al*. (1997), Ekins (1997), Johnstone (1997), Moomaw and Unruh (1997), OECD (1997), Panayotou, (1997), De Bruyn *et al.* (1998), Kaufmann *et al.* (1998), Torras and Boyce (1998), Unruh and Moomaw (1998), Islam *et al.* (1999), Munasinghe (1999), van Veen-Groot and Nijkamp (1999) and others.

measures are taken. Therefore, larger the scale of economic activity, the higher is likely to be the level of pollution.

Composition effect

Economic growth generates structural transformation in economic activities[2]. Sectoral shares in total GDP change as economy grows. Share of manufacturing sector first increases and then it gradually declines, while service sector gradually grows with increase in economic growth. Pollution intensity differs from sector to sector. Manufacturing sector is more energy and resource intensive than service sector. It makes manufacturing sector usually more pollution-intensive than agricultural and service sectors. As a result, energy and resources use increases at an increasing rate with increase in manufacturing activities and environmental degradation likely to increase at an increasing rate with economic growth. However, as an economy switches more and more to services, relative intensity of energy and resource use in production and consumption are likely to grow less rapidly than output and with further increase in economic growth, environmental degradation likely to increase at a decreasing rate. Thus, environmental quality changes with structural transformations driven by economic growth.

Abatement effect

Net pollution in a country is an outcome of pollution generation and pollution abatement. Abatement measures are determined by demand and supply factors. There is an 'Engel's law-type' relationship between income and demand for environmental quality (Selden and Song, 1994; Panayotou, 1997; Islam *et al.* 1999). Production, consumption and pollution are likely to be very low during the earliest stage of economic growth. Marginal utility of consumption is very large during this period, while the marginal disutility of pollution is small. People might prefer more consumption than cleaner environment, resulting zero-abatement. With economic growth, production, consumption and pollution will increase and the direct effect of economic growth on pollution might be large. Several factors, such as rate of economic growth, peoples' tastes and preferences will influence the duration of zero-abatement. Once this phase is over, abatement effort will increase rapidly and marginal efficiency of abatement will be very high. With faster increase in abatement, the marginal utility of consumption will decline and marginal concern over pollution will increase rapidly. Eventually the marginal utilities will converge and yielding a J curve for abatement. Selden and Song (1994), theoretically derived such J curve using basic neo-classical growth model as modified by Forester (1973)[3].

Economic growth on the one hand creates demand for pollution abatement and on the other hand enables to supply resources for this. It not only helps to acquire better technology for pollution abatement but also enables to establish and enforce environmental regulations.

3. The Model

Using the above decomposition of the EKC we shall now develop our structural model in this section.

To decompose the environmental impact of economic growth into its determinants as mentioned in the above section, we define pollution as a composite variable in the following way. Pollution level of a country is actual pollution emissions per capita (Bongraarts, 1992; Clark, 1992; Harrison 1992; Islam *et al.* 1999).

[2] It is widely assumed that at the earlier stage of development, countries specialise in the export of 'natural resource-based product'. After accumulating some capital they specialise in the export of 'labour intensive manufactured goods' and with rapid growth, high savings and investment their specialisation transformed into 'more capital intensive sophisticated technology products'.

[3] For theoretical derivation process see Coursey (1992); Selden and Song (1994) and Stokey (1998)

$$Pollution = \frac{Actual\ \ Pollution\ \ Emission}{Population}$$

$$Pollution = \frac{GDP}{Population} * \frac{Actual\ \ Pollution\ \ Emission}{GDP}$$

$$Pollution = \left(\frac{GDP}{Population}\right) * \left(\frac{Potential\ \ Pollution\ \ Generation}{GDP}\right) * \left(\frac{Actual\ \ Pollution\ \ Emission}{Potential\ \ Pollution\ \ Generation}\right)$$

This could be written as follows:

$$P = P_S * P_C * P_A \qquad (1)$$

In the above definition, GDP-population ratio represents total change in the magnitude of economic activities, which could be termed as *scale effect*. Pollution generation per unit of GDP changes with change in the economic activities. Potential pollution generation is total pollution generated in a country without any abatement process. While actual pollution emission is net pollution generation after abatement process, if any. Therefore, potential pollution generation-GDP ratio could represent *composition effect*. The actual pollution emission – potential pollution generation ratio is a pollution abatement measure which could represent *abatement effect*. Therefore, P, P_S, P_C, and P_A in equation-1 could be identified as pollution index, scale effect, composition effect, and abatement effect in pollution respectively.

3.1. Model Specification

(a) *Scale effect function*:

Scale effect of environmental degradation stems from the economic activities of a country. If higher economic activities deplete more (natural) resources, they may generate greater pollution. Therefore, per capita GDP is used as an explanatory variable for scale effect. In the current literature per capita GDP is either *only* or the *main* explanatory variable.

Therefore, sale effect function is formulated as follows. We considered it to be linear and quadratic in GDP per capita.

$$P_S = \alpha_0 + \alpha_1 Y + \alpha_2 Y^2 \qquad (2)$$

(+) (+) (-)

where Y is GDP per capita. The signs under each of the variables indicate our expectations regarding the respective coefficient from the empirical analysis.

(b) *Composition effect function*:

Share of different sectors in GDP of an economy is a good reflection of the structure of economy. Manufacturing sector being mostly responsible for polluting and resource depleting its share in GDP are used as an explanatory variable for composition effect. Here manufacturing percentage in GDP will be a proxy for structural changes in the economy.

Therefore, composition effect function is formulated as follows. We consider it linear and quadratic in manufacturing share in GDP.

$$P_C = \beta_1 M + \beta_2 M^2 \qquad (3)$$

(+) (-)

where *M* is the share of manufacturing sector in GDP. The signs under each of the variables indicate our expectations regarding the respective coefficient from the empirical analysis.

(c) *Abatement effect function*:
Abatement effect is the result of environmental degradation control measures, which will be determined by the demand for better environment (demand side) and the supply of resources for better abatement (supply side). With higher level of national income people tends to demand for better environment and a country is expected to divert more resources for abatement measures. Thus both demand and supply sides of the abatement effect are directly influenced by national income level. In addition, literacy level of a country could influence the demand for better environment. The higher the level of literacy, the greater is likely to be the awareness of population for better environment. Peoples' preferences likely to change and thus people demand cleaner environment. This might be manifested in policy-making process in democratic governing system. Therefore, popular democratic rights may have impact on the supply side of abatement effect. Deacon (1999) and Torras and Boyce (1998) has shown that non-democratic government might have lower policy response for pollution control and therefore, turning point (if any) will be at a higher level of economic growth than under democratic government. Harbaugh *et al*. (2000) and Eriksson and Persson (2002) theoretically proved such relationship between democracy and pollution. Eriksson and Persson (2002) suggested including measures of democracy as an explanatory variable in EKC-regression (p 14).

Therefore we specify abatement measures as a function of national income, literacy rate and popular democratic rights. As there is a time lag between the rise in income and its transmission effect on the change in pollution level, the income variable we used is a lagged per capita GDP (*I*) as common in the current literature. The specification of our abatement function, we use, is linear but quadratic in lagged per capita GDP.

$$P_A = \delta_0 + \delta_1 I + \delta_2 I^2 + \delta_3 L + \delta_4 R \qquad (4)$$

(+) (+) (-) (-) (-)

where *I* is lagged per capita GDP, *L* is literacy rate, and *R* is a measure of popular democratic rights. The signs under each of the variables indicate our expectations regarding the respective coefficient from the empirical analysis.

3.2 The structural equation:

Substituting equation-2, equation-3 and equation-4 in equation-1 we find the following structural relation:

$$P = \left(\alpha_0 + \alpha_1 Y + \alpha_2 Y^2\right) * \left(\beta_1 M + \beta_2 M^2\right) * \left(\delta_0 + \delta_1 I + \delta_2 I^2 + \delta_3 L + \delta_4 R\right)$$

$$P = \begin{pmatrix} \alpha_0\beta_1 M + \alpha_0\beta_2 M^2 + \alpha_1\beta_1 YM + \alpha_1\beta_2 YM^2 \\ +\alpha_2\beta_1 Y^2 M + \alpha_2\beta_2 Y^2 M^2 \end{pmatrix} * \left(\delta_0 + \delta_1 I + \delta_2 I^2 + \delta_3 L\right.$$

$$\begin{aligned} P = {} & \alpha_0\beta_1\delta_0 M + \alpha_0\beta_1\delta_1 MI + \alpha_0\beta_1\delta_2 MI^2 + \alpha_0\beta_1\delta_3 ML + \alpha_0\beta_1\delta_4 MR + \alpha_0\beta_2\delta_0 M^2 \\ & +\alpha_0\beta_2\delta_1 M^2 I + \alpha_0\beta_2\delta_2 M^2 I^2 + \alpha_0\beta_2\delta_3 M^2 L + \alpha_0\beta_2\delta_4 M^2 R + \alpha_1\beta_1\delta_0 YM \\ & +\alpha_1\beta_1\delta_1 YMI + \alpha_1\beta_1\delta_2 YMI^2 + \alpha_1\beta_1\delta_3 YML + \alpha_1\beta_1\delta_4 YMR + \alpha_1\beta_2\delta_0 YM^2 \\ & +\alpha_1\beta_2\delta_1 YM^2 I + \alpha_1\beta_2\delta_2 YM^2 I^2 + \alpha_1\beta_2\delta_3 YM^2 L + \alpha_1\beta_2\delta_4 YM^2 R + \alpha_2\beta_1\delta_0 Y^2 M \\ & +\alpha_2\beta_1\delta_1 Y^2 MI + \alpha_2\beta_1\delta_2 Y^2 MI^2 + \alpha_2\beta_1\delta_3 Y^2 ML + \alpha_2\beta_1\delta_4 Y^2 MR + \alpha_2\beta_2\delta_0 Y^2 M^2 \\ & +\alpha_2\beta_2\delta_1 Y^2 M^2 I + \alpha_2\beta_2\delta_2 Y^2 M^2 I^2 + \alpha_2\beta_2\delta_3 Y^2 M^2 L + \alpha_2\beta_2\delta_4 Y^2 M^2 R \end{aligned} \qquad (5)$$

By using reduced form coefficients (Π's), we could rewrite the above composite equation as follows:

$$P = \Pi_1 M + \Pi_2 MI + \Pi_3 MI^2 + \Pi_4 ML + \Pi_5 MR + \Pi_6 M^2 + \Pi_7 M^2 I + \Pi_8 M^2 I^2$$
$$+\Pi_9 M^2 L + \Pi_{10} M^2 R + \Pi_{11} YM + \Pi_{12} YMI + \Pi_{13} YMI^2 + \Pi_{14} YML + \Pi_{15} YMR$$
$$+\Pi_{16} YM^2 + \Pi_{17} YM^2 I + \Pi_{18} YM^2 I^2 + \Pi_{19} YM^2 L + \Pi_{20} YM^2 R + \Pi_{21} Y^2 M$$
$$+\Pi_{22} Y^2 MI + \Pi_{23} Y^2 MI^2 + \Pi_{24} Y^2 ML + \Pi_{25} Y^2 MR + \Pi_{26} Y^2 M^2 + \Pi_{27} Y^2 M^2 I$$
$$+\Pi_{28} Y^2 M^2 I^2 + \Pi_{29} Y^2 M^2 L + \Pi_{30} Y^2 M^2 R \qquad (6)$$

To recover 10 structural parameters from 30 estimated reduced form coefficients, we use following 24 restrictions on the reduced form coefficients:

$$\frac{\Pi_1}{\Pi_2} = \frac{\Pi_6}{\Pi_7} = \frac{\Pi_{11}}{\Pi_{12}} = \frac{\Pi_{16}}{\Pi_{17}} = \frac{\Pi_{21}}{\Pi_{22}} = \frac{\Pi_{26}}{\Pi_{27}} = \frac{\delta_0}{\delta_1} \qquad (7)$$

$$\frac{\Pi_1}{\Pi_3} = \frac{\Pi_6}{\Pi_8} = \frac{\Pi_{11}}{\Pi_{13}} = \frac{\Pi_{16}}{\Pi_{18}} = \frac{\Pi_{21}}{\Pi_{23}} = \frac{\Pi_{26}}{\Pi_{28}} = \frac{\delta_0}{\delta_2} \qquad (8)$$

$$\frac{\Pi_1}{\Pi_4} = \frac{\Pi_6}{\Pi_9} = \frac{\Pi_{11}}{\Pi_{14}} = \frac{\Pi_{16}}{\Pi_{19}} = \frac{\Pi_{21}}{\Pi_{24}} = \frac{\Pi_{26}}{\Pi_{29}} = \frac{\delta_0}{\delta_3} \qquad (9)$$

$$\frac{\Pi_1}{\Pi_5} = \frac{\Pi_6}{\Pi_{10}} = \frac{\Pi_{11}}{\Pi_{15}} = \frac{\Pi_{16}}{\Pi_{20}} = \frac{\Pi_{21}}{\Pi_{25}} = \frac{\Pi_{26}}{\Pi_{30}} = \frac{\delta_0}{\delta_4} \qquad (10)$$

3.3 Recovery of Scale, Composition and Abatement Effect

The equation-6 will be estimated and using estimated parameters scale, composition and abatement effect functions will be recovered.

3.3.1 *Recovery of the Scale effect function:*

Re-arranging equation-6 the scale effect function can be identified as,

$$\hat{P}_S = \begin{pmatrix} \hat{\Pi}_1 \overline{M} + \hat{\Pi}_2 \overline{MI} + \hat{\Pi}_3 \overline{MI}^2 + \hat{\Pi}_4 \overline{ML} + \hat{\Pi}_5 \overline{MR} + \hat{\Pi}_6 \overline{M}^2 \\ +\hat{\Pi}_7 \overline{M}^2 \overline{I} + \hat{\Pi}_8 \overline{M}^2 \overline{I}^2 + \hat{\Pi}_9 \overline{M}^2 \overline{L} + \hat{\Pi}_{10} \overline{M}^2 \overline{R} \end{pmatrix}$$
$$+ \begin{pmatrix} \hat{\Pi}_{11} \overline{M} + \hat{\Pi}_{12} \overline{MI} + \hat{\Pi}_{13} \overline{MI}^2 + \hat{\Pi}_{14} \overline{ML} + \hat{\Pi}_{15} \overline{MR} + \hat{\Pi}_{16} \overline{M}^2 \\ +\hat{\Pi}_{17} \overline{M}^2 \overline{I} + \hat{\Pi}_{18} \overline{M}^2 \overline{I}^2 + \hat{\Pi}_{19} \overline{M}^2 \overline{L} + \hat{\Pi}_{20} \overline{M}^2 \overline{R} \end{pmatrix} Y$$
$$+ \begin{pmatrix} \hat{\Pi}_{21} \overline{M} + \hat{\Pi}_{22} \overline{MI} + \hat{\Pi}_{23} \overline{MI}^2 + \hat{\Pi}_{24} \overline{ML} + \hat{\Pi}_{25} \overline{MR} + \hat{\Pi}_{26} \overline{M}^2 \\ +\hat{\Pi}_{27} \overline{M}^2 \overline{I} + \hat{\Pi}_{28} \overline{M}^2 \overline{I}^2 + \hat{\Pi}_{29} \overline{M}^2 \overline{L} + \hat{\Pi}_{30} \overline{M}^2 \overline{R} \end{pmatrix} Y^2 \qquad (11)$$

Here scale effect in pollution is recovered using sample mean values of all variables except *Y*. The first parenthesis of the above equation is its intercept, the second parenthesis is the coefficient of *Y*, and the last parenthesis is the coefficient of Y^2 respectively.
The above function thus similar to the equation-2 and gives the predicted values of scale effect in *P* for different levels of *Y*.

3.3.2 *Recovery of the composition effect function:*

Re-arranging equation-6 the composition effect function can be identified as,

$$\hat{P}_C = \begin{pmatrix} \hat{\Pi}_1 + \hat{\Pi}_2 \overline{I} + \hat{\Pi}_3 \overline{I}^2 + \hat{\Pi}_4 \overline{L} + \hat{\Pi}_5 \overline{R} + \hat{\Pi}_{11} \overline{Y} + \hat{\Pi}_{12} \overline{YI} + \hat{\Pi}_{13} \overline{YI}^2 + \hat{\Pi}_{14} \overline{YL} \\ +\hat{\Pi}_{15} \overline{YR} + \hat{\Pi}_{21} \overline{Y}^2 + \hat{\Pi}_{22} \overline{Y}^2 I + \hat{\Pi}_{23} \overline{Y}^2 \overline{I}^2 + \hat{\Pi}_{24} \overline{Y}^2 \overline{L} + \hat{\Pi}_{25} \overline{Y}^2 \overline{R} \end{pmatrix} M$$
$$+ \begin{pmatrix} \hat{\Pi}_6 + \hat{\Pi}_7 \overline{I} + \hat{\Pi}_8 \overline{I}^2 + \hat{\Pi}_9 \overline{L} + \hat{\Pi}_{10} \overline{R} + \hat{\Pi}_{16} \overline{Y} + \hat{\Pi}_{17} \overline{YI} + \hat{\Pi}_{18} \overline{YI}^2 + \hat{\Pi}_{19} \overline{YL} \\ +\hat{\Pi}_{20} \overline{YR} + \hat{\Pi}_{26} \overline{Y}^2 + \hat{\Pi}_{27} \overline{Y}^2 I + \hat{\Pi}_{28} \overline{Y}^2 \overline{I}^2 + \hat{\Pi}_{29} \overline{Y}^2 \overline{L} + \hat{\Pi}_{30} \overline{Y}^2 \overline{R} \end{pmatrix} M^2 \qquad (12)$$

Here composition effect in pollution is recovered using sample mean values of all variables except *M*. The two parentheses of the above equation are the coefficients of the linear and quadratic terms of *M* respectively. The above function thus similar to the equation-3 and gives the predicted values of composition effect in *P* for different levels of *M*.

3.3.3 *Recovery of the abatement effect function:*
Re-arranging equation-6 abatement effect function can be identified as,

$$\hat{P}_A = \left(\hat{\Pi}_1\bar{M} + \hat{\Pi}_6\bar{M}^2 + \hat{\Pi}_{11}\bar{Y}\bar{M} + \hat{\Pi}_{16}\bar{Y}\bar{M}^2 + \hat{\Pi}_{21}\bar{Y}^2\bar{M} + \hat{\Pi}_{26}\bar{Y}^2\bar{M}^2\right)$$
$$+\left(\hat{\Pi}_2\bar{M} + \hat{\Pi}_7\bar{M}^2 + \hat{\Pi}_{12}\bar{Y}\bar{M} + \hat{\Pi}_{17}\bar{Y}\bar{M}^2 + \hat{\Pi}_{22}\bar{Y}^2\bar{M} + \hat{\Pi}_{27}\bar{Y}^2\bar{M}^2\right)I$$
$$+\left(\hat{\Pi}_3\bar{M} + \hat{\Pi}_8\bar{M}^2 + \hat{\Pi}_{13}\bar{Y}\bar{M} + \hat{\Pi}_{18}\bar{Y}\bar{M}^2 + \hat{\Pi}_{23}\bar{Y}^2\bar{M} + \hat{\Pi}_{28}\bar{Y}^2\bar{M}^2\right)I^2$$
$$+\left(\hat{\Pi}_4\bar{M} + \hat{\Pi}_9\bar{M}^2 + \hat{\Pi}_{14}\bar{Y}\bar{M} + \hat{\Pi}_{19}\bar{Y}\bar{M}^2 + \hat{\Pi}_{24}\bar{Y}^2\bar{M} + \hat{\Pi}_{29}\bar{Y}^2\bar{M}^2\right)L$$
$$+\left(\hat{\Pi}_5\bar{M} + \hat{\Pi}_{10}\bar{M}^2 + \hat{\Pi}_{15}\bar{Y}\bar{M} + \hat{\Pi}_{20}\bar{Y}\bar{M}^2 + \hat{\Pi}_{25}\bar{Y}^2\bar{M} + \hat{\Pi}_{30}\bar{Y}^2\bar{M}^2\right)R \qquad (13)$$

Here abatement effect in pollution is recovered using sample mean values of all variables except *I, L* and *R*. The first parenthesis of the above equation is its intercept, and the other four parentheses are the coefficients of *I*, I^2, *L* and *R* respectively. The above function thus, similar to the equation-4 and gives the predicted values of abatement effect in *P* for different levels of *I*, I^2, *L* and *R*.

4. Description of Data and their Sources

P (*pollution index*)
Only pollution of carbon dioxide is considered in this study (but the model could be used for any pollution index). Since carbon dioxide is the main atmospheric gas which contributes to global warming (84%) (Madden, 1980; Seitz, 1995: 108; EIA, 1998). On the other hand data for wide range of countries for longer period of times are available for carbon dioxide only. Data are for per capita carbon dioxide emissions from fossil-fuels (in metric tons of carbon).
Source: Carbon Dioxide Information Analysis Center[4], Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831-6335, USA (http://cdiac.esd.ornl.gov/ftp/ndp030/).

Y (*per capita GDP*)
Per Capita GDP based on exchange rates is used. While some researchers used GDP per capita based on exchange rates and others used GDP per capita based on purchasing-power-parity, we use GDP per capita based on 1995 exchange rates for two reasons: (a) to increase data range up to most recent time and for larger number of countries, and (b) because Arrighi and Drangel (1986), Korzeniewicz and Martin (1994) and others argued that “exchange rate GDP better captures a country’s control over the world product and its power in trade networks” (Roberts and Grimes, 1997: 192). The only best source for GDP in PPP data is Summers and Heston (1991) has data up to 1992. On the other hand, GDP data taken from World Development Indicator 2000 on CD-ROM (World Bank, 2000) has data up to 1999. GDP data measures total output of goods and services for final use occurring within the domestic territory of a given country. Data are in constant 1995 US dollars and dollar figures are converted from domestic currencies using 1995 official exchange rates. Per capita GDP is calculated by me using total GDP and total population data taken from same source. Many authors used GDP data from the World Bank data base[5].
Source: World Bank (2000).

M (*share of manufacturing sector in GDP*)
Industries belonging to International Standard Industrial Classification (ISIC) divisions 15-37 are included in manufacturing data. Value of net output of a sector is calculated by adding values of all outputs and subtracting intermediate inputs. Compensations for depreciation

[4] Data for Norway, Democratic Republic of Congo and Republic of Congo are from IEA (1999).
[5] Panayotou (1997); Roberts and Grimes (1997); Agras and Chapman (1999); and others.

fabricated assets or depletion and degradation of natural resources are not accounted. The ISIC revision 2 is used to determine the origin of value added in a sector.
Source: World Bank (2000).

I (l*agged per capita income*)
Three years average of per capita GDP.

L (*literacy rate*)
People aged 15 and above who can understand, read and write a short, simple statement on their everyday life are considered as literate.
Source: World Bank (2000).

R (*measures for popular democratic rights*)
Popular democratic rights data are constructed by adding data on political rights and civil liberties, constructed by the Freedom House, USA. Barro (1996), Torras and Boyce (1998), Barrett and Graddy (2000), Bhattarai and Hammig (2001) and others used similar measures.

Freedom House constructed index of political right and civil liberties for each country and the scales for both are from 1 to 7. Score of 1 is for most free and 7 for least free. Therefore, lower value of R indicates higher popular democratic rights and higher value indicates lower popular democratic rights. Freedom House selected 8 items for political rights and 14 items for civil liberties. Political rights are considered as peoples' ability to participate freely in the political process and respective items are selected to measure it. Similarly civil liberties are considered as "freedoms to develop views, institutions and personal autonomy apart from the state" (Freedom House web page) and respective items are selected to measure them. For each item each country is awarded a raw point of 0 to 4. Therefore one country could have a highest possible score of 32 for political right and 56 for civil liberties. In final stage a country is assigned a final score for each of two categories on the basis of the following table. Final score for both political rights and civil liberties are summed together to make an index for popular democratic rights. Thus the value of this index ranges from 2 to 14, where a value of 2 reflects a country with the most political and civil liberties and a value of 14 reflects a country with the least of such freedom. We reverse the order of these indices and use as popular democratic rights variable in our analysis. Reversing in order make result interpretation easy and comparable with other variables.
Source: Freedom House, USA (http://www.freedomhouse.org).

Countries covered

This paper uses annual data from 128 countries. Selected countries are divided into three categories according to their income per capita as grouped by the World Bank. They are high income (per capita GNP of US $9,266 or above), middle income (per capita GNP of US $2,995 - $9,265), and low income countries consisting of lower middle income (per capita GNP of US $756 - $2,995) and low income countries (per capita GNP of US $755 or less).

Data Period
Data are from 1973 to 1997. For some countries data are not available for this duration and in those cases data of available years are used.

5. Estimation Techniques and Results

In the current empirical literature, a single global EKC has been generally estimated on the basis of global data. It essentially assumes that the same relationship holds for all countries[6]. But there are structural differences among countries in terms of industrialization, production-consumption basket, level of technology, level of awareness about environment and so on. Several sets of different pollution aggravating as well as mitigating forces emanating from these structural differences might be working behind environmental situations in different ways (Islam, 1997). This might have different environmental outcomes from country to country and thus, generating different environmental transition paths in different countries.

[6] The authors have estimated the basic model with and without economic openness using global data of 128 countries in a different paper.

Recently, few researchers (List and Gallet, 1999; Stern and Common, 2001) argue that a single global model EKC relationship is a 'misspecification' and therefore, the EKC relationship very likely differ across regions and income groups. For instance, Islam (1997) find the EKC relationship in Asia differ from other regions of the world. We, however, find it imperative that the difference should focus on group of countries with different income levels rather than on different geographical regions. Economic activities are different in groups of countries with different levels of income. It is not unreasonable to assume that environmental impacts vary among different income groups. Therefore, we divide our data from 128 selected countries into three groups: (a) high income group, consisting of data from high-income countries, (b) medium income group, consisting of data from upper medium-income countries, and (c) rest-of-the-world, consisting of data from lower medium- and low-income countries[7]. Thus, countries in each group are of similar ranges of per capita income across different regions.

We estimated regressions for four different groups, namely: (i) *Global*, consisting of all countries, (ii) high income group (*H-income*), (iii) medium group (*M-income*), and (iv) rest-of-the-world or low income group (*L-income*).

In order to recover the values of the respective parameters in *scale*, *composition* and *abatement* functions, composite Equation-6 has been estimated for all the four groups of countries separately.

Equation-6 has been estimated using their two versions: *fixed-* and *random* effects. The fixed effects approach takes a group specific constant term (as slope parameters) in the model. The random effects approach takes those group specific constant terms as group specific disturbances. However, there is a constant term identical for each group and for all periods in the random model. Both fixed- and random-effects models have their limitations. In fixed effects model, slope parameters are estimated by using mean deviated values of the individual variables. Thus it loses a large number of degrees of freedom (equal to the number of countries). The random effects model has been criticized because of its assumption of no correlation between individual country effects and included variables (regressors). The Hausman test was performed to determine whether random effects model is preferred to fixed effects model. Here the null hypothesis is that there is no correlation between individual country effects and included variables. Large value of the Hausman statistic indicates that the fixed effects model is preferred to random effects model. (Hausman, 1978; Hsiao 1986; Baltagi, 1995; Greene, 1997).

Estimated coefficients are presented in the Table-2, Table-3, Table-4 and Table-5 in appendix[8]. We find that random effects are preferred in case of both high income and upper medium income groups and fixed effect is preferred for global and developing country group. We find that maximum regressors are significant at least at the 10 percent level. There is a danger of multicollinearity among regressors which are multiplicative combinations of five underlying variables. But the statistical significance of most of these regressors and high values of R^2 are, however, noteworthy.

We use coefficients of the composite equation in only estimating scale, composition and abatement effect functions for the models. Hence magnitude and sign of individual parameter of the composite equation are of limited interest. Values of estimated coefficients from the above tables are plugged in Equation-11, Equation-12 and Equation-13 to recover scale, composition and abatement functions respectively.

5.1 Estimated scale effect:

Plugging estimated values of coefficients from Equation-6 in Equation-11, the structural equation of the scale effect function in our model for each of the four groups becomes:

$$\hat{P}_{S\ (Global)} = -24.66 + 5.68Y - 0.06Y^2 \qquad (14)$$

[7] We grouped countries into high-, upper medium-, and lower medium- and low-income following the classification of the World Bank and as of 2000.

[8] Available from author on request.

$$\hat{P}_{S\ (H-income)} = -24.64 + 8.96Y - 0.06Y^2 \qquad (15)$$

$$\hat{P}_{S\ (M-income)} = -36.18 + 23.53Y + 0.42Y^2 \qquad (16)$$

$$\hat{P}_{S\ (L-income)} = 1.94 + 63.91Y - 2.37Y^2 \qquad (17)$$

Recovered scale effect equation is quadratic in Y for each group except for medium income group. It means that, with other factors remaining constant, carbon dioxide emission has a positive relation with GDP per capita in the initial phase and has a negative relation in the later phase. This indicates that environmental quality is initially degrading at an increasing rate with increased economic activities and later at a diminishing rate. But environmental quality is degrading at an increasing rate and after certain level of per capita income it is degrading at a faster rate in the case of medium income countries.

Partial effect of increase in per capita GDP on carbon dioxide emission is predicted for each of four groups using respective equations at different levels of per capita GDP. Corresponding graphs are presented in the figures 1a, 1b, 1c, 1d.

Global scale effect has an increasing trend at a diminishing rate. Scale effects of each of the other three groups are different in nature; although there is some sort of qualitative similarity between Global- and H-Income group's scale effects. Scale effect for H-Income countries is increasing with a very minor diminishing trend; but, scale effect for M-income countries is increasing at an increasing rate.

L-income countries' scale effect differs markedly from others. It is increasing and after certain level of per capita income it is expected to start decreasing. It might be due to their early abatement measures[9].

5.2 Estimated composition effect:

To recover structural equation of the composition effect function, estimated values of coefficients of Equation-6 are used in Equation-12. Thus, the composition effect functions for the four groups become:

$$\hat{P}_{C\ (Global)} = 167.96M - 425.16M^2 \qquad (18)$$

$$\hat{P}_{C\ (H-income)} = 1039.04M - 1700.84M^2 \qquad (19)$$

$$\hat{P}_{C\ (M-income)} = 880.41M - 1258.18M^2 \qquad (20)$$

$$\hat{P}_{C\ (L-income)} = 414.46M - 452.13M^2 \qquad (21)$$

The recovered composition effect equations are quadratic in M (manufacturing percentage in GDP). As explained earlier, M is used as a composite proxy for structural changes in the economy. Therefore, composition effect shows that, with other factors remaining unchanged, carbon dioxide emission has a positive relation with

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[9] Low income countries are found to be adopting abatement measures at a lower level of per capita income in comparison to other groups as indicated by their abatement effect function in a later section?

structural change in economy[10] in the earlier phase and has a negative relation in the later phase while mean M is still increasing. Thus, environmental quality is found to degrade with changes in economic structure before it starts to improve at a later stage.

Graphs of estimated values of carbon dioxide emission corresponding to different levels of manufacturing percentage in GDP are presented in the figures 2a, 2b, 2c, 2d.

Composition effect curve has an inverted U-shape hump in all cases. In case of Global composition effect, the hump comes quicker and at a lower level of per capita emission. Composition effect for H-income countries is similar to that of Global composition effect; but its turning point is at a higher level of per capita emission. Composition effects for M-income and L-income countries follow the same pattern with a late turning point. Late turning point, in case of M-income countries, might be due to increased manufacturing production without adopting much abatement measures. These countries seem to achieve comparative advantage over H-income countries with a view to catching up them quickly in terms of per capita income level. The abatement function as estimated in the next section shows that these countries might have adopted clean-up measures after certain level of income.

In the case of L-income country-group, turning point come late compare to H-income and M-income groups; but it is achieved at a much lower level of per capita emission. They achieve a turning point at a much lower level of per capita emission due to their very low level of manufacturing production and consumption. Similarly, late turning point might be due to their limited availability of resources.

5.3 Estimated abatement effect:

Inserting estimated values of coefficients of Equation-6 in Equation-13, the structural equation of the abatement effect function for each of the four groups becomes:

$$\hat{P}_{A\ (Global)} = 16.54 + 0.77I - 0.20I^2 - 10.01L - 0.02R \qquad (22)$$

$$\hat{P}_{A\ (H-income)} = 73.55 + 2.49I - 0.07I^2 + 33.44L - 0.06R \qquad (23)$$

$$\hat{P}_{A\ (M-income)} = 18.03 + 17.79I - 0.62I^2 - 1.37L - 0.42R \qquad (24)$$

$$\hat{P}_{A\ (L-income)} = 6.51 + 13.19I - 1.58I^2 - 0.21L + 5.15R \qquad (25)$$

Recovered abatement effect equations are quadratic in lagged per capita GDP (I). It shows that, with other factors remaining constant, carbon dioxide emission has a positive relation with lagged per capita GDP during the earlier stage and has a negative relation during the later stage.

As we have noted in section-3, both adult literacy (L) and democratic rights (R) have some influence on a country's environmental policy measures. Environmental quality has a negative relation with both adult literacy and popular democratic rights in all cases except in case of H-income and L-income country-group. It might be that higher level of adult literacy generates awareness for better environment and create demand for better environmental policies which in turn helps to improve environment. Similarly, better democracy help to manifest better environmental policy and thus helps to improve environmental quality. Environmental quality has a positive relation with adult literacy in case of H-income country, while in case of L-income country, it has a positive relation with popular democratic rights. There is almost no change in adult literacy in H-income countries during the data period. As a result adult literacy

[10] Structural change takes place with relatively smaller contribution from agricultural and service sectors.

might not have any impact on environmental quality in case of H-income country-group[11].

Graphs of estimated values of carbon dioxide emissions corresponding to different levels of lagged per capita income are presented in the figures 3a, 3b, 3c, 3d.

Figure-3a shows Global abatement effect is decreasing with increase in lagged per capita GDP. Abatement effect of L-income countries follows a qualitative similar pattern as shown by the Figure-3d. But there are marked differences in abatement effects of H-income and M-income countries. H-income countries abatement effect is almost horizontal (Figure-3b), whereas, abatement effect of M-income countries has an increasing phase followed by a steep fall.

From the above abatement effect curves of the four groups, it could be concluded that L-income countries are adopting abatement measures at a lower level of per capita income in comparison to other groups. This might be due to L-income countries' low share in global manufacturing/industrial production and consumption. It seems that M-income countries are not adopting many such measures, whereas, H-income countries seems to adopt such measures steadily.

6. Conclusion

Although EKC debate has recently led to a large literature, they are generally based on reduced form single equation model and could not explain much insight into the underlying structural causes of relation between economic growth and environmental quality. They have very little scope for policy prescription. Our structural model of the relationship is an attempt to overcome this limitation. This model encompasses the decomposition of the economic growth-environment relationship in terms of *scale*, *composition* and *abatement* effects. We define pollution as an outcome of multiplicative interaction of the above three effects and formulate individual specification of each of them. We have estimated our model in two stages: firstly substituting each of three functions into pollution equation, we get its reduced form specification. Then we estimate the reduced form equation with worldwide data of 128 countries. Estimated coefficients of this reduced form relationship are used to recover values of the structural parameter.

In the existing literature, a single global EKC relationship has been usually estimated on the basis of global data. It is assumed that the same relationship holds for all countries. But several sets of different pollution aggravating and mitigating forces that emanate from structural differences among countries might generate different environmental transition paths. We therefore, have divided 128 countries into high-, medium- and low-income country groups and then examined whether estimated relationship between economic growth and environment vary across the three groups. We estimated our model for high-, medium- and low-income country groups separately following the above mentioned two stages estimation method.

The *scale* and *abatement* effects for H-income, M-income and L-income country groups, in general, differ markedly. Scale effect of M-income and L-income country groups differ markedly from the Global scale effect, although there are some qualitative similarities between scale effects of H-income country group and Global one. *Abatement* effect of H-income and M-income country groups differ markedly from the Global abatement effect, although there are some qualitative similarities between abatement effects of L-income country group and Global one. *Composition* effect shows some similar pattern across groups.

Each of the three effects differs widely across income groups and therefore, global aggregation is a 'misspecification' of the EKC

[11] It suggests us to exclude this variable in case of H-income country. But we keep this variable for uniformity across groups and their comparison.

relationship. In general, increasing economic activities with some sort of abatement efforts are taking place in H-Income countries and surprisingly, L-income countries seem to be experiencing similar trends even at a lower level of per capita income. However, M-income countries are found to be increasing economic activities without much abatement measures, which perhaps, is due to their desire for catching-up H-income country group quickly.

7. Summary:

The Environmental Kuznets Curve (EKC) debate has recently developed a large literature contributed by many authors across disciplines. Studies have mostly examined net effect of changes in per capita gross domestic product (GDP) on the environmental quality, although some have examined the relationship adding variables, such as population density, per capita GDP growth rate, average per capita GDP of a number of years, etc. A few authors have used policy variables, such as 'contract enforceability', as an underlying factor behind the EKC relationship. But the empirical results of the EKC relationship in the existing studies are not always unequivocal, nor there a consensus on the underlying explanations.

Models in the existing studies do generally mask socio-political diversities and cannot explain much insight into the underlying structural causes of relation between economic growth and environmental quality. The mechanism by which economic growth first aggravates the environmental quality and then renders improvement is not yet well explained. Therefore, existing studies seem to have very little scope for policy prescription for the environmental improvement. Some authors, have suggested formulation of structural model of the EKC relationship in order to obtain more insight of the underlying interacting forces.

We develop a structural model for analyzing economy-environment relationship to overcome the above limitations. We decompose the EKC relationship by breaking down net environmental effect of economic activities into three major determinants: *scale*, *composition* and *abatement* effects. Using the above decomposition, we develop a structural model. We define pollution as an outcome of multiplicative interaction of the above three effects and formulate individual specification of each of them. It seems that important socio-political variables, such as democratic and political rights, that may have strong impact on environmental quality, have been omitted in the existing studies. We incorporate additional socio-political variables, such as *adult literacy rate, popular democratic rights*, to explain the underlying causes of the relationship. We apply our model for empirical testing of the relationship with worldwide data of 128 countries. We have estimated our model in two stages: firstly substituting each of three functions into pollution equation, we get its reduced form specification. Then we estimate the reduced form equation. Estimated coefficients of this reduced form relationship are used to recover values of the structural parameter.

In the existing literature, a single global EKC relationship has been usually estimated on the basis of global data. It is assumed that the same relationship holds for all countries. But several sets of different pollution aggravating and mitigating forces that emanate from structural differences among countries might generate different environmental transition paths. We therefore, have divided 128 countries into high-, medium- and low-income country groups and then examined whether estimated relationship between economic growth and environment vary across the three groups.

The *scale* and *abatement* effects for high-, medium- and low-income country groups, in general, differ markedly. Scale effect of medium- and low-income country groups differ markedly from the global scale effect, although there are some qualitative similarities between scale effects of high-income country group and global one. *Abatement* effect of high- and medium-income country groups differ markedly from the global abatement effect, although there are some qualitative similarities between abatement effects of low-income country group and global one. *Composition* effect shows some similar pattern across groups.

Each of the three effects differs widely across income groups and therefore, global aggregation is a ‘misspecification’ of the EKC relationship. In general, increasing economic activities with some sort of abatement efforts are taking place in high-Income countries and surprisingly, low-income countries seem to be experiencing similar trends even at a lower level of per capita income. However, medium-income countries are found to be increasing economic activities without much abatement measures, which perhaps, is due to their desire for catching-up high-income country group quickly.

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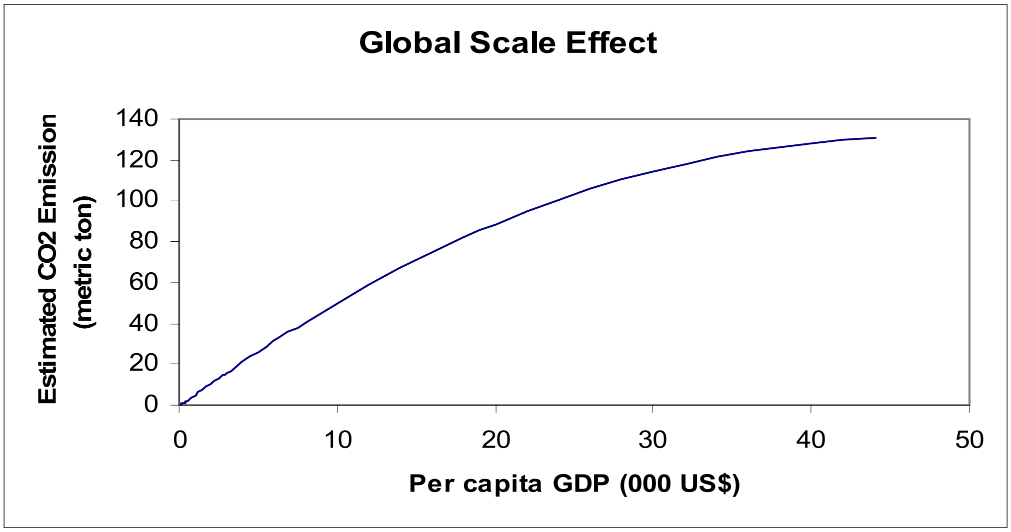

Figure-1a: Global scale effect

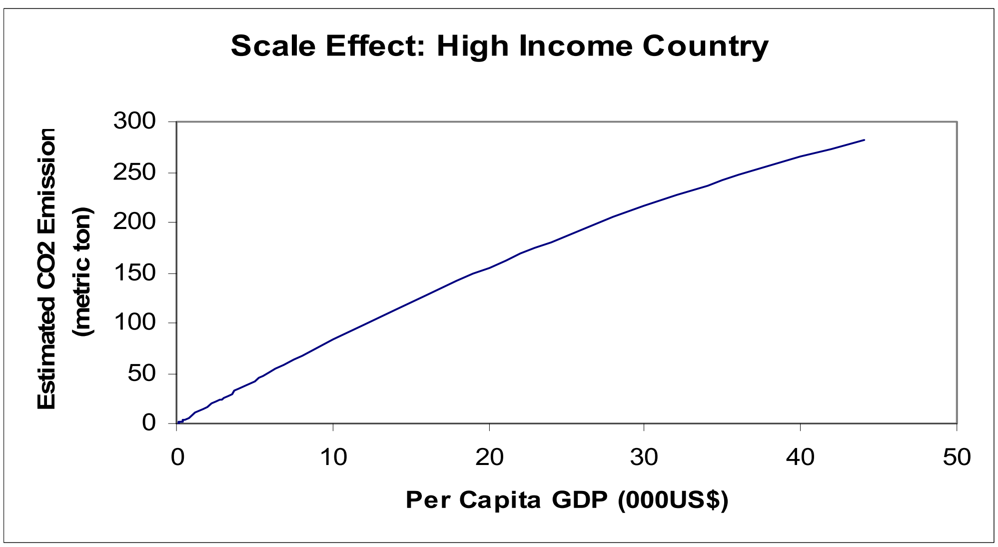

Figure 1b:Scale effect for High income Country-group

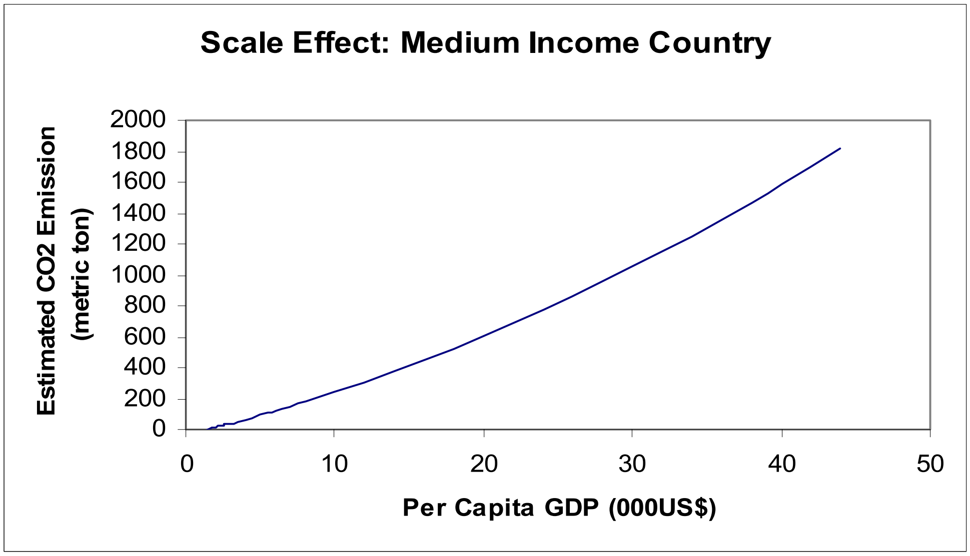

Figure-1c: Scale effect for Medium income Country-group

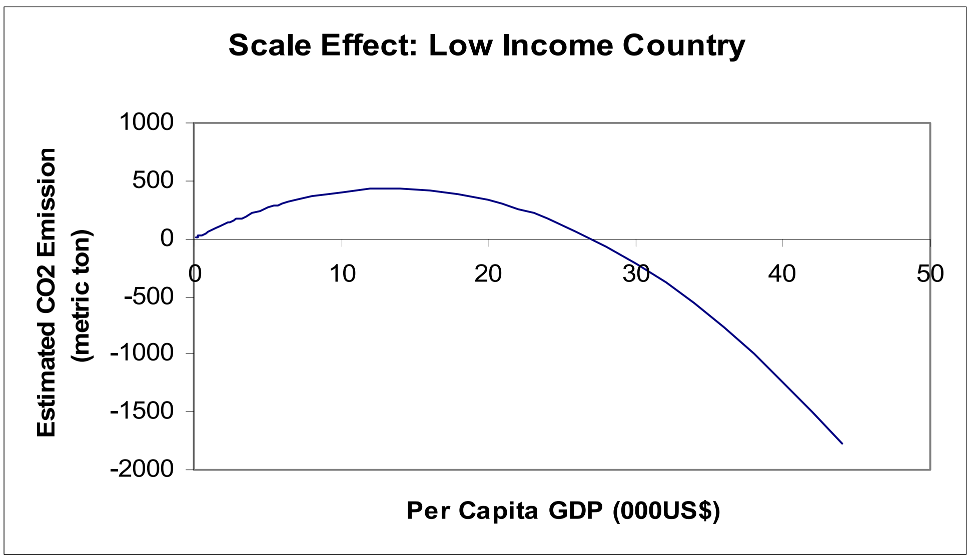

Figure-1d: Scale effect for Low-income Country-group

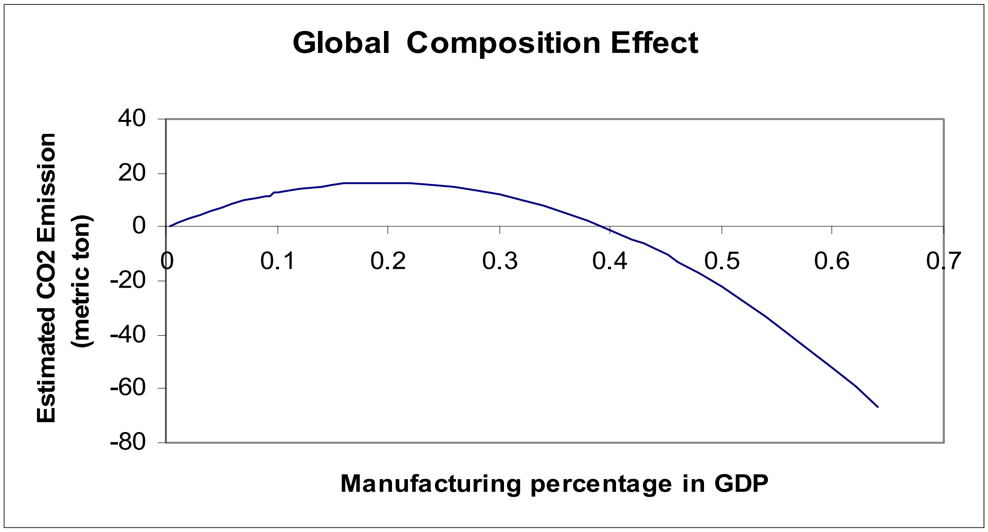

Figure-2a: Global composition effect

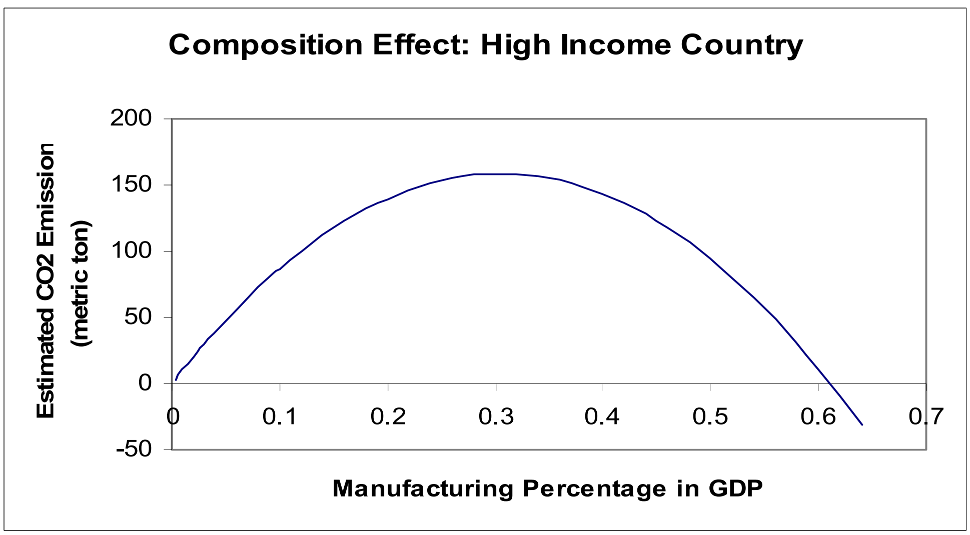

Figure-2b: Composition effect for High Income Country-group

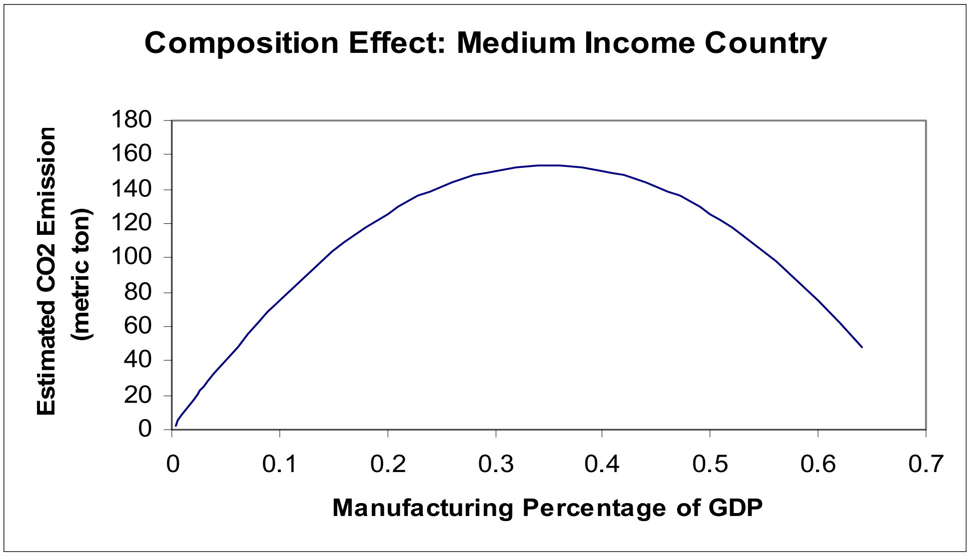

Figure-2c: Composition effect for Medium Income Country-group

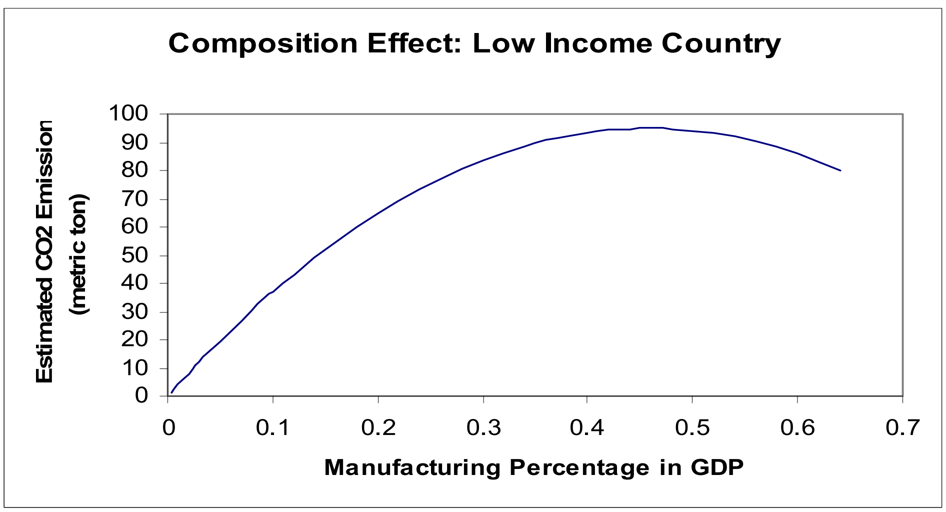

Figure-2d: Composition effect for Low Income Country-group

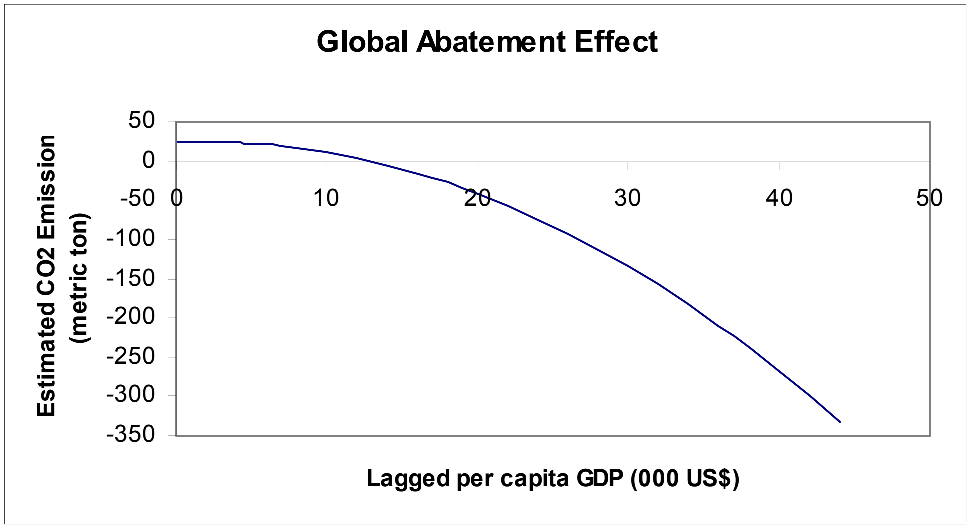

Figure-3a: Global abatement effect

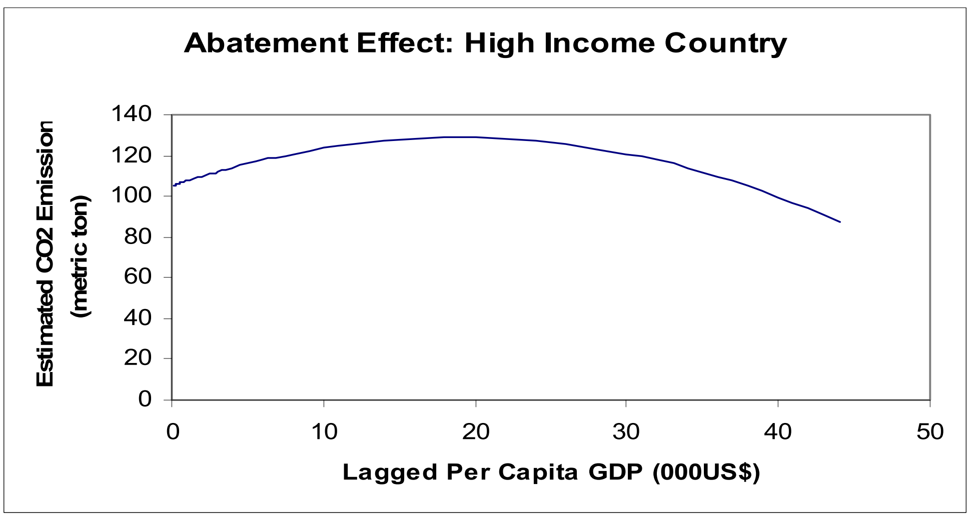

Figure-3b: Abatement effect for High Income Country-group

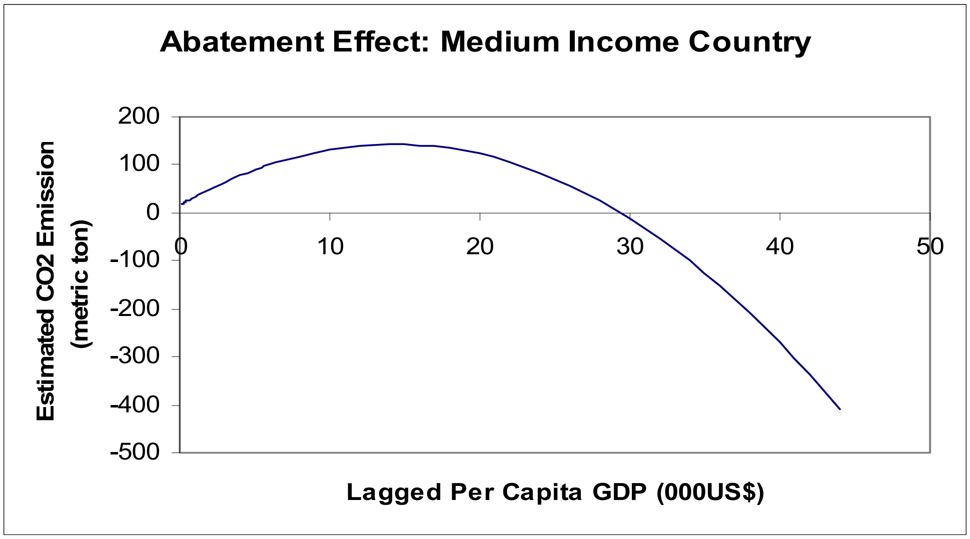

Figure-3c: Abatement effect for Medium Income Country-group

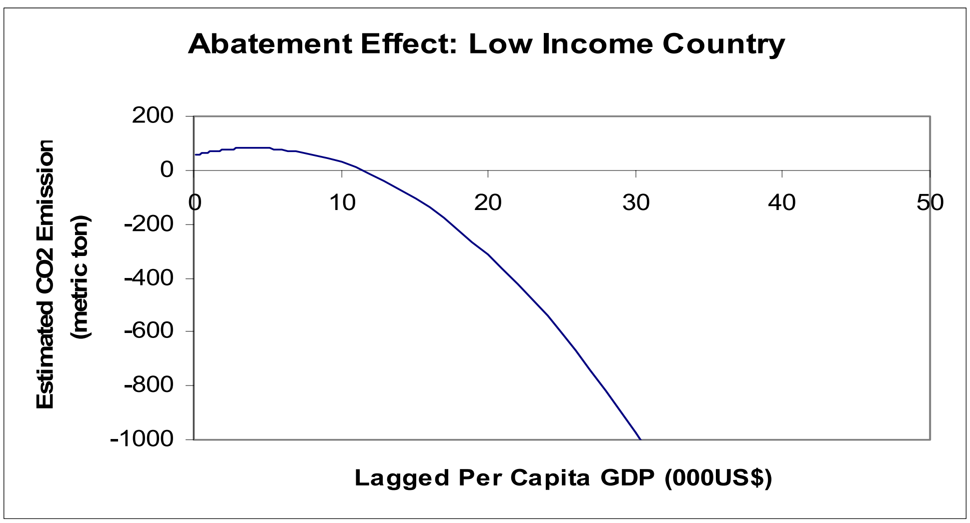

Figure-3d: Abatement effect for Low Income Country-group

Table 1: Measures of popular democratic rights

Score	Political Rights (based on raw points)	Civil Liberties (based on raw points)
1	28 – 32	50 - 56
2	23 – 27	42 – 49
3	19 – 22	34 – 41
4	14 – 18	26 – 33
5	10 – 13	17 – 25
6	5 – 9	9 – 16
7	0 - 4	0 – 8

Source: Freedom House web page

Table 2: Detailed Results for All Country (Global)

Explanatory Variables	Models		
	Pooled Regression	Fixed Effects	Random Effects
M	-9.362 (-3.436)	3.117 (1.721)	-1.994 (-1.140)
MI	28.585 (7.134)	1.458 (0.901)	5.245 (3.262)
MI2	-1.223 (-2.486)	-0.725 (-3.887)	-0.768 (-4.132)
ML	-1.762 (-0.792)	-9.474 (-5.340)	-6.920 (-4.120)
MR	-0.288 (-2.064)	0.101 (1.390)	0.060 (0.838)
M2	27.602 (2.391)	-17.619 (-2.595)	-5.459 (-0.823)
M2I	-85.564 (-6.023)	-8.171 (-1.423)	-18.792 (-3.292)
M2I2	-5.737 (-1.805)	-1.908 (-1.573)	-1.826 (-1.511)
M2L	14.035 (1.375)	27.639 (4.113)	22.928 (3.516)
M2R	0.165 (0.296)	0.248 (0.943)	0.205 (0.784)
YM	26.620 (6.067)	14.658 (7.874)	14.545 (7.871)
YMI	-0.109 (-0.115)	0.416 (1.156)	0.234 (0.652)
YMI2	0.048 (4.534)	0.032 (7.585)	0.036 (8.502)
YML	-0.929 (-0.563)	16.584 (17.043)	13.310 (14.083)
YMR	0.487 (6.762)	-0.030 (-0.799)	0.029 (0.774)
YM2	79.768 (5.041)	47.114 (6.907)	50.103 (7.418)
YM2I	-3.734 (-0.640)	0.786 (0.351)	1.561 (0.699)
YM2I2	-0.172 (-4.050)	-0.155 (-9.041)	-0.163 (-9.580)
YM2L	0.477 (0.069)	-44.196 (-11.167)	-38.507 (-9.979)
YM2R	-1.333 (-4.652)	-0.226 (-1.605)	-0.358 (-2.573)
Y2M	1.955 (3.533)	0.654 (3.028)	0.824 (3.839)
Y2MI	-0.051 (-4.862)	-0.024 (-5.765)	-0.027 (-6.501)
Y2MI2	0.0001 (1.441)	-0.0001 (-3.994)	-0.0001 (-4.294)
Y2ML	-0.547 (-5.381)	-0.579 (-11.858)	-0.561 (-11.640)
Y2MR	-0.017 (-3.691)	-0.011 (-4.721)	-0.012 (-5.361)
Y2M2	-4.901 (-1.721)	-5.535 (-4.874)	-6.138 (-5.462)
Y2M2I	0.165 (3.999)	0.138 (8.408)	0.144 (8.824)
Y2M2I2	-0.0001 (-0.328)	-0.0001 (-1.532)	-0.0001 (-1.739)
Y2M2L	2.976 (6.362)	3.240 (13.901)	3.247 (14.633)
Y2M2R	0.057 (2.953)	0.067 (7.312)	0.070 (7.672)
Constant	0.895 (10.493)		1.159 (13.362)
No of Observations	2503	2503	2503
R^2	0.743	0.968	
df	127		
Likelihood Ratio	5260.05 * * *		
F statistics	132.54 * * *		
LM statistics	6161.87 * * * (with 1 df)		
Hausman Statistics	930.37 * * * (with 30 df)		

t-statistics are in parenthesis

* * * significant at 0.001 level

Table 3: Detailed Results for High Income Country

Explanatory Variables	Models		
	Pooled Regression	Fixed Effects	Random Effects
M	402.32 (2.52)	221.69 (2.84)	207.89 (2.67)
MI	-24.36 (-1.35)	-32.83 (-4.51)	-31.63 (-4.35)
MI2	1.00 (0.96)	0.57 (1.41)	0.55 (1.36)
ML	-488.80 (-2.86)	328.60 (3.68)	307.85 (3.46)
MR	-17.42 (-3.28)	-7.43 (-3.48)	-7.59 (-3.55)
M2	-1207.42 (-1.99)	-952.45 (-2.97)	-880.84 (-2.76)
M2I	108.31 (1.42)	137.42 (4.30)	132.11 (4.14)
M2I2	1.35 (0.22)	-3.41 (-1.43)	-3.35 (-1.41)
M2L	1215.62 (1.80)	-1471.81 (-3.83)	-1374.62 (-3.60)
M2R	64.63 (3.12)	30.73 (3.73)	31.31 (3.80)
YM	69.96 (2.48)	15.16 (1.28)	16.26 (1.38)
YMI	-0.91 (-0.62)	1.18 (1.98)	1.06 (1.79)
YMI2	-0.01 (-0.33)	-0.03 (-2.07)	-0.02 (-1.87)
YML	87.23 (4.14)	28.48 (3.07)	29.28 (3.16)
YMR	3.12 (3.88)	1.69 (5.25)	1.71 (5.33)
YM2	202.67 (1.71)	8.66 (0.17)	17.41 (0.34)
YM2I	-7.93 (-0.85)	-2.90 (-0.77)	-2.36 (-0.63)
YM2I2	0.03 (0.24)	0.10 (1.71)	0.09 (1.52)
YM2L	-258.11 (-3.07)	-52.60 (-1.30)	-60.57 (-1.50)
YM2R	-11.55 (-3.68)	-7.31 (-5.81)	-7.40 (-5.89)
Y2M	2.80 (2.16)	0.39 (0.75)	0.47 (0.90)
Y2MI	-0.003 (-0.09)	0.01 (0.83)	0.01 (0.77)
Y2MI2	0.0002 (1.04)	0.0001 (1.56)	0.0001 (1.28)
Y2ML	-2.37 (-3.81)	-1.16 (-4.42)	-1.18 (-4.48)
Y2MR	-0.09 (-3.29)	-0.06 (-6.01)	-0.06 (-6.05)
Y2M2	-3.73 (-0.64)	-2.21 (-0.90)	-2.60 (-1.06)
Y2M2I	0.04 (0.32)	-0.01 (-0.23)	-0.01 (-0.19)
Y2M2I2	-0.001 (-1.12)	-0.001 (-1.95)	-0.001 (-1.68)
Y2M2L	7.02 (2.81)	3.73 (3.25)	3.87 (3.37)
Y2M2R	0.32 (3.11)	0.27 (6.59)	0.27 (6.63)
Constant	12.40 (17.80)		5.15 (4.33)
No of Observations	574	574	574
R^2	0.655	0.956	
df	27		
Likelihood Ratio	1187.71 * * *		
F statistics	132.21 * * *		
LM statistics	1947.52 * * * (with 1 df)		
Hausman Statistics	21.69 (with 30 df)		

t-statistics are in parenthesis

* * * significant at 0.001 level

Table 4: Detailed Results for Medium Income Country

Explanatory Variables	Models		
	Pooled Regression	Fixed Effects	Random Effects
M	-105.83 (-5.15)	-12.63 (-1.12)	-13.75 (-1.22)
MI	-13.16 (-0.65)	-3.78 (-0.39)	-3.89 (-0.40)
MI2	7.68 (1.11)	9.06 (2.89)	8.99 (2.87)
ML	128.35 (3.48)	38.56 (1.82)	39.72 (1.88)
MR	0.16 (0.10)	-1.87 (-2.33)	-1.90 (-2.37)
M2	548.63 (4.50)	70.06 (0.97)	77.63 (1.07)
M2I	43.22 (0.48)	2.81 (0.06)	2.16 (0.05)
M2I2	-12.46 (-0.47)	-27.49 (-2.25)	-77.12 (-7.22)
M2L	-647.19 (-3.45)	-161.42 (-1.52)	-169.48 (-1.60)
M2R	-3.00 (-0.41)	6.76 (1.97)	6.86 (2.00)
YM	49.58 (2.25)	7.01 (0.67)	6.86 (0.66)
YMI	2.19 (0.21)	13.21 (2.77)	12.98 (2.73)
YMI2	-1.14 (-1.85)	-0.44 (-1.52)	-0.45 (-1.53)
YML	-50.47 (-3.51)	-5.83 (-0.77)	-6.43 (-0.85)
YMR	-0.59 (-0.80)	0.79 (2.19)	0.81 (2.25)
YM2	-304.20 (-3.04)	7.54 (0.15)	5.28 (0.11)
YM2I	-28.17 (-0.69)	42.30 (2.10)	41.60 (2.07)
YM2I2	4.62 (1.69)	1.21 (0.93)	1.20 (0.91)
YM2L	337.50 (4.75)	45.75 (1.12)	50.50 (1.24)
YM2R	3.01 (0.97)	-2.65 (-1.75)	-2.72 (-1.80)
Y2M	-5.92 (-1.13)	7.99 (3.18)	7.90 (3.15)
Y2MI	0.69 (1.24)	-0.08 (-0.31)	-0.09 (-0.34)
Y2MI2	0.02 (0.76)	0.02 (2.03)	0.02 (2.05)
Y2ML	4.30 (3.64)	0.61 (1.01)	0.65 (1.08)
Y2MR	0.10 (1.45)	-0.06 (-1.78)	-0.06 (-1.80)
Y2M2	59.29 (2.63)	-23.67 (-1.99)	-23.16 (-1.95)
Y2M2I	-1.92 (-0.83)	0.47 (0.43)	0.52 (0.47)
Y2M2I2	-0.10 (-1.17)	-0.08 (-1.70)	-0.16 (-1.72)
Y2M2L	-42.03 (-6.74)	-5.33 (-1.37)	-5.91 (-1.53)
Y2M2R	-0.45 (-1.50)	-0.20 (-1.37)	-0.21 (-1.41)
Constant	1.27 (9.19)		1.17 (2.41)
No of Observations	386	386	386
R^2	0.879	0.978	
df	18		
Likelihood Ratio	657.31 * * *		
F statistics	84.06 * * *		
LM statistics	597.03 * * * (with 1 df)		
Hausman Statistics	12.63 (with 30 df)		

t-statistics are in parenthesis

* * * significant at 0.001 level

Table 5: Detailed Results for Low Income Country

Explanatory Variables	Models		
	Pooled Regression	Fixed Effects	Random Effects
M	8.85 (7.14)	21.64 (3.27)	2.46 (3.51)
MI	24.16 (3.06)	54.10 (5.37)	5.04 (1.69)
MI2	-8.76 (-1.04)	-3.17 (-1.01)	-2.65 (-0.85)
ML	9.43 (6.17)	-0.07 (-0.08)	0.88 (0.96)
MR	-0.07 (-0.89)	0.03 (0.93)	0.01 (0.40)
M2	-41.58 (-7.23)	-2.72 (-0.88)	-6.37 (-2.11)
M2I	-77.78 (-2.64)	-12.40 (-1.12)	-13.42 (-1.22)
M2I2	-20.42 (-0.64)	-6.47 (-0.55)	-2.75 (-0.24)
M2L	-60.55 (-8.39)	-2.19 (-0.53)	-7.35 (-1.83)
M2R	-10.34 (-3.96)	-28.01 (-8.05)	-20.08 (-9.59)
YM	-22.03 (-2.66)	-0.60 (-0.18)	0.32 (0.10)
YMI	19.05 (0.07)	34.28 (5.79)	21.79 (0.33)
YMI2	5.60 (2.62)	0.44 (0.56)	0.75 (0.95)
YML	-10.67 (-2.99)	1.51 (0.78)	0.47 (0.25)
YMR	0.43 (2.88)	37.25 (3.89)	0.20 (3.21)
YM2	74.84 (2.35)	7.91 (0.64)	2.49 (0.20)
YM2I	16.59 (0.33)	-4.74 (-0.26)	4.36 (0.24)
YM2I2	-23.17 (-2.57)	-2.09 (-0.64)	-2.63 (-0.81)
YM2L	83.32 (5.21)	-1.44 (-0.18)	7.77 (0.96)
YM2R	-1.72 (-2.54)	0.86 (3.08)	0.65 (2.35)
Y2M	17.50 (2.12)	-1.00 (-0.33)	-0.36 (-0.12)
Y2MI	-8.51 (-3.65)	0.11 (0.12)	0.25 (0.27)
Y2MI2	0.44 (2.24)	-0.13 (-1.42)	-0.17 (-1.89)
Y2ML	-2.41 (-1.36)	-1.83 (-2.18)	-1.64 (-1.97)
Y2MR	-0.15 (-2.39)	0.09 (3.38)	0.07 (2.78)
Y2M2	-104.65 (-3.67)	-9.96 (-0.97)	-13.56 (-1.32)
Y2M2I	-44.54 (-4.50)	-7.53 (-3.41)	-1.83 (-0.49)
Y2M2I2	-2.65 (-3.30)	-12.70 (-5.01)	-0.37 (-1.04)
Y2M2L	5.62 (0.74)	9.52 (2.66)	7.42 (2.10)
Y2M2R	0.59 (2.03)	-3.00 (-2.70)	-0.26 (-2.12)
Constant	0.30 (11.26)		0.23 (8.03)
No of Observations	1543	1543	1543
R^2	0.778	0.977	
df	80		
Likelihood Ratio	3492.61 * * *		
F statistics	154.24 * * *		
LM statistics	5280.17 * * * (with 1 df)		
Hausman Statistics	250.21 * * * (with 30 df)		

t-statistics are in parenthesis

* * * significant at 0.001 level