AIR POLLUTION & ENVIRONMENT SUSTAINABILITY

ECO311A: DEVELOPMENT ECONOMICS

SUBMITTED TO

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PERCENTAGE OF PLAGIARISM

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INTRODUCTION, MOTIVATION OF STUDY & OBJECTIVES OF STUDY

Since Independence, the focus of India has been on development. Although it has brought many benefits to India by boosting our economic growth, it is clear that we are far away from achieving the basic objectives of any society i.e. security of water, health and food. Over the last seventy years, India's strong growth has been able to pull out much of our population from the poverty by increasing employment opportunities but this has resulted in degrading our environment too. Rapid economic development has led to growing scarcity of our natural resources. Poverty and the degraded environment are closely interrelated because a major chunk of our society depends on the environment and its degradation has seriously affected our development in the long term. The impact of past industrialization and exploitation of environment shattered our dream to become an eco-friendly nation. Mrs. Indira Gandhi in the Stockholm Declaration of 1972 discussed the doctrine of "Sustainable Development". Thereafter, in 1987 a report was issued by the World Commission on Environment and Development in which they tried to link environment protection and economic development. Also, the Rio Declaration 1992 structured the principles of Sustainable Development. The main purpose of economic development is to provide a quality standard of living since industrial development creates more jobs than any other field which in turn increases the possibility of its adverse effects on the environment. Dust, smoke, and toxic gases originating from thermal power plants, mines and other factories make this environment hazardous to live. The United Nations Conference on Sustainable Development in 2012 issued 17 Sustainable Goals (SDGs) to tackle environmental economic and political challenges.

The objective of this paper is to look into the relationship between environment sustainability and economic development and see if some steps have been taken in this regard. We are trying to find out what are the reasons behind that relationship so that we can address them in future. For empirical research, the whole course of paper can be divided into three objectives:

(i) Determining the validity of Environment Kuznets Curve (EKC) for group of 10 South & Southeast Asian countries.

(ii) Effect of polluting activities like production of coal and thermal power plants, i.e. coal consumption on the emission of polluting gases like carbon dioxide.

(iii) The relation between absolute carbon dioxide emissions with development with relevance to the concept of take-off

LITERATURE REVIEW

Impact of Climate Change on Bangladesh

Bangladesh is located near world's largest delta, Sundarbans. Its land is very fertile for agriculture; the problem of natural disaster comes into the picture because of its geographical location. Bangladesh has now facing adverse problems because of incoming cyclones, Frequent high temperature, Sea level rise etc. Because of change in climate their economic development was not getting in pace. It has a population of 150 million and their literacy level is around 47.5%. It has seen that their annual Population growth rate is 2.2%. There 75% of the population lives in rural areas, there are all still focusing on primary sector for income. Dhaka is now being referred as the most densely populated city in the world. The main problem with Bangladesh is that they don't have multiple developed urban cities. They only have Dhaka as their financial, cultural, IT capital.

In Bangladesh more than 80% of their area is prone to flooding, Cyclones are now getting frequent. Salinity in water resources is also a major problem for them. It is very difficult for any economy to prosper under the shadow of natural disaster. Because no matter what they will do better-living standards, their work won't last long. Climate change has a serious impact on Sundarbans, largest mangrove forest. The only place of living for Royal Bengal Tiger is here. This natural beauty is recognized as world heritage by UNESCO. Salinity and rise in water level are the major problems.

There are many towns situated on the coastal belt of Bangladesh which are on the brink of getting flooded. Sea level rise makes seawater to enter the land which in reverse damage the buildings, block drainages etc. Many important urban cities are facing problems because of flooding. The investors are not willing to invest money because they feel in coming 5-10 years, it will all come under water. As a result, the economic development in Bangladesh is slowed and their productivity is not able to take its full shape. It is not surprising why around 40% of Bangladesh population lives in slums, which are in fact highly prone to disaster.

The reason for taking activities concerned with coal as a proxy for polluting activities

Talking about Power generation, electricity is an important ingredient in making development a reality. Generating electricity is the leading cause of pollution, emission of CO2 in the environment is causing the problem of toxic pollutants in the air as well as chronic global warming. Nearly 80% of all Coal power plant emits carbon dioxide which is a Greenhouse gas. Considering the case of US will give a picture of impact coal has on the environment. Coal power plants produce less than half of the electricity in the USA but account for nearly 80% of power plant carbon emissions. The case though discusses the USA but is also relevant to the case of Asia. the rise of Asia was marked from the dawn of the 1990s with GDP of Asia becoming the largest in the world and incidentally, also became the largest emitter of Carbon. Most of the power plants are coal based and thus coal proves to be a good proxy for polluting activities.

Carbon Emissions and Economic Development

CO2 emissions today from human activities today are higher than ever in human history. Global CO2 were 150 times more in 2011 than in 1850. This huge shift can be attributed to rapid economic development initiated by Europe and North America followed by Asia and Latin America. The concentration effect of emissions can be seen from the fact that top 10 emitters contribute 78% of global emissions, all of which are large economies with large population and energy consumption. As per reports suggested too much dependence on industries for economic development leads to exploitation of the resources. However, there is always a dichotomy between environment and economic development. Saving one side will give an impact on the other. To achieve economic prosperity, we need to bypass some laws. Though CO2 is attributed to energy production, we don't find an exact relation for countries which we try to obtain from our work.

EKC

Environmental Kuznets Curve or EKC shows how the environmental degradation varies with economic growth. The diagram was named after the economist Simon Kuznets whose broad contributions were in the field of inequality and economic development which showed that as an economy grows, inequality first increases and then decreases which came out to be an inverted U-shaped graph. It is an inverted U-shaped diagram which states that as a country develops, pollution increases but with further development, it decreases. In EKC, stages of economic growth are taken on X-axis and environment

degradation on Y-axis which gives the familiar inverted U shaped graph which implies increasing pollution with development at first and later on decreases which has been attributed to the fact that at low-income levels, people care more about economic development than environment quality but as income rises people start focussing more on quality of environment and environment sustainability.

This relationship between economic development and degradation is very strong and thus strong focus is required to check out for development which causes minimum harm to the environment. This is one of the reasons of environmental regulations on industries and why do developing countries generally tend to loosen out these restrictions than the developed ones.

But, the concept of EKC is not well-established as works have been done by various economists which contradicts the EKC for a combination of countries and time frames. The work (Aslanidis and Iranzo 2009, 803-810) analyzed the relationship between carbon dioxide emissions and per capita GDP growth rate in 77 non-OECD countries using panel regression for the term of 1971-1997 and found no evidence of EKC. Similarly, many other works exist which found no EKC relationship but some found the evidence in their cases. Thus, it becomes imperative to check whether the countries of focus follow EKC and the implications of it.

WORKING MODEL

The work focuses on three objectives as mentioned in the introduction section. We will first focus on the section of Environmental Kuznets Curve (EKC). We try to see how the countries selected performs in terms of validity of EKC individually and as a pooled group. The model involved is as follows:

$$ln(CO_2/P) = \alpha_i + \gamma_t + \beta_1 ln(GDP/P)_{it} + \beta_2 (ln(GDP/P)_{it})^2 + \varepsilon_{it}$$

where

$ln(CO_2/P)$ is the natural logarithm of carbon dioxide emission per capita [CO_2 is the carbon dioxide emission and P is the Population]

α_i and γ_t are intercept parameters where i represents the cross section of countries and t represents the year

$ln(GDP/P)_{it}$ is the income per capita

β_1 and β_2 are the slopes of the model and ε_{it} is the stochastic error term.

Now, the trend between per capita emissions and per capita gdp depends on slope parameters & the following cases arise:

1. If $\beta_1 = \beta_2 = 0$, then no relation exists
2. If $\beta_1 < 0$ and $\beta_2 = 0$, then there is a positive relationship and negative if $\beta_1 < 0$
3. If $\beta_1 > 0$ and $\beta_2 < 0$, then the relationship is inverted U-shaped, the EKC
4. If $\beta_1 < 0$ and $\beta_2 > 0$, then the relationship is U-shaped.

Next comes the section of finding the relationship between the carbon dioxide emission and the activities like production and consumption of coal. The reason for using coal as a proxy for such activities has been discussed in the literature review. The model comprises as follows:

$$ln(CO_2)_{it} = \beta_1 + \beta_2 ln(Production)_{it} + \beta_3 ln(Consumption)_{it} + \Lambda_{it}$$

where

$ln(CO_2)_{it}$ is the natural log of carbon dioxide emission (in Kilo tons)

$ln(Production)_{it}$ is the natural log of coal production in short tons [1 short tons = 907.185 Kg]

$ln(Consumption)_{it}$ is the natural log of coal consumption in short tons

β_1, β_2, β_3 are the parameters and Λ_{it} is the stochastic error term

For the above 2 models, there are 10 developing countries from South and Southeast Asia and 350 observations for 35 years from 1980 to 2014 as majority of South Asian countries, particularly India and China take-off in this period.

Country code: China (1), Hong Kong (2), India (3), Indonesia (4), Japan (5), South Korea (6), Malaysia (7), Singapore (8), Thailand (9), USA (10)

We worked on different models: Fixed Effects, Random Effects and Pooled Ordinary Least Square models and got the results for each and finally selected one of the models based on standard diagnostics as mentioned in upcoming sections.

Finally, to check how the development phase, embarked by the take-off affects the carbon dioxide emission (and in general pollutants emission). To do this, we defined the relative emission taken as carbon dioxide emission in that year and divided it by the year of take-off, which we obtained from the paper: Takeoffs, Landing, and Economic Growth by Debayan Pakrashi and Paul Frijters. The data was

METHODOLOGY AND DATA SOURCES

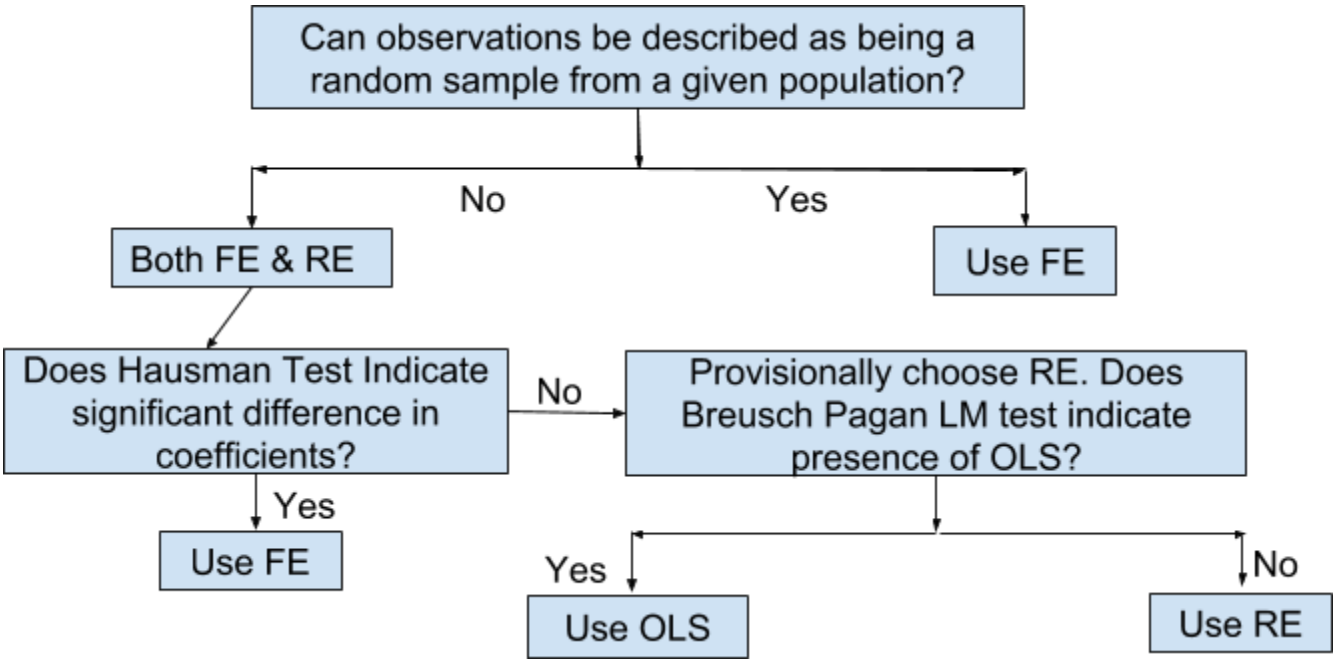
We are interested in finding the relationship between (i) the carbon dioxide emissions and the economic growth, as well as between (ii) the carbon dioxide emission and the production and consumption of coal. The study is focused on 10 countries as mentioned above and the data take the range from 1980 to 2014. The data is collected from the World Bank website, except CO_2 emission is collected from the U.S. Energy Information Administration which is a governmental body responsible for collecting, analyzing and disseminating information on energy. To factor economic growth, per capita GDP is used as a proxy for it. The CO_2 emissions measured in short tons and the other measurement gauges for different variables are mentioned in the model section.

Panel data (see Appendix A1) analysis is used to detect the EKC for the pollutants and economic growth. Panel Data helps in analyzing the dynamics of changes in various countries over a period of time. It provides a very powerful regression by considering both the spatial and temporal dimensions of the data.

There is also an option to use pooled OLS (see Appendix A2) in addition to panel data analysis. Thus, there is a requirements of some tests to determine which model is apt.

Now, it is required to discuss the diagnostic tests to be used to choose the most relevant model of panel data analysis.

The correct method is to first



Thus, first we would focus on Hausman Test (see Appendix A3).

The other test is the **Breusch Pagan LM test** which is directly available in stata. Under the null hypothesis, pooled OLS is chosen whereas RE is chosen in alternate hypothesis.

Thus, for both (i) and (ii), we perform RE, FE and pooled OLS and use the best model by applying the diagnostic tests by following the chart provided above.

RESULTS

(i) $ln(CO_2)_{it} = \beta_1 + \beta_2 ln(Production)_{it} + \beta_3 ln(Consumption)_{it} + \Lambda_{it}$

For the model considering carbon dioxide emission with production and consumption of coal, following are the results:

Hausman Test (see Appendix A4 for Stata results)

Prob> χ^2 = 0.9008 which much greater than 0.05. Thus, we accept the null hypothesis and choose RE.

Now, the question remains whether to use pooled OLS or RE. Thus, we performed Breusch Pagan LM Test.

Breusch Pagan LM Test (see Appendix A5 for Stata results)

prob> χ^2 = 0.0000 which is less than 0.05. SO, we reject null hypothesis which implies alternate hypothesis is true and hence, use **RE** which gives the following results (see Appendix A6 for Stata results):

Coefficient	Estimate	Standard Error	P>|z| | Significant
β_1	451,773.2	308,825.9	0.144 | Insignificant
β_2	0.3408563	0.1014462	0.001 | Significant
β_3	1.930654	0.0942374	0.000 | Significant

(ii) $ln(CO_2/P) = \alpha_i + \gamma_t + \beta_1 ln(GDP/P)_{it} + \beta_2 (ln(GDP/P)_{it})^2 + \varepsilon_{it}$

The equations to be estimated are summarized as follows:

Cross Section effects: $ln(CO_2/P) = \alpha_i + \beta_1 ln(GDP/P)_{it} + \beta_2 (ln(GDP/P)_{it})^2 + \varepsilon_{it}$

Period effects: $ln(CO_2/P) = \gamma_t + \beta_1 ln(GDP/P)_{it} + \beta_2 (ln(GDP/P)_{it})^2 + \varepsilon_{it}$

Applying Hausman Test like the above and working for both cross-section and period effect models (see Appendix A7 & A8), we got to know that **FE** is the desired model.

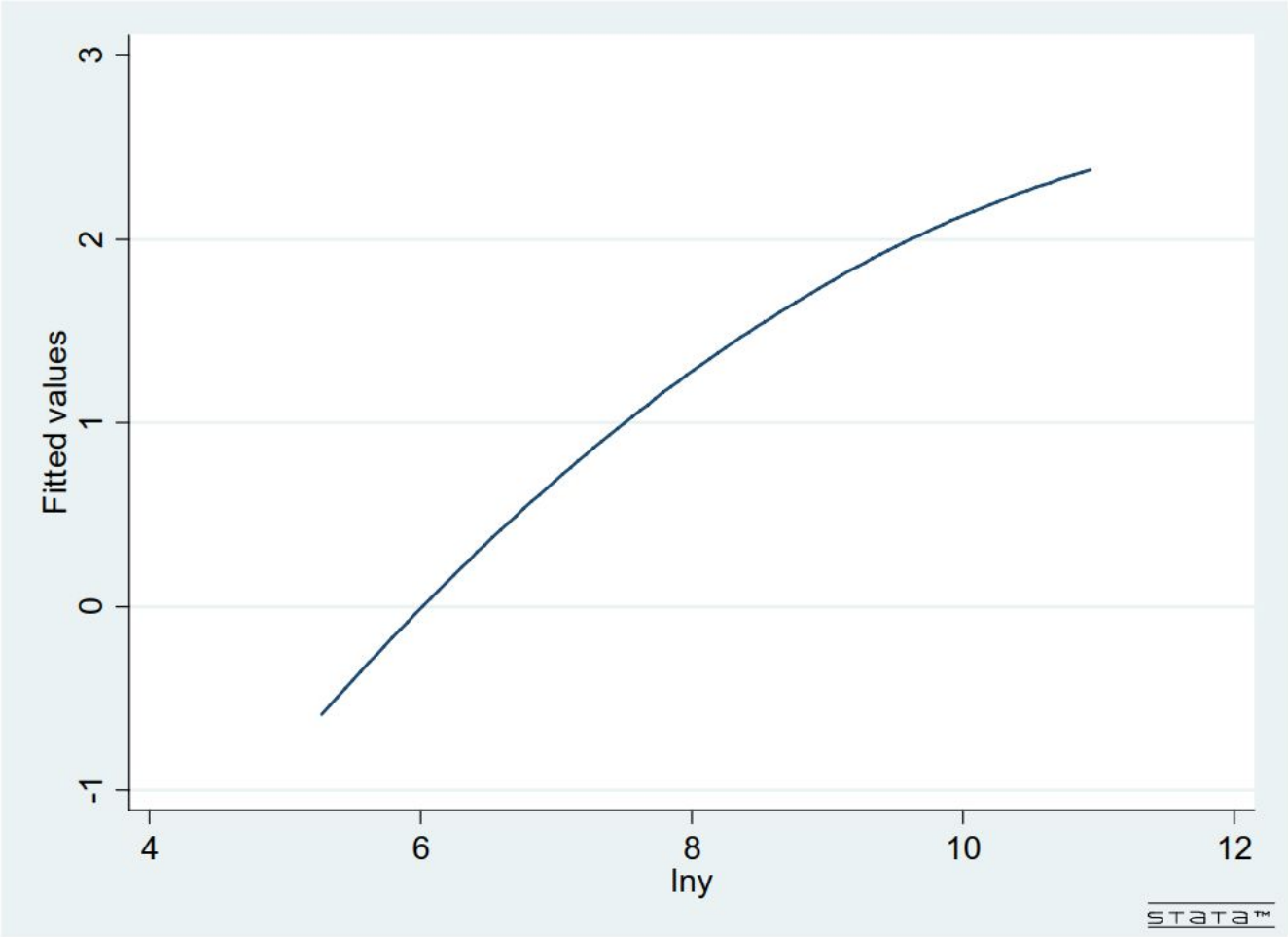
Thus, comparing the results for cross section and period effect, we get that cross section has higher adjusted R Square and hence is a better representative of the process. This is summarized below:

Coefficients	Cross section effect	Period effect
constant	-6.966786	-5.515677
β_1	1.681949	1.658652
β_2	-0.07835	-0.0914963
Adjusted R Square	0.7738	0.4602

Now, as $\beta_1 > 0$ and $\beta_2 < 0$, therefore the condition for EKC is satisfied.

Below are given the countrywise EKC graph and the graph for the whole region cumulated.

(EKC Country-wise)



(EKC of all countries combined except USA)

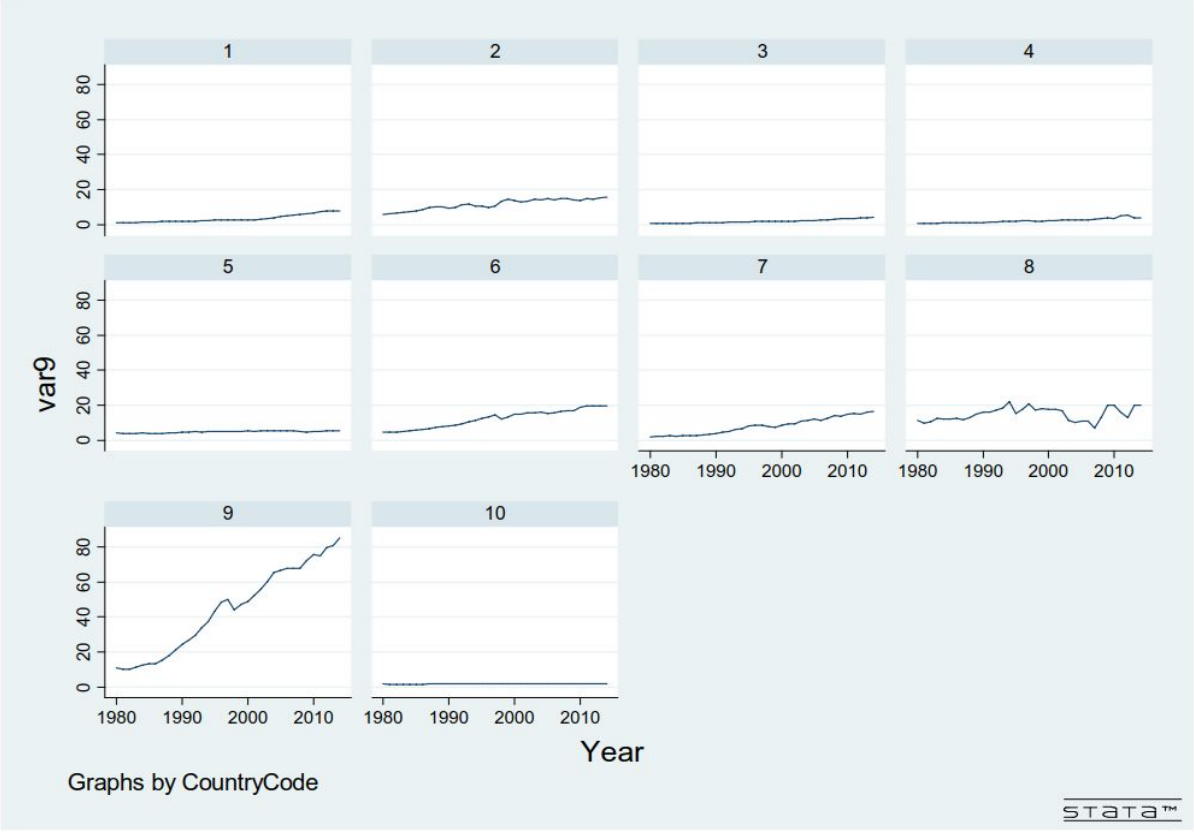
(iii) This focuses on the relative emission of carbon dioxide which is defined by us as the ratio of emission of that year to emission in take-off year. Note that for some countries, data was not available for take-off year as some countries take-off before 1960 and data is available only after that.

Take-off year for China is 1977, India 1988, Indonesia 1986, Japan 1946, South Korea 1966, Malaysia 1968, Singapore 1966, Taiwan 1963, Thailand 1958.

Note: For Malaysia, data of 1968 was not available. So, data for 1970 was used. In case of Singapore, the value for the year of take-off was 1/10th of the year preceding and following it, so the average of the 2 years was taken. For Thailand also, the data of year 1958 was not available so 1960 was taken and

similarly year 1960 was taken for USA, though it is a developed country and is just provided for comparisons.

The graphs obtained show a common trend that with development, amount of carbon dioxide emissions increase and then the amount of emissions remain the same. Though following from the reasoning of EKC that per capita emission of carbon dioxide should decrease, there has not been any decrease in the relative amount of carbon dioxide emissions for the developed countries like Japan and USA, whereas the Japan is experiencing an increase which clearly is an alarming situation. A pretty interesting feature is observed in the case of Thailand, where the increase is not in the factors of 10 or 20 but 80 times. No literature was available on the relative measures but the literature do state that one of the reasons for this increase is that around 35% of the emissions are from automobile vehicles, a close percentage to power sector. There has been a steep increase in the vehicles especially the three wheelers which is a great cause for it but fortunately, Thailand is working in the issue and has developed many plans and even targets for 2050.



(Countrywise relative emissions of Carbon Dioxide)

CURRENT SITUATION IN INDIA

India has been accounted for major industrialization after the enactment of the economic liberalization in 1991. National Productivity Council of India estimated the cost of environment damage done due to rapid industrialization costs approximately 32 billion $. This is causing irreparable damage to our ecology. The high rate of growth of population in India is adversely affecting the environment. The Government under the NGT Act 2010, created National Green Tribunal (NGT) which will provide a specialized forum to handle cases regarding environment protection and conservation of forests. Famous economist Amartya Sen says "economic growth is one of the aspects in the process of economic development, it is the right for future generations to get Quality Air, Land and Environment". India is one of the fastest growing nations in the world which has led to unplanned urbanization, pollution control and the risk of accidents. Many of our existing water resource had been polluted. This contamination causes many major diseases like hepatitis, Jaundice and diarrhoea. Today India is facing huge problem in the fields of land quality and shortage of water, in other words with the rise in per capita income there is an increase in ecological degradation which in turn reduces welfare of the people. Due to an increase in migration of villagers from rural background to cities leading to faster growth of slum areas in metropolitan cities. Today per capita forest cover in the country is only 0.06 hectare. India is highly vulnerable to calamities caused by Climate change. Our government has submitted its Intended Nationally Determined Contributions (INDC) to ratify the Paris Agreement on the birth anniversary of Mahatma Gandhi. In the agreement, all countries have to work on the global rise in temperature and reduce it to 2 degrees Celsius. The Paris agreement is adopted by 185 nations and has been enforced already in 55 countries. India's INDC ambitions requires funds and transfer of technologies of green energy from developed nations. It is estimated that $2.5 trillion is required to achieve India's climate change demands by 2030.

CHALLENGES AND WAY FORWARD

Assessment and evaluation of frameworks being laid down in successful countries from which India could learn to evolve its own framework for ecological balance. Despite achieving technological advanced industries our understanding towards the ecological dynamics is still limited. Our ancestor and modern knowledge should combine to give all mix strategy to maintain ecological balance. Every

life form takes time to rejuvenate or turning out ratio. Approach for sustainable development is by proper utilization of resources using the appropriate knowledge available. Easy access of data resources makes our system more reliable. Currently our Political system conventionally centralizes power in the hands of few, even when we have universal suffrage to vote. Often those are in power try to make profits out of economic system. However, time is changing mobilization of public awareness creates pressure in the existing system from below and global treaties are pressuring it from above. Time has come when political leaders itself seeing benefits from environmental conservation in the long term. As per Kyoto Protocol of 1997 India is facing from International Community to reduce the GHGs emission below 5%, since India is third largest producer of GHGs. Government of India is also enforcing laws on air and water pollution to reduce environmental degradation. Indian government has shown concerns in degradation of environment. The rapid expansion of Indian economy resulted in adverse and harmful environmental conditions that are affecting the people of India. Most probable reason for this is considered to be high population density and huge population size. Thus, environmental quality can increase. For this reason, more effective policies must be implemented and controlled in order to have a viable environment.

CONCLUSION

From the study of relation between carbon dioxide emission and consumption and production activities, the conclusion comes out that both Production and Consumption have significant coefficients. Thus, both have significance in causing pollution which is measured as CO_2 emission. Consumption is significant variable to explain the Pollution. There is positive association ship between CO_2 emission and Consumption. It is as per our economic theory because normally as more coal is consumed, more is the pollution because the coefficient is positive. Precisely, for every 1% increase in coal consumption, carbon dioxide emission goes up by 1.93%. Though the carbon emissions are also affected by coal production but the impact is quite low as compared to that of consumption. Therefore, model is following the economic theory for the given countries.

According to the empirical results obtained from panel data, we can say now that more the country consume more will the pollution caused in their countries. It does not matter how much any country produce coal, the thing which matters is how much they consume out of it.

Coming to the work on EKC, it comes out that the countries of interest follow EKC as the coefficient of natural logarithm of per capita GDP is positive while the coefficient of square of natural logarithm of per capita GDP is negative which means that the emission levels will first increase with increase in per capita GDP and then subsequently decrease as the theory reasons out that the prior focus is on economic development and after a certain threshold level of per capita GDP, which is different for different countries. But there are many surprising interpretations too that come out. Take-off period is taken from 1843-1860 for USA and USA is developed country right from the advent of 20th century. but still we don't see the fall that is expected in emissions. Thus, it is required for countries like USA to take steps to reduce carbon emissions and switch to alternate sources of energy. This also highlights the implications of USA not signing the Paris Treaty as it is the second largest carbon dioxide emitter on Earth after China. Similar story holds for Japan which take-off in 1946 and landed in 1974 but still don't show any sign of turnover, it is still showing a growing trend. Surprisingly, for Japan, the trend seems to be a bit convex which means positive rate of growth of emissions. It poses serious issues not on the regional or national levels but also on global levels as Japan is the 4th largest producer of carbon dioxide on Earth. Even advanced and countries which are expected to adapt swiftly like Hong Kong are exhibiting depressing trends with landing in 1995 and still not showing any reversal. But, the worst of all are China and South Korea. Both are towards the increasing phase of carbon dioxide emissions but the point of concern is that they are not showing virtually no sign of diminishing growth. Both exhibits almost straight line relationships which a very grave situation. China is the biggest emitter of carbon dioxide gas which is approximately twice the emission of USA and approximately five times that of India. Also, the reasoning that China is in a very low state of income so will accelerate with fast pace doesn't hold much ground as it has risen from poor to upper middle income countries and thus is close to be among developed countries but at the cost of environment. As a result, China has recently taken many strides towards renewable energy which may not be reflected in the data as data is upto the year 2014. Coming to the case of India, India stands at a lower per capita GDP. Thus, it is confirm that it would take a huge leap of development which would lead to rapid increase in carbon emissions and

pollution. But, India is currently third largest producer of carbon dioxide in the world. Thus, it is imperative to focus on reduction in carbon emissions even when it is in the development phase as the base is so large.

Coming to the relative carbon dioxide emissions relative to take-off year, it is observed that most of the developing countries have increase in emissions by a factor of around 10. But, as discussed before the developed countries and high income countries like Hong Kong, Singapore, Japan and USA also have increase by nearly a factor of 10, though some of them have landed or lie in high income regions. This requires to take a step by oneself in the direction of emission reduction. Special attention is needed for countries like Thailand, which are exhibiting the increase by a factor of 80, i.e. 80 times current emission levels compared to that of take-off year.

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Appendix

A1. Panel Data

The standard from of panel regression is as follows:

$$y_{it} = \alpha + \beta' X_{it} + \varepsilon_{it}$$

here i represents the country, t the year of observation. α is a constant and β is vector of coefficients of covariates. There are 2 types of panel models broadly based on whether the omitted variables (which are assumed to be fixed over time but depends on individual) are correlated with the covariates or not. If they are not correlated, then Random Effect model is sufficient whereas if they are correlated, we have to use Fixed Effect models which has the form:

$$y_{it} = \alpha + \beta' X_{it} + \varepsilon_{it}$$

$$\varepsilon_{it} = \mu_i + u_{it}$$

here μ_i is fixed over time and depends on individual cross section, in this case the country and u_{it} is random error.

In the random effect model, both the terms are random as the μ_i is not dependent on covariates whereas μ_i is allowed to be correlated with covariates in Fixed Effect.

A2. Pooled Ordinary Least Square (Pooled OLS)

Pooled Ordinary least square or generally called pooled OLS is just the plain OLS which ignores the panel structure of data and hence the values are pooled to be just N X T individual data points. Thus, the pooled OLS form is same as OLS and is given as follows:

$$y = \beta_1 + \beta_2 X' + \varepsilon$$

where all these are vector of respective variables but the number of data values is NXT.

A3. Hausman Test

Hausman Test is used to compare between Fixed Effect and Random Effect models and is defined as follows:

$$m = [\beta_{FE} - \beta_{RE}]'[var(\beta_{FE}) - var(\beta_{RE})]^{-1}[\beta_{FE} - \beta_{RE}]$$

which is a Wald χ^2 test with $k-1$ degrees of freedom, where k is the number of regressors in the model. In the null hypothesis, RE is chosen as both RE and FE are consistent but RE is more efficient with smaller variance whereas in alternate hypothesis, FE is chosen as RE is inconsistent.

A4. Hausman Test Result

	Coefficients (b) FE	(B) RE	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
Consumption	1.93272	1.930654	.0020657	.0059306
Production	.3383592	.3408563	-.0024972	.0064825

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

chi2(2) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= 0.21
Prob>chi2 = 0.9008

A5. Breusch Pagan LM Test Result

Breusch and Pagan Lagrangian multiplier test for random effects

Emissionkt[CountryCode,t] = Xb + u[CountryCode] + e[CountryCode,t]

Estimated results:

	Var	sd = sqrt(Var)
Emissio~t	4.07e+12	2018204
e	9.45e+09	97200.93
u	9.56e+11	977960.1

Test: Var(u) = 0

chibar2(01) = 5563.87

Prob > chibar2 = 0.0000

A6. Random Effect Result

Random-effects GLS regression — Number of obs = 350

Group variable: CountryCode — Number of groups = 10

R-sq: within = 0.9890 — Obs per group: min = 35

between = 0.7836 — avg = 35.0

overall = 0.8217 — max = 35

Wald chi2(2) = 30513.67

corr(u_i, X) = 0 (assumed) — Prob > chi2 = 0.0000

Emissionkt	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Consumption	1.930654	.0942374	20.49	0.000	1.745952	2.115356
Production	.3408563	.1014462	3.36	0.001	.1420254	.5396873
_cons	451773.2	308825.9	1.46	0.144	-153514.4	1057061
sigma_u	977960.1					
sigma_e	97200.926					
rho	.99021796	(fraction of variance due to u_i)				

A7. Hausman Test Results

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. hausman FE RE
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	Coefficients (b) FE	(B) RE	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
lny	1.681949	1.677341	.0046083	.
lny_sq	-.07835	-.07774	-.00061	.

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

chi2(2) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= 6.98
Prob>chi2 = 0.0305
(V_b-V_B is not positive definite)

A8. Cross Section & Period Effect Results

(a) For Cross Section Effect:

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Fixed-effects (within) regression               Number of obs      =       350
Group variable: CountryCode                     Number of groups   =        10

R-sq:  within  = 0.7110                         Obs per group: min =        35
       between = 0.8039                                        avg =      35.0
       overall = 0.7738                                        max =        35

                                                F(2,338)           =    415.85
corr(u_i, Xb)  = 0.4779                         Prob > F           =    0.0000
```

lne	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lny	1.681949	.1016402	16.55	0.000	1.482022	1.881876
lny_sq	-.07835	.0061504	-12.74	0.000	-.0904479	-.0662521
_cons	-6.966786	.4147784	-16.80	0.000	-7.782658	-6.150914
sigma_u	.52197499					
sigma_e	.20583747					
rho	.8654211	(fraction of variance due to u_i)				

```
F test that all u_i=0:     F(9, 338) =   149.28              Prob > F = 0.0000
```

Since, Prob > F is less than 0.05. So, the null hypothesis that all parameters are irrelevant is false. So, FE holds. Also, constant term is significant.

(b) For Period Effect:

```
Fixed-effects (within) regression               Number of obs      =       350
Group variable: CountryCode                     Number of groups   =        10

R-sq:  within  = 0.7604                         Obs per group: min =        35
       between = 0.5792                                        avg =      35.0
       overall = 0.4602                                        max =        35

                                                F(36,304)          =     26.80
corr(u_i, Xb)  = 0.3618                         Prob > F           =    0.0000
```

lne	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lny	1.658652	.0979403	16.94	0.000	1.465925	1.851378
lny_sq	-.0914963	.0062654	-14.60	0.000	-.1038254	-.0791673
t1	-.5893268	.1252347	-4.71	0.000	-.8357633	-.3428902
[illegible]	[illegible]	[illegible]				
_cons	-5.515677	.4673519	-11.80	0.000	-6.435332	-4.596023

Since, Prob > F is less than 0.05. So, the null hypothesis that all parameters are irrelevant is false. So, FE holds. Also, constant term is significant.