

UNIVERSITI PUTRA MALAYSIA

DETERMINANTS AND CONVERGENCE OF CO2 EMISSIONS IN THE DEVELOPING ECONOMIES

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DETERMINANTS AND CONVERGENCE OF CO₂ EMISSIONS IN THE DEVELOPING ECONOMIES



Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

September 2013

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DEDICATION

To my loving husband and three beautiful children



Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

DETERMINANTS AND CONVERGENCE OF CO₂ EMISSIONS IN THE DEVELOPING ECONOMIES

By

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September 2013

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The year 1991 saw developing countries categorized by the UNFCCC as "Non-Annex I Countries" which represent the countries held responsible for the rapid growth of the world's CO₂ emissions. The commitment to meet social and economic development goals and the pressures of their huge size of the economy, high energy consumption, large population and exploding growth rates have intensified the growth of carbon emissions in these countries. In this study, a range of factors from socio-economic to institutional aspects, are selected for analysis, which based on theory and previous empirical studies are identified as the potential determinants of carbon emissions. Thus, the first and second objectives of this research are to determine the factors affecting the growth of CO_2 emissions in the selected 126 developing countries for the period 1971-2009. The investigation will include analysis based on regions i.e. Africa, Latin America and the Caribbean, Middle East and North Africa and Asia and the Pacific. The study analyzes a dynamic panel model utilizing the Generalized Method of Moments (GMM) technique. The results on socio-economic factors found that GDP per capita, energy consumption from fossil fuels (EFF), energy usage (EUS), inflows of foreign direct investment (FDI), urbanization (URB), industrial production (IND), agriculture production (AGR) and level of education (EDU) have shown a highly significant impact on the growth of carbon emissions in the entire developing region. All these factors indicated a highly significant positive relationship with per capita CO₂ emissions except for urbanization which had a negative relationship. In all four regions studied, GDP per capita and EFF have been illustrated to be the most significant factors affecting growth of carbon emissions.

The analysis on institutional aspects is focused on the Kyoto Protocol, political stability, legal structure and property rights, corruption and freedom of trade on CO₂



emissions. The results showed that the Kyoto commitment (K_{com}) to be the sole indicator with a negative and statistically significant relationship which can be interpreted to mean that signing and ratifying the Protocol is not an indication of intention to reduce carbon emission. The four institutional factors analyzed did not portray any significant relationships with the growth of CO₂ emissions in the region.

The final objective was to examine the existence of convergence of the per capita CO_2 emissions which was crucial to come up with appropriate suggestions for policy implementation and the implications of CO_2 emissions in the region. Based on the Phillips and Sul's (2007) log-*t* model, it is seen that per capita CO_2 emission levels do converge for the whole developing region. However, on a regional basis, only Latin America and the Caribbean exhibited convergence in CO_2 per capita while the other regions showed a divergence. Nevertheless the three regions which displayed divergence portrayed certain characteristics of club convergences. Firstly, only a small number of club convergences were identified for each region. Secondly, a majority of these countries were in the divergence category. Finally, each of the club convergences was found to be in congruence with income classifications. In other words high income countries form one club while low income countries form another.

The discussion on policy implications was focused on existing policies that could be appropriately implemented to control increases in CO_2 emissions. The evaluation was based on the findings of the determinants in each region and from the perspective of the club convergences identified. The findings on all regions indicate that GDP per capita and energy consumption from fossil fuel (EFF) have significant effects on carbon emissions. However, energy consumption (EUS) per se was found to significant only for the LAC and the Asia-Pacific regions. A uniform policy may thus not be suitable to control the problem of emissions in these regions. A better method would be to consider each club of countries whose emissions are converging to similar levels. According to Burnett (2013) understanding different clubs of countries whose emissions are converging at similar levels will help policymakers to develop differentiated policies.

Since these nations are highly dependent on fossil fuels, it is best to implement an array of energy policies that may have direct or indirect effects on reducing CO_2 emissions (Dinica, 2002). Thus, it is suggested that a good starting point for these nations may be to focus on energy conservation policies. Energy conservation policies could be in the form of energy savings and introduction of alternative sources of energy through participation in CDM projects to promote clean energy development such as hydroelectric, geothermal, nuclear, biomass, wind and solar. Other policies like deforestation, strengthening regulations and environmental laws together with strict enforcement can be implemented in each region or country but may depend on their economic circumstances and societal awareness of issues related to environmental problems.

This study attempts to meticulously analyze the growth of CO_2 emissions in 126 developing economies that cover one third of the countries in the world. As future large emitters these countries' efforts to cut CO_2 emissions will be vital. The researcher found that there has not been any comprehensive analysis of CO_2 emissions involving developing economies on such a big scale. Application of a

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dynamic panel model such as the generalized method of moments (GMM) econometric technique is still relatively new for a scope of study of this size. Further, convergence analysis of per capita CO_2 emissions is crucial to guide policymakers' projection models when preparing climate change policy proposals. As such it is hoped that any information gained through this study will be helpful for policymakers, specifically the scenarios on carbon emissions from the perspective of developing countries which may help create awareness that are useful in combating the problem of climate change in the future.



Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PENENTU DAN ANALISIS PENUMPUAN PELEPASAN KARBON DIOKSIDA (CO₂) DI NEGARA SEDANG MEMBANGUN

Oleh

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Tahun 1991 menyaksikan negara sedang membangun dikategorikan oleh UNFCCC "Non-Annex I Countries", iaitu sebagai negara negara vang boleh dipertanggungjawabkan terhadap peningkatan pesat pelepasan karbon dioksida dunia. Komitmen untuk memenuhi matlamat pembangunan sosial dan ekonomi selain tekanan saiz ekonomi negara yang besar, penggunaan tenaga yang tinggi, jumlah penduduk yang besar, dan kadar pertumbuhan ekonomi yang meledak telah memperhebat peningkatan pelepasan karbon dioksida di negara-negara ini. Dalam kajian ini, beberapa faktor, dari aspek sosioekonomi hingga keinstitusian telah dipilih untuk analisis. Berdasarkan teori dan kajian bersifat empirikal terdahulu, faktorfaktor ini dikenal pasti sebagai penentu yang berkemungkinan terhadap pelepasan karbon dioksida. Justeru, objektif pertama dan kedua kajian adalah untuk menentukan faktor yang mempengaruhi peningkatan pelepasan CO₂ di 126 buah negara sedang membangun terpilih bagi tempoh 1971-2009. Tinjauan mencakupi analisis berdasarkan rantau, iaitu Afrika; Amerika Latin dan kepulauan Carribean (LAC); Timur Tengah - Utara Afrika; serta Asia dan Asia-Pasifik. Kajian ini menganalisis model panel dinamik menggunakan teknik "Generalised Method of Moments" (GMM). Penemuan berkaitan dengan faktor sosioekonomi mendapati bahawa keluaran dalam negeri kasar (KDNK) per kapita, penggunaan tenaga daripada bahan api fosil (EFF), penggunaan tenaga (EUS), aliran masuk pelaburan langsung asing (FDI), pembandaran (URB), pengeluaran perindustrian (IND), pengeluaran pertanian (AGR) dan tahap pendidikan (EDU) menunjukkan kesan yang sangat ketara terhadap peningkatan pelepasan karbon di keseluruhan rantau sedang membangun ini. Kesemua faktor ini menunjukkan hubungan positif yang ketara dengan pelepasan CO₂ per kapita kecuali faktor pembandaran yang menunjukkan hubungan yang negatif. Di keempat-empat rantau yang dikaji, KDNK per kapita dan EFF didapati merupakan faktor paling ketara yang mempengaruhi peningkatan pelepasan karbon.



Analisis terhadap aspek keinstitusian difokuskan kepada kesan Protokol Kyoto, kestabilan politik, struktur undang-undang dan hak harta benda, rasuah dan kebebasan perdagangan berkaitan dengan pelepasan CO_2 . Hasil penemuan kajian memperlihatkan komitmen Kyoto (K_{com}) sebagai penunjuk tunggal yang menggambarkan hubungan yang negatif dan ketara dari segi statistik, yang boleh ditafsirkan sebagai membawa maksud bahawa mengesahkan dan menandatangani Protokol Kyoto bukanlah penunjuk terhadap hasrat untuk mengurangkan pelepasan karbon. Empat faktor keinstitusian yang dianalisis tidak menggambarkan sebarang hubungan yang ketara dengan peningkatan pelepasan CO_2 di rantau negara sedang membangun itu.

Objektif terakhir meneliti kewujudan penumpuan pelepasan CO₂ per kapita. Objektif ini adalah penting khususnya dalam mengemukakan cadangan yang sesuai bagi pelaksanaan dasar dan implikasi pelepasan CO₂ di rantau ini. Berdasarkan model logt Phillips-Sul (2007), penemuan kajian menunjukkan kewujudan penumpuan dalam tahap pelepasan per kapita CO₂ bagi keseluruhan rantau negara sedang membangun itu. Walau bagaimanapun, berdasarkan rantau, hanya Amerika Latin dan kepulauan Caribbean menunjukkan penumpuan dalam pelepasan CO₂ manakala rantau Afrika, Asia Timur Tengah dan Afrika Utara, dan Asia-Pasifik pula menunjukkan pencapahan. Meskipun demikian, ketiga-tiga wilayah yang menunjukkan pencapahan menggambarkan ciri-ciri penumpuan kelompok (club convergences) yang tertentu. Pertama, hanya beberapa penumpuan kelompok sahaja yang dikenal pasti bagi setiap rantau. Kedua, sebahagian besar negara di rantau tersebut tergolong dalam kategori pencapahan. Akhir sekali, setiap penumpuan kelompok didapati bersepadan dengan kategori pendapatan. Dengan erti kata lain, negara berpendapatan tinggi membentuk satu kelompok, manakala negara berpendapatan rendah membentuk suatu kelompok lain.

Perbincangan berkaitan dengan implikasi dasar tertumpu pada dasar sedia ada yang boleh dilaksanakan dengan sewajarnya untuk mengawal peningkatan pelepasan CO₂ Penilaian dilakukan berdasarkan penemuan terhadap penentu di setiap rantau dan juga dari perspektif penumpuan kelompok yang telah dikenal pasti. Penemuan yang diperoleh terhadap semua rantau menunjukkan KDNK per kapita dan penggunaan tenaga daripada bahan api fosil (EFF) mempunyai kesan yang ketara terhadap Walau bagaimanapun, penggunaan tenaga (EUS) itu sendiri pelepasan karbon. hanya didapati ketara bagi rantau Amerika Latin (LAC) dan Asia Pasifik. Oleh yang demikian, suatu dasar yang seragam mungkin tidak sesuai untuk mengawal masalah pelepasan CO₂ di rantau-rantau ini. Cara yang lebih baik ialah mempertimbangkan setiap kelompok negara yang penumpuan pelepasannya berada pada tahap yang Menurut Burnett (2013), memahami kelompok negara berbeza yang sama. penumpuan pelepasannya berada pada tahap yang sama akan membantu para pembuat dasar membangunkan dasar yang terbeza.

Memandangkan negara-negara ini amat bergantung pada bahan api fosil, melaksanakan beberapa dasar tenaga yang mungkin memberikan kesan yang langsung atau tidak langsung terhadap pengurangan pelepasan CO_2 (Dinica, 2002) merupakan langkah yang terbaik. Oleh yang demikian, mungkin langkah permulaan baik yang dicadangkan untuk negara-negara ini adalah untuk memfokuskan dasar pemuliharaan tenaga. Dasar pemuliharaan tenaga boleh dilaksanakan dalam bentuk penjimatan tenaga dan pengenalan sumber tenaga alternatif menerusi penyertaan

dalam projek CDM untuk menggalakkan pembangunan tenaga bersih seperti hidroelektrik, nuklear, biojisim, angin dan solar. Dasar-dasar lain seperti pembasmian hutan, pengukuhan pengawalan dan undang-undang alam sekitar di samping penguatkuasaan yang tegas boleh dilaksanakan di setiap rantau atau negara. Walau bagaimanapun, ini bergantung pada keadaan ekonomi dan kesedaran sosial negara-negara ini terhadap isu-isu yang berkaitan dengan masalah alam sekitar.

Kajian ini berusaha untuk menganalisis dengan teliti peningkatan pelepasan CO_2 di 126 buah negara sedang membangun yang mencakupi satu pertiga daripada negara di dunia. Sebagai pelepas CO₂ yang besar pada masa hadapan, usaha negara-negara ini untuk mengurangkan pelepasan CO2 adalah penting. Pengkaji mendapati bahawa belum ada sebarang analisis yang menyeluruh berkaitan dengan pelepasan CO₂ melibatkan negara yang sedang membangun pada skala yang besar. Penggunaan model panel dinamik seperti teknik ekonometrik "Generalised Method of Moments" (GMM) secara relatifnya masih baharu bagi skop kajian seluas kajian ini. Tambahan pula, analisis penumpuan pelepasan CO₂ per kapita adalah penting untuk memandu model pengunjuran para pembuat dasar apabila mereka menyediakan cadangan dasar perubahan iklim. Oleh hal yang demikian, diharapkan sebarang maklumat yang diperoleh menerusi kajian ini akan memberikan manfaat kepada para pembuat dasar, khususnya dalam senario berkaitan dengan pelepasan karbon dari perspektif negara yang sedang membangun. Maklumat ini juga seterusnya diharapkan dapat membantu mewujudkan kesedaran yang berguna dalam menangani masalah perubahan iklim pada masa hadapan.

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LIST OF ABBREVIATIONS

ADF	Augmented Dickey Fuller
ARDL	Autoregressive Distributed Lag
ASEAN	Association of South East Asian Nations
BRIC	Brazil, Russia, India and China
CDIAC	Carbon Dioxide Information Analysis Center
CDM	Clean Development Mechanism
CERs	Certified Emission Reductions
CH ₄	Methane
CFCs	Chlorofluorocarbons
CO_2	Carbon Dioxide
DOLS	Dynamic Ordinary Least Square
DVDCs	Dynamic Variance Decompositions
ECM	Error Correction Modelling
EKC	Environmental Kuznets Curve
EPA	Environmental Protection Agency
EU	European Union
FAO	Food and Agriculture Organization
FDI	Foreign Direct Investment
G7	Group Seven Countries
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GHGs	Greenhouse Gases
GMM	Generalized Method of Moments
GMM-SYS	Generalized Method of Moments System
GNP	Gross National Product
Gt	Gigatonne
HFCs	Hydro Fluorocarbons
IEA	International Energy Agency
IMF	International Monetary Fund
IPAT	Environmental Impact $(I) = Population (P) * Affluence (A) * Technology (T)$
IPCC	Intergovernmental Panel on Climate Change
IPS	Im. Pesaran and Shin
ISO	International Organization for Standardization
Л	Joint Implementation
LLC	Levin, Lin and Chu
LAC	Latin America and the Caribbean
MENA	Middle East and North Africa
NO _x	Nitrogen Oxides
N_2O	Nitrous Oxide
NGOs	Non-Governmental Organizations
NMVOC	Non-Methane Volatile Organic Compounds
OECD	Organization for Economic Cooperation and Development
OPEC	Organization Petroleum Exporting Countries
PFCs	Petro Fluorocarbons
PP	Phillips-Perron
QELRO	Limitation and Quantified Emission Reduction Objectives
R&D	Research and Development
SF6	Sulphur Hexafluoride

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SO_2	Sulfur Dioxide
STIRPAT	Stochastic Impacts Regression on Population, Affluence and Technology
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
VAR	Vector Autoregression
VDCs	Variance Decompositions
VECM	Vector Error Correction Modelling
WDI	World Development Indicator



CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Since the beginning of the year 1990, the world has been expressing concern about the issue of climate change, specifically global warming resulting from the effects of greenhouse gas emissions. This environmental problem has taken centre stage as it is thought to be the world's greatest challenge since it threatens the lives of billions of people. It has caused ice caps to melt, the sea level to rise and weather behaviour to be irregular and difficult to predict (IPCC, 2007). Consequently, all these have resulted in a negative impact on the ecosystems as shown by the increasingly common occurrence of costly natural disasters such as storms, hurricanes, floods and droughts around the world. In the Intergovernmental Panel on Climate Change (IPCC) report, it was stated that human activities greatly affect this issue and if not addressed quickly the results will be catastrophic (IPCC, 2007).

The high concentration of greenhouse gases in the atmosphere is the main cause of the global warming. Among these gases, anthropogenic carbon dioxide (CO_2) emissions are believed to be the principal factor responsible for the greenhouse effect. This fact justifies why CO₂ emissions are considered by specialists to be the best available indicator of climate change (Carlsson and Lundström, 2003; OECD, 2007; Quadrelli and Peterson, 2007). In spite of international efforts to reduce the atmospheric level of CO₂, emissions of this gas is still growing in many countries. The issue was thus raised as a serious global issue with the adoption of the Kyoto Protocol¹ on 11 December 1997 in Kyoto, Japan. The United Nations Framework Convention on Climate Change $(UNFCCC)^2$ is the international environmental treaty aimed at fighting global warming and is responsible for the protocol that was set to be enforced on 16 February 2005. The Protocol witnessed 37 industrialised countries also known as "Annex I countries³", committing themselves on principle to cut their greenhouse gas emissions to below the 1990 benchmark level (i.e. 5.2 percent) over a five-year period 2008-2012. The six poisonous greenhouse gases emissions which are of concern are carbon dioxide (CO_2) , methane (CH_4) , nitrous oxide (N_2O) and three other fluorinated gases hydro fluorocarbons (HFCs), petro fluorocarbons (PFCs) and sulphur hexafluoride (SF6).

Basically, it is observed that these emissions arise due to human actions via manufacturing activities, power generation plants, transportation activities and also agricultural production. Energy is found to be the most important anthropogenic source of CO_2 emissions (estimated to be about two thirds) and the primary energy supply source for the world is fossil fuels, namely coal, oil and natural gas. Coal, which is identified to be the highest source of CO_2 emissions, has been widely used as the cheapest resource for power generation from as early as the beginning of the

¹ The Kyoto Protocol was established at the third conference of the parties (COP3) in 1997.

² The UNFCCC was founded in 1992 at the "Rio Earth Summit".

³ See Appendix 1 for the list of Annex 1 countries.

industrial age. This has particularly affected developing countries which hold the belief that becoming an industrialized nation may improve national income per capita and consequently the citizens' well-being, the developing countries have made their move to achieve their target but at the expense of the environment.

Understanding the needs of developing countries, the majority of which is fall under the "Non-Annex I countries" (Table 1.1) category, and their commitment towards their social and economic development goals, the Kyoto Protocol has somehow adopted a principle of "common but differentiated responsibilities". Under this principle the parties agreed that the per capita emissions and the share of emissions of developing countries were still relatively low and thus would be allowed to grow so as to meet their social and economic development needs (UNFCCC, 2006). However this does not mean that the developing countries should not be responsible for their actions as any effects of climate change will likely be most felt by these countries, the very countries that are least prepared to deal with them. Hence becoming signatories to the Kyoto Protocol also required them to put efforts into reducing their CO₂ emissions. Despite the fact that the developed countries were historically responsible for the largest share of the global greenhouse gases emissions, their share is however expected to fall continuously in the coming years. Currently, it appears that the pattern of CO₂ emissions growth has changed whereby since the year 1991, the developing countries have instead been blamed for the rapid growth in the world's CO_2 emissions (Figure 1.1).

Figure 1.2 shows that the developing countries' carbon emissions are projected to exceed that of the developed countries by the year 2015. Hence, being the next potential largest emitters, it is more significant to focus on this Non-Annex I countries which are still developing. Majority of these nations belong to the lowincome and lower-middle income groups whilst some are categorized as uppermiddle income and high-income economies.⁴ Though these countries' share of CO₂ emissions per capita is considered as being relatively small, the need to meet their social and economic development goals will require them to increase their energy consumption and hence it is foreseen that their share of CO₂ emissions will continue to increase persistently. Over half of the energy-related CO₂ emissions growth is expected to be from China, Asia and Middle East and about 55 percent of the growth from the non-Organization for Economic Co-operation and Development (OECD) countries. Furthermore, fossil fuels, especially coal, are recognized to be the major source of energy supply in the developing countries apart from oil and natural gas. Hence a matter of concern their ability to take effective action in relation to climate change due to their heavy dependency on fossil and solid fuels like wood that contribute to large carbon emissions (Han and Chatterjee, 1997).

⁴ See Appendix 3for the list of countries in each income group.

Table 1.1:	List of Non-An	nex 1 countrie	s under the	Kyoto Proto	col				
Afghanistan	Bosnia & Herzegovina	Costa Rica	Gabon	Jordan	Maldives	Niger	Sao Tome & Principe	Swaziland	Uzbekistan
Albania	Botswana	Côte d'Ivoire	Gambia	Kazakhstan	Mali	Nigeria	Saudi Arabia	Syrian Arab Rep.	Vanuatu
Algeria	Brazil	Croatia	Georgia	Kenya	Marshall Islands	Niue	Senegal	Tajikistan	Venezuela, RB
Angola	Brunei Darussalam	Cuba	Ghana	Kiribati	Mauritania	Oman	Serbia	Tanzania, Un. Rep.	Vietnam
Antigua & Barbuda	Burkina Faso	Cyprus	Grenada	Kuwait	Mauritius	Pakistan	Seychelles	Thailand	Yemen
Argentina	Burundi	Congo, DR	Guatemala	Kyrgyzstan	Mexico	Palau	Sierra Leone	Timor-Leste	Zambia
Armenia	Cambodia	Djibouti	Guinea	Lao PDR	Micronesia, Fed. Sts.	Panama	Singapore	Togo	Zimbabwe
Azerbaijan	Cameroon	Dominica	Guinea-Biss <mark>au</mark>	Lebanon	Mongolia	Papua New Guinea	Solomon Islands	Tonga	
Bahamas	Cape Verde	Dominican Republic	Guyana	Lesotho	Montenegro	Paraguay	Somalia	Trinidad & Tobago	
Bahrain	Central African Republic	Ecuador	Haiti	Liberia	Morocco	Peru	South Africa	Tunisia	
Bangladesh	Chad	Egypt	Honduras	Libya	Mozambique	Philippines	Sri Lanka	Turkmenistan	
Barbados	Chile	El Salvador	India	Lithuania	Myanmar	Qatar	St. Kitts & Nevis	Tuvalu	
Belize	China	Equatorial Guinea	Indonesia	Macedonia, FYR*	Namibia	Republic of Korea	St. Lucia	Uganda	
Benin	Colombia	Eritrea	Iran, Islamic Republic	Madagascar	Nauru	Rwanda	St. Vincent & the Grenadines	Un. Arab Emirates (UAE)	

Table 1.1: List of Non-Annex 1 countries under the Kyoto Protocol





Figure 1.1: Regional Shares of CO₂ emissions in 1973 and 2008

(Source: International Energy Agency (IEA) - Key World Energy Statistics 2009)

Notes: Asia*** excludes China.

World includes international aviation and international marine bunkers, together shown as Bunkers CO₂ emissions are fuel combustion only.



Figure 1.2: Total Greenhouse Gas Emissions by Region⁵

(Source: http://epa.gov/climatechange/emissions/globalghg.html)

Another central issue that needs to be addressed is how the developing countries can be made to play a greater role in future climate talks (Rong, 2010), particularly the 'Basic Four' nations, referring to Brazil, South Africa, India and China.⁶ The pressure is due to their large population, huge economic size, high energy consumption and, more importantly, their rapid growth rates which may consequently accelerate the growth of CO_2 emissions. The current lack of any form of legal agreement to control their emissions may cause them to take tackling this issue lightly. Their commitment is however vital to reduce future emissions levels. Figure 1.1, shows that the regional shares of CO_2 emissions from fuel combustion in developing nations, namely from Asia (include China), Middle East, Latin America and Africa, has increased tremendously from 14.3 percent in 1973 to 44.3 percent in 2008. Table 1.2 divides the non-Annex 1 party into five different panels or regions: Africa, Latin America and the Caribbean, Middle East and North Africa, South Asia and East Asia and Pacific.

⁵Reference: (1) SGM Energy Modeling Forum EMF-21 Projections, Energy Journal Special Issue, in press, reference case CO₂ projections. (2) Non-CO₂ emissions are from EPA's Global Anthropogenic Emissions of Non-CO₂ Greenhouse Gases 1990-2020. ⁶ Brazil, South Africa, India and China are non-Annex 1 countries.

	Africa	Latin America & the Caribbean	Middle East & North Africa	South Asia	East Asia & Pacific
A	ngola	Antigua & Barbuda	Algeria	Afghanistan***	Brunei
B	enin	Argentina	Bahrain	Bangladesh	Cambodia
B	otswana	Belize	Djibouti	Bhutan	China
В	urkina Faso	Bolivia	Egypt	India	Fiji
B	urundi	Brazil	Iran	Maldives	Indonesia
С	ameroon	Chile	Iraq	Nepal	Kiribati
С	ape Verde	Colombia	Jordan	Pakistan	Republic of Korea
С	entral African Rep.	Costa Rica	Kuwait	Sri Lanka	Lao PDR
С	had	Cuba	Lebanon		Malaysia
С	omoros	Dominica	Libya		Marshall Islands
С	ongo, DR	Dominican Rep.	Morocco		Micronesia, Fed. Sts.
С	ôte d'Ivoire	Ecuador	Oman		Mongolia
E	quatorial Guinea	El Salvador	Oatar		Myanmar
E	ritrea	Grenada	Saudi Arabia		Palau
Fi	thiopia	Guatemala	Svria		Papua New Guinea
G	abon	Guvana	Tunisia		Philippines
G	ambia	Haiti	LIAE		Samoa
G	hana	Honduras	Vemen		Solomon Islands
G	uinea	Iamaica	remen		Singapore
G	uinea Ninea Dissou	Maviao			Theiland
U	uniea-Dissau	Nicorogue			Timor Looto
K.	ellya	Danama			Timor-Leste
	ibaria**	Panama			Vonuetu
		Paraguay			Vanuatu
M	ladagascar	Peru			vietnam
M	lalawi	St. Kitts & Nevis			
M	lali	St. Vincent & the Grenadines			
N					
M	lauritius	Irinidad & Tobago			
M	lozambique	Uruguay			
N	amibia	Venezuela, RB			
Ν	iger				
N	igeria				
R	wanda				
Sa	ao Tome & Principe				
Se	enegal				
Se	eychelles				
Si	ierra Leone				
Se	omalia***				
So	outh Africa				
Si	udan				
S	waziland				
Т	anzania				
T	ogo				
U	ganda				
Z	ambia				
Z	imbabwe				

Table 1.2: List of Non-Annex 1 countries representing the five regions

*** Countries of non-party to Kyoto Protocol. **Countries are not parties of UNFCCC. Source: UNFCCC and the World Bank Data.

1.2 The Kyoto Protocol, Institutional Factors and CO₂ Emissions

Adoption of the Kyoto Protocol is the first step which shows the seriousness of the UNFCCC to fight global warming and the commitment of Annex 1 countries to reduce GHG emissions. The prime objective of this protocol is to establish a legally binding international agreement which requires participating countries to be committed in dealing with the issue of global warming and greenhouse gases. Although non-Annex 1 countries do not have the same commitment as the Annex 1 countries, their participation in the Kyoto Protocol is vital and necessary and thus a majority of them have signed and ratified the treaty.⁷

De Zeeuw (2008) compared the Kyoto Protocol (1997) which serves to reduce greenhouse gas emissions, with the Montreal Protocol (1987), which serves to phase out chlorofluorocarbons (CFCs) which are blamed for causing the depletion of the ozone layer. The two protocols differ in terms of the number of countries which have signed and ratified the treaties whereby the Montreal Protocol saw participation by 181 countries whilst the Kyoto Protocol in its first phase was much smaller with only 40 countries (Annex I parties). After the withdrawal of the USA from the Kyoto Protocol in 2001, due to its government's belief that the requirements of the treaty would be too costly to implement and would not effectively deal with the problem because many large polluters such as China are excluded, it has been argued that the basis of this agreement is very weak. Even after Russia ratified the protocol and the treaty became effective on 16 February 2005, there were arguments raised about the stability of the coalitions. Why the emphasis on Annex I countries specifically? This is because the parties of the UNFCCC commonly agreed that GHG emissions originated in developed countries and hence they are responsible for the largest share of current global emissions. There is also an argument that the main contributor to damage is from the level of the stock of greenhouse gases and not the level of emissions as agreed in the Kyoto Protocol treaty (De Zeeuw, 2008).

In taking the lead to initiate cutting GHGs the developed countries showed their commitment by coming up with national or joint reduction targets (formally known as "limitation and quantified emission reduction objectives" (QELRO)) as stated in Article 4.1. The European Union has set a target for a joint reduction of 8 percent, Japan set theirs at 6 percent, Russia at 0 percent and the United States, a non-signatory, at 7 percent. Conversely the treaty permits Australia and Iceland to increase emissions to 8 percent and 10 percent respectively. Under the Kyoto Protocol, 39 of the 40 Annex 1 countries pledged their 2012 first round commitments. Thirty four of them committed to reduce their greenhouse gases level in relation to their 1990 emission levels.⁸ Unfortunately many perceive the Kyoto Protocol as having failed simply because in 2011 many countries were still far from achieving the targeted CO_2 emissions reductions. However this does not mean that the protocol has been completely unsuccessful (Aichele and Felbermayr, 2011).⁹



⁸ See Appendix 4 (ii) for the list of Annex 1 countries commitments.

⁹ Aichele, R. and Felbermayr, G. (2011). What a difference Kyoto made: Evidence from instrumental variables estimation. Ifo Working Paper No. 102 June 2011. Institute for Economic Research at the University of Munich.

Any feasible solution to the challenge of stabilizing global emissions concentrations needs to involve both richer countries and developing economies (Duro and Padila, 2006). To ensure active involvement and cooperation of both developed and developing economies, under the first Kyoto Protocol it was agreed that developing countries were not subject to quantitative emission reduction commitments but to limit their emissions and thus the CDM was designed. The CDM seems to be the only link between the Kyoto Protocol and developing countries whereby its workability will help ensure the effectiveness of the Kyoto Protocol and developing countries' willingness to participate in a future global emissions regime (Sari and Meyers, 1999). It is a "project-based mechanism" proposed under article 12 of the Kyoto Protocol intended to encourage Annex 1 countries to meet their emission caps and to invest and finance projects and programs in developing countries that are parties to the Kyoto Protocol which are vulnerable to the adverse effects of climate change. Annex 1 countries may earn certified emission reductions (CERs) credits whereby 2 percent is levied on CERs issued by CDM as a form of income for the **UNFCCC** Adaptation Fund.



Figure 1.3: Registered Project Activities by Host Party (Source: Clean Development Mechanism (CDM) Annual Report 2010)

Essentially the idea behind this mechanism is to stimulate sustainable development and reduce emissions of GHGs and at the same time give Annex 1 countries the opportunity to meet their emission reduction targets. So far most of the CDM projects' with active participation from Annex II countries are mainly in China, India, Brazil, Mexico, Malaysia, Indonesia and Republic of Korea besides a number in Pakistan, Vietnam, Philippines, Thailand and Egypt (Figure 1.3).¹⁰ The types of projects activities registered range from large scale (56.20 percent) to small scale (43.80 percent)¹¹ investments and also include the estimated amount of emission reductions of CO₂ equivalent per annum which must be stated by the project participants. The CDM annual report stated that there are CDM projects activities in

¹⁰ Refer to Issuance of CERs at http://unfccc.int.

¹¹ CDM Executive Board Annual Report 2010.

about 70 countries but the registered projects worldwide are concentrated only in a few countries -50 countries have fewer than 10 projects and 21 countries just one project.

Alvarez-Diaz et al. (2011) stated that there are extensive empirical studies examining the possible factors contributing to the increasing level of CO₂ emissions which focus on the role of production and economic growth. Nevertheless it seems reasonable to consider other factors as well to be included in the analysis of the CO_2 emissions. Interestingly North (1994) drew attention to the importance of including the institutional structure of production in analyzing economic performance; hence projecting the ideas that the institutional structure could be of relevance apart from the common economic factors, to explain the phenomenon of rising concentrations of CO₂ emissions. Accordingly, Alvarez-Diaz et al. (2011) focused on the role of organizational and institutional factors as the determinants of CO₂ emissions in an effort to open the "black box" in this study. Though the institutional factors should be taken to be of relevance in understanding the level of CO_2 emissions across countries, unfortunately factors such as political stability or reforms, economic freedom, corruption and democracy are not widely investigated. Majority of the studies conducted whether theoretically or empirically, emphasize mainly on their association with the economic growth of a nation rather than its environmental quality.

Farzin and Bond (2006) stated in their study, and most authors tend to agree that the relationship between environmental quality and economic development is of significance and should not be isolated from political institutions that function as the policy makers in a particular country. It is somehow a norm to assume that government institutions in developing countries are weaker, inefficient and more corrupt than those in developed countries as it has unmistakably been proven to be true for the large developing countries that are experiencing explosive economic growth such as China, Indonesia and India whereby their corruption levels are notoriously above those prevailing in developed countries (Lopez and Mitra, 2000). As Farzin and Bond (2006) concluded, as long as demand for environmental quality is deemed to be a public good in a given country, a structural system that accounts for feedbacks between the economy, environment, and institutions, although it could be somewhat complex, might help to provide valuable insights for formulation of environmental policy. To complement this further the convention framework on climate change should have a set of institutions that does not only involve international governmental organizations but also national governments, research or private institutions, and non-profit and nongovernmental organizations which Dutt (2009) describes as "a set of mechanisms and institutions that govern environmental outcomes on an international level".

Although environmental degradation problems were initially detected and experienced by developed nations, this complex problem will inevitably be exacerbated by the rightful aspirations of those countries that are currently going through the initial stages of traditional industrialization (Mielnik and Goldemberg, 2000). The World Bank Annual Report 2010 thus urges developed countries that produced most of the greenhouse gas emissions in the past to act now to shape the future world climate by ramping up funding for adaptation and mitigation in developing countries, where most future growth in emissions will occur.¹² Since majority of these countries are dependent on fossil fuels to generate their energy, mitigation actions are called for. Different developing countries may have different mitigation capabilities so as to cater to their economic structure. Since climate change issues are so important to the developing world, the World Bank itself has integrated them into all of its new sector strategies and intensified its efforts to support climate risk management in its core operations (World Bank Annual Report, 2010).

1.3 Overview of CO₂ Emissions Trend: Global and the Five Regions

 CO_2 or carbon dioxide is the major greenhouse gas pollutant contributing significantly, estimated to be about 60 percent, to the world's atmosphere. The combustion of fossil fuels is identified to have emitted excessive amounts of this particular greenhouse gas; CO_2 is thus classified as the main driver behind the world's problem of global warming. Scientists commonly believe that CO_2 emissions result from the extensive usage of fossil fuels to generate energy due to human economic activities. So long as worldwide economic stability and development require energy, and the world depends on these fossil fuels (in 2011 fossil fuels accounted for about 82 percent of the world's shares of primary energy use)¹³ to generate energy, the problem of CO_2 emissions growth will persist.

World

The world emissions of carbon from the consumption of fossil fuels and cement production grew rapidly in the mid70s (Figure 1.5a). The burning of fossil fuels alone released around 21.3 billion tons of carbon dioxide annually. Out of this estimated amount natural processes are only able to absorb about half, so there is a net annual increase of 10.65 billion tons of atmospheric carbon dioxide. A UNFCCC report in 2007 identified the top thirty emitters of CO₂ emissions in the world. The developing countries were found to constitute 50 percent of the top thirty emitters with China and India being the top two largest emitters followed by South Korea, Iran and Mexico. It is also interesting to note that three ASEAN¹⁴ members, Indonesia, Thailand and Malaysia are listed among the top thirty emitters.¹⁵

In 2007 there was an all-time high increase in emissions, i.e. 8365 million metric tons of carbon representing an increase of 1.7 percent from 2006. The dramatic increase in emissions was contributed by developing countries with their high demand for coal and, oil and gas energy-intensive industrial production. However the share from developed countries shrank from 61 percent in 1971 to 47 percent in 1990 and reduced further to 39 percent in 2007. Between 2007 and 2008, global CO_2 emissions increased by 0.4 Gt corresponding to a growth rate of 1.5 percent. For the first time in 2008, the aggregate emissions of the developing countries were larger than those from the developed countries indicating diverging trends. As illustrated by Figure 1.4, emissions from Annex I countries decreased by almost 6 percent. In

¹² The World Bank Annual Report 2010.

¹³ According to US Energy Information Administration (EIA).

¹⁴ Association of the South East Asian Nation (ASEAN).

¹⁵ See Appendix 5 for the list of 30 top emitters in 2007.

analyzing the comparative global change in CO_2 emissions between 2006-07 and 2007-08, it was seen that the total consumption of fossil fuels particularly demand for coal by non-Annex 1 countries had increased in 2007-08 whereas the Annex 1 countries showed a decrease which implied that this was the main cause for the increase in emissions in developing countries. Hence it is not surprising to see that at the regional level, as reported by the IEA, CO_2 emissions had increased significantly in China (8 percent), the Middle East (7 percent), other Asian countries (4 percent) and Latin America (4 percent).¹⁶

Africa

Between 1980 to 2001, Africa's per capita CO_2 emissions rate declined by 5 percent whereby the region's absolute CO_2 emissions as well as per capita carbon dioxide emissions rate were the lowest in the world in 2001(Figure 1.5b). Though fossil-fuel CO_2 emissions in Africa are low, the member countries' total emissions had increased 12-fold, touching 310 million metric tons of carbon in 2007. Africa has very low carbon dioxide emissions because of its lack of a large transportation sector, combined with relatively low rates of electrification, appliance penetration, and industrialization. South Africa is the region's major carbon emitter, accounting for 61 percent of Africa's total carbon dioxide emissions in the year 2001. On the other hand Nigeria whose population is three times larger than that of South Africa has carbon dioxide emissions growing modestly, at an average of 1.0 percent a year. This reflects the relative absence of industrial development in the country. Both countries released the most carbon per dollar of GDP throughout the 1980s and 1990s, implying that these are respectively, the most industrialized (South Africa) and largest energy producing (Nigeria) nations in Africa.

Latin America and the Caribbean

Popularly known as the "Developing America," the region's fossil-fuel emissions have grown almost ten-fold since 1950 reaching 435 million metric tons of carbon in 2007. Annual regional per capita CO₂ emissions doubled between 1950 and 1973 and have grown modestly since. Between 1980 and 2001, Latin American CO₂ emissions grew by 54 percent, an average of 2.1 percent annually with Mexico and Brazil accounting for 52.7 percent of the 2007 regional total carbon emissions, emitting more than 100 million metric tons of carbon (Figure 1.5c). The two countries also appear to be among the top 20 fossil-fuel CO₂ emitting countries in the world (Table 1.2). Other countries in the region emitting more than 10 million metric tons of carbon annually are Argentina, Venezuela, Chile, Columbia, Peru and Trinidad and Tobago. The Caribbean islands, which comprise Netherland Antilles and, Trinidad and Tobago have high per capita emissions exceeding 6.0 metric tons of carbon per person per year.

Middle East and North Africa

Though the region contributes a large fraction of the world's oil their energy consumption from fossil fuels and cement produce only 6.2 percent of the global CO_2 emissions. The Middle East exhibited a dramatic singularity of CO_2 emissions

¹⁶ CO₂ Emissions from Fuel Combustion *Highlights* (2010 Edition).



Figure 1.4: Comparison of Global Change in CO₂ Emissions between 2006-07 and 2007-08

(Source: IEA Statistics 2009 & 2010 Editions)

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in 1991 during the Kuwaiti oil field fires which caused 130 million metric tons of carbon to be released into the atmosphere. In contrast the region's three major fuel consumers discharged 65 percent of the region's fossil-fuel CO_2 in 2007: Iran, 135.3 million metric tons of carbon and Saudi Arabia, 109.7 million metric tons of carbon. Gas flaring was a major source of regional emissions accounting for almost half of the total fossil-fuel CO_2 emissions in the region before infrastructure became available for gas use and reinjection. Growth in emissions has been nearly continuous since 1950, although it started from a very low base. Despite rapid growth in per capita emissions until 1973, in the late 1970s and 1980s there was not much changes, but it began to grow again during the 1990s exceeding the global average (Figure 1.5d). Four Middle Eastern countries are listed among the five highest national per capita CO_2 emission rates in the world for 2007 - Qatar (14.03 metric tons of carbon per person), Kuwait (9.30), United Arab Emirates (8.44), and Bahrain (8.06).

South Asia

Representing South Asia are Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka, which show a more stable upward trend of per capita CO_2 emission rates (Figure 1.5e). Per capita emissions in the region are below 1.0 metric tons with Afghanistan starting as low as 0.01 metric ton of carbon per person per year. Starting from 1998, the region touched per capita emission of 1.0 metric ton and the rate has continued to rise steadily. Of all the seven nations, India has shown a remarkable growth in CO_2 emissions accounting for nearly 5 percent of global emissions and is ranked 3rd highest top emitters (see Appendix 5). Although over 62 percent of the region's coal consumption is in India its per capita emission is still the lowest, recorded at 1.2 metric ton in 2007.

East Asia and Pacific

Carbon dioxide emissions grew substantially in this region between 1980 and 2001, rising by 151 percent or 4.5 percent annually (Figure 1.5f). The bulk of the region's carbon dioxide emissions come from its populous giant, China. In 2007 China was the number one top emitter accounting for 22.3 percent of the total global emissions (see Appendix 5). The Far East's emissions however showed a drop for the first time between 1997 and 1998 ending fifty years of growth averaging at approximately 7 percent per year. CO₂ emissions in 2007 exceeded one billion metric tons of carbon, a 36-fold increase over the 1950 emission level. The emissions growth since 1948 in this region reflects not only the growth in South Korea and Indonesia, but also in Thailand, Taiwan, Malaysia, Philippines, Singapore and other less populous nations.¹⁷ Indonesia was ranked 15th and Thailand ranked 23rd in the list of top CO₂ emitters, both of which showed the fastest growth among the developing Asian countries between 1980 and 2001 indicating that these two countries' had developed their energy-intensive industries (see Appendix 5). Meanwhile South Korea the most developed nations in the region, was ranked 9th. Coal is still the major source of fossil-fuel CO₂ in the region.



¹⁷ South Korea is categorized as high income economies (see Appendix 3).



Figure 1.5: Per Capita CO₂ Emissions (metric tons) for the World and the Five Developing Regions (Source: Carbon Dioxide Information Analysis Centre (CDIAC) for the World Bank)



1.4 Problem Statement

The Non-Annex I countries are still developing and economic growth is the key ingredient to improve their people's standard of living a better quality life. Since economic growth plays a critical role in these countries which are striving to be among the high income economies, they are thus reluctant to make any commitments under the Kyoto Protocol as they oppose any measure to reduce greenhouse gas emissions that might constrain their economic development (Mielnik and Goldemberg, 2000). Understanding the stance of these countries, the Kyoto parties agreed that the share of global emissions originating in developing countries will be allowed to grow to meet social and development needs (UNFCCC). The problem however is that to achieve such economic development will be at the expense of the environment. The fact is that the growth of CO_2 emissions in years to come is expected to be largely contributed by the developing countries. As reported by Hohne et al. (2003) emissions of Non-Annex I parties are increasing rapidly and CO₂ emissions from fossil fuels are expected to overtake those of Annex I countries in the coming decades. In addition deforestation activities have also contributed largely to the CO₂ emissions of developing countries.¹⁸

The UNFCCC reports that these non-Annex 1 countries emit 63 per cent of CO_2 , 26 percent of methane and 11 percent of N₂O. Consequently controlling the developing countries' CO_2 emissions is widely recognized as being important for at least three reasons: firstly, because of their anticipated growing share of global emissions throughout the 21st century; secondly, because of the concerns expressed by developing countries policy makers and negotiators that the restraint of CO_2 emissions could threaten their economic development prospects; and thirdly, because of the possible vulnerability of many developing countries especially low-lying and island nations, to the future effects of global warming (Pearson and Fouquet, 1996). The reasons given are acceptable and though there are those who argued that economic growth involves an increase in emissions of carbon dioxide any attempt to curtail emissions would restrict their economic growth (The Russia Journal, 2003). Thus it is crucial to investigate the relationship between economic growth and CO_2 emissions of the developing countries.

Though the question of whether there is a linkage between CO_2 emissions and economic development has been established, much of the argument that arises among researchers is regarding the direction of causality between the two variables. As hypothesized by the Environmental Kuznets Curve (EKC) theory as income per capita increases so does pollutants emissions per capita but beyond a certain level of income the growth in pollutants flattens out before it starts to decrease as income increases further. Additionally there are several other key and significant macroeconomic variables that have also been investigated linking them with CO_2 emissions. The question on what determines global CO_2 emissions is a much discussed issue and different researchers have come up with different factors to explain the phenomenon.



¹⁸ Höhne, N., Galleguillos, C., Blok, K., Harnisch, J., Phylipsen, D., 2003. Evolution of Commitments under the UNFCCC: Involving Newly Industrialized Countries and Developing countries. Research Report 20141255, UBA-FB 000412. Ecofys, Berlin, Germany.

Factors or determinants such as energy usage as well as macroeconomic variables for instance gross domestic product (GDP), foreign trade, trade openness and demographic factors like population and urbanization are relevant and are commonly and widely investigated in different studies. It should be noted that there could be other essential factors that could be observed and possibly have implications on governing the level of emissions, such as the level of education, percentage of power production based on fossil fuels, the institutional framework like the Kyoto protocol, political stability, economic freedom and corruption and the economic structure of these countries for instance the ratio of industry to agriculture. So far the consensus on this issue is rather inconclusive as findings were inconsistent among the advanced nations. It is observed that there is also limited understanding of the effects of the economic development process on CO_2 emissions and the study of the effect of institutional factors on emissions in a majority of the non-Annex 1 countries.

A typical conservative view is to blame the problem primarily on increasing energy consumption and this is undeniable because the energy sector has been identified to be the largest source of CO_2 emissions for developing countries since the late 1980s. Even the report made by 122 non-Annex 1 countries for the year 1994 saw 70 parties claiming that the energy sector was the largest source of CO₂ emissions whereas only 45 parties stated that it was the agriculture sector.¹⁹ In spite of substantial growing number of research studies conducted on developing countries, both scientific and policy studies, these have been concentrated more on a specific countries which show remarkable economic growth and most populated nations such as China, India, Brazil, Indonesia, South Korea and Mexico. So covering as many of these developing countries that are parties of non-Annex 1 as possible is crucial in understanding the patterns and the key determinants of CO₂ emissions in each of the five regions and the overall developing region. Thus the essence of this research is to analyze the main driving factors affecting change in CO₂ emissions for the five regions of the non-Annex 1 parties. It is hoped that the findings may help provide more effective policy solutions. It is understood that the potential severe consequences of global warming which is climate changes can be harmful to the world population, governments and nongovernmental efforts to mitigate and adapt to these consequences have increased and become more apparent.

Alvarez-Diaz et al. (2009) stated that the need to understand the complex process of climate change implies the need to examine all possible determinants of CO_2 emissions. Thus an institutional framework that features an international panel is crucial not only to monitor global environmental impacts, guide policies and measures but also more significantly to coordinate constituencies as well as generate information and knowledge. In line with this international negotiation like the 1997 Kyoto Protocol have laid out a modest set of mandatory reductions in GHG emissions by developed countries and subsequently followed by developing countries. The long delay between the adoption and enforcement of the protocol is mainly due to the question of which countries should have binding emission reduction obligations and the estimated costs of these obligations. Furthermore there is a question on how to incorporate and support developing countries, which did not account for a big share of emissions in 1997 but soon will, like China which showed strong increases in emissions in recent years (Grunewald and Martinez-Zarzoso,

¹⁹ http://en.wikipedia.org/wiki/Kyoto_Protocol

2009). This was the concern brought up by the United States during the era of the Clinton Administration where they declined to submit the Kyoto Protocol ratification to the senate if key developing countries did not show "meaningful participation" to limit GHG emissions (Eizenstat, 1998)²⁰.

Being the future largest emitters with a huge population, the developing countries' efforts and roles in addressing the issues at international, national and local levels are seen to be very significant. Signing and ratifying the Kyoto Protocol is a start but may not be sufficient if a strong legal framework to regulate drivers and quell environmental degradation are not there to support the system. Further, currently the protocol does not feature global participation and hence any efforts by the Kyoto signatories on carbon emission abatement may not be effective if these non-participating countries are not responsive in cutting their carbon emissions as well and this may end up offsetting the efforts made by the coalition of Kyoto countries (Silva and Zhu, 2009). It is also observed that each of these five regions differ in terms of their economic freedom, political or government stability and level of corruption. Thus it is just as essential to investigate whether these institutional factors play a relevant role in affecting the level of CO_2 emissions in each region.

In order to control the rise in the level of CO_2 emissions, there is certainly a need for appropriate environmental and energy policies and full support from those responsible nations that choose to participate and abide by the Kyoto treaty to ensure its success. Thus to begin with it is essential firstly to collect information, understand and then examine thoroughly the geographical distribution of CO_2 emissions in each of the five regions of the developing countries so that policymakers can study the impact of environmental policies implemented. The question also arises on whether convergence of CO₂ emissions could occur similar to income and hence could be thought to be a part of economic growth. Convergence in relative CO_2 emissions implies that countries are not following independent paths in pollution control, but are collectively moving towards a common standard of environmental performance (Lee and Chang, 2008). If this holds true then, it becomes clear that global CO_2 emissions should be reduced significantly and per capita emissions should gradually move toward further convergence (Bohringer and Welsch, 2004). Hence the focus on examining the existence of convergence of CO₂ emissions among developing countries is essential so as to clarify whether a common energy and environmental policy is reasonable to be applied to these countries. In addition, if convergence exists in these regions it would help to avoid the need for substantial resources transfers.

Specifically, this study aims to examine the following research questions: What was the growth pattern of CO_2 emissions during the period 1971 to 2009 in the four regions? What are the key factors or sources of determinants which contributed to the growth of CO_2 emissions during the period? Does energy usage or energy consumption generated by fossil fuels per se portray the most significant determinant in contributing to the growth of CO_2 emissions? Is the Kyoto Protocol sufficient in providing a platform to monitor the level of CO_2 emissions emitted by its members? Is the Kyoto Protocol able to attract participations by developing countries in its program? Do institutional factors such as political stability, legal structure and

²⁰ United States had signed in 12 November 1998 but were not intending to ratify the Kyoto Protocol until now.

property rights, corruption and freedom of trade show significant effects on the growth of CO₂ emissions? Do per capita CO₂ emissions levels converge among the countries in the four regions and the whole developing region? Is the speed of the convergence rate identified more or less similar in all the regions compared with the whole developing region? Is it possible to determine clearly whether the groups of countries converge to different equilibriums? Can club convergences be determined without doubt among the countries in the four regions and the whole developing region if divergence occurs? Do the club convergences identified represent certain distinct characteristics which demonstrate the differences between each other?

1.5 Objectives of the Study

The general purpose of this study is to investigate and analyze the growth of CO₂ emissions in the 4-regions of non-Annex 1 countries within the time frame of 1971-2009. These nations may differ in terms of income per capita but are similar as they are considered by the World Bank to be developing countries and the UNFCCC classifies them as members of the non-Annex 1 party.

The objectives of this study specifically aim:

- 1. To determine the factors affecting CO_2 emissions in selected developing countries and four regions i.e. Latin America and the Caribbean, Africa, the Middle East and North Africa and the Asia-Pacific economies.
- 2. To examine the significance of the Kyoto Protocol and institutional factors such as political stability, legal structure and property rights, corruption and freedom of trade on the countries' level of CO₂ emissions.
- 3. To investigate the existence of convergence of per capita CO_2 emissions in these regions and the whole developing region.

1.6 Significance of the Study

The developing countries have shown remarkable economic growth over the past decade. At the same time the growth was accompanied by a rapid increase in CO₂ emissions. The question of their ability to respond to this global problem is of concern because of two main facts:

- (i) Majority of these developing nations are from the low income and lowermiddle income groups which need to improve their standard of $living^{21}$.
- (ii) These countries rely heavily upon fossil fuels to generate energy that is significant for their growth and thus higher carbon emissions are expected.

Looking at the scenario it seems any effort at reducing CO₂ emissions will have an impact on the economic growth of these developing nations as economic development relies very heavily on the energy sector. However, Mielnik and Goldemberg (2000) argued that the use of the energy intensity indicator can be an alternative measure to preserve the economic development while reducing greenhouse gas emissions for the fulfilment of the Kyoto Protocol goals. Crucial factors that could be observed and possibly have implications are GDP per capita, energy consumption, urbanization, education level, fossil fuels energy consumption

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²¹ See Appendix 3 for the list of non-Annex 1 countries in each income group.

and economic structure of these countries for instance their industrial production and agricultural production. Hence examining the non-Annex 1 parties' patterns of CO_2 emissions, will help provide comprehensive understanding of the growth of CO_2 emissions in these developing regions.

For deeper evaluation of the sources of CO_2 emissions and on whether the energy sector is the key determinant, it would be thus of significance to identify the end users of energy in each region. This would help to provide better and more efficient strategic environmental planning for future further reduction in CO_2 emissions. The main motivation for testing the relationship between environmental quality and economic growth is that it allows policymakers to judge the response of the environment to economic growth (Narayan and Narayan, 2010). Thus the empirical analysis conducted is not intended to put forward new policies but rather to provide a solid basis for policy initiatives of CO_2 emissions in the regions of the developing world. It may also highlight the need to consider that different countries in different regions may need different types of policies that can benefit both their development and environment. This study attempts to meticulously analyze the growth of CO_2 emissions in these developing economies.

In discussing the issues of policies to control or limit CO_2 emissions, there is a need to examine the most debated institutional framework introduced by UNFCCC that is the 1997 Kyoto Protocol, and the international treaties responsible for monitoring global GHG emissions. As future large emitters developing countries participation in signing and ratifying the protocol is of importance to ensure their commitments in efforts to reduce CO_2 emissions. Though majority of these non-Annex I parties have ratified the protocol, the fact of whether they are committed to actually do so is rather questionable because they face no real restrictions under the treaty; and their dependence on industrialization and modernization to provide jobs and income to their growing populations (Swinton and Sarkar, 2008). Therefore a study on how developing countries play a role in limiting emissions and how the Kyoto Protocol creates incentives that can benefit them through providing them opportunities and encourage them to actively participate could help policymakers to strategize nationally to meet the Kyoto obligations.

Another significant point of this study is the considerable number of developing countries (126 nations) involved, covering around one third of the countries in the world. The thirty-nine years of annual data is analyzed and estimated by applying the generalized method of moments (GMM) econometric method which is quite popular in macroeconomic time series dealing with panel models. This method is chosen not merely because of its profound impact on the field of macro-econometrics but also its essentiality in a wide variety of applications. Two major advantages of using panel data analysis are: (i) It utilizes more information and hence there is more variability in the data. Thus inference of model parameters can be more accurate. (ii) It is able to control omissions or missing or unobserved factors. It was found that there has not been any previous comprehensive analysis dealing with the study of CO₂ emissions for developing economies on such a big scale. As such any information gained is hoped to be very helpful to policymakers specifically from the perspective of developing countries vis-à-vis the scenarios of carbon emissions that are able to initiate awareness which may be useful in combating the problem of climate change resulting from global warming in the future.

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A final point to note is the study on convergence analysis of per capita CO_2 emissions of these developing countries. Panopoulou and Pantelidis (2009) stated that the question of the existence of cross-country convergence is crucial in guiding policymakers' projection models to prepare climate change policy proposals. Furthermore as mentioned by Romero-Avila (2008) most projection models guiding policymakers assume convergence in emissions, when preparing emissions abatement strategies to reduce the problem of climate change. Hence it is undeniably critical to analyze the convergence of per capita CO₂ emissions in these developing nations which may differ from those of advanced nations so as to provide the policymakers with a proper and clear scenario to plan their own climate change policy proposals that could cater to their individual countries' needs. The examination of the CO₂ emissions convergence employed the log-t regression model proposed by Phillips and Sul (2007) based on a nonlinear time-varying model to investigate and discuss the pattern of convergence in each region and the selected developing region as a whole. In fact one essential advantage of choosing the Phillips and Sul (2007) log-t test is its ability to test not only for the overall convergence hypothesis but also for club convergence.

1.7 Organization of the Study

This thesis is organized into five different chapters. The first chapter provides an introduction to the study. It discusses some insights on the Kyoto protocol regarding the rise in the level of greenhouse gases emissions specifically CO_2 via economic activities. It focuses on the developing countries which are classified as the non-Annex 1 party by UNFCCC which are expected to be the future potential largest global emitters of CO_2 emissions due to their development needs. This chapter covers the problem statement, objectives and significance of the study.

Chapter two begins with a brief description and discussion on the UNFCCC, the Kyoto Protocol and developing countries before proceeding with reviewing the theory of the relationship between economic growth and environment in general. Then it continues to further examine the relationship between economic growth and CO_2 emissions by reviewing previous studies. The same chapter encompasses discussion on the empirical analysis of the determinants of global CO_2 emissions, the relevancy of various institutional factors, and other sources of growth conducted in previous studies. The study on past and current analysis pertaining to the Kyoto protocol is conducted to examine its role as an international treaty that regulates and monitors globally, not only the CO_2 emissions but also other GHG emissions. A similar analysis is carried out on various literatures on the issues of CO_2 convergence from absolute, sigma, beta to time-series analysis of convergence.

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The third chapter describes the methodology of the study, its framework, empirical models and sources of various data gathered. Chapter four presents the results of the analysis including a comprehensive discussion on the empirical findings of the investigated topic. Finally Chapter five is focused on analysis by interpreting the results obtained, linking them with the objectives set out earlier, and eventually drawing conclusions. This chapter also includes discussions on policy recommendations and describe some limitations of the study before ending with suggestions for future research.

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