Dynamics of CO_2 Emissions in Emerging Markets: Evidence from BRICs, MINTs and Iran over 1990-2011

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Submitted to the
Institute of Graduate Studies and Research
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy
in
Economics

Eastern Mediterranean University
February 2016
Gazimağusa, North Cyprus

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ABSTRACT

Human induced environmental impacts were started more than 10000 years ago with the agricultural revolution. However, after beginning of the industrial revolution which was almost 200 years ago, the most destructive human impacts have begun to be observed. Together with the industrialization, rapid population growth, huge energy demand, the unavoidable human impacts on the earth were started. The most important one is the climate change and global warming. During the 20^{th} century, many evidences of global warming were proved by the scientists. Accelerating concentrations of the greenhouse gases (GHGs) – more specifically the increasing amount of carbon dioxide (CO_2) emissions – in atmosphere are accepted as the main causes of climate change.

Developed and developing countries have two different perspectives about the global warming. Developed countries suggest the immediate solution of the problem, by implementing the necessary energy and environment related policies to reduce the CO_2 emissions and then stop the climate problem. However, developing countries firstly aim to accomplish their development and then to treat the environmental issues. Regarding developing countries, environmental issues have also become a certain problem starting from 1980s. The water and air quality in developing countries is worse than the developed countries nowadays which also create health issues in addition to environmental problems. Carbon dioxide (CO_2) has the greatest share among greenhouse gases (GHGs) and it is widely accepted as the main reason of climate change and global warming. Therefore, this study firstly aims to decompose the CO_2 emissions (which are the most important reason of the greatest environmental problem) in BRICs (Brazil, Russia, India, and China) and in MINTs (Mexico, Indonesia, Nigeria, and Turkey) from 1990 to 2011 to see the effects of different factors on CO_2 emissions. A decomposition method which is called the refined Laspeyres index method (suggested by Sun in 1998) was utilized and the impacts of four main factors including economic activity, energy intensity, population effect, and carbon intensity have been considered. In addition, as a case study, Iran's CO_2 emissions have also decomposed for the same period to identify the factors that are affecting them. For Iran, both refined Laspeyres index method and logarithmic mean Divisia index methods were utilized to analyze the factor changing CO_2 emissions and to provide a comparison between these methods. Empirical findings reveal that each of these factors has different impacts on each country's carbon emissions. As a third aim, the decoupling factor that is suggested by OECD was calculated and the existence of decoupling between economic growth and environmental pollution was tested for every research country. Finally, different policy suggestions for each country have been provided.

Keywords: CO_2 emissions, global warming, BRICs, MINTs, decomposition analysis, refined Laspeyres index method, logarithmic mean Divisia index method, Iran

ÖZ

İnsan kaynaklı çevresel etkilerin ortaya çıkışı günümüzden 10000 yıl kadar öncesine, tarım devrimine kadar dayanmaktadır. Lakin en yıkıcı insan kaynaklı çevresel etkilerin ortaya çıkması ise daha yakın bir tarihe, 200 yıl kadar önceki sanayi devrimine işaret etmektedir. Sanayileşme ile birlikte hızlı nüfus artışı, yüksek enerji tüketimi ve şehirleşme gibi faktörlerin bir araya gelmesi neticesinde geri dönüşü olmayan insan kaynaklı çevresel etkiler ortaya çıkmıştır. Bu çevresel sorunların en önde geleni iklim değişikliği ve küresel ısınmadır. Yirminci yüzyıl boyunca küresel ısınmanın çeşitli kanıtları, çeşitli bilim insanları tarafından ispatlanmıştır. İklim değişikliğinin temel sebebi olarak da atmosferde yoğunluğu artan sera gazları – özellikle karbon dioksit gazının miktarındaki artış – gösterilmektedir.

Gelişmekte olan ülkeler ve gelişmiş ülkeler bu çevresel soruna farklı bakış açılarıyla yaklaşmaktadır. Ekonomik kalkınmasını tamamlamış olan gelişmiş ülkeler, sorunun ivedilikle, uygun enerji ve çevre politikalarıyla çözümünü önerirken, gelişmekte olan ülkeler ilk olarak ekonomik kalkınmayı tamamla sonra çevreyi düzelt felsefesini benimsemişlerdir. Gelişmekte olan ülkelerdeki çevre sorunları da 1980'li yıllardan itibaren hissedilir düzeyde artış göstermektedir. Bu ülkelerdeki hava ve su kalitesi gelişmiş ülkelere kıyasla ciddi oranda düşüktür ve bu durum beraberinde çevresel sorunların yanı sıra sağlık sorunlarını da getirmektedir. Karbon dioksit sera gazları arasında en yüksek orana sahiptir ve iklim değişikliği ile küresel ısınmanın öne çıkan sebebi olarak kabul edilir. Bu sebeple bu çalışma, gelişmekte olan BRICs (Brezilya, Rusya, Hindistan ve Çin) ve MINTs (Meksika, Endonezya, Nijerya, Türkiye) ülkelerindeki karbon dioksit emisyonlarını (başka bir deyişle en büyük çevre

sorununun arkasındaki en önemli faktörü) 1990 – 2011 dönemi için ayrıştırmayı amaçlamaktadır. Böylece farklı etkenlerin karbon dioksit emisyonlari üzerindeki etkileri de araştırılmış olunacaktır. Analiz çerçevesinde Sun (1998) tarafından önerilen rafine Laspeyres endeks ayrıştırma yöntemi kullanılmış, dört önemli faktörün (ekonomik aktivite etkisi, nüfus etkisi, enerji yoğunluğu etkisi ve karbon yoğunluğu etkisi) karbon emisyonları üzerindeki etkisi tahlil edilmiştir. BRIC ve MINT ülkelerinin yanı sıra Iran için de aynı zaman aralığında emisyon ayrıştırma analizi gerçekleştirilmiş, rafine Laspeyres endeks methoduna ek olarak logaritmik ortalı Divisia endeks methodu kullanılmıştır. Böylece karbon emisyonlarına etkiyen faktörlerin yanında iki method arasında bir karşılaştırma anlizi gerçekleştirilmiştir. Ampirik bulgular, dokuz ülke için de dört etkenin farklı derecelerdeki etkilerine dikkati çekmiştir. Çalışmada ayrıca OECD tarafından önerilen ayrışım faktörü her ülke için hesaplanmış, ekonomik büyüme ile çevresel bozulma arasında bir ilişki olup olmadığı analiz edilmiştir. Sonuç olarak her ülke için ayrı ayrı politikalar önerilmiştir.

Anahtar Kelimeler: Karbon dioksit emisyonları, küresel ısınma, BRIC ülkeleri, MINT ülkeleri, ayrıştırma analizi, rafine Laspeyres endeks ayrıştırma yöntemi, logaritmik ortalı Divisia endeks yöntemi, Iran

To my beloved Mom, Dad, and Sis

ACKNOWLEDGEMENT

I would like to express the deepest appreciation to my supervisor Prof. Sevin Uğural, for her invaluable guidance and advices. I also thank Prof. Fatma Güven Lisaniler and Prof. Salih Turan Katırcıoğlu for their strong encouragement and support during my research. A bunch of thanks also goes to Assoc. Prof. Antonio Rodriguez Andres and Prof. Mehmet Balcılar, not because of thankfulness tradition but their support and motivation in my studies.

I also thank my mom Sonuç Rüstemoğlu, my dad Mehmet Rüstemoğlu, my sister Riayet Rüstemoğlu Kırıkkale, and my brother in law Kemal Kırıkkale. They are very important for me and without their endless support I cannot face the hardest situations. Finally, bunches of thanks for my excellent PhD colleagues Dr. Mary Oluwatoyin Agboola, Elham Taheri, Gizem Uzuner and for my nearest & dearest friend Fatoş Şanlıol, because of their continuing support, understanding and friendship.

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2SLS	Two-Stage Least Squares
AMDI	Arithmetic Mean Divisia Index
ANEEL	Electricity Regulatory Agency (in Brazil)
BRICs	Brazil, Russia, India, China
CGE	Computable General Equilibrium
CH_4	Methane
CO_2	Carbon Dioxide Emissions
DA	Decomposition Analysis
EIA	United States Energy Information Administration
EKC	Environmental Kuznets Curve
ETC	Environmental Technological Changes
EU	European Union
GDP	Gross Domestic Product
GHGs	Greenhouse gas concentrations
IDA	Index Decomposition Analysis
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
LMDI	Logarithmic Mean Divisia Index
LNG	Liquefied Natural Gas
MINTs	Mexico, Indonesia, Nigeria, Turkey
MLI	Modified Laspeyres Index
N_2O	Nitrous Oxide
OECD	Organization for Economic Co-operation and Development

OLS	Ordinary Least Squares
OPEC	Organization of Petrol Exporting Countries
PTC	Production Technological Changes
PV	Photovoltaic
RLI	Refined Laspeyres Index
SDA	Structural Decomposition Analysis
SEM	Simultaneous Equations Model
UNFCCC	United Nations Framework Convention Climate Change

Chapter 1

INTRODUCTION

In the early 1960s the world population was around 3 billion. As a result of the rapid population growth it exceeded 6.5 billion individuals in 2005. Furthermore, in October 2011, the world population reached to 7 billion and 31st October 2011 was celebrated as 7 billionth day. With the increase of world population the need for water, food, energy and technical supply also continued to increase. On the other hand, the rapid population growth has brought certain environmental damage to the earth. Together with this, increase in urban population and industrialization also created a risk for environmental sustainability of the world. Urbanization will continue to increase and in the near future, it is expected that 64 % of the population in developing countries will live in the cities, whereas this number is expected to be 85 % for developed countries.

Another not surprising result of the rapid population growth is the considerable increase in energy demand. For instance, world's electricity consumption is expected to double by 2030 as compared to today. Seventy-eight percent of electricity consumption in the world was generated by fossil fuels in 2011 (World Bank, 2015). The share of renewable energy sources is increasing since there is an increasing awareness about the benefits of these sources. The share of renewable energy sources in world's electric power consumption was equivalent to 19 % in 2011 (World Bank, 2015). Finally remaining 3 % belongs to controversial nuclear sources in this respect.

Increasing consumption of fossil fuels is raising the amount of greenhouse gases (especially the amount of carbon dioxide (CO_2) emissions) and this increase is the main reason of climate change and global warming according to many scientists. Global warming is the most important global environmental problem which creates a certain risk for the lives of all organisms.

Economic growth, energy efficiency and environmental sustainability are connected to each other. Some of the developed countries (including Germany, Spain, and Denmark) showed vigorous tackle for the environmental sustainability. These countries made high investment on renewable energy sources. However, the conventional resource dependence (especially coal in developing countries) is still an important issue which raises CO_2 emissions. As Lotfalipour (2010) states it is the time to change the trajectory from "develop first and then treat the pollution" to "treat the environmental pollution immediately".

According to many economists, the BRICs (Brazil, Russia, India, and China), and MINTs (Mexico, Indonesia, Nigeria, and Turkey) are expected to be the new superpowers of the world in the near future. In world's CO_2 emissions BRICs accounted for 41.2 % and MINTs accounted for 4.4 % in 2011 (World Bank, 2015). Carbon emissions are highly correlated with economic activities, energy consumption and population growth. BRICs accounted 14.3 % and MINTs accounted 4.1 % in world's real GDP in 2011 as World Bank's (2015) data indicates. Furthermore, BRICs constituted 34.2 % of world's energy consumption in 2011, where MINTs constituted 4.8 % in the same year (World Bank, 2015). Finally, BRICs constituted 41.8 % and MINTs constituted 8.6 % of world's population in 2011 (World Bank, 2015).

BRICs and MINTs are the stars of emerging market economies. Therefore while their economies are growing remarkably, the environmental impacts of their growth also gains importance. A sustainable economic growth would also help these countries to increase the life quality.

Since the changes in carbon emissions have captured the attention of researchers, scientists, public and policy makers many studies have been conducted to identify and analyze the factors which are affecting these changes. The increasing carbon dioxide emissions are accepted as the main reason of climate change and global warming, identification of the factors which are accelerating/decelerating these emissions gained importance. An analysis which is examining the CO_2 changing factors therefore put a special emphasis for policy makers to develop some environmentally sustainable projects. Furthermore, such kind of analysis (which is identifying the factors changing carbon emissions) clarifies what is ignored in terms of environmental sustainability while the countries are developing. Various interesting insights and valuable hints could be derived. A decomposition analysis therefore will be a plot for developing environmentally sustainable projects. Since the BRICs, MINTs and Iran constituted 51.5 % of world's population then derived environmentally sustainable projects could be a huge step towards to an ecological world.

Researchers generally followed four different categories of methods including input/output models, computable general equilibrium models, econometric regressions and decomposition analysis methods to identify and analyze the source of various factors on CO_2 emissions changes. Amongst these the main advantage of decomposition analysis methods is, their current versions decomposed the factors which are changing the CO_2 emissions in a perfect way, i.e., these decomposition techniques leave zero residual after the analysis.

In this study our first aim is to decompose the CO_2 emissions in BRIC and MINT countries for the period 1990-2011 using the Refined Laspeyres Index (RLI) method. To accomplish the decomposition analysis, the refined Laspeyres index (RLI) method has been utilized and the impacts of four main factors including economic activity, population effect, energy intensity and carbon intensity on CO_2 emissions have been considered. The study period has been divided into two sub-periods where the first sub-period considers from 1990 to 2000 and the second sub-period considers from 2000 to 2011.

Another popular decomposition method is the Logarithmic Mean Divisia Index (LMDI) method and the second aim of this study is to compare the results of different decomposition analysis. Accordingly a case study on Iran is conducted via both RLI and LMDI methods.

In addition to the decomposition analyses, to test whether there is a decoupling between economic growth and carbon dioxide emissions the decoupling factor (that is suggested by OECD) has also calculated for all 9 countries.

The structure of this thesis is as follows. In the next chapter the environmental issues, namely the climate change and global warming has discussed. Then, in chapter 3, a detailed overview of economic & demographic developments, energy markets and carbon dioxide emissions in BRICs and MINTs from 1990 to 2011 has provided. Chapter 4 includes a brief literature review about the studies which analyzes the changes in carbon emissions. In chapter 5, the refined Laspeyres method has analyzed. Detailed empirical findings of the decomposition analysis and decoupling factor calculations have presented in chapter 6. In the following chapter a decomposition analysis for Iran's carbon dioxide emissions conducted using both RLI and LMDI methods. Finally, chapter 8 concludes the thesis and discusses some policy implications.

Chapter 2

CLIMATE CHANGE AND GLOBAL WARMING

Environmental problems, specifically the climate change and global warming are one of the most important subjects in the world's agenda in this modern era. Many scientists and researchers agree that, the seasonal changes that are observed in earth's temperature, declining capacities of clean water sources, and the periodic changes in rains are directly related with human activities and create a certain threat for the sustainability of the lives of all organisms. Main reasons of those negative problems could be listed as fossil fuel use, rapid population growth, deforestation, high industrialization, international trade, and agriculture & livestock. All of those human activities have already created certain damage on the ecological system. Nowadays; global warming and climate change is accepted as the most important anthropogenic environmental problem.

As the United Nations Framework Convention on Climate Change (UNFCCC, 1992) states and Turkes (2007) cites, human – induced climate change is including the changes resulted from human activities, that are also other than the changes already naturally happened. Additionally Intergovernmental Panel on Climate Change (IPCC, 2007) defines the climate change as the climatic changes that are happened naturally or by humans in a certain period.

Increasing concentrations of greenhouse gases (GHGs) in atmosphere creates the greenhouse effect and this effect lead to an increase in the earth's surface temperature. As a result weather parameters are changing and this will result by extreme weather conditions such as, acid rains, floods, hurricanes and droughts.

2.1 What is the Greenhouse Effect?

Greenhouse gases are constituted by water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), ozone and some chemicals. As the Australian government (2015) states, the greenhouse effect is a natural process that keeps the surface of earth warm. Firstly, the Sun's energy reaches the atmosphere of the earth, and then some of this energy is reflected back to space and the remaining part is absorbed and re-radiated by GHGs. Earth's surface and the atmosphere are warmed by this absorbed energy. This process helps to keep our planet's temperature at approximately 33 degrees Celsius higher than otherwise be, and allowing the life on Earth to continue.

The actual problem is the enhanced greenhouse effect that is caused by the human activities (for instance, burning fossil fuels such as coal, oil and natural gas, agriculture and land clearing, urbanization, industrialization) that are raising the GHG concentrations, therefore our planet's temperature is getting warmer. According to Uzmen (2007) the natural greenhouse effect is not harmful for the living organisms; however, the enhanced greenhouse effect is a threat for the sustainable earth.

The greatest share in GHGs belongs to water vapor and its capacity of heat storage is much higher than the CO_2 and other GHGs. However, as Uzmen (2007) the changes in water vapor in the atmosphere are not affected from the human activities. In addition, the radiation capacity of water vapor is approximately 5 times greater than the other GHGs.

Various gases play a significant role for the greenhouse effect. However, CO_2 is the dirtiest one among all the GHGs, therefore the majority of scientists and researchers focused on it. The share of CO_2 in the atmosphere is 0.03 % and it has the highest share in the GHGs. Regarding the Annex I countries (Annex I countries are former Soviet countries, Eastern Europe countries, OECD countries) CO_2 accounted 81.1 % in overall GHGs where methane (CH_4) comprised 11.7 % and nitrous oxide (N_2O) comprised 5.5 % (UNFCCC, 2011). The increase in GHGs (especially in CO_2) is raising the Earth's surface temperature and this causes the global warming.

Many interesting projects have been conducted about the climate change and global warming. One of those interesting projects was called as EPICA (conducted in 2004). It was organized by the researchers of British Antarctic Survey. The information about climate change was gathered until the period that is 750000 thousand years earlier than today. The empirical findings revealed that the GHGs showed a parallel increase with industrialization that is started 200 years ago. There exists a remarkable acceleration in the concentrations of all GHGs including CO_2, NH_4 and N_2O.

Another interesting research about the evidences of global warming was conducted by the French National Center for Scientific Research in early 2000s. During 2001 – 2002 periods, the researchers analyzed the glaciers that they took from the Everest Mountain. They successfully estimated the gas amount of the glaciers. The empirical findings showed that the gas amount in glaciers was relatively low in the 20th century, if one compare with the other past centuries. This was accepted as certain evidence such as the glaciers were melting rapidly (CNNTURK, 2015).

One more notable research project was conducted in Antarctica and it revealed that after 1974, one and a half million hectares of glaciers has been lost. Furthermore, after 1995 two large glaciers (more than 5000 years old) has also been lost. In the location of the glaciers some new exotic sea organisms have been observed. These were also accepted evidences of global warming.

IPCC's additional 2013 report clearly indicates that globally averaged combined land and ocean surface temperature anomaly was equivalent to -0.35 degrees Celsius in late 19th century, where it has reached to 0.45 degrees Celsius in 2012. It is possible to conclude that the Earth's temperature has almost increased by 1 degree Celsius in 100 years. According to IPCC, the main reason of the temperature increase is the accelerating GHG concentrations that are resulted from the human activities. IPCC (2013) report also indicates that the ocean warming is largest near the surface and the upper 75 meter warmed by 0.11 degrees Celsius per decade from 1971 to 2010, on average.

2.2 Main Causes of Global Warming

Various factors contribute to the climate change and global warming. As Sahin (2007) states these factors can be listed as:

a) Ways of energy production (including thermal power plants, natural gas power plants, electricity production from other fossil fuels)

b) Transportation (including increasing number of cars, buses, trucks, planes, ships. Ninety seven percent oil dependence of the sector in the world)

c) Industrial factors (including cement factories, construction sector, petrochemical plants, refineries, iron and steel industry, chemical industry, other industries. All of these industries are consuming high energy)

d) Industrial agriculture and animal husbandry.

e) Global trade.

f) Tourism.

g) War (arms industry, the oil which is spent for war)

h) Electrical home appliances, cars, domestic heating, domestic lighting, street lighting.

i) Deforestation (reduction in CO_2 absorption capacities of trees)

j) Increase in water vapor, reduction in CO_2 absorption capacities of oceans.

2.3 Possible Consequences of the Climate Change and Global Warming

As Kocaman (2009) states, if the necessary preventions are not taken into account, the following unavoidable impacts of global warming are expected to happen.

1) More severe weather events.

2) Severe droughts in some areas of the world.

3) Heavy rains and floods.

4) Diversity changes in agricultural products.

5) Increase in the rate of spread of disease.

6) The extension of the forest fire season.

7) The increasing risk of heat waves in order to kill people.

8) Increasing tropical storms.

9) Increasing risk of wet lands extinction.

10) Deforestation.

11) Migrations.

12) Decrease in vivid varieties.

13) Ecological degradation.

14) Increase in the sea level.

15) Decrease in the sleep duration of plants.

16) Desertification.

17) Negative impacts on human health.

18) Drought, scarcity and starvation.

2.4 Different Perspectives about the Climate Change and the Global Warming

Despite the majority of researchers and scientists who accept the existence of global warming, there are also some researchers and scientists who have opposite ideas in this respect. For instance, according to William Soon (who is an astrophysicist) the gathered data for global warming covering the last 1000 years was inadequate to prove the existence of global warming (Uzmen, 2007).

Another interesting opinion is accepting the existence of global warming however, the researchers claim the temperature increase is not due to the GHG concentrations increase, it is mainly the result of the Sun's accelerating warming capacity. However, the scientific literature clearly indicated that warming capacity of the sun has not changed during the last 30 years.

Several scientists argued that climate changes periodically happened during the long history of the world and therefore the recent temperature increase could be considered as normal. During millions of years different weather conditions have been observed. For instance, 100 million years ago world's temperature was 6 degree Celsius higher than today's temperature. In the long history of the world, many climate changes, temperature inclines or declines have been observed. However, in the past climate changes took very long time to happen. For instance, glaciations took 10000 years to happen, but the global warming caused mainly by the industrial revolution took only 200 years.

Many scientists accepted that the global warming exists and it is a certain threat for our world's sustainability. Therefore, in this thesis we are analyzing the main cause of global warming, namely the carbon dioxide emissions according to the factor changes.

2.5 Global CO_2 Emission Trends

People needs are unlimited and natural sources are used to meet such needs. Furthermore, in the production process we mostly use the fossil fuels and we left the production waste directly to environment. Together with this, the world population rapidly increased and urbanization also increased. All of these activities have raised the GHG concentrations (mainly CO_2 emissions) in atmosphere therefore people started to face with the climate change and the global warming problems.

The early debate about these environmental issues has started in 1970s and world's overall CO_2 emissions have increased by 191.6 % from 1971 to 2011. The largest CO_2 emitting 20 countries and their shares in overall CO_2 emissions (in 2011) have listed in table 1.

Table 1. Shares of 20 largest CO_2 emitting countries in overall emissions in 2011

1. China	**27.9 %**	11. Canada	1.5 %
2. United States	16.4 %	12. South Africa	1.5 %
3. India	**6.4 %**	**13. Mexico**	**1.4 %**
4. Russia	**5.6 %**	14. United Kingdom	1.4 %
5. Japan	3.7 %	**15. Brazil**	**1.4 %**
6. Germany	2.3 %	16. Italy	1.2 %
7. Korea	1.8 %	17. Australia	1.1 %
8. Iran	**1.8 %**	18. France	1 %
9. Indonesia	**1.7 %**	**19. Turkey**	**1 %**
10. Saudi Arabia	1.6 %	20. Poland	1 %

The BRICs (Brazil, Russia, India and China) are the first focus countries of this study. Overall, BRICs accounted 41.2 % in world's CO_2 emissions where China comprised 27.8 % (world's largest CO_2 emitting country), India comprised 6.4 % (world's 3rd largest CO_2 emitting country), Russia comprised 5.6 % (world's 4th largest CO_2 emitting country), and Brazil comprised 1.4 % (world's 15th largest CO_2 emitting country) in the World's emissions (World Bank, 2015).

On the other hand, the MINTs (Mexico, Indonesia, Nigeria and Turkey) are the second focus countries of this study. These countries accounted 4.4 % in CO_2 emissions where Indonesia comprised 1.7 % (world's 9th largest CO_2 emitting country), Mexico comprised 1.4 % (world's 13th largest CO_2 emitting country), Turkey comprised 1 % (world's 19th largest CO_2 emitting country) and finally Nigeria only comprised 0.3 % (world's 39th largest CO_2 emitting country) in World's emissions (World Bank, 2015). Figure 1 depicts the CO_2 emissions trend in the world from 1971 to 2011.

We also analyzed the factors that are changing Iran's CO_2 emissions; therefore Iran is the third focus point of this study. In 2011, Iran was the 8th largest CO_2 emitting country in the world and it accounted 1.8 % of overall emissions.

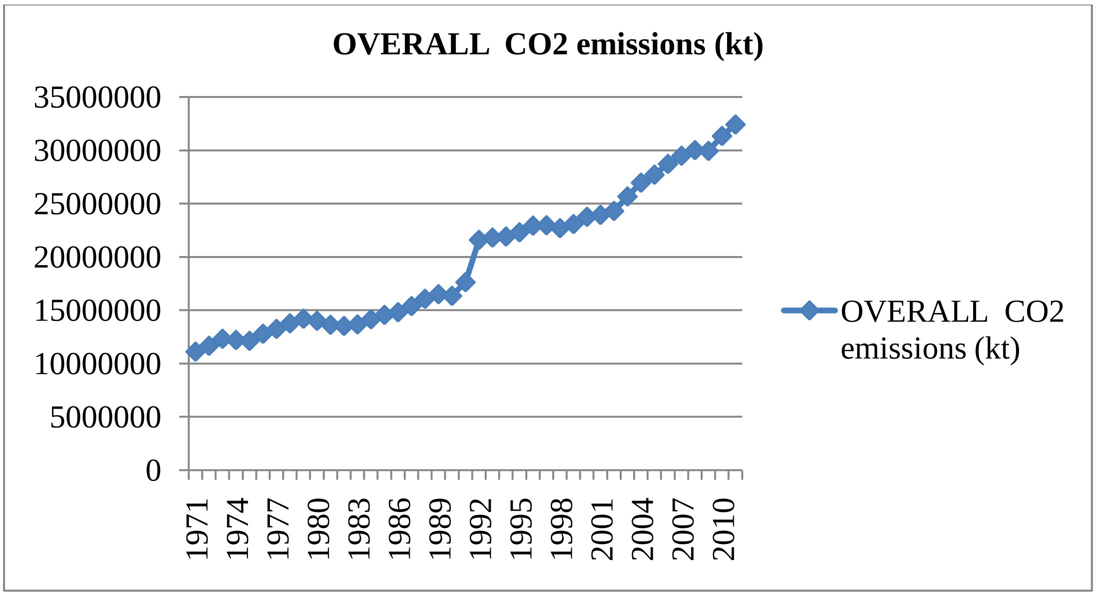

Figure 1. World's overall CO_2 emissions trend from 1971 to 2011

2.6 Factors Affecting CO_2 Emissions

Energy consumption, economic growth and population increase are the main accelerating factors of CO_2 emissions. Global trends of energy consumption, economic growth and population increase are presented in the following sections.

2.6.1 Energy Consumption

Between 1971 and 2011 world's overall energy consumption has increased by 162.2 % (World Bank, 2015). The 20 largest energy consuming countries have listed in the table below. BRICs accounted 34.2 % of world's overall energy consumption in 2011. China constituted 20.8 % (world's largest energy consuming country), India constituted 5.7 % (world's 3rd largest energy consuming country), Russia constituted 5.6 % (world's 4th largest energy consuming country), and Brazil constituted 2 %

(world's 7th largest energy consuming country) in world's overall energy consumption, in 2011 (World Bank, 2015).

On the other hand, MINTs accounted 4.8 % in world's energy consumption in the same year. Indonesia constituted 1.6 % (world's 12th largest energy consuming country), Mexico constituted 1.4 % (world's 14th largest energy consuming country), Nigeria constituted 1 % (world's 18th largest energy consuming country), and Turkey comprised 0.9 % (world's 23rd largest energy consuming country), in world's overall energy consumption, in 2011 (World Bank, 2015).

Finally, Iran was the 11th largest energy consuming country in the world by accounting 1.6 % of the overall energy consumption in 2011. Table 2 presents the 20 largest energy consuming countries in the world, in 2011.

Table 2. Shares of world's 20 largest energy consuming countries in 2011

1. China	**20.8 %**	**11. Iran**	**1.6 %**
2. United States	16.7 %	**12. Indonesia**	**1.6 %**
3. India	**5.7 %**	13. UK	1.4 %
4. Russia	**5.6 %**	**14. Mexico**	**1.4 %**
5. Japan	3.5 %	15.Saudi Arabia	1.4 %
6. Germany	2.4 %	16. Italy	1.3 %
7. Brazil	**2 %**	17.South Africa	1.1 %
8. Korea	2 %	**18. Nigeria**	**1 %**
9. Canada	1.9 %	19. Ukraine	1 %
10. France	1.9 %	20. Spain	1 %

Figure 2 describes the overall energy consumption trend in the world from 1971 to 2011.

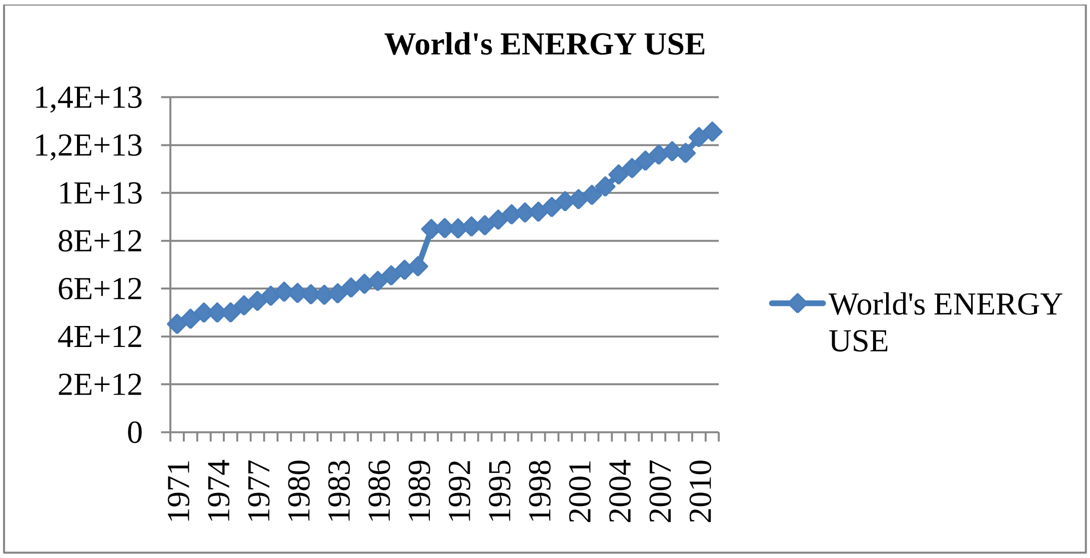

Figure 2. World's overall energy consumption trend from 1971 to 2011

2.6.2 Economic growth

Similar to energy consumption, economic activities are also related with the CO_2 emissions increase. From 1971 to 2011 world's real GDP has increased by 260.4 % (World Bank, 2015). World's largest 20 economies have been listed in the following table.

Table 3. Shares of 20 largest economies in world's real GDP in 2011

1. United States	25.8 %	**11. Brazil**	**2.2 %**
2. Japan	8.6 %	12. Korea	2.1 %
3. China	**7.9 %**	**13. Mexico**	**1.9 %**
4. Germany	5.9 %	**14. Russia**	**1.8 %**
5. United Kingdom	4.7 %	15. Australia	1.5 %
6. France	4.4 %	16. Netherlands	1.4 %
7. Italy	3.4 %	**17. Turkey**	**1.1 %**
8. India	**2.5 %**	18. Saudi Arabia	0.9 %
9. Canada	2.4 %	19. Switzerland	0.9 %
10. Spain	2.3 %	20. Sweden	0.8 %

BRICs accounted 14.3 % in world's overall real GDP in 2011 (World Bank, 2015). The share of China was equivalent to 7.9 % (China was the third largest economy in the world in 2011, however, after one year it surpassed Japan and became the second largest economy) where the share of India was equivalent to 2.5 % (world's 8th largest economy), and the share of Brazil was equivalent to 2.2 % (world's 11th largest economy) in world's overall real GDP (World Bank, 2015). Finally, the share of Russia was equivalent to 1.8 % in World's real GDP and it was the 14th largest economy in 2011. Together with this, MINTs accounted 4.1 % in world's overall real GDP in 2011 (World Bank, 2015). The share of Mexico was equivalent to 1.9 % (world's 13th largest economy), the share of Turkey was equivalent to 1.1 % (world's 17th largest economy), the share of Indonesia was equivalent to 0.7 % (world's 23rd largest economy), and the share of Nigeria was equivalent to 0.3 % (world's 42nd largest economy) in world's overall real GDP (World Bank, 2015). Finally the share of Iran in overall GDP was equivalent to 0.5 % and the country was the 28th largest economy in the world, in 2011. World's real GDP trend from 1971 to 2011 has shown in the figure below.

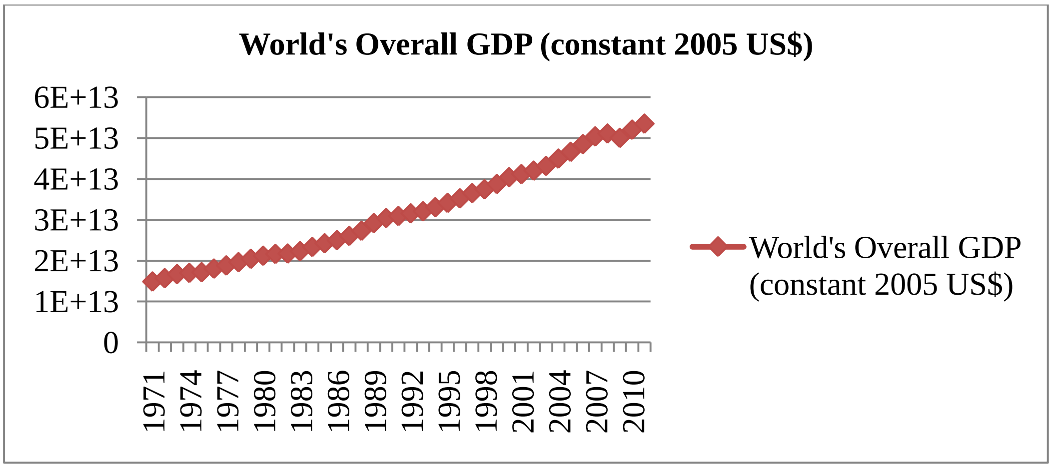

Figure 3. World's real GDP trend from 1971 to 2011

2.6.3 Population

The last major determining factor in world's increasing CO_2 emissions is the population increase. World's population has accelerated by 85 % between 1971 and 2011 (World Bank, 2015). The following table presents the most populous 20 countries in the world, in 2011.

Table 4. Shares of the most populous 20 countries in the world in 2011

1. China	**19.3 %**	**11. Mexico**	**1.7 %**
2. India	**17.6 %**	12. Philippines	1.4 %
3. United States	4.5 %	13. Ethiopia	1.3 %
4. Indonesia	**3.5 %**	14. Vietnam	1.3 %
5. Brazil	**2.8 %**	15. Germany	1.2 %
6. Pakistan	2.5 %	16. Egypt	1.1 %
7. Nigeria	**2.4 %**	**17. Iran**	**1.1 %**
8. Bangladesh	2.2 %	**18. Turkey**	**1.1 %**
9. Russia	**2.1 %**	19. Thailand	1 %
10. Japan	1.8 %	20. France	0.9 %

BRICs accounted 41.8 % in world's population in 2011. China constituted 19.3 % in world's population (world's most populous country) where India constituted 17.6 % (world's second most populous country), Brazil constituted 2.8 % (world's fifth most populous country), and Russia constituted 2.1 % (world's ninth most populous country) (World Bank, 2015).

On the other hand, MINTs accounted 8.6 % in world's population in the same year. Indonesia comprised 3.5 % (world's 4^{th} most populous country), where Nigeria comprised 2.4 % (world's 7^{th} most populous country), Mexico comprised 1.7 % (world's 11^{th} most populous country) and Turkey comprised 1.1 % (world's 18^{th} most populous country) in world's population (World Bank, 2015). Finally, accounting 1.1 % of world's population, Iran was the 17th most populous country in the world. Figure 4 presents the world's population trend from 1971 to 2011.

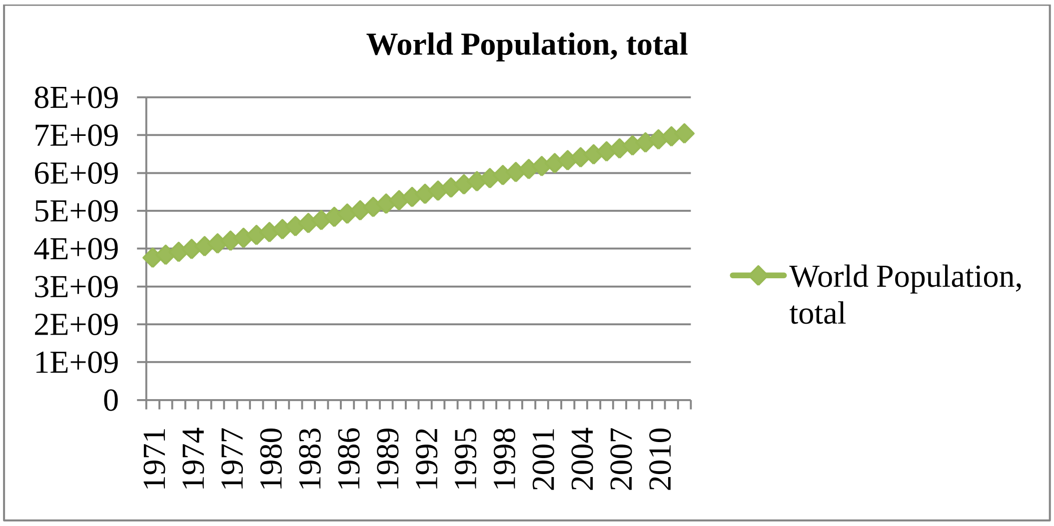

Figure 4. World's population trend from 1971 to 2011

2.7 Environmental Issues in Developing Countries

The environmental quality in many developing countries generally is poor and creates important health issues. The visitors who were visiting these countries noticed the bad environmental quality, such as their eyes were sting, the water made them sick, and their views were obscured by smog. As Greenstone and Jack (2015) states the environmental quality is poor in developing countries because of the increase of individuals' value in income is generally higher than the marginal improvements that are observed in environmental quality. Moreover, according to the authors, the marginal cost of environmental quality improvement is high in developing countries. Another main issue in developing countries is the political economy factors which undermine the effective policymaking.

Regarding air pollution Greenstone and Jack (2015) have used the data for four developing countries (including India, China, Indonesia, and Brazil) and four developed countries (including Russia, Germany, Japan and United States). Their evaluation clearly showed that the air quality was the worst in India. India was followed by China, Indonesia, Brazil and Russia, respectively in this regard. They also emphasized that the air quality was far much better in Germany, Japan and United States as compared with the developing countries. Correspondingly, the disease burden from air pollution was the highest in India. India was followed by Indonesia, China, and Brazil in this respect. According to Greenstone and Jack (2015) the disease burden from air pollution was quite lower in Russia, Japan, United States and Germany if one compare with the developing countries. Regarding water pollution, the analysts clearly stated that Indonesia has the lowest dissolved oxygen where lower dissolved oxygen implies low water quality. Indonesia was followed by India, Brazil and China in this regard. On the other hand, the water quality is quite higher in Germany, Japan, Russia and United states than the developing countries (Greenstone & Jack, 2015). Consequently the disease burden from water pollution is quite lower in US, Germany, Japan and Russia if we compare with China, Brazil, and Indonesia. As a final note India has the highest death rate due to the poor water quality.

2.8 The Kyoto Protocol

Since the concern and awareness about environmental issues caused by CO_2 and other GHG emissions has risen, the countries arranged a series of meetings to discuss and reduce the climate change problem. They firstly organized the Intergovernmental Panel on Climate Change (IPCC) and they ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1992. In 1995, the countries have decided to follow IPCC's reports for the environmental policies in the Berlin meeting. Finally the Kyoto Protocol was adopted in Japan in late 1997. According to the protocol 5 % reduction should be achieved by 2012 as compared with the 1990 level. The main strategy of Kyoto Protocol was the reduction of fossil fuel consumption to prevent the climate change and reduce the global warming. There were three different mechanisms for Kyoto Protocol, namely the joint implementation mechanism, clean development mechanism and emission trading. The ratification process for Kyoto Protocol took many years. Most of the countries (including Turkey, Russia, and Iran) were not voluntary to ratify the protocol.

In this study we are looking at the impacts of future super power countries, such as BRICs and MINTs to global warming through CO_2 emissions. We utilized the refined Laspeyres index (RLI) method to identify the emissions changing factors in these countries. In addition, Iran's carbon dioxide emissions were also analyzed by utilizing both RLI and the logarithmic mean Divisia index (LMDI) methods. Finally, the decoupling factor that is suggested by OECD to test whether there is a link between economic growth and environmental degradation.

Chapter 3

OVERVIEW OF BRICS AND MINTS

3.1 Economic and Demographic Developments in BRICs

Substantial changes have been observed in economies and demographic structures of BRIC and MINT countries during the study period. An overview of economic and demographic developments for our research countries is presented below.

Brazil is an upper middle income country and it has the 10th largest economy in the world, according to World Bank's 2013 real GDP rankings. Furthermore, it has achieved a remarkable economic growth performance during the study period. Country's real GDP has increased from 598.5 billion US$ (in 1990) to 1.13 trillion US$ (in 2011) and this corresponds to 88.3 % increase (World Bank, 2015). Accordingly, Brazil's real GDP per capita has risen from $3999 to $5721 between 1990 and 2011. Due to the remarkable economic growth and social progress approximately 26 million people have rescued from poverty between 2003 and 2013. In addition, as World Bank's data indicates the GINI coefficient has decreased to 0.54 in 2013. Brazil also achieved a spectacular success for reducing its inflation. In 1990, country's inflation was equivalent to 2950 % (country was fighting with hyperinflation) and it has successfully decreased to 6.6 % in 2011 (World Bank, 2015).

Brazil's GDP structure has also changed during the study period. The shares of agriculture and industry sectors have decreased from 8.1 % to 5.1 % and 38.7 % to 27.2 % between 1990 and 2011, respectively. However, the share of services has increased from 53.2 % (in 1990) to 67.7 % (in 2011) (World Bank, 2015). Therefore, it is possible to state that Brazil has transformed to a service based economy, in this period.

Despite the remarkable success in its economy, Brazil still has some challenges in many economic areas. For instance, GDP growth in Brazil declined to 2.1 % from 2011 to 2014, and in 2014 it was estimated as 0.1 %, i.e. the country began to show the signs of stagnation. Moreover, primary deficit in Brazil was equivalent to 0.6 % and the overall deficit was estimated as 6.7 % in 2014 (World Bank, 2015). To decrease the fiscal deficit, authorities declared the entitlement reduction measures, discretionary expenditure cuts and Treasury's support reduction to public banks and electricity sector (World Bank, 2015). Another major problem of Brazil is severe drought which creates a risk for electricity and water rationing in some parts of country. It has some possible consequences such as it may affect economic activity and prices negatively and it may pose risks to real incomes for people who are living in the poor regions. There exist regional differences in Brazil in terms of social indicators. The economic conditions of South and Southeast regions are better than the North and Northeast regions. Brazil also struggles for decreasing deforestation of the rain forests and other sensitive biomes; however the country also has some challenges to overcome, such as combining the benefits of agricultural growth, environmental protection and sustainable development.

Brazil's success in economic growth is dependent to the current adjustment and adoption of growth targeting reforms. Increasing the productivity and competitiveness is crucial for Brazil to accomplish the economic growth and development goals.

Important demographic changes in Brazil have also been observed in the period 1990 – 2011. Country's population has increased by 31.6 %, from 149.6 million individuals to 196.9 million individuals from 1990 to 2011 (World Bank, 2015). Annual population growth was calculated as 1.3 % for the research period, on average. Urbanization has also significantly increased in Brazil, from 1990 to 2011. In 1990, 73.9 % of population was living in the urban areas. However, as World Bank's data indicates, this value has increased to 84.6 % in 2011. As a final note, Brazil has the highest urban population rate among the all research countries.

Russia is a high income country and it has the 14th largest economy in the world, according to World Bank's 2013 real GDP rankings. The country always plays a significant role in the world's political, economic and historical agenda. After the collapse of Soviet Union, Russia's economy faced with contraction and the contraction continued until the late 1990s. However, after 1990s, the country achieved a remarkable economic growth and its real GDP has increased from 684.2 billion US$ (in 1992) to 948 billion US$ (in 2011) which corresponds to 38.6 % increase, overall (World Bank, 2015). Correspondingly, per capita real GDP has risen from $4601 to $6631 in the study period. Similar to Brazil, Russia also showed a remarkable success to reduce its inflation. In 1993, the inflation rate was estimated as 874.6 % however; in 2011 it has declined to 8.4 % (World Bank, 2015).

Similar to Brazil, Russia's GDP structure also showed remarkable changes between 1992 and 2011. The shares of agriculture and industry sectors have declined from 7.4 % to 4.4 % and from 43 % to 37.4 % in that period (World Bank, 2015). On the other hand, as World Bank's data indicates, the share of services has increased from 49.6 % (in 1992) to 58.2 % (in 2011).

Despite the positive changes in general economic indicators, Russia's economy is expected to contract by 3.8 % and 0.3 % in 2015 and 2016, respectively (World Bank, 2015). The main reasons of the decreasing GDP are the delayed large infrastructure projects of the Russian government, demand uncertainties and dearness of capital. Another main reason is the decreasing investment that is resulted from the private investors who are cutting back on investment programs. Trade shock, geopolitical uncertainties and the economic sanctions are the other main factors that are affecting the Russian economy, negatively.

The slump in oil prices was the main shock and it started to affect the Russian economy negatively in the late 2014. However, the Russian government and Central Bank were able to manage the shock by applying the policies swiftly. On the other hand, due to the decreasing real incomes and wages, consumption growth is expected to become negative, since 2009. For Russia, the economic impact of sanctions will likely to continue. Therefore, integration of the country with rest of the world will be helpful to overcome the negative impacts of sanctions.

The continued dearth of investment and insufficient amount of affordable credit are the two major risks for the growth of Russia's economy. Furthermore, decreasing foreign direct investment could reduce the transfer of innovation and technology that is important for Russia's economic growth potential. As clearly stated by World Bank, systematically lower investment rates will also reduce the country's growth potential. In addition, accessing to the external finance is a constraint for Russia, therefore a policy for the careful management of financial sector risks will be essential.

Interesting demographic changes have been observed in Russia, during the study period. Country's population has declined from 148.6 million individuals (in 1992) to 142.9 million individuals (in 2011) (World Bank, 2015). Annual average population growth was estimated as -0.2 % between 1992 and 2011, for Russia. Finally, 73.3 % urban population rate (in 1992) has only increased to 73.7 % (in 2011) (World Bank, 2015).

India is a lower middle income country and it has the 8th largest economy in the world, according to World Bank's 2013 real GDP rankings. India's real GDP has increased from 350.2 billion US$ (in 1990) to 1.33 trillion US$ (in 2011) (World Bank, 2015). Correspondingly, India's real GDP per capita has accelerated from $403 to $1086 in the same period (World Bank, 2015). Country's economy grew by 6.6 % annually (on average) and as the World Bank states, the growth and development of India has been one of the most spectacular achievements of recent times. As a result of this spectacular growth, India has accomplished an agricultural production revolution and it has transformed from the nation which is dependent on grain imports to a global agricultural powerhouse which is a net food exporter, nowadays. Furthermore, due to the rapid development, India's life expectancy and literacy rates have increased and the health conditions have improved. India is expected to have the largest and youngest labor force very soon.

Similar to Brazil and Russia, India's GDP structure have showed substantial changes during the study period. The share of agriculture has decreased from 29 % to 18.4 % between 1990 and 2011 as the World Bank's data indicates. On the other hand, the shares of industry and services have accelerated from 26.5 % to 33.1 % and from 44.5 % to 48.5 % from 1990 to 2011, respectively. India's inflation rate was calculated as 7.8 % on average for the entire research period.

Despite its rapid economic growth India is still a lower middle income country and it has some certain challenges. For instance, over 400 million people in India still live under the poverty line. In addition, approximately 53 million people who escaped from poverty during 2005 – 2010, are still under the risk to fall back into poverty.

One of the main issues in India is the inequity in all dimensions, namely region, caste, and gender. India's real GDP has reached to $1086 in 2011; however, in some regions of the country, real GDP per capita was less than $450. There are some disadvantaged groups in India who cannot benefit from the economic growth and women who should take their rightful place in the system. India also needs more investments for creating the jobs, housing and infrastructure in order to make cities more green and livable. Improving the quality of education is another main issue for India, since more than 90 % of the working age population has not completed the secondary education. Despite India's health indicators have improved and maternal and child mortality rates are generally low; still there are some regions in the country where the mortality rates could be compared with the world's poorest regions.

India's infrastructure also necessitates improvement. More than 30 % of rural people are not able to access to an all-weather road and only 20 % of national highways is four – lane (World Bank, 2015). The capacities of ports and airports are inadequate and the speed of trains is very low. Approximately 300 million people are not connected to national electrical grid and the manufacturing sector is small and is not developed.

India's population has accelerated from 868.9 million individuals to 1.22 billion individuals from 1990 to 2011 (World Bank, 2015). Annual average population growth rate was calculated as 1.6 % which is relatively higher than world's average. India's urban population has increased from 25.5 % to 31.2 % between 1990 and 2011 (World Bank, 2015). India is the country that has the minimum urban population rate among the whole of research countries. Despite the percentage increase in urban population seems slow, India is in a massive urbanization wave such as 10 million people move to urban areas each year for job searching and opportunity.

Starting from 1978 China has moved from a centrally planned economy to a market economy and it has experienced a spectacular growth and development. During the study period China's real GDP has increased from 525.8 billion US$ to 4.2 billion US$ that corresponds to 698.8 % increase (World Bank, 2015). Among the all research countries China has the greatest growth performance. Annual average growth rate for the Chinese economy was calculated as 10.3 % for the study period and as a result 500 million people has lifted out of poverty. Correspondingly, real GDP per capita has increased from $462.7 (in 1990) to $3121 (in 2011) and today China (as an upper middle income developing country) has the second largest economy in the world, according to World Bank's 2013 real GDP rankings. Nowadays, China plays an important role in the global economy.

Similar to the other BRIC countries, China's GDP structure showed significant changes. The share of agriculture sector has substantially declined from 26.7 % (in 1990) to 9.5 % (in 2011), where the share of industry has increased from 40.9 % (in 1990) to 46.1 % (in 2011) (World Bank, 2015). The share of services in GDP has increased more rapidly than the share of industry. In 1990, it was equivalent to 32.4; however, in 2011 it has reached to 44.3 % (World Bank, 2015). The average inflation rate for China in this period was calculated as 4.8 %. Moreover, in the years 1998, 1999, 2002 and 2009 negative inflation (i.e. deflation) has been observed in China.

Despite significant improvements observed in China, still 99 million people live under poverty. Poverty is an important challenge for the country, since it has the second largest number of poor people in the world, after India. Other fundamental challenges for China are high inequality, rapid urbanization, environmental sustainability and external imbalances. Since moving up from middle-income to high-income status is more difficult than low-income to middle-income, China should carefully adopt the significant policies, immediately. Instead of 10 % rapid growth, 7 % sustainable growth that focuses environmental quality, pollution reduction, education improvement, healthcare improvement and social protection is more preferable for China, as the authorities also confirmed.

China's population has accelerated from 1.13 billion to 1.34 billion from 1990 to 2011 (World Bank, 2015). In the same period, annual population growth rate has declined from 1.5 % to 0.5 %. Nowadays, China is facing with some demographic pressures such as, aging population and the internal migration of labor. Urban population in China has also increased remarkably. In 1990, only 26.4 % of overall population was living in the urban areas. However, in 2011 urban population rate has increased to 50.5 % (World Bank, 2015).

3.2 Economic and Demographic Developments in MINTs

Mexico is another upper middle income country that is located in Latin America – Caribbean region and it has the 13th largest economy in the world according to World Bank's 2013 real GDP rankings. Country's real GDP has increased from 561 billion US$ to 991.6 billion US$ in the 1990 – 2011 interval. Consequently, per capita real GDP has accelerated from $6525 to $8307.6 in the same period (World Bank, 2015). Annual average economic growth rate for the research period was calculated as 2.8 % from 1990 to 2011.

The share of agriculture in Mexico is relatively smaller than the other MINT countries. It has decreased from 7.8 % (in 1990) to 3.4 % (in 2011) as World Bank's data indicates. On the other hand the share of industry has significantly risen from 28.4 % to 36.3 % between 1990 and 2011. Furthermore, the share of services showed a small decrease (from 63.7 % to 60.3 %) from 1990 to 2011 (World Bank, 2015). Mexico also showed a remarkable success to reduce its inflation. The inflation rate has decreased from 26.6 % to 3.4 % during the research period.

Country's economic growth has been lower than its expected value between 2010 and 2012 thus it could not help to reduce the poverty. The main reason of this, there was no enough jobs to pay the adequate wages created in recent years. As a result of the increased female labor force participation rate and net-zero migration to the US, labor force increased in Mexico and the economy could not successfully absorb these impacts. However, public transfers and low dependency ratio have helped to reduce the poverty.

Mexico’s economic growth is showing a recovery after two years of cyclical weakness. As the World Bank states, country’s GDP has increased by 1.4 % and 2.1 % respectively in 2013 and 2014. Economic growth was resulted by manufacturing exports, largely from the double digit increase in the automobile sector for the fifth consecutive year. Domestic demand is low in Mexico, while private consumption is accomplished by low consumer confidence and low wage growth. Mexico’s economic growth is expected to increase until 2017. Significant growth in US will help to increase Mexico’s manufacturing exports that will also be expected to recover low domestic investment and consumption.

Mexican government should apply some policies in the areas of labor, education, competition policy, financial sector, telecommunications and energy legislation, increasing productivity, competitiveness and potential output growth. Privatization of the energy sector will help to increase the economic growth rate and it will also raise the productivity of oil and gas sectors.

Country’s population was around 86 million in 1990 and by increasing 38.7 % it has reached to 119.4 million in 2011 (World Bank, 2015). Annual population growth was calculated as 1.6 % on average, in this period. In addition, urban population has accelerated from 71.4 % to 78.1 % in Mexico, between 1990 and 2011 (World Bank, 2015).

Indonesia is a lower middle income country that is located in South Asia & Pacific region and it has the 20th largest economy in the world, according to the World Bank's 2013 real GDP rankings. The country also showed a remarkable growth during the study period. Indonesia's real GDP has accelerated from 150 billion US$ (in 1990) to 402.4 billion US$ (in 2011) (World Bank, 2015). As a result of the considerable economic growth (168.1 % GDP increase in 1990 – 2011) real GDP per capita has increased to $1650.5 (in 2011) from $840.2 (in 1990) (World Bank, 2015). Today, Indonesia is the 4th most populous country in the world and it's also a member of G20. The major great success in Indonesia has achieved for poverty reduction. In 2014, the poverty rate was estimated as 11.3 %, where this value was more than its double only 15 years ago.

Indonesia's GDP structure has also changed from 1990 to 2011. In this period the share of agriculture has decreased from 19.4 % to 13.8 %, where the share of industry has increased from 39.1 % to 44.8 % (World Bank, 2015). The share of services has not changed considerably. During the research period it remained around 41.4 %.

Despite its remarkable success in poverty reduction still approximately 28 million Indonesians live below the poverty line out of 252 million individuals. Indonesia currently fails to accomplish some Millennium Development Goals (MDG) targets. For instance, the country still suffers 228 infant deaths for every 100000 live births and 190 maternal deaths for every 100000 live births. The aim of Millennium Development Goals is to reduce the infant deaths at most to 105 for every 100000 live births.

Indonesia began to implement some economic development plans where they are spanning from 2005 to 2025. The development plans are segmented into 5 year medium – term plans where each of them different development targets have. The current medium term development plan that covers 2015 to 2020 is targeting the developments on infrastructure and the improvements of social assistance programs in education and healthcare. Therefore, each medium – term development plan considers shifts in public spending and these allow more investments that are directly affecting the poor and near-poor people.

Population of Indonesia has increased from 178.6 million to 243.8 million from 1990 to 2011 (World Bank, 2015). This change corresponds to 36.5 % increase. Annual population growth rate was calculated as 1.5 %, on average, for the research period in Indonesia. Urban population has also significantly increased from 30.6 % to 50.7 % between 1990 and 2011 (World Bank, 2015).

Nigeria is located in Sub – Saharan Africa and it is the most populous country in the continent. Together with this, Nigeria is the greatest oil exporter in Africa and it has the largest natural gas reserves in the continent. Furthermore, Nigeria is still a lower middle income country and it has the 42nd largest economy in the world, according to World Bank's 2013 real GDP rankings. Real GDP in Nigeria has accelerated from 56.4 billion US$ to 166.8 billion US$ between 1990 and 2011 and this is equivalent to 195.6 % increase. Consequently real GDP per capita has risen from $590 to $1015 from 1990 to 2011 (World Bank, 2015). Despite its remarkable growth performance, Nigeria is still far behind of the other MINT countries. For research period, annual growth rate was calculated as 5.5 % on average.

GDP structure of Nigeria has showed substantial changes from 1990 to 2011. The share of agriculture has declined from 31.5 % to 22.3 % (World Bank, 2015). The sharp decline has observed in the Nigeria's industry sector. The share of industry has decreased from 45.3 % to 24.8 % between 1990 and 2011 (World Bank, 2015). However, the share of services in Nigeria's economy has increased very rapidly. In 1990, the share of services was equivalent to 23.2 %, and in 2011, this value has reached to 52.9 % (World Bank, 2015).

Nigeria achieved a remarkable success to reduce inflation. As World Bank (2015) states the headline inflation decreased from 12.2 % to 8.1 % from the end of 2012 to the end of 2014. Similarly, the core inflation declined from 13.7 % to 6.2 % and the food inflation dropped to 9.2 % from 10.2 % in the same period. Poverty rate also decreased from 32.7 % to 30.4 % between 2010 and 2014 (World Bank, 2015). Nigeria also has a large potential to achieve a prosperous economy and to reduce poverty and inequality further and improve the quality of health care, education and infrastructure.

Oil and gas GDP was declined by 13.1 % and 1.3 % in 2013 and in 2014 respectively. The main reason of the declined oil GDP was the oil theft in the Niger Delta region of the country. Another major problem is the sharp decrease in oil prices that is started to observe in the third quarter of 2014. It was also the main reason of the challenges to the country's external balance and public finances. Oil accounts approximately 90 % of exports, therefore the trade shock put strong downward pressure on the national currency. Thus, Naira (the national currency of Nigeria) depreciated by 30 % and the gross foreign reserves has decreased from 39 billion US$ (in July 2014) to 30 billion US$ (in March 2015) (World Bank, 2015).

The Nigerian government followed a prudent fiscal policy in recent years. As a result, fiscal deficit and public sector debt have declined. Nigeria also applied a careful monetary policy which aimed to stabilize the Naira. Therefore, the inflation rate of the country has also decreased.

Nigeria's population has accelerated from 95.6 million to 164.2 million during the study period (World Bank, 2015). Annual population growth rate was calculated as 2.6 % on average and this value is much greater than BRIC and other MINT countries. Urban population has also risen from 29.7 % (in 1990) to 44.4 % (in 2011) (World Bank, 2015). Furthermore among the 9 research countries, Nigeria has the second largest rural population rate after India.

Turkey is an upper middle income country that is placed in between Central Asia and Europe and it has the 17^{th} largest economy of the world according to World Bank's 2013 real GDP ranking. Between 1990 and 2011, country's real GDP has increased from 270.6 billion US$ to 614.6 billion US$, that corresponds to 127.1 % increase. Accordingly real GDP per capita has increased from $5012.9 (in 1990) to $8413.3 (in 2011). In addition, Turkey became one of the largest middle – income partners of the World Bank Group (WBG). Turkey also achieved a remarkable success to reduce its inflation, as Brazil and Russia did. Inflation was equivalent to 106 % in 1994; however, it has declined to 6.5 % in 2011 as World Bank's data indicates. Turkey's economy suffered from recessions in 1994, 1999, 2001 and 2008.

Turkey's economic growth slowed down during the 2008 global crises however, labor markets have recovered fast after the crisis. Turkey also became more competitive, during the past decade the country moved 16 spots ahead to number 43 in the World Economic Forum's Global Competitiveness Index. As a result of the fundamental reforms that are carried out after 2001, Turkey's financial sector remained relatively strong during the time of the financial crises.

Similar to the other MINT countries Turkey's GDP structure has also changed significantly over 1990 – 2011. The share of agriculture has declined from 18 % to 9.1 % between 1990 and 2011 (World Bank, 2015). The share of industry has slightly decreased from 32.2 % to 27.5 % in the same period. On the other hand, the share of services showed a considerable increase from 49.8 % to 63.5 % from 1990 to 2011 (World Bank, 2015).

Turkey's main challenges for sustainable growth are increasing productivity and competitiveness. Together with this, the country should reduce its reliance on foreign savings. Turkey considers getting support from the World Bank Group to achieve its development goals. Strategic areas of the implemented development program contain health, education, public finances, energy, climate change, private sector development, municipal services and environmental management.

Turkey's population has accelerated from 54 million (in 1990) to 73.1 million (in 2011) and this is equivalent to 35.3 % increase (World Bank, 2015). Annual population growth rate was calculated as 1.4 % for the period 1990 – 2011 and the share of urban population has increased from 59.2 % to 71.3 % in the same time interval.

3.3 Comparison of the Economic and Demographic Developments in BRICs and MINTs

Regarding BRICs, China is the country that experienced the most spectacular economic growth during the study period. Its economy has expanded by 698.8 %. China is followed by India in this regard. India's economy has expanded by 278.6 % between 1990 and 2011. Brazil's economic growth could be also considered as remarkable (88.3 % in the same period). On the other hand, the Russian economy suffered from crisis during the 1990s, therefore, its 38.6 % overall economic growth is relatively smaller than the other BRIC countries. Figure 5 shows the real GDP changes in BRICs over 1990 – 2011.

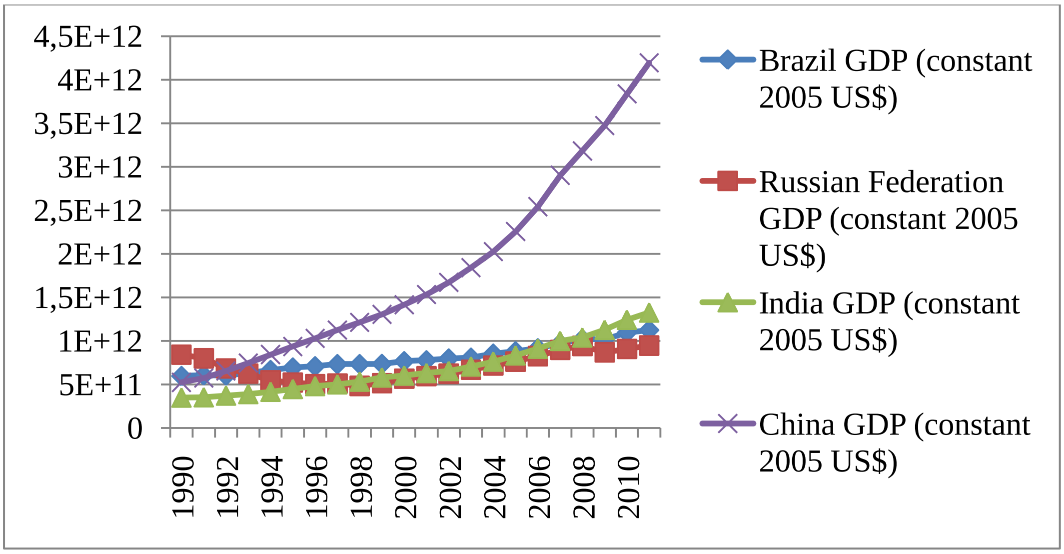

Figure 5. Real GDP in BRICs over 1990-2011

Consequently, China's real GDP per capita has also showed a rapid pace of growth. In India and Brazil, the real GDP per capita has also considerably increased. On the other hand, Russia's real GDP per capita has sharply declined in 1990s. After 1998, it has followed a rapidly increasing trend. Figure 6 depicts the changes of real GDP per capita in BRICs from 1990 to 2011.

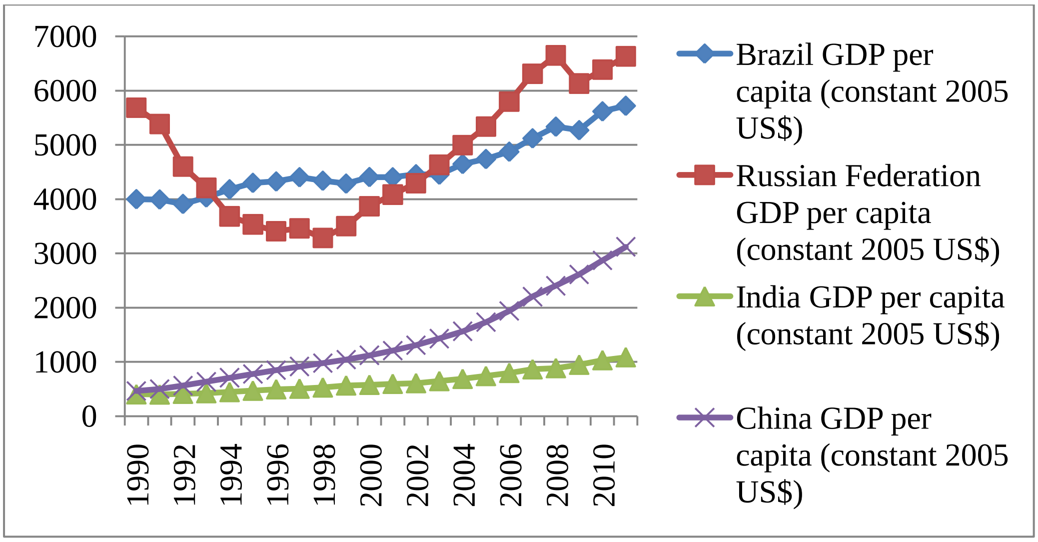

Figure 6. Real GDP per capita in BRICs over 1990-2011

India's population has showed the fastest growth in the study period. Country's population has risen by 40.5 % from 1990 to 2011. Brazil has followed India in this regard. Its population has accelerated by 31.6 %. Besides it is the most populous country in the world, China's population has only increased by 18.4 % between 1990 and 2011. China already showed the signs of aging problem and in the near future it is expected that India will become the most populous country in the world. Russia's population has declined by 3.9 % from 1992 to 2011. Similar to China, Russia also has an aging problem. Figure 7 describes the population changes in BRICs from 1990 to 2011.

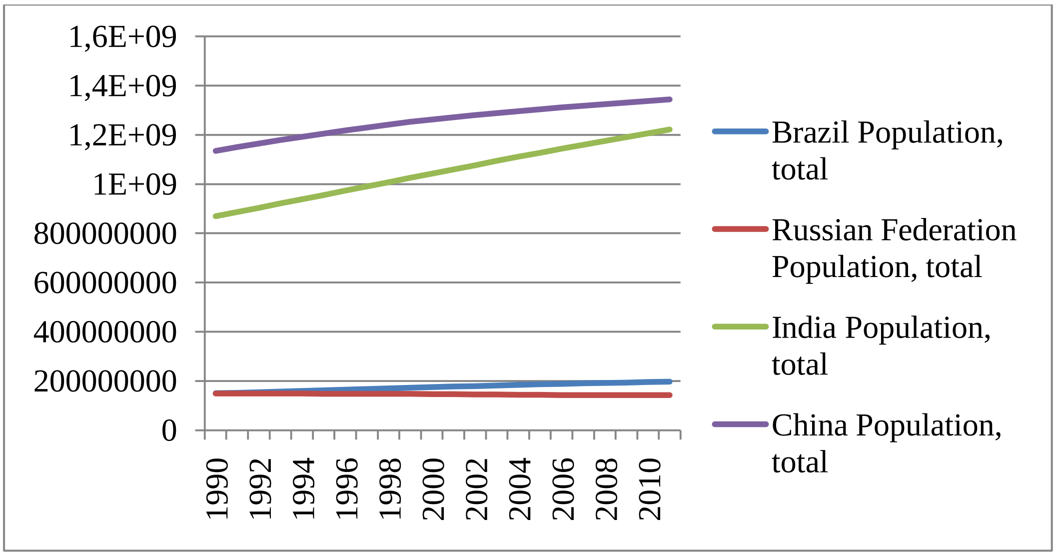

Figure 7. Population trend in BRICs over 1990-2011

Urbanization also plays a significant role in CO_2 emissions acceleration. Similar to the other concepts, BRICs has different dynamics in urban population changes. Brazil is the country that has the highest urban population rate. Almost 85 % of people live in cities in Brazil. It has been followed by Russia; however, in Russia urban population rate followed a constant trend during the study period. Urban population rate has also increased remarkably in China. Recently, approximately 50 % of the population lives in urban areas. In BRICs, India is the country that has the highest rural population rate. Figure 8 describes the trends in urbanization in BRICs during the research period.

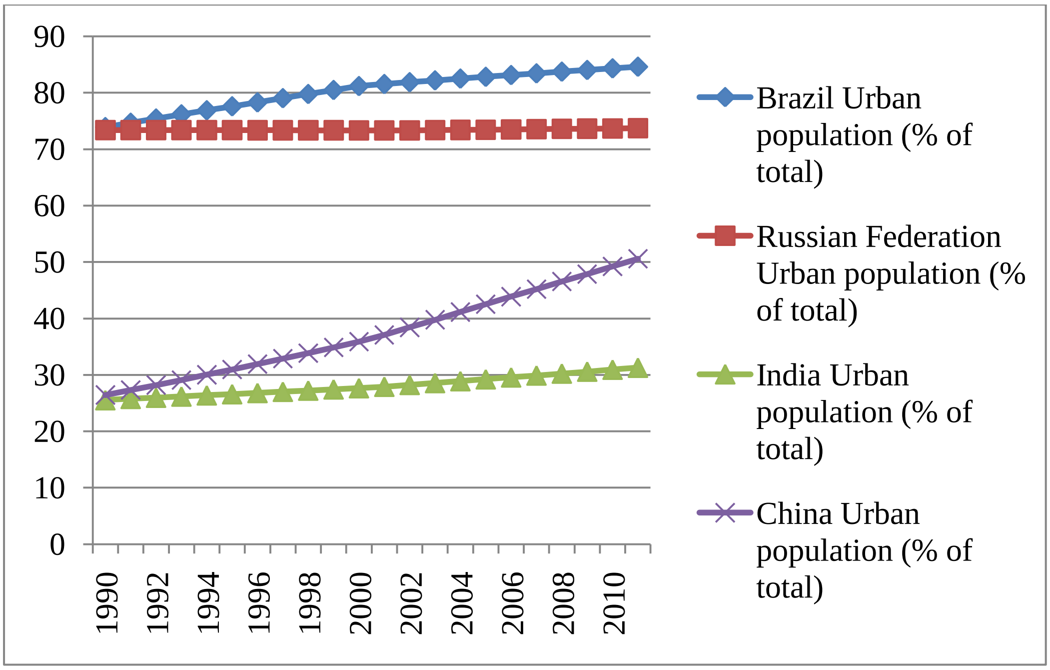

Figure 8. Urban population rate in BRICs over 1990-2011

Regarding MINTs, Nigeria showed the fastest economic growth performance. Between 1990 and 2011, country’s real GDP has increased by 195.6 %. However, Nigeria is still far behind of the other MINT countries in GDP ranking. Nigeria is followed by Indonesia (168.1 % increase in real GDP) and Turkey (127 % increase in real GDP) in this regard. Finally Mexico’s real GDP has increased by 76.5 % in the study period. Figure 5 shows the real GDP changes in MINTs from 1990 to 2011.

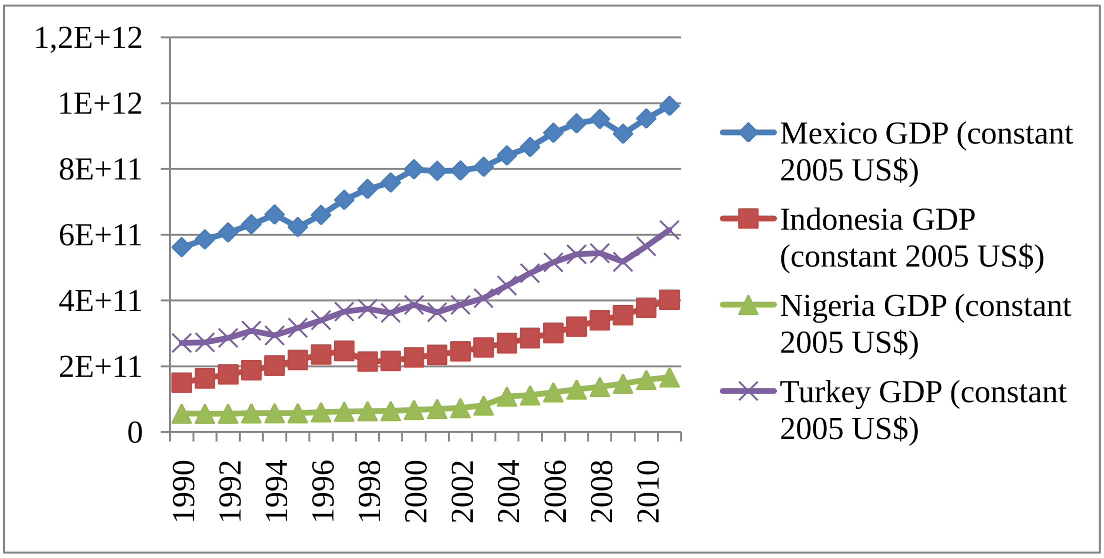

Figure 9. Real GDP in MINTs over 1990-2011

Accordingly real GDP per capita has increased in every MINT countries. Mexico and Turkey are the two upper middle income countries and the gap between their real GDP has closed. Per capita real GDP has also increased remarkably in Indonesia and Nigeria; however, these two countries have followed the other two from far behind. Indonesia and Nigeria are still considered as lower middle income countries. Figure 6 indicates the changes in real GDP per capita in MINTs from 1990 and 2011.

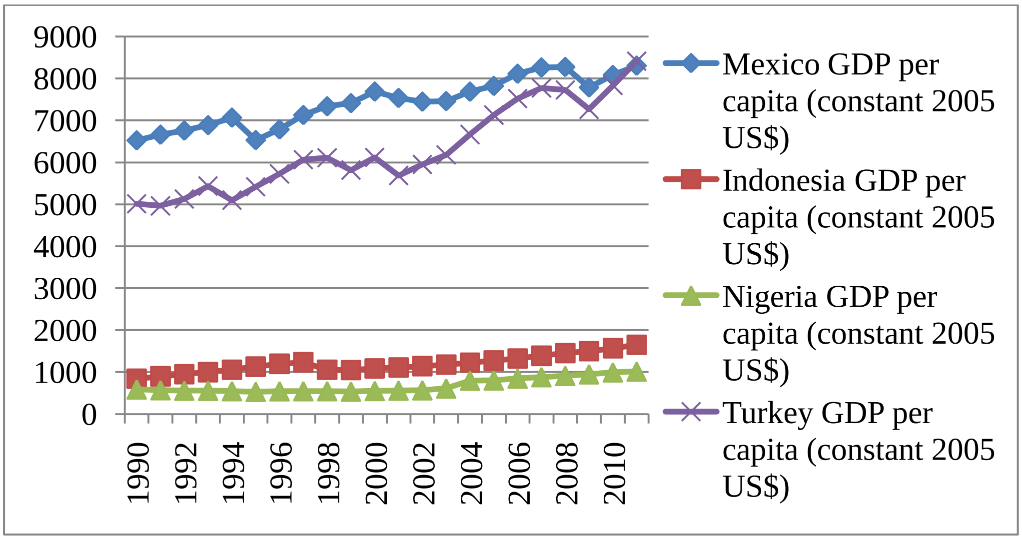

Figure 10. Real GDP per capita in MINTs over 1990-2011

In the study period, Nigeria has showed the highest population growth. Its population has increased by 71.7 % from 1990 to 2011. On the other hand, the population growth in Mexico, Indonesia and Turkey were very close to each other. Mexico's population has increased by 38.6 %, where Indonesia's population has increased by 36.5 % and Turkey's 35.3 %. Figure 7 depicts the population changes in MINTs from 1990 to 2011.

Regarding urbanization, MINTs have showed similar characteristics during the research period. Mexico has the highest urban population rate in MINTS. As World Bank's data indicate more than 78 % of the population lives in urban areas in 2011, in Mexico. Turkey has followed Mexico in this regard (71 % of the population lives in the cities). Indonesia's urban population rate has accelerated from 30.5 % to 50.7 % in the research period. Finally, Nigeria is the country that has the lowest urban population rate (44.3 % in 2011) in MINT countries.

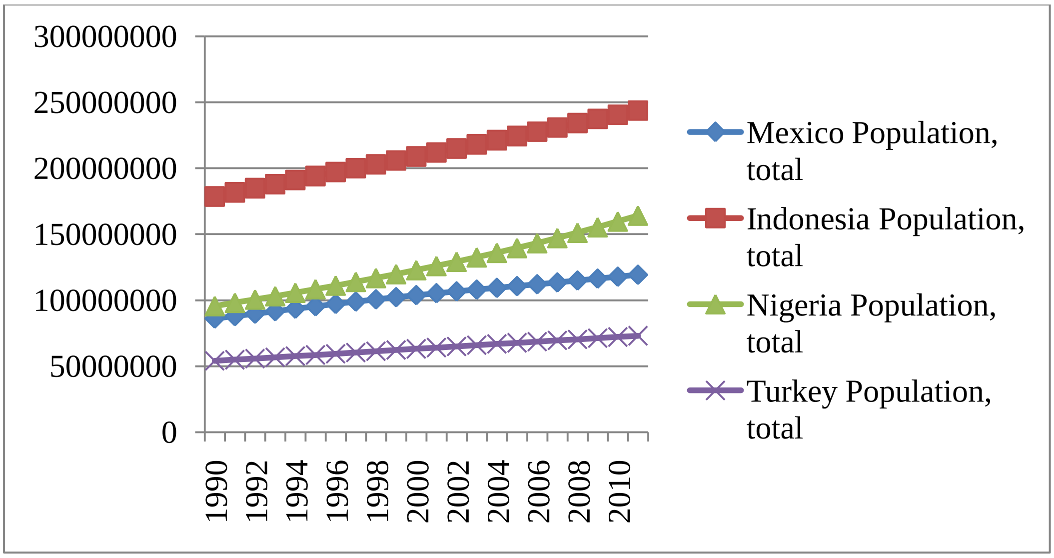

Figure 11. Population trend in MINTs over 1990-2011

Figure 12 describes the urban population rates in MINTs from 1990 to 2011.

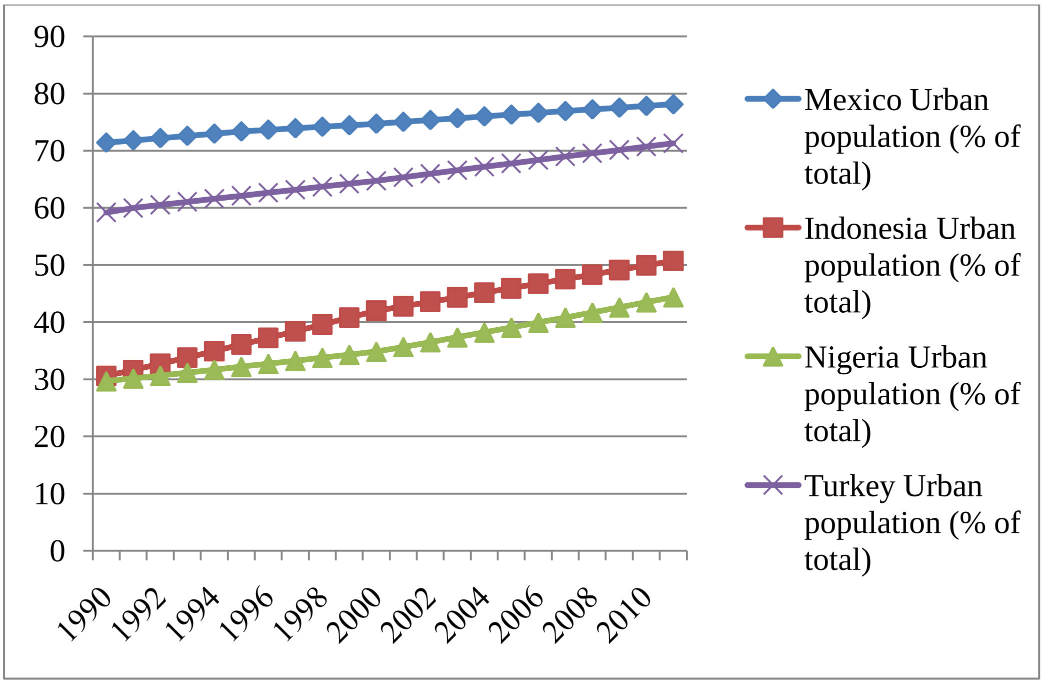

Figure 12. Urban population rate in MINTs over 1990-2011

3.4 Energy Markets in BRIC Countries

Energy always plays an important role on the world's agenda. It always has a strategic, political, and economic importance for the countries. Similar to the other countries, energy is also essential for the developing countries to achieve their development goals. Additionally, energy use is also significantly related with the CO_2 emissions. Energy use also has certain environmental impacts; therefore, in this section we analyzed the energy markets in BRIC and MINT countries.

According to the US Energy Information Administration (EIA), Brazil is the 8th largest energy consumer and 10th largest energy producer in the world. Brazil's energy production has increased from 104.1 thousand KT of oil equivalent to 249.2 thousand of oil equivalent between 1990 and 2011 (World Bank, 2015) that corresponds to 139.3 % increase. Brazil's overall energy consumption has considerably increased from 140.2 thousand KT of oil equivalent to 270 thousand

KT of oil equivalent in the same period (World Bank, 2015). The increase in energy consumption in Brazil was calculated as 92.6 %. Consequently, per capita energy use has accelerated from 936.9 kg of oil equivalent to per capita to 1371.1 kg of oil equivalent to per capita, between 1990 and 2011 (World Bank, 2015). Brazil's energy production has increased faster than the energy consumption; however, still the country is an energy importer. Figure 13 depicts the energy consumption and production in Brazil from 1990 and 2011.

Oil and the other liquids are the main source of Brazil's energy consumption and they are followed by natural gas and hydro sources (EIA, 2015). As we mentioned before Brazil's energy production showed a substantial increase. The country has raised its oil and ethanol production. According to EIA (2015) oil accounted 41 % and ethanol accounted 19 % of overall energy production in Brazil. One of the long term goals of the Brazilian government is to increase the oil production further and become one of the largest oil producers in the world. Brazil's oil production is offshore in very deep water (more than 91 %) and also consists of mostly heavy grades. In addition Brazil was the largest petroleum and other liquid producer in South America, in 2013, as the EIA (2015) states.

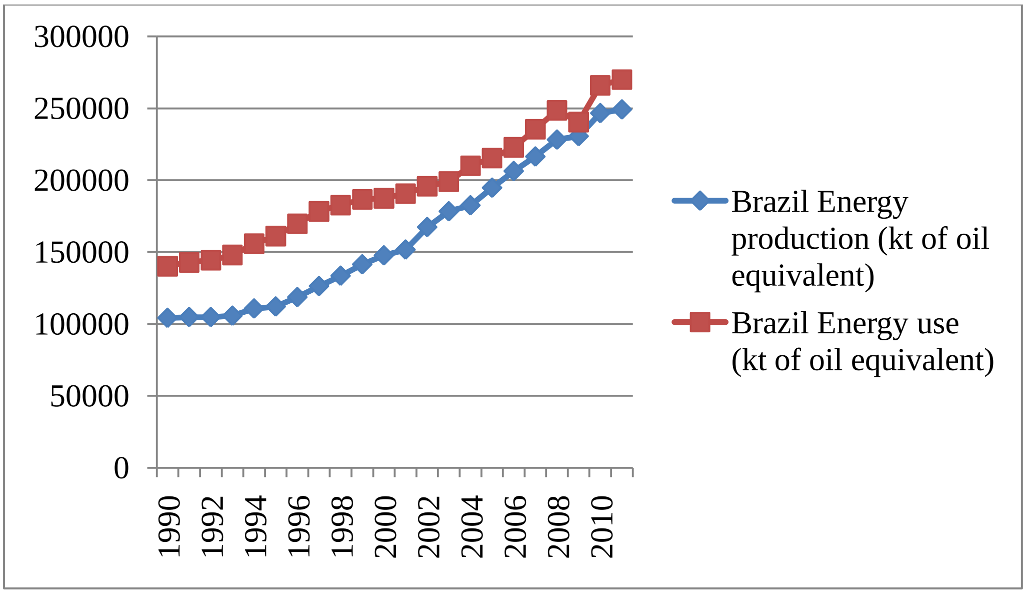

Figure 13. Brazil's energy production and consumption over 1990-2011

The United States was the major customer of Brazil's crude oil until 2013. However, in that year, as a result of its increasing demand, China became the leading importer of Brazil's crude oil (The US accounts 110000 bbl/d where China accounts 115000 bbl/d of crude oil imports) as EIA (2015) indicates. India has the third position in this regard, accounts 49000 bbl/d of crude oil imports. Natural gas accounted only 8 % of Brazil's overall energy use, however; it has the second largest reserves in South America. Natural gas reserves located primarily offshore in the Compos Basin. As EIA (2013) states, Brazil imported 599 bcf of natural gas in 2013 and Bolivia is the main source of these imports.

Electricity is the secondary energy and following the US and Canada, Brazil has the third – largest electricity sector in Americas. Brazil's overall electricity consumption has increased from 217.6 billion KWH to 480.1 billion KWH in the study period and that corresponds to 120.6 % increase (World Bank, 2015). Consequently, per capita electricity consumption has accelerated from 1454.5 KWH to 2438 KWH from 1990 to 2011 (World Bank, 2015). Brazil also achieved a remarkable success in electricity accession. In 1990, 91.9 % of the population was able to access electricity and this value has successfully risen to 98.9 % in 21 years. Brazil's electricity production has increased considerably from 222.8 billion KWH (in 1990) to 531.8 billion KWH (in 2011) and this corresponds to 138.6 % increase (World Bank, 2015). If one compare with the electricity use, it is possible to state that Brazil's electricity production has increased faster. Figure 14 depicts the electricity consumption and production in Brazil between 1990 and 2011.

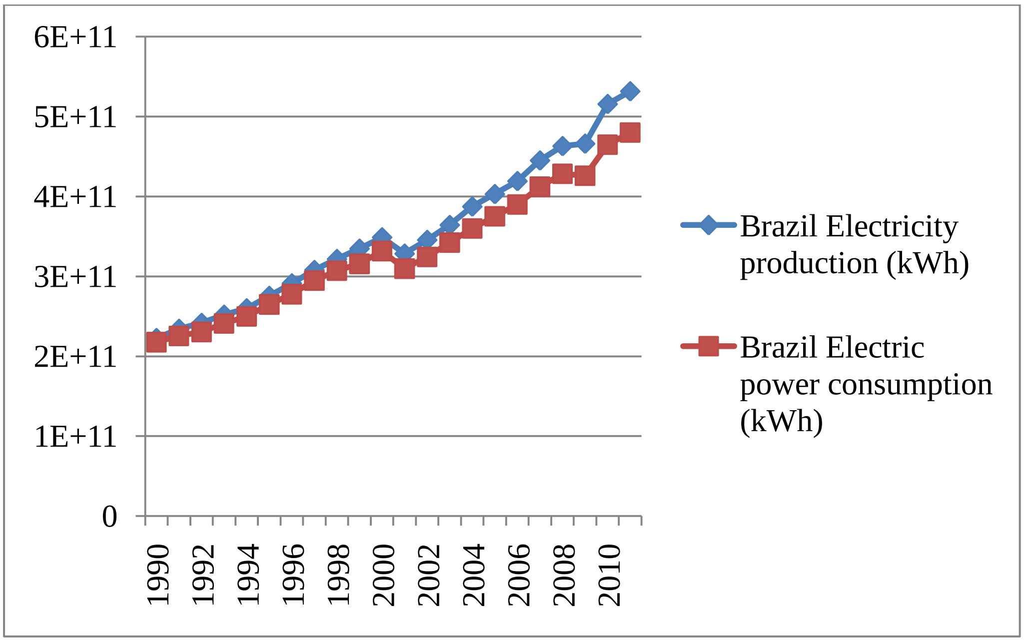

Figure 14. Electricity production and consumption in Brazil over 1990-2011

In 2011, 80.6 % of Brazil's electricity production was generated from the hydro sources. Other renewable sources are also important for Brazil's electricity generation. Approximately 6.6 % of the electricity demand was generated from the renewable (other than hydro) sources, in 2011. Natural gas, nuclear and oil sources accounted 4.7 %, 2.9 % and 2.8 % in Brazil's electricity production in the same year, respectively (World Bank, 2015). On the other hand, coal sources only accounted 2.3

% in electricity generation, in Brazil, in 2011. Brazil is also planning to increase its hydro capacity further.

As EIA (2015) states Russia is the second largest dry natural gas producer and third largest producer of liquid fuels producer in the world. In addition, the country has the largest natural gas reserves and it is one of the most important oil and natural gas producer and exporter of oil and gas in the world. Russia's economy generally dependent to energy exports where oil and gas revenues constituted 52 % of federal budget revenues and more than 70 % of total exports in 2012, as PFC Energy states. As an additional note, Russia is the third largest oil producer in the world, following Saudi Arabia and the US (EIA, 2015). Furthermore, the country produces only modest amount of coal although it has significant coal reserves. Moreover, Russia is the third largest nuclear power generator in the world and it has the fourth largest installed capacity of the nuclear power.

Russia's overall energy production has increased from 1.1 million KT of oil equivalent (in 1992) to 1.3 million KT of oil equivalent (in 2011) and this change corresponds to 15.5 % increase (World Bank, 2015). On the other hand, the energy use in Russia has decelerated from 795.6 thousand KT of oil equivalent (in 1992) to 730.9 thousand KT of oil equivalent (in 2011) and this change corresponds to 8.1 % decrease. As a result, per capita energy consumption has also declined from 5351.2 kg of oil equivalent to 5113.2 kg of oil equivalent between 1992 and 2011 (World Bank, 2015). Figure 15 describes the energy production and consumption in Russia, from 1992 to 2011.

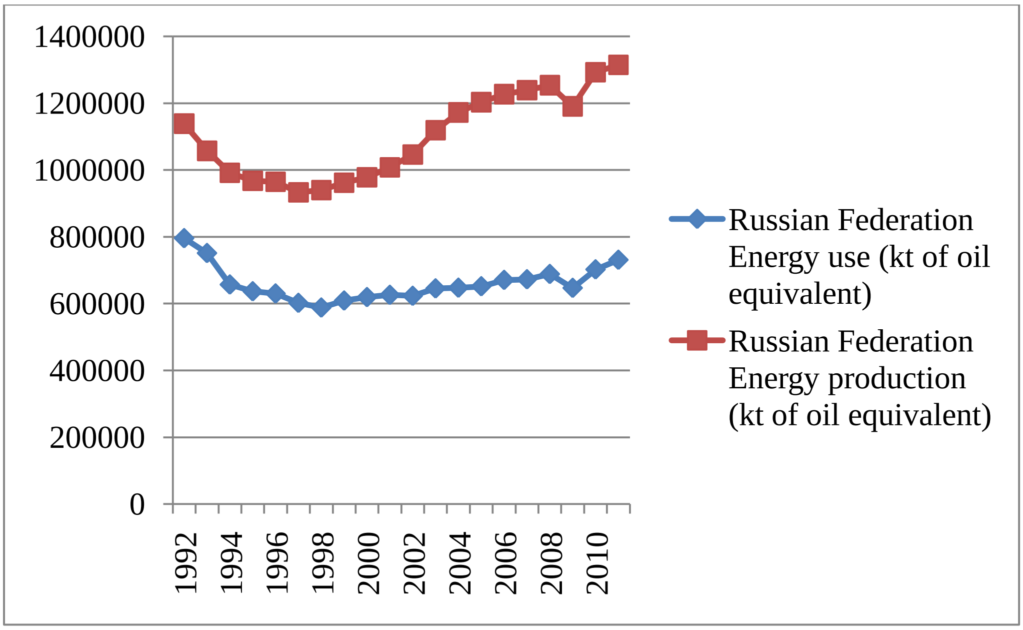

Figure 15. Russia's energy production and consumption over 1992-2011

As the EIA (2015) states 56 % of Russia's energy consumption has accounted by natural gas, 19 % by petroleum and 15 % by coal in 2011. The top five customers of Russia's crude oil were the Germany, Netherlands, China, Poland and Belarus (EIA, 2015). Major destinations of the Russia's natural gas exports in 2012 can be listed as Eastern Europe, Germany, Turkey, and Italy (EIA, 2015).

Russia is one of the largest electric power producers and consumers in the world. Russia's electric power consumption has increased from 908.1 billion KWH (in 1992) to 927.2 billion KWH (in 2011) and this corresponds to 2.1 % increase (World Bank, 2015). As a result, per capita electricity consumption has increased from 6107.5 KWH to 6486 KWH between 1990 and 2011 (World Bank, 2015). Russia's electricity production has increased faster than the consumption in the same time interval. In 1992 overall electricity production of the country was approximately equivalent to 1.008 trillion KWH and this value has reached to 1.05 trillion KWH in 2011 (World Bank, 2015). This change corresponds to 4.1 % increase in electricity production. Figure 16 describes the electricity production and consumption in Russia from 1992 to 2011.

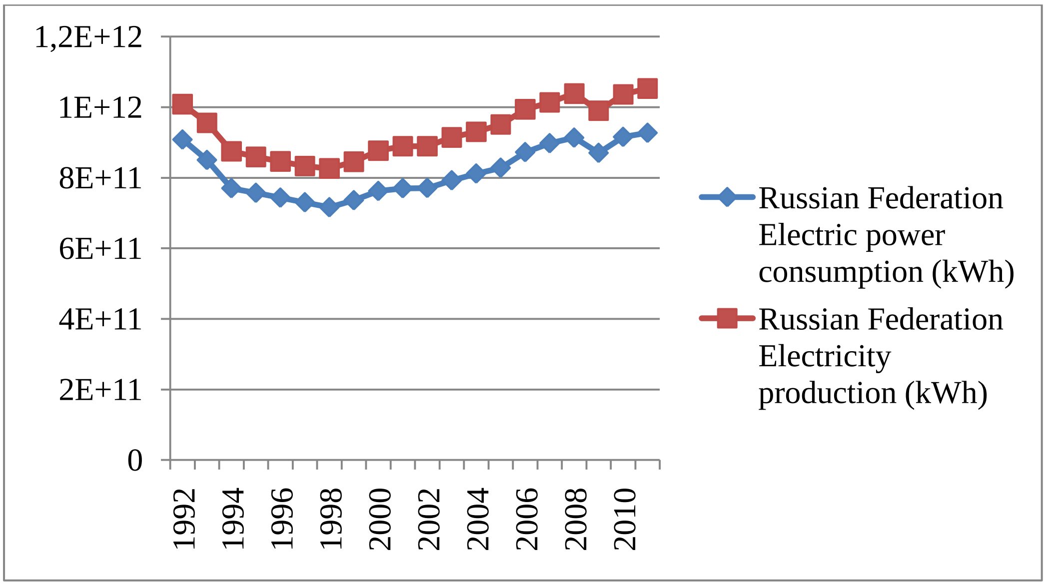

Figure 16**.** Electricity production and consumption in Russia over 1992-2011

Natural gas is the main source is the main source of Russia's electricity production. As the World Bank data indicates 49.3 % of electricity demand was generated from the natural gas reserves in 2011. Natural gas was followed by nuclear (16.4 %), hydro (15.8 %) and coal (15.5 %) sources (World Bank, 2015). On the other hand oil sources were accounted 2.6 % in Russia's electricity generation. Furthermore, despite the country's potential, Russia generated only 0.05 % of its electricity from the renewable (other than hydro) sources. Russia's access to electricity was 100 % during the entire study period (World Bank, 2015).

Following China, the United States and Russia, India was the fourth largest energy consumer in the world, in 2011 (EIA, 2015). The country has remarkable fossil fuel sources however; it has become more dependent on energy imports in recent years.

India has a dynamic growth and modernization in the recent decades therefore the need of energy supply continues to grow. India's energy production has accelerated from 291.8 thousand KT of oil equivalent (in 1990) to 541 thousand KT of oil equivalent (in 2011) and this change corresponds to 85.4 % increase (World Bank, 2015). On the other hand, the energy use in country has increased faster than the energy production. India's energy use has accelerated from 316.7 thousand KT of oil equivalent to 749.4 thousand KT of oil equivalent between 1990 and 2011 (World Bank, 2015). Correspondingly, per capita energy use has risen from 364.5 kg of oil equivalent to 613.7 kg of oil equivalent in the same period (World Bank, 2015). India's energy imports showed a substantial increase as figure 17 indicates.

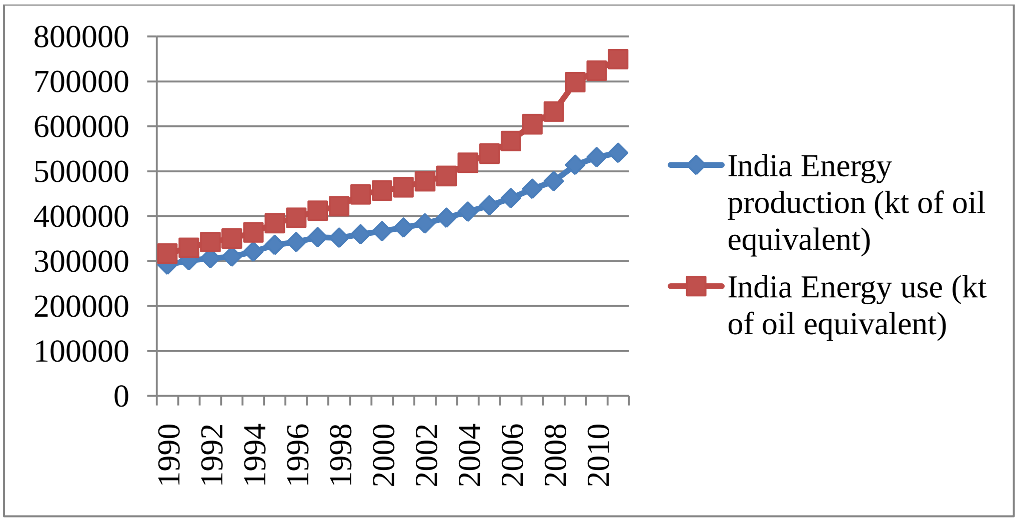

Figure 17. India's energy production and consumption over 1990-2011

As the EIA (2015) states, coal is the major source of the energy consumption in India. In 2012, it accounted 44 % of overall Indian energy use. Biomass & waste and petroleum & other liquids (each of them) accounted equally 22 % overall energy consumption (EIA, 2015). On the other hand, natural gas and hydro sources constituted only 7 % and 3 % of the India's energy use in 2012, as the data of EIA (2015) indicates.

After the US, China and Japan, India was the fourth largest crude oil and petroleum products consumer in 2013 (EIA, 2015). According to EIA (2015), India had 5.7 billion barrels of proved oil reserves in early 2014 and majority of the sources was in the western part of the country. In addition, 48 % of the crude oil production was offshore in 2013. Middle East countries (other than Saudi Arabia, Iran and Iraq) accounted 22 % of the India's petroleum and other liquid imports in 2013. In the same year, the other major importers were namely Saudi Arabia, Iraq, Venezuela, Nigeria and Iran. As the EIA (2015) states, they accounted 20 %, 14 %, 12 %, 8 % and 6 % of overall Indian petroleum imports in 2013, respectively. Together with this, India also exports motor fuel, kerosene, jet fuel and naphtha to various countries.

Natural gas is a remarkable substitute for coal in fertilizer production and electricity generation in India. However, as the EIA (2015) states the consumption of natural gas began to exceed its production in 2004 and India started to import natural gas from Qatar from that year. India aims to meet the increasing natural gas demand by increasing its investment on new degasification facilities. In the early 2014, the country had 47 trillion cubic feet of natural gas reserves and similar to its oil reserves the majority was located offshore. In addition, India was the 4th largest Liquefied Natural Gas (LNG) importer in 2013 (EIA, 2015).

Coal is the main source of energy in India. India has the fifth largest coal reserves in the world. Furthermore, as the EIA (2015) states India is the third largest producer and it is the third largest consumer of coal in the world, in 2012. Recently, India's coal consumption has increased faster than its production. Therefore, India's dependence on coal imports is also increasing. According to EIA (2015) the top 3 countries were Indonesia, Australia and South Africa where India imports coal in 2012.

India's electricity production has increased from 289.4 billion KWH to 1.1 trillion KWH between 1990 and 2011 (World Bank, 2015). This change corresponds to 263.6 % increase. Coal is the major source of India's electricity generation and it accounted 68 % of overall production in 2011 (World Bank, 2015). Coal was followed by hydro, natural gas, renewable (other than hydro), nuclear and oil sources, in this regard. Those sources accounted 12.4 %, 10.3 %, 5 %, 3.2 % and 1 % of overall electricity generation in 2011, respectively (World Bank, 2015). In the same period the electric power consumption has accelerated from 234.2 billion KWH to 835.4 billion KWH and this change corresponds to 256.6 % increase (World Bank, 2015). Correspondingly, per capita electricity consumption has increased from 269.6 KWH (in 1990) to 684.1 KWH (in 2011) (World Bank, 2015). As a result of the insufficient fuel supply, power generation and transmission capacity, the country suffers from electricity shortages. Regarding BRICs, India has the greatest share of transmission and distribution losses. In 2011, 21.1 % of the electricity output got lost (World Bank, 2015). Although India's access to electricity has increased from 50.9 % to 75 % in twenty years, it is still relatively lower than the other BRIC countries. Figure 18 indicates India's electricity production and consumption during the study period.

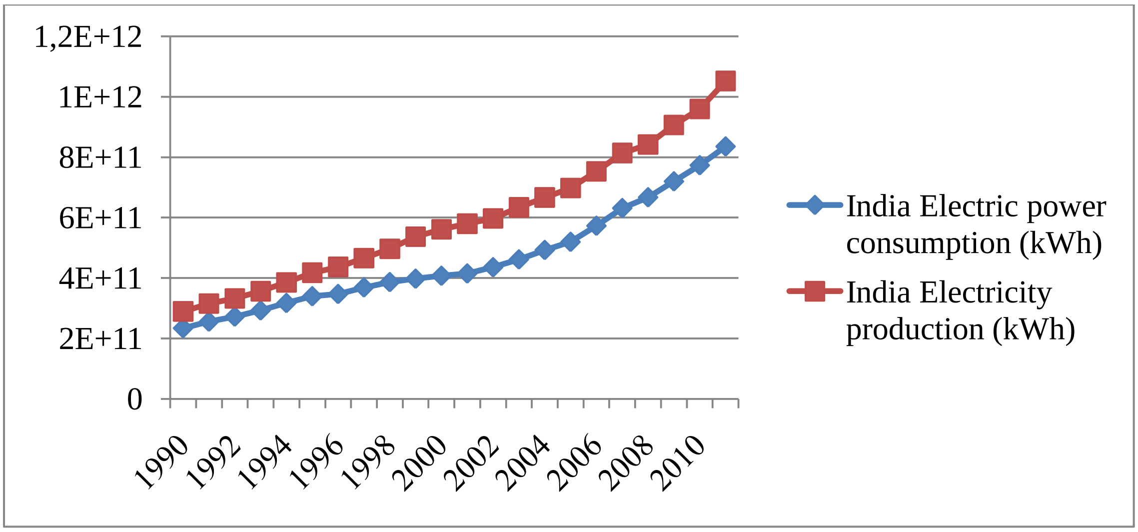

Figure 18. Electricity production and consumption in India over 1990-2011

Over its 1.3 billion individuals, China is the most populous country in the world. Together with its fast growing economy, China became the largest energy producer and consumer in the world. As a result of rapidly increasing demand, China began to be more influential in world energy markets. China's energy consumption was equivalent to 870.6 thousand KT of oil equivalent in 1990 and by showing 213.3 % increase it has risen to 2.7 million KT of oil equivalent in 2011 (World Bank, 2015). Accordingly per capita energy consumption has increased from 767 kg of oil equivalent to 2029.4 kg of oil equivalent during the study period (World Bank, 2015). In the same period, China's energy production has showed 176.2 % increase. It has accelerated from 880.8 thousand KT of oil equivalent (in 1990) to 2.43 million KT of oil equivalent (in 2011) (World Bank, 2015). China's energy consumption and production has showed in the figure below.

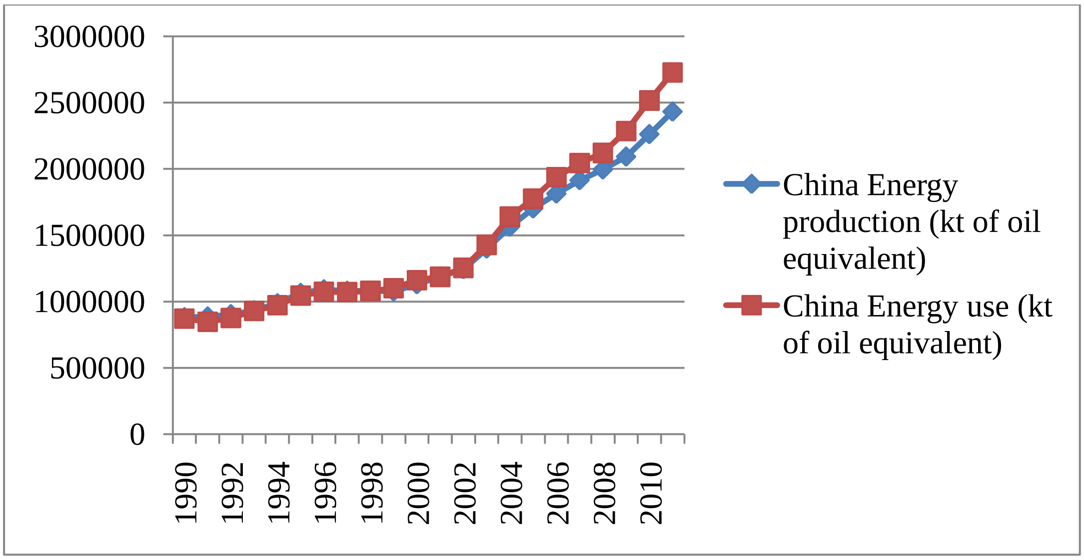

Figure 19. China's energy production and consumption over 1990-2011

According to EIA (2015), China became the largest global energy consumer in 2011 and following the US, it became the second largest oil consumer in the world. Until the early 1990s China was a net oil exporter, however, due to its rapidly increasing oil demand, the country became the world's second largest importer of crude oil and petroleum products since 2009. Furthermore, China moved from second – largest oil importer to the first in 2014 and China's annual net oil import was equivalent to 6.1 million barrels per day in the same year (EIA, 2015). Saudi Arabia (accounted 16 % of crude oil imports) was the major source of China's crude oil in 2014. Saudi Arabia was followed by Angola (accounted 13 % of crude oil imports), Russia (accounted 11 % of crude oil imports), Oman (accounted 10 % of crude oil imports), Iraq (accounted 9 % of crude oil imports), and Iran (accounted 9 % of crude oil imports) in this regard. China aims to improve its domestic oil pipeline network for the integration of oil supply and demand centers and for the diversification of its oil import sources.

Despite natural gas production and consumption is rapidly increasing in China, the fuel accounted only 5 % of country's energy use in 2012. China also aims to improve its natural gas sector by heavy investments. Moreover, there was a robust growth in natural gas demand of China in recent years, mostly in the coastal urban areas. As a result, China became the third largest LNG importer in the world. The major LNG import sources of China can be listed as Qatar (accounted 34 % of the LNG imports), Australia (accounted 19 % of the LNG imports), Malaysia (accounted 15 % of the LNG imports) and India (accounted 12 % of the LNG imports) (EIA, 2015).

China is the largest coal producer and consumer in the world. The country is responsible from the half of the world's coal consumption (EIA, 2015). China became the largest electricity producer in the world, in 2011. China's electricity production has accelerated from 621.2 billion KWH (in 1990) to 4.7 trillion KWH (in 2011) (World Bank, 2015). The spectacular change in electricity production was calculated as 659.1 %. Coal was the main source of Chinese electricity production. It constituted 79 % of overall electricity generation, in 2011. Coal was followed by hydro sources (constituted 14.8 % of overall electricity generation, in 2011). As a result of the diversification efforts of China, the share of renewable sources (other than hydro) has increased from 0.04 % (in 1994) to 2.2 % (in 2011) in electricity generation (World Bank, 2015). On the other hand, nuclear sources, natural gas sources and oil sources and oil sources accounted 1.8 %, 1.8 %, and 0.2 % in power generation, in 2011, respectively (World Bank. 2015).

Electricity consumption has increased by 664.9 % from 579.6 billion KWH (in 1990) to 4.4 trillion KWH (in 2011) (World Bank, 2015). Accordingly per capita electricity consumption has accelerated from 510.6 KWH to 3298 KWH between 1990 and

2011 (World Bank, 2015). China's electricity power transmission and distribution losses was equivalent to 5.7 % of overall output in 2011, that is relatively lower than other BRIC countries. According to World Bank (2015) China's access to electricity has increased from 94.2 % to 99.7 % during the study period. Figure 20 shows the electricity power production and consumption in China, over 1990 – 2011.

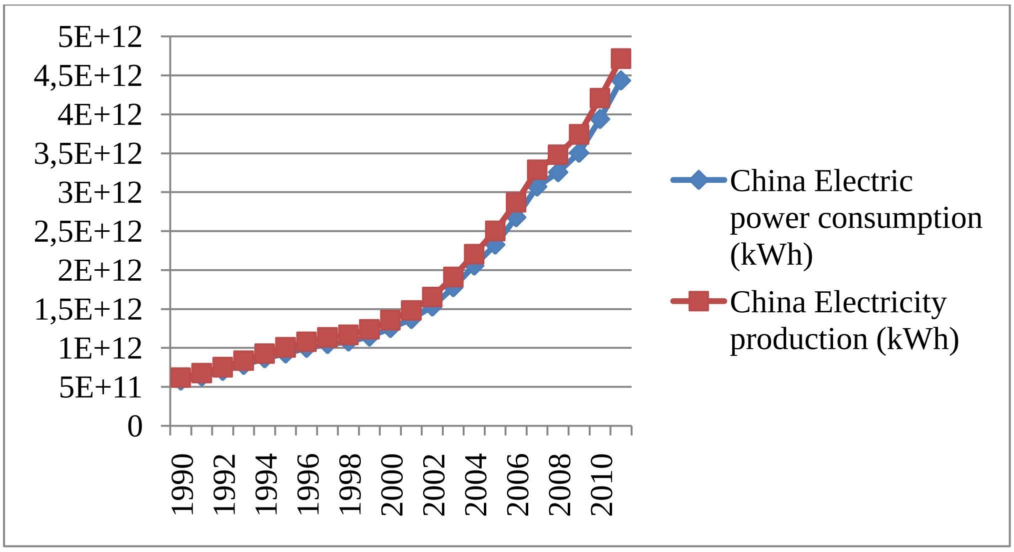

Figure 20. Electricity production and consumption in China over 1990-2011

3.5 Energy Markets in MINT Countries

Mexico is one of the fundamental non – OPEC oil producer and it is the largest sources of US imports as the EIA (2015) states. It is in the top 10 largest oil producers in the world and following the US and Canada, the country is the third largest oil producers in the Americas. Mexico is also an important energy trade partner of the US. Mexico's energy production has increased from 194.6 thousand KT of oil equivalent to 228.2 thousand KT of oil equivalent between 1990 and 2011, where this change was equivalent to 17.2 % increase (World Bank, 2015). On the other hand, Mexico's energy consumption has increased faster than the production.

As World Bank's data (2015) indicates the energy consumption has accelerated from 122.4 thousand KT of oil equivalent (in 1990) to 186.1 thousand KT of oil equivalent (in 2011) and this change was equivalent to 52 % increase. Therefore it is possible to state that Mexico's energy exports are decreasing. Consequently, per capita energy consumption in Mexico has increased from 1423.1 kg of oil equivalent to 1559.7 kg of oil equivalent in the research period. Figure 21 depicts the energy production and consumption in Mexico from 1990 to 2011.

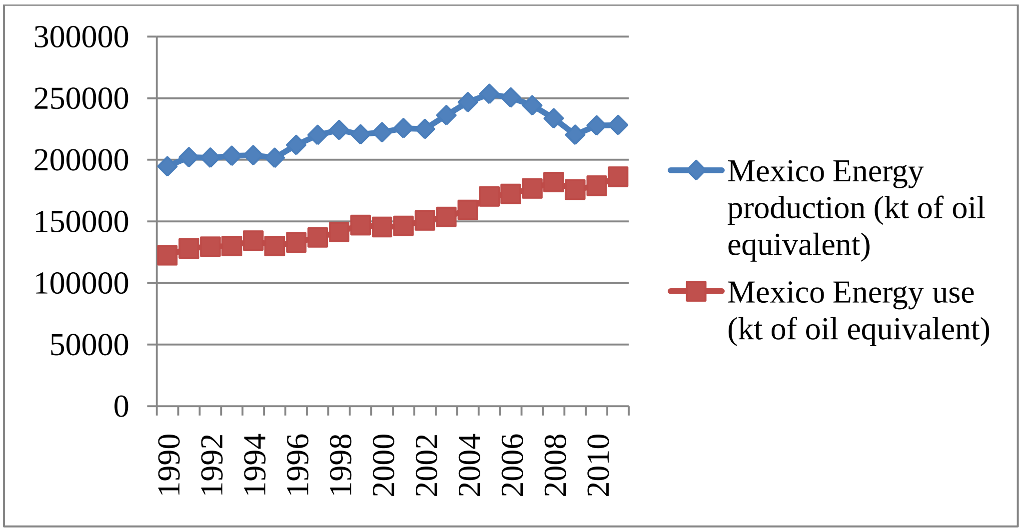

Figure 21. Mexico's energy production and consumption over 1990-2011

Petroleum was the major source of Mexico's energy consumption in 2012. It accounted 53 % of energy use (World Bank, 2015). Petroleum was followed by natural gas (it accounted 36 % of overall consumption), coal (5 %), hydro (4 %), and nuclear (1 %) in this regard (EIA, 2015). In addition, Mexico's oil production has decreased since 2005, due to the production declines from Cantarell and other large offshore fields. Natural gas is replacing the oil for electricity generation, but Mexico is an importer of the natural gas, therefore higher level of its consumption implies higher dependence on more pipeline imports. The country imports natural gas mostly from the US.

Mexico's electricity production has accelerated from 115.8 billion KWH (in 1990) to 295.8 billion KWH (in 2011) and this change was equivalent to 155.4 % (World Bank, 2015). Natural gas was the major source for Mexico's electricity production. In 2011, it comprised 52.8 % of the power generation (World Bank, 2015). Natural gas was followed by oil, hydro, coal, renewable (other than hydro) and nuclear sources in this respect. Each of these sources comprised 16.2 %, 13.7 %, 12 %, 3.9 %, and 2.2 % in Mexico's power generation respectively (World Bank, 2015). In the same period Mexico's electricity consumption has increased by 151 %, from 99.5 billion KWH to 249.7 billion KWH (World Bank, 2015). Consequently per capita electricity consumption has increased from 1155.7 KWH (in 1990) to 2091.7 KWH (in 2011) (World Bank, 2015). For Mexico, access to electricity has also increased from 95.2 % to 99.2 % between 1990 and 2010 (World Bank, 2015). On the other hand, Mexico's electric power transmission and distribution loss was 15.4 % in 2011 and this value is relatively higher than the other MINT countries. Figure 22 depicts the electricity production and consumption in Mexico from 1990 to 2011.

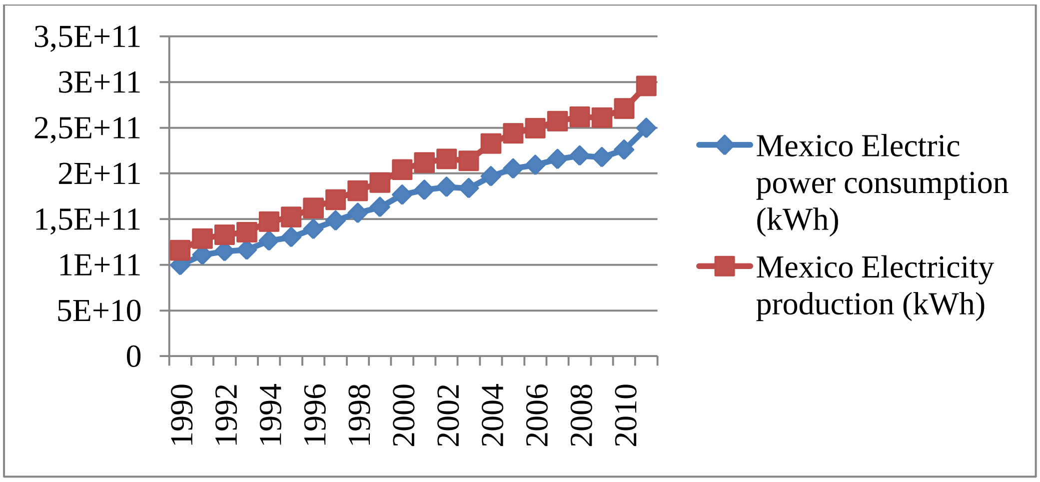

Figure 22. Electricity production and consumption in Mexico over 1990-2011

Indonesia is the most populous country in the South Asia region and the fourth most populous country in the world. Indonesia has begun to transform its energy production to domestic consumption from serving export markets since the demand for electricity has rapidly increased. There are some challenges in Indonesia's energy industry such as regularity uncertainty and lack of investment. In order to meet its increasing domestic energy demand, Indonesia struggles to attract new investments. On the other hand, according to EIA (2015), Indonesia was the largest coal exporter (in 2012) and the fourth largest LNG exporter (in 2013), in the world.

Indonesia's energy consumption has increased from 98.6 thousand KT of oil equivalent (in 1990) to 209 thousand KT of oil equivalent (in 2011) and this change corresponds to 111.9 % increase (World Bank, 2015). As a result, per capita energy consumption has risen from 552.1 kg of oil equivalent (in 1990) to 857.3 kg of oil equivalent (in 2011) (World Bank, 2015). Indonesia's energy production has increased from 168.5 thousand KT of oil equivalent to 394.5 thousand KT of oil equivalent between 1990 and 2011 (World Bank, 2015). The increase in Indonesia's energy production was calculated as 134.2 %. Figure 23 describes the energy production and consumption in Indonesia from 1990 to 2011.

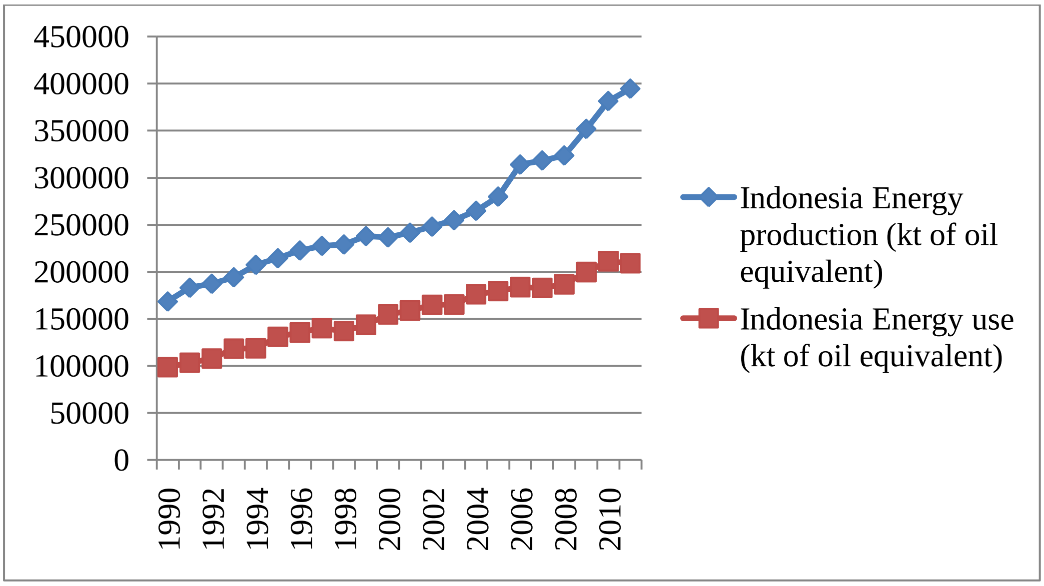

Figure 23. Indonesia's energy production and consumption over 1990-2011

The highest share in Indonesia's energy mix belongs to oil (36 % in 2012). Biomass & other renewable, coal and natural gas followed oil in this regard. Each of these sources accounted 27 %, 20 % and 17 % of Indonesia's energy consumption, respectively in 2012 (EIA, 2015). As a result of the decreasing oil production and increasing domestic demand, Indonesia exit from OPEC in 2009 and the level of oil imports has increased. The major import sources of Indonesia's crude oil were Saudi Arabia, Nigeria, Azerbaijan and United Arab Emirates (EIA, 2015). Additionally, Indonesia is also exporting its oil to various countries. The major export destinations were Japan, Thailand, Australia, Singapore, South Korea, and China (EIA, 2015). Indonesia's natural gas production has increased remarkably from 2002 to 2012 (25 % increase has observed) and Indonesia still exports almost the 50 % of its natural gas. After Qatar, Malaysia, and Australia, Indonesia was the fourth largest liquefied natural gas (LNG) exporter in 2013 as the EIA (2015) states. Major importers of

Indonesia's LNG exports were Japan, South Korea, China, and Taiwan. Furthermore, Indonesia is the largest exporter of coal and it exports 75 % of the production. Indonesia's coal production has increased rapidly between 2002 and 2012. The major coal importers of Indonesia can be listed as India, China, South Korea, Japan, and Taiwan.

Indonesia's electricity production has increased from 32.6 billion KWH (in 1990) to 182.3 billion KWH (in 2011) where this change corresponds to 458.3 % increase (World Bank, 2015). In the same period, electricity consumption has increased much faster than the production. Between 1990 and 2011, the power consumption has accelerated by 462 % from 29.5 billion KWH to 165.7 billion KWH (World Bank, 2015). As a result per capita electricity consumption has increased from 165.1 KWH to 679.7 KWH in the research period. Figure 24 describes the electricity production and consumption in Indonesia during the study period.

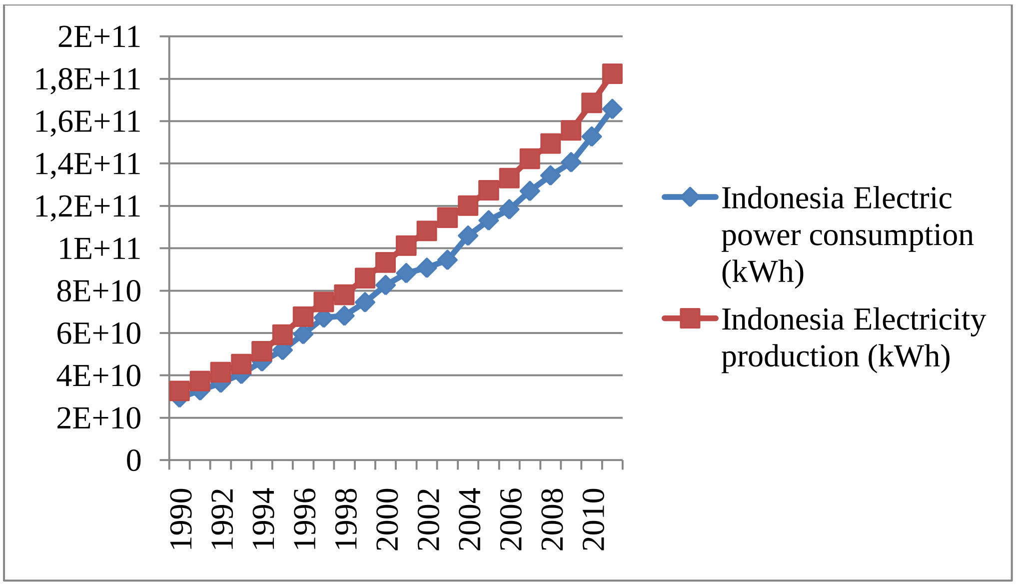

Figure 24. Electricity production and consumption in Indonesia over 1990-2011

As a result of the faster consumption increase, Indonesia faces with shortages. Country's electricity access has increased from 66.9 % to 94.2 % between 1990 and 2010, however; this value is still behind of Mexico and Turkey. Indonesia's power transmission and distribution losses were equivalent to 9.1 % in 2011 as the World Bank's (2015) data indicates. Coal is the major source of power generation and it accounted 44.4 % of electricity production in 2011 (World Bank, 2015). Coal was followed by oil, natural gas, hydro and renewable (other than hydro) sources. Each of these sources accounted 23.2 %, 20.3 %, 6.8 % and 5.2 % of power generation, in 2011, respectively (World Bank, 2015).

Nigeria is the largest oil producer in Africa. Moreover, it is in the top 5 LNG exporters in the world. Nigeria has a remarkable oil production capacity; however, it has instability and supply disruption problems. Furthermore the natural gas sector is restricted by the inadequate infrastructure that is not able to monetize the currently flared natural gas.

Nigeria's overall energy production has increased by 70.3 % in the research period from 150.5 thousand KT of oil equivalent (in 1990) to 257 thousand KT of oil equivalent (in 2011) (World Bank, 2015). Similarly, the energy consumption in the country has accelerated from 70.6 thousand KT of oil equivalent to 118.3 thousand KT of oil equivalent in the same period (World Bank, 2015). The increase in energy consumption was calculated as 67.6 %. On the other hand, per capita energy consumption in Nigeria has declined from 738.2 kg of oil equivalent to 720.6 kg of oil equivalent between 1990 and 2011 (World Bank, 2015). Energy production and consumption in Nigeria showed in the figure 21, below.

Traditional solid biomass and waste (including charcoal, wood, crop residues and manure) comprised the 80 % of Nigeria's energy consumption in 2012 (EIA, 2015). Traditional solid biomass was followed by oil, natural gas and hydro sources in this regard. Each of these sources respectively comprised 13 %, 6 % and 1 % of Nigeria's energy consumption in 2012 (EIA, 2015). Regarding crude oil, Nigeria has the second largest amount of reserves in Africa. However, the reserve estimations are under stagnation as a result of low exploration activity. Crude oil output has declined by 25 % between 2005 and 2009 due to the infrastructure attacks and escalating oil theft (EIA, 2015). Europe is the major regional importer of Nigeria's crude oil. According to EIA (2015), Europe accounted 45 % of Nigeria's crude oil imports (where Netherlands comprised 10 %, Spain comprised 9 % and other European countries comprised 25 %) in 2014. Asia, Americas and Africa followed Europe in this regard. Asia accounted 27 % (where India comprised 18 %, Indonesia comprised 4 %, other Asian countries comprised 6 %), Americas accounted 15 % (where Brazil comprised 10 %, US comprised 3 % and other American countries comprised 2 %) and Africa accounted 13 % (where South Africa comprised 7 %, other African countries comprised 6 %) of Nigeria's crude oil exports (EIA, 2015).

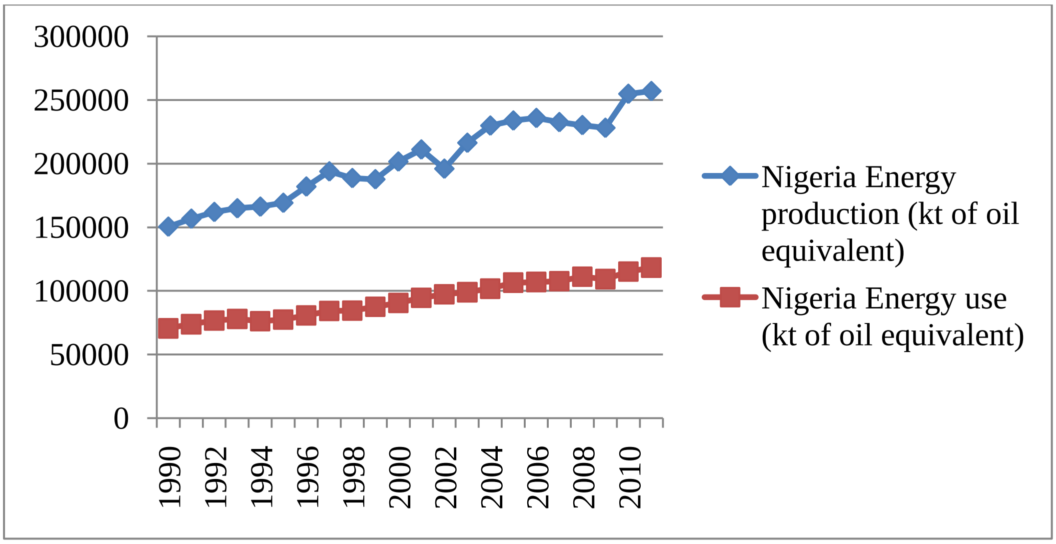

Figure 25. Nigeria's energy production and consumption over 1990-2011

Nigeria has the largest proved natural gas reserves in the continent of Africa. Furthermore, the country has the 9th largest natural gas reserves and it is an important LNG exporter in the world. Asia accounted 54 % of Nigeria's LNG exports (where Japan comprised 23 %, Korea comprised 17 %, and other Asian countries comprised 14 %) (EIA, 2015). Asia was followed by Europe, Americas and Middle East in this respect. Europe accounted 31 % (where Spain comprised 14 % and other European countries comprised 17 %), Americas accounted 14 % (where Mexico comprised 7 % and other American countries comprised 7 %) and the Middle East accounted 1 % of Nigeria's LNG exports (EIA, 2015).

Nigeria has a very certain electricity problem. Electrification ratio in Nigeria has only increased from 41.8 % to 48 % in the research period (World Bank, 2015). Almost 90 million people in Nigeria (more than half of the population) still do not have access to electricity. Nigeria's power consumption has increased by 194.9 %, from 8.3 billion KWH to 24.5 billion KWH in the research period. Correspondingly per capita power consumption has risen from 86.7 KWH to 148.9 KWH between

1990 and 2011; however, Nigeria still has one of the lowest rates of per capita power consumption in the world. Natural gas was the dominating source of Nigeria's power generation (accounted 63.3 % in 2011) as the World Bank (2015) states. Natural gas was followed by hydro (accounted 20.9 %), and oil (15.8 %) in this respect. Nigeria does not use nuclear, coal or renewable (other than hydro) sources to produce electricity. As a final note, Nigeria has reduced its transmission and distribution losses successfully from 38.4 % to 9.6 % in the study period (World Bank, 2015). Figure 26 shows the electricity production and consumption in Nigeria from 1990 to 2011.

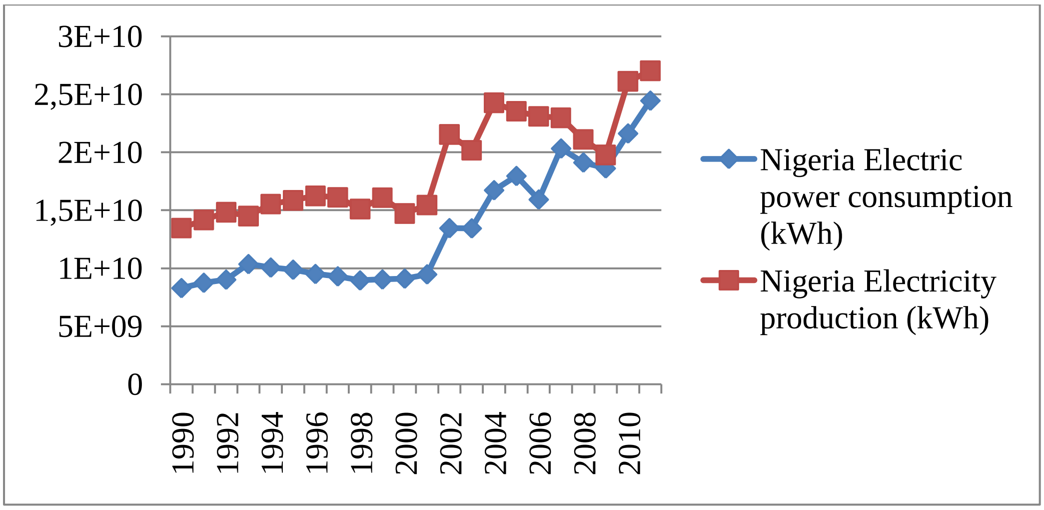

Figure 26. Electricity production and consumption in Nigeria over 1990-2011

Turkey is placed on a strategic region that connects Central Asia, Russia, Middle East, Europe and the country became an important transit hub for oil and natural gas. Turkey's economy has expanded over the past decade, therefore its petroleum and other liquids consumption has showed a significant increase. The country has limited domestic oil reserves thus it imports almost all of its oil supplies.

Turkey's energy consumption has rapidly increased during the study period. It accelerated from 52.8 thousand KT of oil equivalent (in 1990) to 112.5 thousand KT of oil equivalent (in 2011) where this change corresponds to 113.3 % increase (World Bank, 2015). Accordingly per capita energy consumption in Turkey has increased from 977.1 kg of oil equivalent to 1539.3 kg of oil equivalent between 1990 and 2011 (World Bank, 2015). On the other hand, Turkey's energy production has only increased by 24.2 %, from 25.8 thousand KT of oil equivalent (in 1990) to 32.1 thousand KT of oil equivalent (in 2011) (World Bank, 2015). Turkey's energy imports dependence showed a rapid pace of increase in the study period. Figure 27 presents Turkey's energy production and consumption between 1990 and 2011.

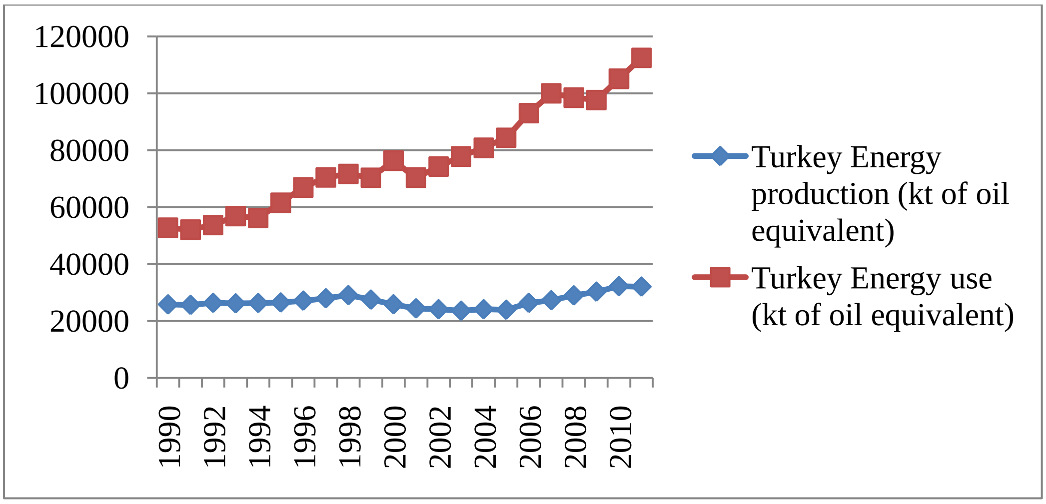

Figure 27. Turkey's energy production and consumption over 1990-2011

According to EIA (2015) Turkey produced 13 % of its crude oil in 2014. Iraq, Iran, Saudi Arabia, Nigeria and Kazakhstan were the major sources of Turkey's crude oil imports. Each of these countries respectively accounted 27 %, 26 %, 10 %, 8 % and 8 % in Turkey's crude oil supply mix in 2014 (EIA, 2015). Turkey has also a substantial role in natural gas transit, since its position is between the world's second largest natural gas market, Europe, Caspian Basin and the Middle East. However, Turkey's natural gas reserves are very limited therefore the country imports natural gas from Russia, Iran, Azerbaijan, and Algeria. Each of these countries, respectively comprised 57 %, 20 %, 10 % and 8 % of Turkey's natural has imports (EIA, 2015). Coal (especially lignite) is the most abundant energy resource in Turkey and it is also important for electricity generation.

In Turkey, both electricity production and consumption have expanded in the period 1990 – 2011. The power consumption has increased by 294.8 % from 50.1 billion KWH (in 1990) to 197.9 billion KWH (in 2011) (World Bank, 2015). Accordingly, per capita power consumption showed a substantial increase in Turkey, from 928.4 KWH to 2709.3 KWH between 1990 and 2011 (World Bank, 2015). In 2011, natural gas was the leading source of Turkey's electricity production (where it accounted 45.4 % of overall production). Natural gas was followed by coal, and hydro sources in this respect. Each of these sources respectively constituted 28.9 % and 22.8 % of overall production (World Bank, 2015). Renewable (other than hydro) and oil sources had minor contributions to Turkey's electricity production (where renewable sources accounted 2.5 % and oil sources accounted 0.4 % in 2011) (World, Bank, 2015). As a final note, Turkish government plans to diversify the electricity production by nuclear power. Turkey's access to electricity was 100 % in 2010, and the country's electricity power transmission and distribution losses were equivalent to 14.1 % in 2011. This value was higher than Nigeria's and Indonesia's but less than Mexico's transmission and distribution losses. Figure 28 describes the electricity production and consumption in Turkey from 1990 to 2011.

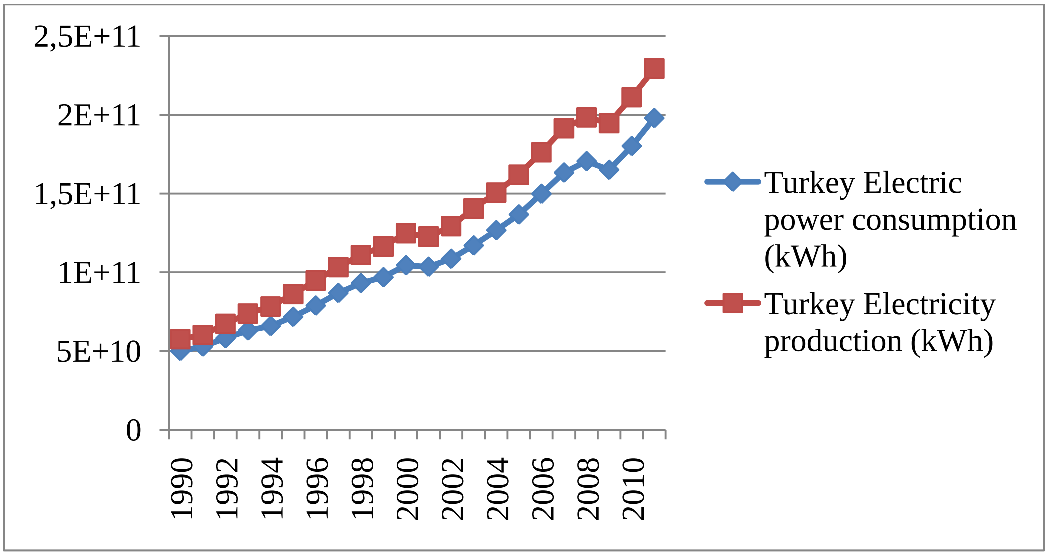

Figure 28. Electricity production and consumption in Turkey over 1990-2011

3.6 Comparison of the Energy Markets in BRICs and MINTs

Brazil's energy consumption has increased by 92.6 % and energy production has increased by 139.3 % in the study period (World Bank, 2015). Besides its energy production has increased significantly faster than the consumption, Brazil is still an energy importer. Russia's energy consumption has declined by 8.1 % from 1992 to 2011 where the energy production has increased by 15.5 % in the same period. Russia is a net exporter of energy and it always plays an important role in the world's energy agenda. India's energy consumption and production have expanded by 136.6 % and 85.4 % respectively. As a result, India's energy import dependence has remarkably increased in the research period. The highest energy consumption increase was observed in China. The energy consumption and production has increased respectively by 213.3 % and 176.2 % between 1990 and 2011. In 1990, China was an energy exporter; however, the country became a net energy importer due to the rapidly increasing energy demand. Table 5 summarizes the changes in energy production and consumption in BRICs, from 1990 to 2011.

Table 5. Changes in energy consumption and production in BRICs over 1990-2011

	Change in energy consumption	Change in energy production	Exporter/Importer
Brazil	92.6 %	139.3 %	Importer
Russia	-8.1 %	15.5 %	Exporter
India	136.6 %	85.4 %	Importer
China	213.3 %	176.2 %	Importer

Regarding the secondary energy use (electricity), the fastest consumption increase was observed in China (664.9 % increase between 1990 and 2011) (World Bank, 2015). India and Brazil has followed China in this regard. The power consumption in these countries has respectively increased by 256.6 % and 120.6 % from 1990 to 2011 (World Bank, 2015). On the other hand Russia's electricity consumption has only increased by 2.1 % between 1992 and 2011. Figure 29 depicts the electricity consumption in BRICs.

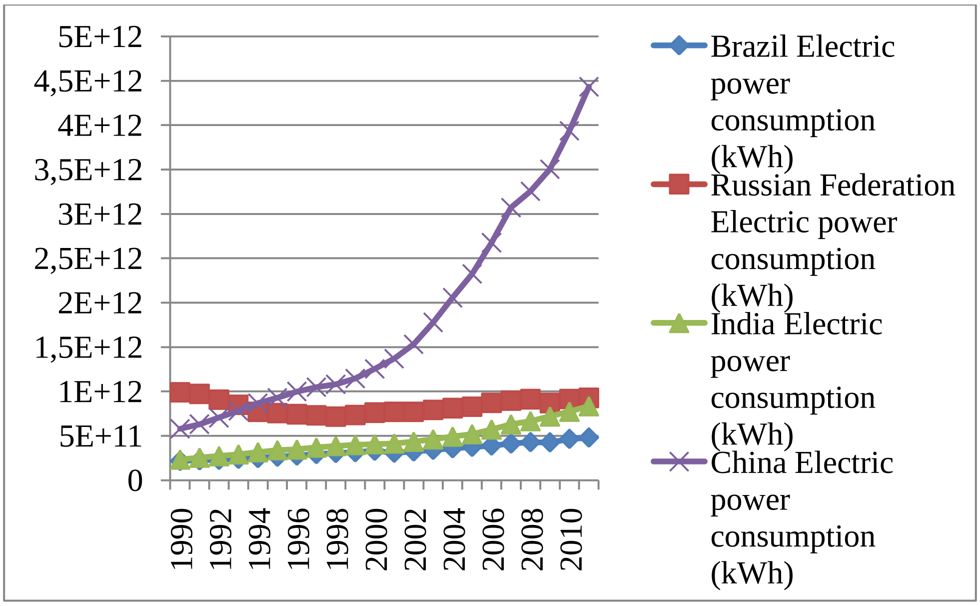

Figure 29. Electric power consumption in BRICs over 1990-2011

Regarding BRICs, India has the lowest electrification rate (75 %) as the World Bank's data indicates. In Brazil, hydro is the major source of the electricity generation, where in Russia it is the natural gas. On the other hand, China and India mostly use coal for power generation. Russia also produces a remarkable amount of its electric power from nuclear, hydro, and coal sources.

Regarding MINTs, the fastest increase in energy production and consumption was observed in Indonesia, during the study period. The country's energy production and consumption has respectively accelerated by 134.2 % and 111.9 % from 1990 to 2011 as the World Bank's (2015) data indicates. Nigeria's energy production and consumption has respectively accelerated by 70.3 % and 67.6 % in the same time interval (World Bank, 2015). Mexico's consumption has increased much faster than its production and this lead to a decline in Mexico's energy exports (production and consumption has risen respectively 17.2 % and 52 %) as World Bank's data indicates. Finally Turkey's energy consumption has increased by 113.3 % while its production has only increased by 24.2 % between 1990 and 2011 (World Bank, 2015). Turkey is the only energy importing country in the MINTs. Table 6 describes the changes in energy consumption and production in the MINTs, during the research period.

Table 6. Changes in energy production and consumption in MINTs over 1990-2011

	Change in energy production	Change in energy consumption	Exporter/Importer
Mexico	17.2 %	52 %	Exporter
Indonesia	134.2 %	111.9 %	Exporter
Nigeria	70.3 %	67.6 %	Exporter
Turkey	24.2 %	113.3 %	Importer

Regarding electric power use, fastest increase was observed in Indonesia (462 % increase during the research period) (World Bank, 2015). The country was followed by Turkey (294.8 % increase), Nigeria (194.9 % increase) and Mexico (151 %

increase) (World Bank, 2015). Natural gas is the major source of the electric power generation in Mexico, Nigeria and Turkey; however, it is the coal for Indonesia's. In Mexico, oil, hydro and coal, in Indonesia oil and natural gas, in Nigeria hydro and oil, and finally in Turkey coal and hydro have important shares in the power generation. Nigeria has the lowest electrification rate in MINTs, only 48 % of the population was able to access the electricity in 2010 (World Bank, 2015). Figure 30 describes the electric power consumption in MINTs over 1990 – 2011.

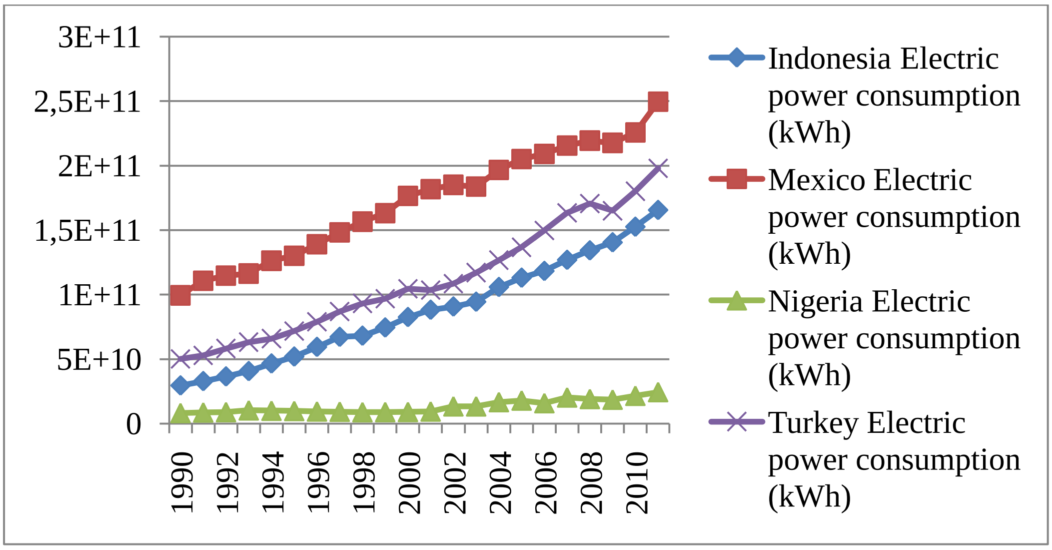

Figure 30. Electric power consumption in MINTs over 1990-2011

3.7 CO_2 Emissions in BRICs

CO_2 emissions in Brazil have increased from 208.8 thousand KT (in 1990) to 439.4 thousand KT (in 2011) (World Bank, 2015). The change in Brazil's CO_2 emissions was calculated as 110.4 %. Consequently, per capita emissions in Brazil have increased from 1.4 tons to 2.2 tons in the same period (World Bank, 2015). In Brazil, transportation is the main sector that is contributing the CO_2 emissions. It accounted 44.6 % in the Brazilian CO_2 emissions, in 2011 (World Bank, 2015). Transportation was followed by manufacturing industries & construction, electricity & heat production, residential buildings & commercial & public services, and other sectors. Each of these economic activities accounted 30.7 %, 15.5 %, 4.9 % and 4.3 % in Brazil's CO_2 emissions, respectively in 2011. Figure 31 depicts the contribution of economic sectors on Brazil's CO_2 emissions from 1990 to 2011.

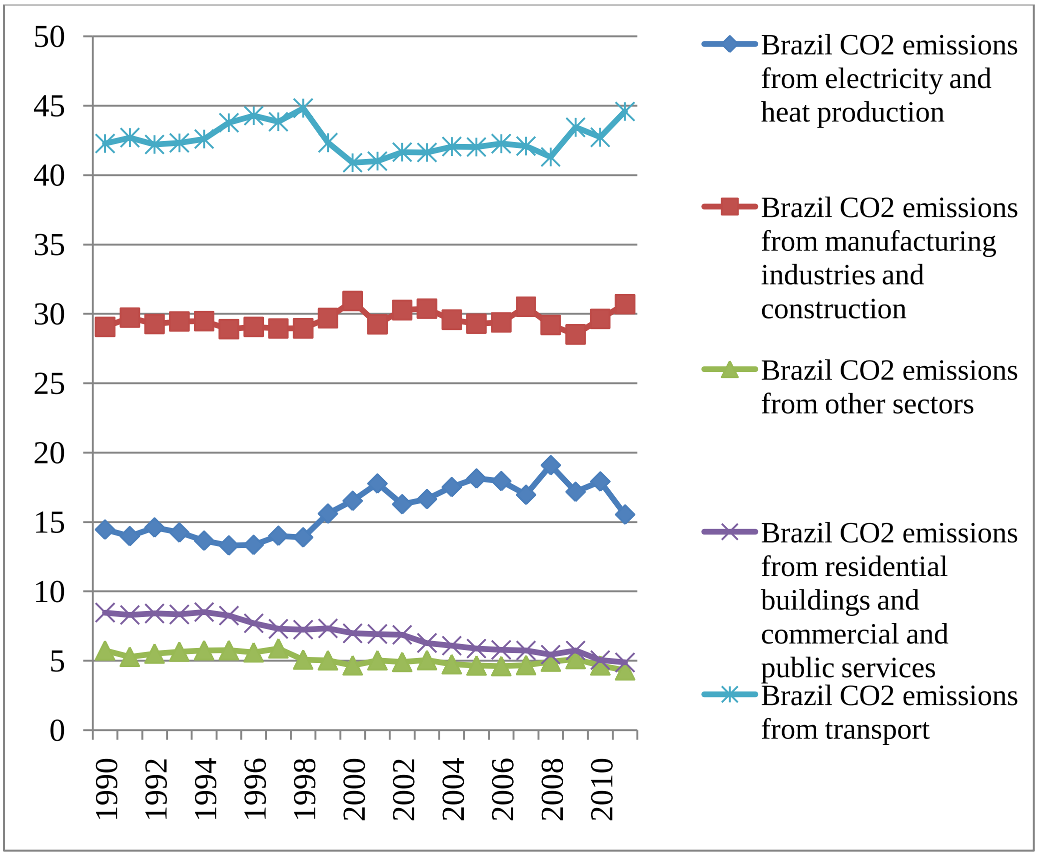

Figure 31. Contribution of economic activities to Brazil's CO_2 emissions over 1990-2011

In Brazil, liquid fuels accounted 65.8 % in CO_2 emissions in 2011. Solid fuels and gas fuels comprised 14.6 % and 11.5 % in Brazil's CO_2 emissions in the same year.

In Russia the CO_2 emissions has declined from 2.1 million KT to 1.8 million KT from 1992 to 2011 (World Bank, 2015). The decrease in Russia's CO_2 emissions was calculated as 13.2 %. As a result, per capita CO_2 emissions have decreased from 14 tons to 12.6 tons in the same period (World Bank, 2015). Regarding economic activities, electricity and heat production is the major sector that contributes to Russia's CO_2 emissions. In 2011, it accounted 60.5 % of overall emissions (World Bank, 2015). Electricity and heat production was followed by manufacturing & construction, transport, residential buildings & commercial & public services, and other sectors. Each of these economic sectors constituted 15.2 %, 15 %, 8.3 % and 1 % in Russia's CO_2 emissions, respectively in 2011 (World Bank, 2015). Figure 32 describes the shares of economic activities in Russia's CO_2 emissions from 1990 to 2011.

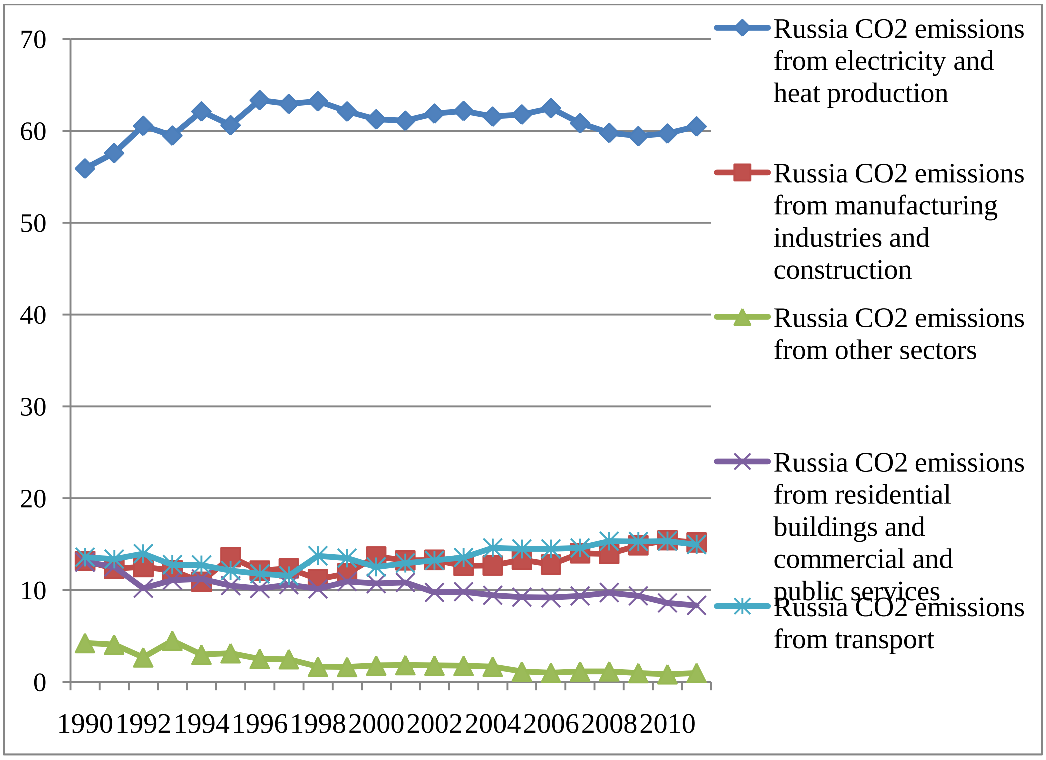

Figure 32. Contribution of economic activities to Russia's CO_2 emissions over 1990-2011

Gaseous fuels had the largest share in Russia's CO_2 emissions (accounted 49.6 %) in 2011. Gaseous fuels were respectively followed solid fuels (25 %) and liquid fuels (22.2 %) in this respect (World Bank, 2015).

India's CO_2 emissions have accelerated from 690.5 thousand KT to 2.1 million KT between 1990 and 2011 (World Bank, 2015). The change in India's CO_2 emissions was equivalent to 200.4 %. Correspondingly, per capita CO_2 emissions have increased from 0.8 tons (in 1990) to 1.7 tons (in 2011) (World Bank, 2015). Similar to Russia, electricity & heat production comprised the largest share (55.2 %) in India's CO_2 emissions, in 2011 (World Bank, 2015). Electricity & heat production was followed by manufacturing & construction, transport, residential buildings & commercial & public services, and other sectors in this regard. Those economic sectors constituted 27.1 %, 9.7 %, 5.6 % and 2.4 %, respectively in India's CO_2 emissions (World Bank, 2015). Figure 33 describes the shares of economic activities in India's CO_2 emissions from 1990 to 2011.

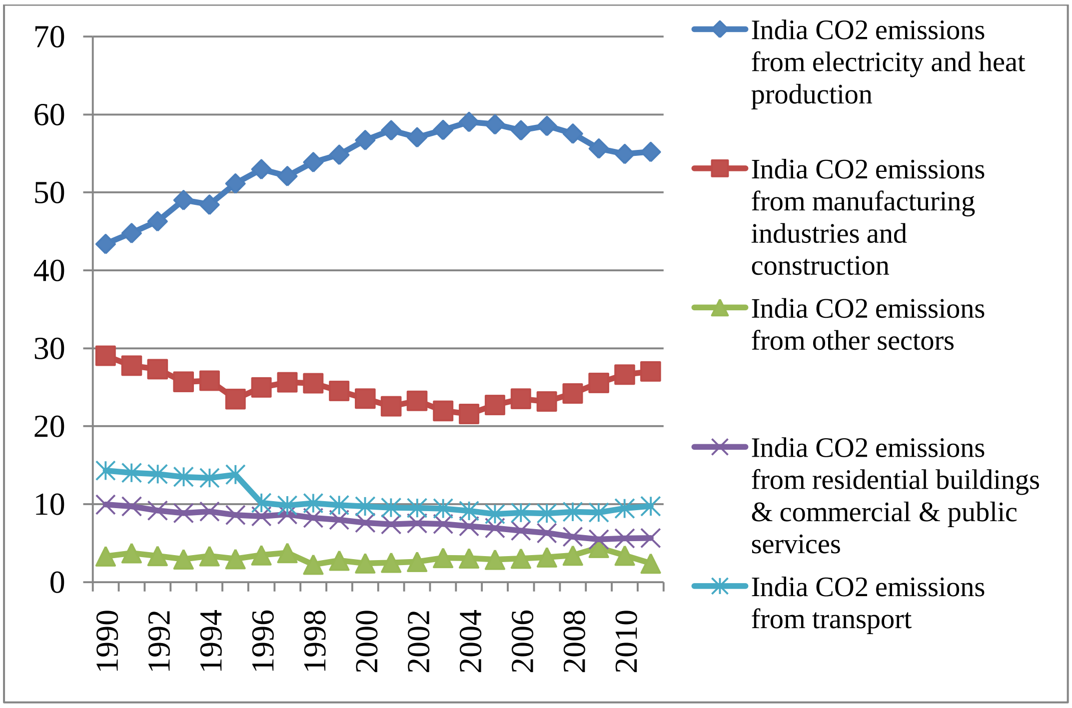

Figure 33. Contribution of economic activities to India's CO_2 emissions over 1990-2011

India has huge coal dependence for its primary and secondary energy generation; therefore solid fuel consumption had the largest share in India's CO_2 emissions (solid fuels accounted 70 % in the India's CO_2 emissions in 2011) as the World Bank's (2015) data indicates. Liquid fuels and gaseous fuels followed solid fuels in this respect. Each of these sources comprised 19.8 % and 4.4 % in India's CO_2 emissions in 2011 (World Bank, 2015).

Between 1990 and 2011, China's CO_2 emissions have increased rapidly from 2.5 million KT to 9 million KT, thus China became the largest CO_2 emitting country in the world (World Bank, 2015). China's CO_2 emissions have accelerated 260.4 % in this period. Accordingly, per capita emissions have risen from 2.2 tons to 6.7 tons from 1990 to 2011 (World Bank, 2015). Parallel to Russia and India, electricity & heat production was the major determining economic activity in China's CO_2 emissions. It constituted 53.6 % of the Chinese CO_2 emissions in 2011 (World Bank, 2015). Electricity & heat production was followed by manufacturing & construction, transport, residential buildings & commercial & public services, and other sectors in this regard. In 2011, each of these economic sectors has comprised 31.3 %, 7.8 %, 5.7 %, and 1.6 % in China's CO_2 emissions respectively (World Bank, 2015). Figure 34 describes the contribution of economic sectors on China's CO_2 emissions over 1990 – 2011.

Similar to India, China's emissions were also the result of solid fuel consumption (it accounted 73.3 % in Chinese CO_2 emissions in 2011) (World Bank). Parallel to India, liquid fuels and gaseous fuels followed solid fuels in this respect. Each of these sources accounted respectively 12.4 % and 2.7 % in China's CO_2 emissions (World Bank, 2015).

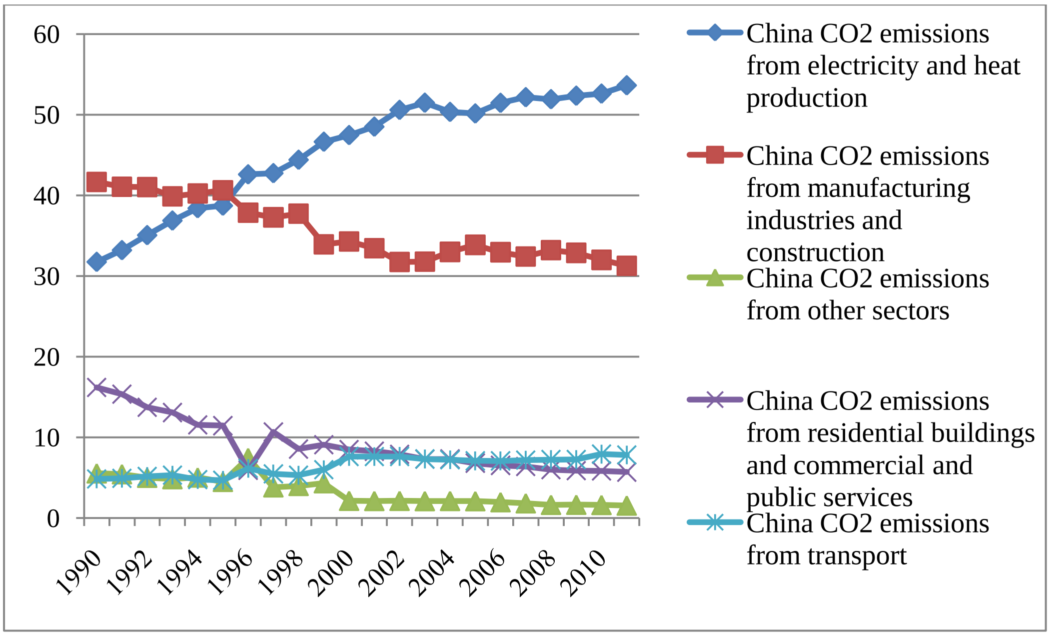

Figure 34. Contribution of economic activities to China's CO_2 emissions over 1990-2011

3.8 CO_2 Emissions in MINTs

Mexico's CO_2 emissions have accelerated from 314.2 thousand KT (in 1990) to 466.5 thousand KT (in 2011) (World Bank, 2015). The increase in Mexico's CO_2 emissions was calculated as 48.4 %. Consequently, per capita CO_2 emissions have increased from 3.7 to 3.9 tons between 1990 and 2011 (World Bank, 2015). Electricity & heat production and transport are the two leading economic activities that increasing Mexico's CO_2 emissions. Each of these economic activities respectively constituted 44.1 % and 35.2 % in Mexico's CO_2 emissions, in 2011 (World Bank, 2015). Manufacturing & construction, residential buildings & commercial & public services, and other sectors followed transportation in this respect. These economic activities respectively comprised 13.3 %, 5.4 % and 2 % in Mexico's CO_2 emissions in 2011 (World Bank, 2015). Figure 31 shows the contribution of economic activities on Mexico's CO_2 emissions from 1990 to 2011.

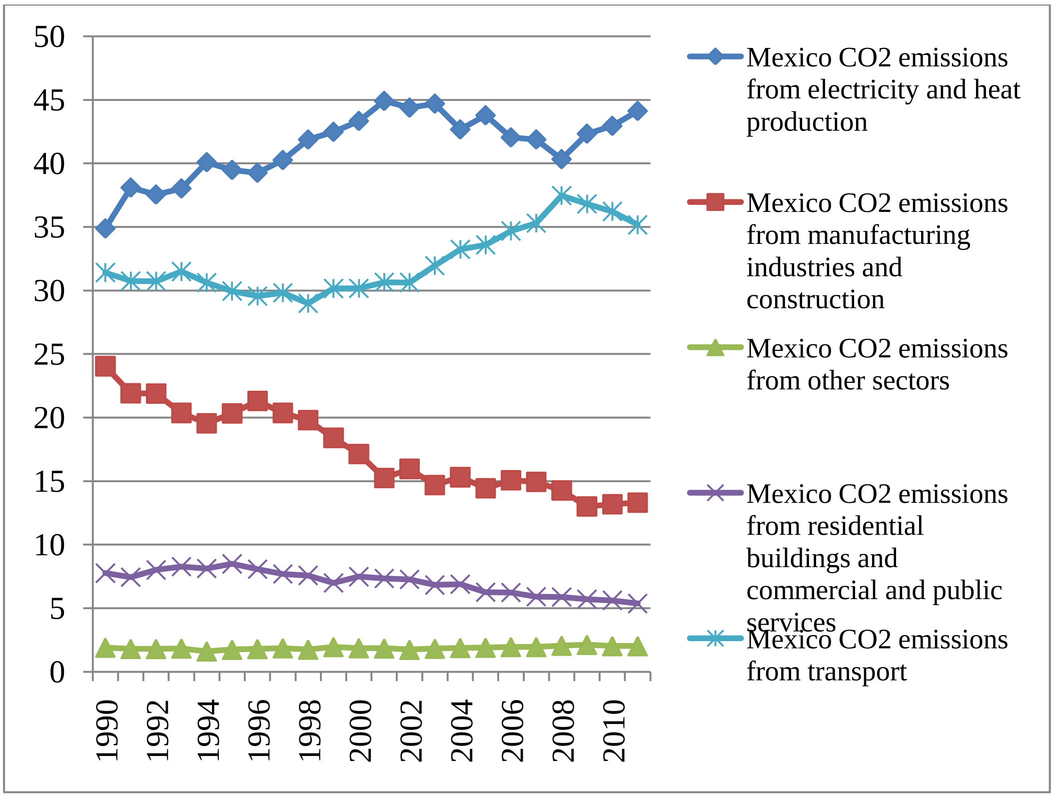

Figure 35. Contribution of economic activities to Mexico's CO_2 emissions over 1990-2011

Similar to Brazil, the liquid fuels were the major determining fuel type in Mexico's CO_2 emissions (it constituted 58.5 % in overall emissions) (World Bank, 2015). Gaseous fuels (accounted 27.6 %) and solid fuels (accounted 8.4 %) followed liquid fuels in this regard (World Bank, 2015).

Indonesia's overall CO_2 emissions have rapidly accelerated from 149.5 thousand KT (in 1990) to 564 KT (in 2011) (World Bank, 2015). The change in Indonesia's CO_2 emissions has calculated as 277.1 %. As a result, per capita emissions have risen from 0.8 tons to 2.3 tons between 1990 and 2011 (World Bank, 2015). In Indonesia, three economic activities have major impacts on country's CO_2 emissions. These economic activities are namely, electricity & heat production, manufacturing & construction, and transport where each of them accounted 38.8 %, 27.7 % and 26.9 % in Indonesia's overall CO_2 emissions in 2011 (World Bank, 2015). On the other hand, residential buildings & commercial & public services and other sectors have minor contributions on Indonesia's CO_2 emissions. In 2011, these economic activities comprised 4.6 % and 2 % of the emissions, respectively (World Bank, 2015). Figure 36 describes the contribution of the various economic activities on Indonesia's CO_2 emissions over 1990 – 2011.

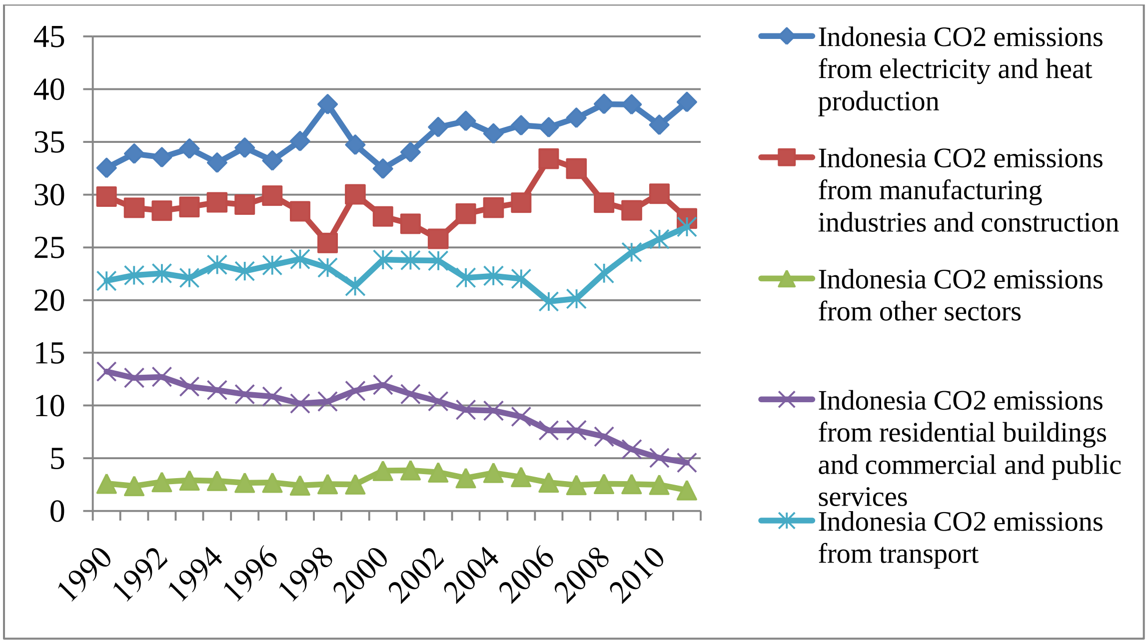

Figure 36. Contribution of economic activities to Indonesia's CO_2 emissions over 1990-2011

Solid and liquid fuels were the main determining fuel types in Indonesia's CO_2 emissions. In 2011, each of these fuel types respectively comprised the 44 % and 37.5 % of the overall carbon emissions. Finally the gaseous fuels accounted 14.1 % in Indonesia's CO_2 emissions (World Bank, 2015).

Nigeria's overall CO_2 emissions have increased by 94 % during the study period from 45.3 thousand KT (in 1990) to 88 thousand KT (in 2011) (World Bank, 2015). Correspondingly per capita CO_2 emissions have increased from 0.47 tons to 0.53 tons in the same period. Similar to Brazil, transport was the major determining economic activity in Nigeria's CO_2 emissions (it accounted 44.6 % of the emissions in 2011) (World Bank, 2015). Transport was followed by electricity & heat production in this regard. It constituted 34.3 % in Nigeria's CO_2 emissions in 2011 (World Bank, 2015). Other sectors, manufacturing & construction, and residential buildings & commercial & public services had minor contributions to Nigeria's CO_2 emissions in the same year. Each of these economic activities respectively constituted 8.5 %, 8.2 % and 4.4 % in overall emissions in 2011 (World Bank, 2015). Figure 37 depicts the contribution of economic activities in Nigeria's CO_2 emissions over 1990 – 2011.

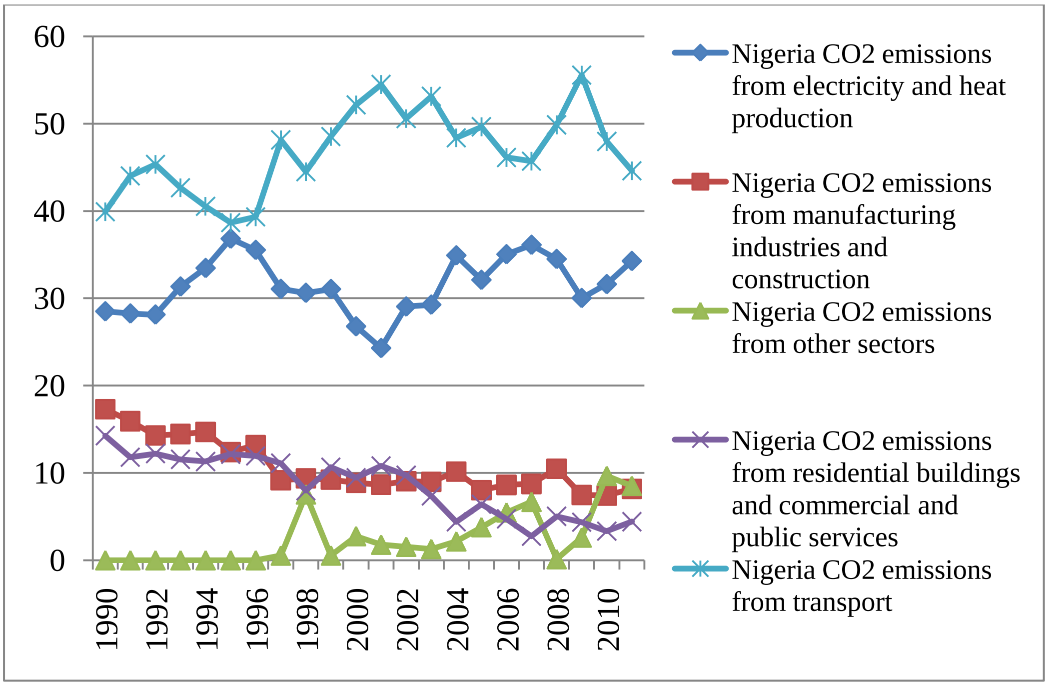

Figure 37. Contribution of economic activities to Nigeria's CO_2 emissions over 1990-2011

Similar to Mexico, liquid fuels and the gaseous fuels were the major contributing fuels on Nigeria's CO_2 emissions in the research period. On the other hand, solid fuels had minor impacts on overall CO_2 emissions in Nigeria (World Bank, 2015).

Turkey's overall CO_2 emissions have considerably increased during the research period. The CO_2 emissions have risen from 145.9 thousand KT (in 1990) to 320.8 KT (in 2011) where this increase was equivalent to 120 % (World Bank, 2015). Accordingly the per capita CO_2 emissions have increased from 2.7 tons to 4.4 tons between 1990 and 2011 (World Bank, 2015). Similar to Mexico and Indonesia, electricity & heat production was the major determining economic activity that rising Turkish CO_2 emissions in the research period (it comprised 42.4 % in overall CO_2 emissions in 2011) (World Bank, 2015). Manufacturing & construction, residential buildings & commercial & public services, transport had also considerable contributions to Turkish CO_2 emissions. In 2011, each of these economic activities accounted respectively 18.9 %, 17.3 %, and 16 % in Turkey's CO_2 emissions (World Bank, 2015). Finally other sectors had minor impacts on the overall emissions (it accounted 5.4 % in 2011) (World Bank, 2015). Figure 38 indicates the contribution of economic activities on Turkish CO_2 emissions over 1990 – 2011.

Turkey's solid fuel use was the major determining consumption type in 2011. It accounted 40.7 % of overall CO_2 emissions (World Bank, 2015). Gaseous and liquid fuels followed solid fuels in this respect. In 2011, these fuel types comprised 26.3 % and 23.2 % of Turkey's CO_2 emissions, respectively (World Bank, 2015).

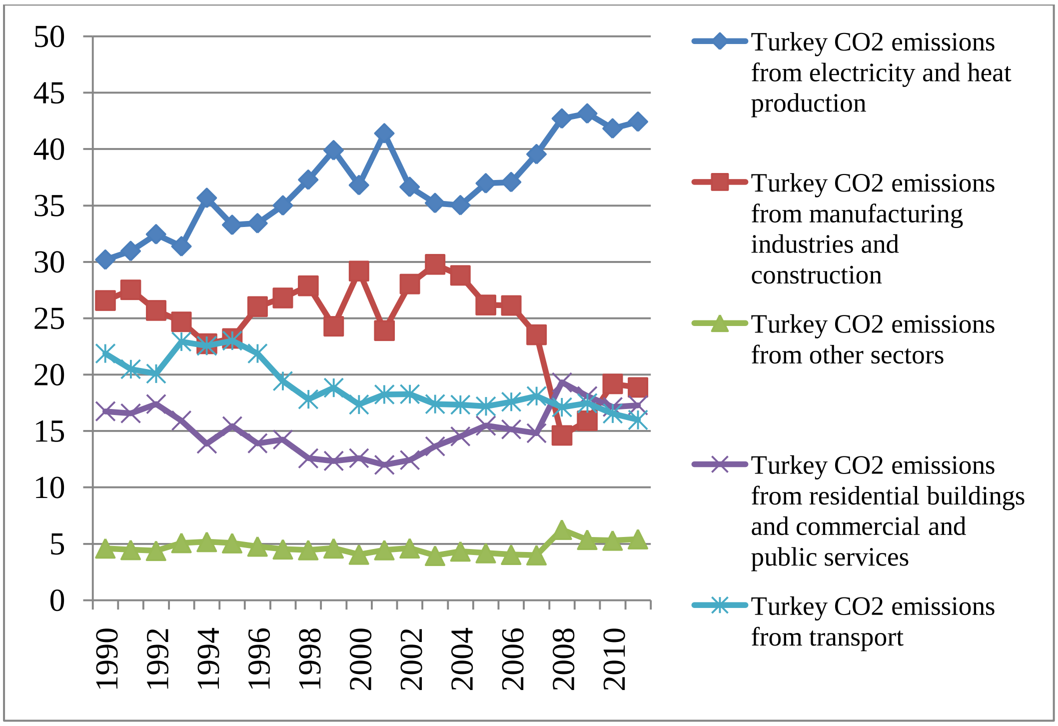

Figure 38. Contribution of economic activities to Turkey's CO_2 emissions over 1990-2011

3.9 Comparison of the CO_2 emissions in BRICs and MINTs

Regarding BRICs fastest CO_2 emissions increase was observed in China, from 1990 to 2011. In this period the Chinese CO_2 emissions has risen by 266.5 %. India and Brazil has followed China, in this respect. The CO_2 emissions in each of these countries have increased 200.4 % and 110.4 % respectively. On the other hand, Russia's CO_2 emissions have declined by 13.2 % in this period. Together with this, Russia has the highest per capita emissions, among BRIC countries. In 2011, per capita CO_2 emissions in Russia were equivalent to 12.2 tons (World Bank, 2015). China, Brazil and India followed Russia in this respect. Per capita CO_2 emissions were equivalent to 6.7 tons, 2.2 tons and 1.7 tons in those countries, respectively (World Bank, 2015). Despite Russia's per capita emissions are relatively higher than China and India, the air quality in Russia is better. China's and India's populations are almost 9 times and 8 times greater than Russia's, respectively. Furthermore

China and India have a vast consumption of coal, while Russia produces its energy mostly from natural gas reserves. The pollution coefficient of coal is much higher than natural gas. Therefore the air quality in China and India is worse than Russia and Brazil. Figure 39 depicts the CO_2 emissions in BRICs for the study period.

Regarding MINTs, fastest emission increase was observed in Indonesia over 1990 – 2011. The country's CO_2 emissions have increased by 277.1 % in the study period. Indonesia was followed by Turkey, Nigeria and Mexico in this regard. CO_2 emissions in those countries were respectively accelerated by 120 %, 94 % and 48.4 %. Per capita emissions were largest (4.4 tons) in Turkey, in 2011. Turkey was followed by Mexico (3.9 tons), Indonesia (2.3 tons), and Nigeria (0.5 tons) in this regard (World Bank, 2015). Coal dependence creates some air pollution problems especially for Indonesia, and Turkey. Indonesia's overall CO_2 emissions have surpassed Mexico's in the study period. Figure 40 describes the CO_2 emissions in MINTs from 1990 to 2011.

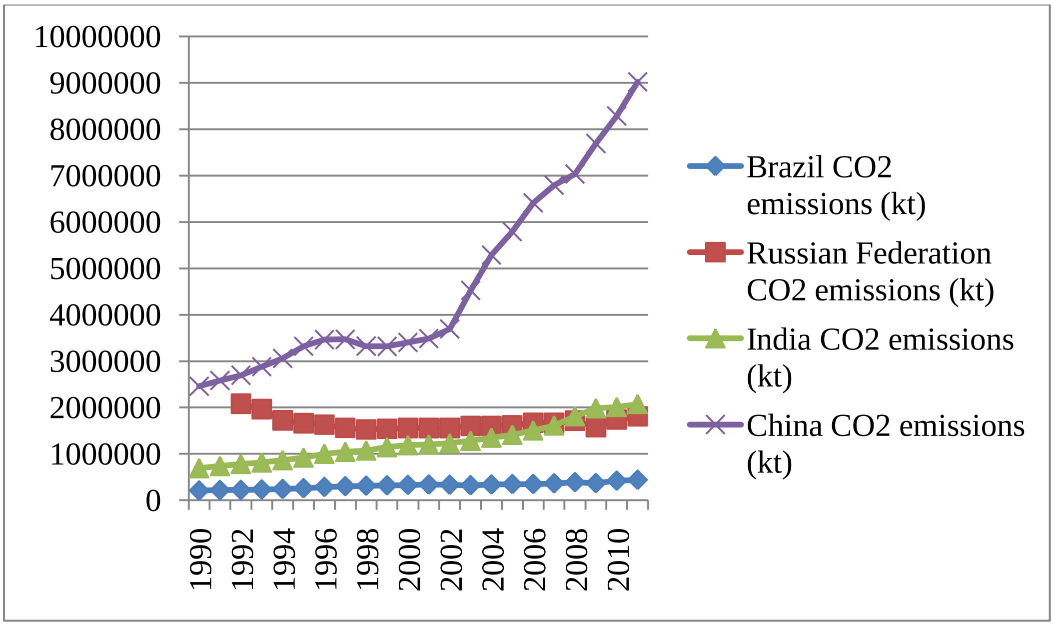

Figure 39. CO_2 emissions trend in BRICs over 1990-2011

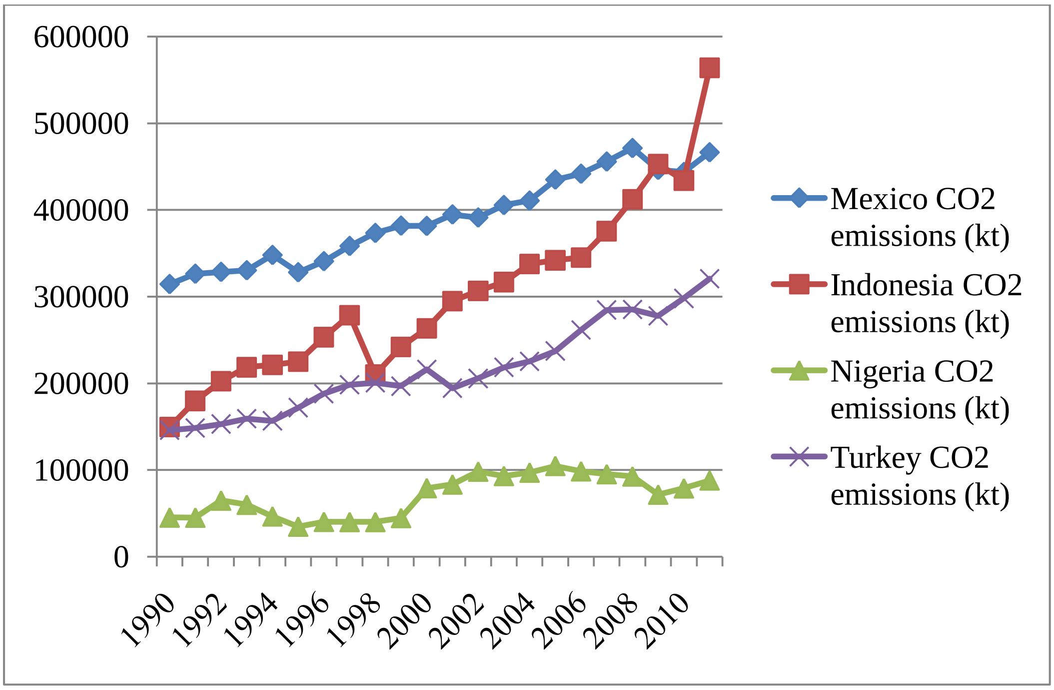

Figure 40. CO_2 emissions trend in MINTs over 1990-2011

Chapter 4

LITERATURE REVIEW

For analyzing the changes in CO_2 emissions, researchers roughly followed four main categories of methodologies. These methodologies can be listed as general equilibrium models, input output models, econometric regressions and decomposition analysis methods. In the following sections, each of those methodologies will be provided by some examples from the literature. Since our research mainly focuses on decomposition analysis, further exercises will be provided from this regard.

4.1 Computable General Equilibrium Model

A computable general equilibrium (CGE) model is a quantitative method to examine the impact of policy and economic shocks in the overall economy (IDB, 2015). As a result of its nature, CGE is a significantly useful tool for policy design.

In 2010, Aydin & Acar analyzed the economic and environmental implications of Turkey's access to the European Union. Utilizing a CGE analysis the authors focused to the impacts of three important components of Turkey's EU access: First, free movement of capital between Turkey and EU; second, free movement of labor between Turkey and EU; and third the reduction of CO_2 emissions in Turkey to achieve EU's 2020 emission reduction targets. In addition, a particular analysis conducted for the influence of CO_2 emissions reduction targets in both Turkey and EU and its possible impacts on the price of carbon in 2020. The analysts assumed that the labor movement would be from Turkey to EU and the capital movement would be from EU to Turkey. Finally their empirical findings revealed that different CO_2 emission targets for both EU and Turkey would bring a change in comparative advantages and therefore a change in interregional competitiveness.

4.2 Input – Output Model

According to Bess & Ambargis (2011) the input – output models if applied correctly are the powerful tools for analyzing the economy – wide impacts of an initial change that is observed in economic activity.

Yabe (2004) analyzed the CO_2 emissions of Japanese industries from 1985 to 1995 using input – output tables. The analyst separately considered the impacts of production technological changes (PTC) and environmental technological changes (ETC) on CO_2 emissions. In addition the analyst analyzed backward and forward linkage effects for every sector to determine which sector spreads or receives CO_2 emissions – impacts across all the sectors. Yabe's empirical findings showed that both of the technologies reduced CO_2 emissions in late 1980s however, not during the recession period in early 1990s. Trade factors also reduced the CO_2 emissions in both periods. However, as Yabe emphasized backward and forward linkage effects reduced CO_2 emissions in late 1980s but not in early 1990s.

4.3 Econometric Regression

Econometric regression models are widely used for analyzing the changes in CO_2 emissions. Recently environmental Kuznets curve (EKC) hypothesis become very popular regarding econometric studies. According to the EKC hypothesis, in the early stages of economic development, environmental pollution shows a rapid increase; however after reaching to a certain income level it begins to decrease

(Karakaya et al., 2013). This hypothesis examines the relationship between per capita GDP and per capita CO_2 emissions. An inverted U – shaped curve will be expected between per capita GDP and per capita CO_2 emissions according to the EKC hypothesis (Katircioglu, 2014).

Shen (2006) tested the EKC hypothesis for China from 1993 to 2002. Using the theoretical framework that environmental pollution and economic growth are jointly determined Shen formulated a simultaneous equations model (SEM) to analyze the relationship between CO_2 emissions and GDP. For estimating the SEM, the author used a two-stage least squares (2SLS) and also applied a Hausman test for income exogeneity. The author observed three main differences between single polynomial equation estimators that were commonly used in EKC literature and simultaneous equation estimators. There were differences that necessitates different policy implications, thus the author suggested simultaneity between environmental pollution and income before the regression of models in future EKC studies.

Zheng et al. (2008) also investigated the EKC hypothesis between the economic growth and environmental pollution for China from 1985 to 2005. The analysts used GDP as an economic indicator where waste water, solid wastes, and waste gas were used as environmental indicators. Their empirical findings indicated that there was a long – run co-integration between the per capita CO_2 emissions from the three pollutants and GDP per capita according to panel co-integration test. The authors also compared panel co-integration results with the dynamic OLS estimator and within OLS estimator and they concluded that the panel co-integration estimation was more preferable. Their empirical findings also revealed all of the pollutants were inverse U-shaped and water pollution was improved earlier than solid and gas pollution.

Karakaya et al. (2013) tested the validity of EKC hypothesis for Turkey from 1960 to 2010. The researchers used economic growth, energy consumption and CO_2 emissions as the main indicators. The Dynamic OLS model was utilized in the study and the empirical findings revealed that instead of the inverted U shaped EKC (as it was expected), there was an inverted N shaped EKC between per capita CO_2 emissions and per capita GDP. In addition, they proved that there was a significant relationship between CO_2 emissions and energy use.

Katircioglu (2014) investigated the long run equilibrium relationship between international tourism, energy use and environmental pollution in Turkey. The study results showed that there was a long term relationship between tourism, energy consumption and CO_2 emissions. Moreover the empirical findings from the impulse response and variance decompositions showed that there was a positive reaction from energy consumption and therefore CO_2 emissions to the tourism development changes is positive, and this relation becomes stronger in the long run. He also concluded that tourism development in Turkey has considerably increased the energy consumption and related CO_2 emissions.

Furthermore, in his another study Katircioglu (2014) examined the tourism induced EKC hypothesis for Singapore. His study revealed that there were a long-run equilibrium relationship between the tourism development and CO_2 emissions. In addition, his empirical findings showed that there were negatively significant impacts of tourist arrivals on CO_2 emissions both in the short run and in the long run.

Moreover Granger causality tests showed that there was a unidirectional causality from tourism development to CO_2 emission growth in long run in the economy of Singapore. Thus the analyst proved that tourism induced EKC hypothesis exists for the case of Singapore.

4.4 Decomposition Analysis

Decomposition analysis techniques could be considered generally in two main groups. In the first group there are studies including the derivations and expansions of the decomposition techniques. However, in the second group there are country based decomposition analysis studies.

4.4.1 Mathematical Decomposition Analysis Studies

In 2000, Ang and Liu presented a new decomposition method namely the Log Mean Divisia Index (LMDI) method and as the analysts emphasized this method has some desirable properties such as perfect decomposition and consistency in aggregation. The authors also defined the perfect decomposition and consistency in aggregation. Perfect decomposition implies that there is no residual term in decomposition results. Consistency in aggregation implies that estimates for subgroups could be aggregated in a consistent manner. Finally they also provided two case studies on energy – related carbon dioxide emissions.

Ang and Zhang (2000) provided a survey of index decomposition analysis in energy and environmental studies. Their paper classified more than 100 studies according to the aggregate indicator, application area and decomposition scheme.

Albrecht et al. (2002) criticized the former conventional decomposition methods because of their high residuals especially for analyses considering long periods with many variables. As an alternative, the authors presented the Shapley decomposition technique for CO_2 emissions from 1960 to 1996. The main advantage of this method was also clearly stated by the authors. The method presented a correct and symmetric decomposition with no residuals. The authors firstly extended Kaya Identity with nine components. Then they utilized Shapley method for four countries and the empirical findings revealed that carbon intensity of energy use and de-carbonization of economic growth had more impact on CO_2 emissions than the conventional decomposition techniques. Albrecht et al. (2002) also reported that population growth had higher impact on CO_2 emissions than the de-carbonization efforts.

In 2003, Ang et al. showed that Albrecht et al.'s (2002) decomposition technique and Sun's (1998) decomposition technique were exactly the same. The authors also extended the work of Albrecht et al. (2002) by providing an up-to-date and complete overview of perfect decomposition techniques and their role in energy and environment analysis.

Ang et al. (2004) contributed to index decomposition analysis (IDA) methodology by extending the two factor Fisher index decomposition approach to n factors and made a complement to existing additive approach. The analysts also emphasized that the provided approach possesses some desirable properties but its formula was more complex than the other adopted index decomposition analysis approaches.

Ang (2004) compared the current decomposition techniques and tried to address the best decomposition method in his paper. The analyst also emphasized the usefulness of decomposition analysis techniques and concluded that the Log Mean Divisia Index (LMDI) method should be the preferred method.

Furthermore, in his following study Ang (2005) provided a practical guide for LMDI approach. The paper includes general formulation process, examples and summary tables.

Duro and Padilla (2006) provided a methodology to decompose the inequalities in per capita CO_2 emissions into two interaction terms and Kaya factors. The authors used the Theil index inequality and presented this decomposition method for analyzing group inequality components. As a result, the authors achieved an advantage to analyze the factors behind inequalities in per capita CO_2 emissions among countries, within the group of countries and between the groups of countries.

Liu (2006) provided an overview of several methodologies that are based on energy consumption. The author made a comparison according to the size of residual term and concluded that the adaptive weighting Divisia and the simple average Divisia index method, were representing the smallest residual term. The author also presented a complete decomposition model to solve the residual problem.

Ang and Liu (2006) compared the International Energy Agency (IEA) model with other decomposition methods. As the authors cited, the IEA model based on the Laspeyres Index Method and also included in international collaborative initiative on energy indicators for sustainable development for possible adoption. Using data of the United States the authors clearly stated that residual term of IEA model could be significant and estimation results of the intensity and structure changes given by the model could be different from the estimation results derived from other decomposition methods. The residual term was becoming larger when the changes in intensity and/or structure variables were significant. In developing countries, the impact of structure and intensity are generally larger than developed countries, therefore the researchers concluded that there was a question whether IEA model was convenient for developing countries.

4.4.2 Country Based Decomposition Analysis Studies

Fankhauser and Cornillie (2004) decomposed the energy data to determine the factors behind energy intensity improvement. The authors analyzed energy structure of energy intensive former Soviet Union and Central & Eastern European countries.

Paul and Bhattacharya (2004) decomposed the energy – related CO_2 emissions in India for the period 1980-1996. Utilizing refined Laspeyres index (RLI) method the authors considered the impact of four main factors, namely pollution effect, energy intensity, economic activity and structural changes. Their empirical findings showed that economic activity has the largest accelerating contribution to CO_2 emissions in all economic sectors. Regarding transportation and industry sectors a remarkable CO_2 emissions decline was observed by the authors as a result of improved energy intensity and fuel switching. Additionally, the authors reported that reducing impact of energy intensity and pollution effect was equivalent to zero in agricultural CO_2 emissions in India.

Wang et al. (2005) decomposed the Chinese CO_2 emissions from 1957 to 2000. Utilizing LMDI method the authors concluded that China obtained a remarkable success to reduce the CO_2 emissions as a result of improved energy intensity. Furthermore fuel switching and increasing renewable energy use also helped to reduce CO_2 emissions in China.

Kawase et al (2006) decomposed the CO_2 emissions in Japan and they tried to establish the long – term climate stabilization scenarios for other countries and medium – term scenarios for Japan. In their study, the analysts utilized the extended Kaya identity to decompose changes in Japan's CO_2 emissions. Identified factors were CO_2 capture and storage, energy efficiency, economic activity, carbon intensity and energy intensity. The analysts also developed a reduction balance table and reported that to achieve the 60 % CO_2 emissions reduction target, energy intensity and carbon intensity should be decreased 2-3 times greater than the previous historical changes.

Ma and Stern (2008) decomposed the Chinese CO_2 emissions from 1980 to 2003. The authors utilized the log mean Divisia index (LMDI) method and they also analyzed the impact of structural effect on CO_2 emissions. Empirical findings showed that (1) the structural effects (includes the shifts of production between sub-sectors) decreased overall energy intensity, (2) since 2000, an increase in energy intensity was observed and this was the result of negative technological process, (3) structural changes have increased the energy intensity between 1980 and 2003, (4) technological progress was the major determining contributor of declining energy intensity, and (5) inter – fuel substitution was contributing little to the energy intensity changes in the research period.

Hatzigeorgiou et al. (2008) decomposed the CO_2 emissions in Greece from 1990 to 2002 by using the arithmetic mean Divisia index (AMDI) method and log mean Divisia index (LMDI) method. The authors compared the two methodologies and clearly underlined that LMDI (that is developed from AMDI) was more preferable. The authors examined impact of four main factors on CO_2 emissions. The identified factors were income effect, energy intensity effect, fuel share effect, and population effect. Empirical results showed that income effect was the major accelerating factor in Greek's CO_2 emissions where energy intensity reduced the amount of emissions.

Papagiannaki and Diakoulaki (2009) decomposed the CO_2 emissions from passenger cars in Greece and Denmark for the period 1990-2005. The authors utilized the Laspeyres index method. Empirical findings revealed that the transportation sector (especially passenger cars) was responsible for the half of the emissions in both countries. The examined factors were vehicle ownership, technology of cars, fuel mix, engine capacity, and annual mileage.

Zhang et al. (2009) decomposed the energy related CO_2 emissions in China from 1991 to 2006. The authors utilized refined Laspeyres index method that is developed by Sun and four main factors had been considered including energy intensity, structural changes, CO_2 intensity, and economic activity. Their empirical findings showed that economic activity was the largest increasing effect on CO_2 emissions in China for every economic sector. In addition, the authors proved that China achieved a remarkable decline in CO_2 emissions because of the improved energy efficiency. Furthermore they concluded that CO_2 intensity and structural changes had minor impacts on overall Chinese CO_2 emissions.

Timilsina and Shresta (2009) examined the factors influencing CO_2 emissions in transport sector of selected Asian countries from 1980 to 2005. The authors analyzed the changes in per capita GDP, modal shift, fuel mix, population, emission coefficients and energy intensity. Empirical findings showed that GDP per capita and population were major determining factors in CO_2 emissions from transport sector of the countries such as Korea, China, India, Indonesia, Sri Lanka, Malaysia, Thailand and Pakistan. On the other hand, the decline in energy intensity reduced the CO_2 emissions in Mongolia. In Bangladesh, Vietnam, and the Philippines researchers reported that per capita GDP, energy intensity, and population were the responsible factors for CO_2 emissions resulted from transportation.

Akbostanci et al. (2009) decomposed the CO_2 emissions for Turkish economy from 1970 to 2006. Utilizing the log mean Divisia index (LMDI) method (that is developed by Ang in 2005) the analysts examined the changes in CO_2 emissions in three aggregated sectors including agriculture, industry, and services. In addition, the analysts divided energy sources into four groups, namely solid fuels, natural gas, electricity and petroleum. They concluded that the economic activity and energy intensity played an important role in CO_2 emission changes, however structure effect had only minor contributions to emission changes.

Furthermore, in 2011 Akbostanci et al. decomposed the CO_2 emissions of Turkey's manufacturing industry from 1995 to 2001. The researchers utilized LMDI method and they examined the changes in CO_2 emissions due to economic activity, activity structure, energy intensity, energy mix, and emission factors. Empirical findings revealed that industrial activity and energy intensity were the major determining factors in CO_2 emissions during the study period. The researchers also reported that coal was the major CO_2 emissions accelerating fuel and iron & steel basic industries were the dirtiest economic sectors regarding Turkish manufacturing industry.

Kumbaroglu (2011) decomposed the CO_2 emissions in Turkey between 1990 and 2007 by utilizing refined Laspeyres index (RLI) method. Five major economic sectors including agriculture, manufacturing, transportation, electricity and residential sector was considered and the impacts of four major factors namely the scale effect, composition effect, energy intensity, and carbon intensity were examined. The impacts of fuel switching and activity changes and sectored CO_2 emissions were also analyzed. The author derived important hints for Turkey's energy planning and climate policy.

Finally Mishina and Muromachi (2012) decomposed the CO_2 emissions in Japan's transportation sector by utilizing three different methodologies, namely refined Laspeyres index method, log mean Divisia index method and modified Laspeyres index method. The authors underlined the shortcomings of RLI and LMDI methods (i.e. problems with the distribution of interaction terms when some factors change negatively) and they provided MLI method to resolve these problems by distributing the interaction terms to factors according to changes in every factor. The authors also concluded that MLI method was providing a better decomposition results than LMDI and RLI methods due to the distribution of interaction terms.

Chapter 5

METHODOLOGY AND DATA COLLECTION

5.1 Introduction to Decomposition Analysis

The main feature of decomposition analysis (DA) is to separate the changes according to the contributions of various specified factors. The steps of a decomposition analysis are (1) the definition of data (2) determination of the level of disaggregation (3) decomposition analysis method selection (4) application of a period – wise or a time – series DA method (5) evaluation of the empirical findings. As Ang (1995) states a period – wise analysis makes a comparison between the first and last year of the selected period and does not consider the details of the intervening years. Period – wise analysis is generally used in multi-country studies because of its less data need (Ang, 1995). On the other hand, a time series analysis applies time series data; therefore, its empirical findings present how the impacts of explanatory factors have changed over time.

A decomposition analysis method can have a multiplicative or an additive mathematical form (Hatzigeorgiou et al., 2008). In the additive decomposition approach the absolute change of an item is decomposed where the ratio change of an aggregate is decomposed in the multiplicative decomposition approach. Some analysts clearly stated that the main reason to choose a multiplicative or an additive decomposition method is frequently a matter of presentation (Hoekstra & Bergh, 2003).

There are two ways for decomposition of indicator changes at sector level: first way is the structural decomposition analysis (SDA) and second way is the index decomposition analysis (IDA). As Kumbaroglu (2011) states SDA is dependent to the input – output analysis of quantitative economics. Rose and Casler (1996) provided the theoretical foundations and major features of SDA in their study. On the other hand IDA uses the index number concept under several methods that are linked to various index number calculations (Kumbaroglu, 2011). Both structural and index decomposition analysis methods are utilized in energy and CO_2 decomposition studies. Regarding CO_2 emissions decomposition studies, the use of IDA is much larger (Kumbaroglu, 2011). Hoekstra and Bergh (2003) provided a comparison between structural and index decomposition analysis methodologies, and they stated that SDA is better for more refined decomposition of technological and economic impacts. On the other hand, IDA is a better approach for more detailed time and country analysis. As Ma and Stern (2008) states IDA has a main advantage over SDA, such as it can be applied to any data at any level of aggregation.

5.2 The Refined Laspeyres Index Method

Several decomposition techniques have been developed and utilized under IDA methodology. As Kumbaroglu (2011) states the Laspeyres index method is isolating the impact of a specific variable by letting that variable to change between two years. On the other hand, this method holds the other variables constant at their base year values. The main issue with the Laspeyres index method is the sum or product of the estimated factors does not equal to the observed changes in CO_2 emissions, therefore a residual term arises. In order to eliminate this residual term a refinement process is proposed by Sun (1998). As a result, the residual term was distributed to each variable and this approach was referred as refined Laspeyres index method.

According to Ang and Zhang (2000) the RLI method passes from all tests (such as zero value robustness, factor – reversal, time – reversal) and possesses some desirable properties. The RLI method is utilized for this thesis is based on the extended Kaya identity.

We used the Kaya identity as a basis to examine the role of different factors on CO_2 emissions. The Kaya identity describes CO_2 emissions as a multiplication of four factors, such as population (POP), per capita production (GDP/POP), energy intensity of production (ENG/GDP), and carbon intensity of energy consumption (CO_2/ENG) where

$$CO_2 = POP * (GDP/POP) * (ENG/GDP) * (CO_2/ENG) \qquad (1)$$

For the overall CO_2 emissions estimations we used the extended form of the Kaya identity such as

$$CO_2^t = \sum_i CO_{2i}^t = \sum_i POP_i^t * \frac{GDP_i^t}{POP_i^t} * \frac{ENG_i^t}{GDP_i^t} * \frac{CO_{2i}^t}{ENG_i^t} \qquad (2)$$

The change in CO_2 emissions from base year 0 to target year t, can be represented as ΔCO_2 and it can be decomposed to four factors: (1) the changes in economic activity effect (represented by ΔEA), (2) the changes in population (represented by ΔPOP), (3) the changes in energy intensity effect (represented by ΔENG), and (4) the changes in carbon intensity effect (represented by ΔCAR). We used the additive form of the RLI method in this thesis, therefore overall CO_2 emissions changes calculated as

$$\Delta CO_2 = \Delta EA + \Delta POP + \Delta ENG + \Delta CAR \qquad (3)$$

i.e.

$Change\ in\ CO_2 emissions =$

$Change\ in\ economic\ activity + Change\ in\ population +$

$Change\ in\ energy\ intensity + Change\ in\ carbon\ intensity$ (4)

The changes in economic activity, population effect, carbon intensity and energy intensity are also equivalent to

$$\Delta EA = EA^t - EA^0;$$

$$\Delta POP = POP^t - POP^0;$$

$$\Delta CAR = CAR^t - CAR^0;$$

$$\Delta ENG = ENG^t - ENG^0;$$

The contribution of changes in economic activity, population, energy intensity, and carbon intensity on the change in CO_2 emissions from year 0 to t can be calculated from the equations (5) to (8). In these equations, the Laspeyres decomposition is refined and the residual term is distributed using the 'jointly created and equally distributed' principle (Sun, 1998). As a result, halves, thirds and quarters of the residual terms are taken where two, three and four variables are changing, respectively. For the further discussion about RLI, Ang and Zhang's (2001) work can be followed.

$$Economic\ Activity\ Effect = \Delta EA(j) \sum_j \Big\{ POP(j)ENG(j)CAR(j) + \frac{1}{2} * \big(\Delta POP(j)ENG(j)CAR(j) + POP(j)\Delta ENG(j)CAR(j) + POP(j)ENG(j)\Delta CAR(j)\big)\Big\} + \Delta EA(j) \sum_j \{\frac{1}{3} * (\Delta POP(j)\Delta ENG(j)CAR(j) + \Delta POP(j)ENG(j)\Delta CAR(j) + POP(j)\Delta ENG(j)\Delta CAR(j)) + 1/4 * (\Delta POP(j)\Delta ENG(j)\Delta CAR(j))\} \quad (5)$$

The 5th equation describes the economic activity effect. It explains the changes in CO_2 emissions resulted from the changing activity levels. An increase in economic activity raises the carbon dioxide emissions and a decrease in economic activity reduces the carbon dioxide emissions.

$$Population\ Effect =$$

$$\sum_j \Delta POP(j)\{EA(j)ENG(j)CAR(j) + \frac{1}{2} * (\Delta EA(j)ENG(j)CAR(j) + EA(j)\Delta ENG(j)CAR(j) + EA(j)ENG(j)\Delta CAR(j))\} + \sum_j \Delta POP(j)\{\frac{1}{3} * (\Delta EA(j)\Delta ENG(j)CAR(j) + \Delta EA(j)ENG(j)\Delta CAR(j) + EA(j)\Delta ENG(j)\Delta CAR(j)) + 1/4 * (\Delta EA(j)\Delta ENG(j)\Delta CAR(j))\} \quad (6)$$

Equation 6 is the population effect and it reflects the changes in carbon dioxide emissions are resulted from the changes in population.

$$Energy\ Intensity =$$

$$\sum_j \Delta ENG(j)\{EA(j)POP(j)CAR(j) + \frac{1}{2} * (\Delta EA(j)POP(j)CAR(j) + EA(j)\,\Delta POP(j)CAR(j) + EA(j)POP(j)\Delta CAR(j))\} + \sum_j \Delta ENG(j)\{\frac{1}{3} * (\Delta EA(j)\Delta POP(j)CAR(j) + \Delta EA(j)POP(j)\Delta CAR(j) + EA(j)\Delta POP(j)\Delta CAR(j)) + 1/4 * (\Delta EA(j)\Delta POP(j)\Delta CAR(j))\} \quad (7)$$

Equation 7 describes the energy intensity. It shows an indication of the efficiency in energy process and conversion technologies. Together with this, energy intensity effect underlines the energy conservation. Improving energy efficiency decreases CO_2 emissions where negative technological process accelerates the amount of overall emissions.

$$Carbon\ Intensity\ Effect = \sum_j \Delta CAR(j) \left\{ \begin{matrix} EA(j)POP(j)ENG(j) + \frac{1}{2} * \\ \left(\begin{matrix} \Delta EA(j)POP(j)ENG(j) + EA(j)\Delta POP(j)ENG(j) + \\ EA(j)POP(j)\Delta ENG(j) \end{matrix} \right) \end{matrix} \right\} +$$

$$\sum_j \Delta CAR(j)\{\frac{1}{3} * (\Delta EA(j)\Delta POP(j)ENG(j) + \Delta EA(j)POP(j)\Delta ENG(j) + EA(j)\Delta POP(j)\Delta ENG(j)) + \frac{1}{4} * (\Delta EA(j)\Delta POP(j)\Delta ENG(j))\} \quad (8)$$

The 8th equation presents the carbon intensity that is used to analyze the impact of fuel switch on CO_2 emissions. When the energy mix becomes more carbon intensive then the CO_2 emissions will increase. On the other hand, if the energy mix becomes less carbon intensive (for instance, if renewable energy sources are used instead of conventional energy sources) then a substantial decline could be observed in CO_2 emissions.

5.3 Data Collection

The data set consists the period between 1990 and 2011 and it was sourced from the World Bank's World Development Indicators (WDI) and from the US Energy Information Administration (EIA). The data considers the macroeconomic indicators (including inflation, real GDP, unemployment, sectoral real GDP, per capita real GDP), energy market indicators (including energy use and production data, electricity consumption and production data, per capita energy use, per capita electricity consumption, electric power production according to fuel types), the demographic data (including population changes, urbanization), and the carbon emissions data (including overall emissions, per capita emissions, emissions according to the economic sectors, and emissions according to fuel types) for all research countries.

Chapter 6

DECOMPOSITION OF CO_2 EMISSIONS IN BRICS AND MINTS OVER 1990 – 2011

In this thesis we decomposed the CO_2 emissions in BRICs (Brazil, Russia, India, and China) and in MINTs (Mexico, Indonesia, Nigeria, and Turkey) for the period between 1990 and 2011. The data were sourced from World Bank, and the refined Laspeyres index method has been utilized to accomplish the decomposition analysis. Impacts of four main factors, including economic activity, population, energy intensity, and carbon intensity on CO_2 emissions have been considered. The study period has been divided into two sub-periods, where the former encompasses between 1990 and 2000, and the latter encompasses between 2000 and 2011. In addition the decoupling factor that analyzes the link between CO_2 emissions and economic growth is given in the last section of the chapter. The empirical findings of decomposition analysis presented below.

6.1 Decomposition of CO_2 emissions in BRICs

6.1.1 Decomposition of CO_2 emissions in Brazil

Brazil achieved a remarkable economic growth performance and its real GDP has increased by 88.3 % from 1990 to 2011 (World Bank, 2015). Therefore the economic activity effect played a significant role in Brazil's CO_2 emissions in both sub-periods. In the early 1990s, economic activity effect has followed a reducing impact on cumulative CO_2 emissions; however, after that period it has followed an accelerating impact until the end of study period. At the beginning of first sub-period, the share of economic activity was – 3.3 % in Brazil's CO_2 emissions. However, at the end of first sub-period (in 2000), it has increased to 21 %. The economic activity effect has followed the carbon intensity and the population effect in this period. On the other hand, the impact of economic activity effect on Brazil's CO_2 emissions became more visible. Its share in emissions has reached to 52.2 %, in 2011. Since the country has achieved a significant economic growth, an increasing economic activity in CO_2 emissions is consistent. Figure 41 depicts the impact of economic activity in Brazil's CO_2 emissions over 1990 – 2011.

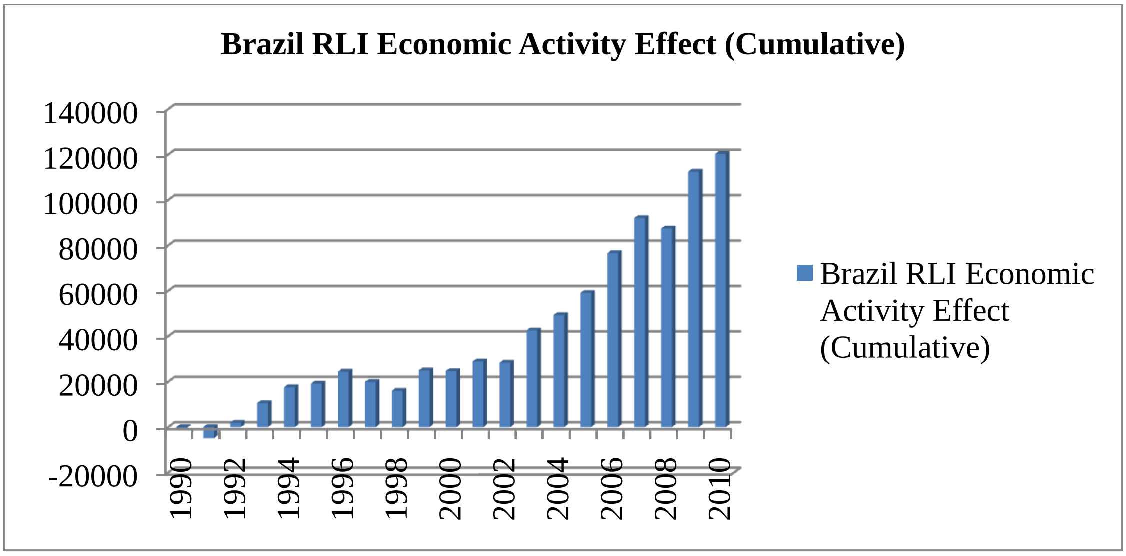

Figure 41. Impact of economic activity effect in Brazil's CO_2 emissions over 1990-2011

Today, Brazil is the fifth most populous country in the world and its population has increased by 31.6 % in the study period as the World Bank's data indicates. Since the population of Brazil has risen gradually, an increasing impact of population effect on CO_2 emissions was expected and it was observed. Population effect was the second major determining factor in Brazil's CO_2 emissions in the study period. Its share was equivalent to 34.1 % and 36.2 % at the end of first (in 2000) and second (in 2011) sub-periods, respectively. Figure 42 depicts the impact of population effect on Brazil's CO_2 emissions from 1990 to 2011.

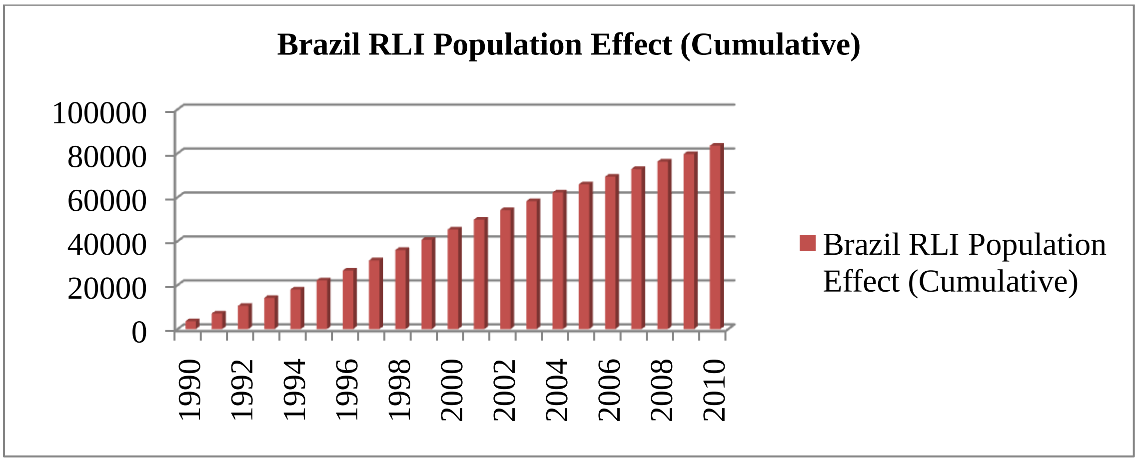

Figure 42. Impact of population effect in Brazil's CO_2 emissions over 1990-2011

Energy intensity has followed a minor increasing impact in Brazil's CO_2 emissions during the study period. In the early 1990s its share in overall emissions was equivalent to 7.6 %. However, due to the negative technological process that is observed in late 1990s, the share of energy intensity in overall emissions has increased to 9.2 % at the end of first sub-period. On the other hand, energy intensity followed a decreasing trend after 2000; therefore its share has decreased to 2 % in overall emissions, at the end of second sub-period. Brazil's energy consumption has increased by 92.6 % from 1990 to 2011, where the real GDP has increased by 110.4 % in the same period (World Bank, 2015). In addition, 10 out of 21 years of research period energy intensity has sharply increased the CO_2 emissions in Brazil. These results clearly indicate that Brazil has a long way to achieve its energy efficiency goals. A negative energy intensity impact is more preferable for Brazil to offset the accelerating impacts of other factors. Figure 43 depicts the impact of energy intensity in Brazil's CO_2 emissions from 1990 to 2011.

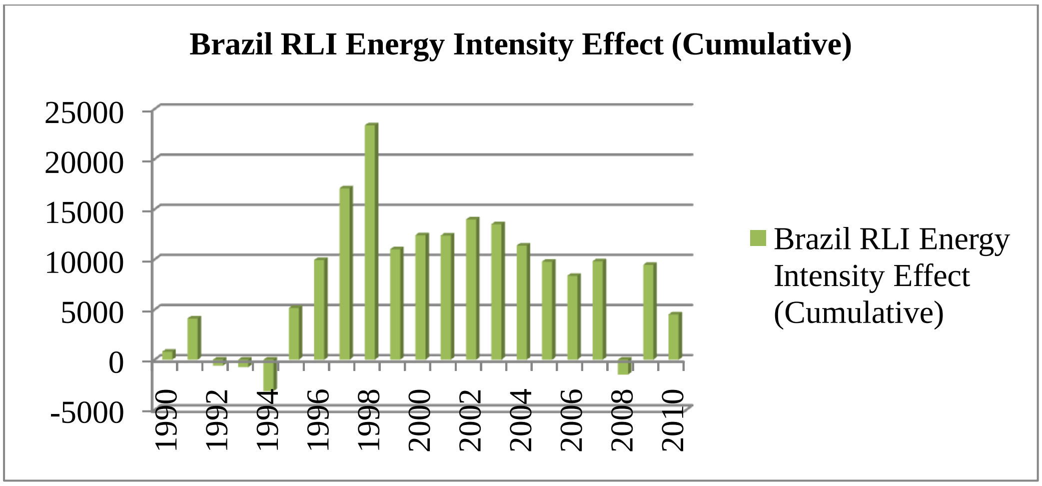

Figure 43. Impact of energy intensity in Brazil's CO_2 emissions over 1990-2011

Carbon intensity is the factor where its impact on Brazil's CO_2 emissions has changed the most. In the early 1990s the share of carbon intensity in overall CO_2 emissions was equivalent to 61.6 %. At the end of first sub-period (in 2000) the share of carbon intensity has decreased to 35.6 %. Furthermore, the share has declined to 9.7 % at the end of second sub-period. This is mainly due to the decrease of the shares of solid and liquid fuels in CO_2 emissions. The share of solid fuels has decreased from 17.1 % (in 1990) to 14.6 % (in 2011), where the share of liquid fuels has decreased from 72.1 % (in 1990) to 65.8 % (in 2011). On the other hand, the share of gas fuels has accelerated from 3.6 % to 11.5 % in the same period (World Bank, 2015). Since the carbon coefficient of gas fuels is relatively smaller than liquid and solid fuels, then the decline in the carbon intensity was an expected result. Furthermore, the share of renewable energy sources (excluding hydro) in power production has increased from 1.7 % to 6.6 % in the same period and this fuel switch has also helped to reduce the carbon intensity. In 8 out of 21 years the carbon intensity has reduced Brazil's CO_2 emissions. However, similar to the energy intensity, negative carbon intensity effect is more preferable in order to offset the impacts of other CO_2 emissions accelerating factors. Figure 44 depicts the impact of carbon intensity on Brazil's CO_2 emissions from 1990 to 2011.

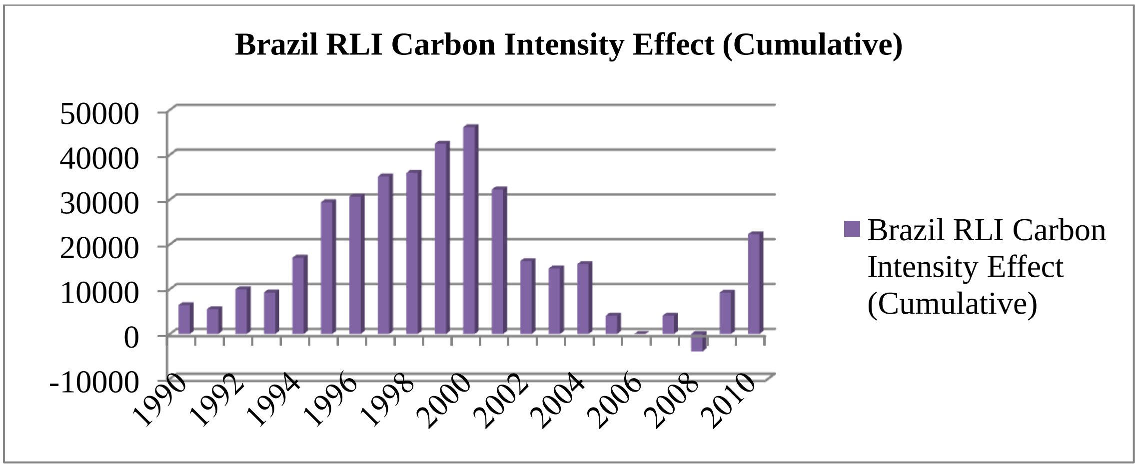

Figure 44. Impact of carbon intensity in Brazil's CO_2 emissions over 1990-2011

To sum up, it is possible to state that economic activity was the major determining factor of Brazil's CO_2 emissions. Population effect has followed the economic activity in this respect. On the other hand, energy intensity and carbon intensity effects had minor accelerating impacts on Brazil's CO_2 emissions. Figure 45 depicts the impact of all factors on Brazil's carbon emissions from 1990 to 2011.

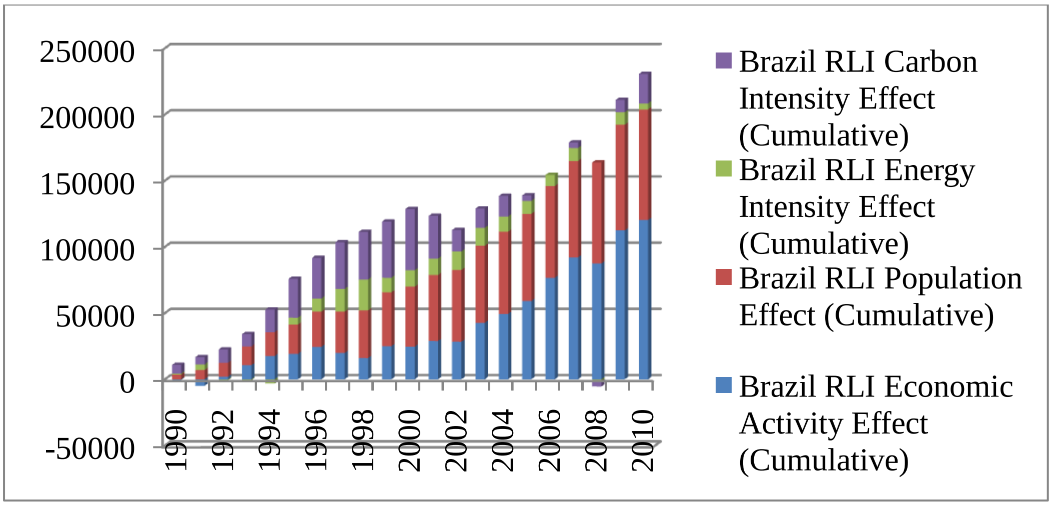

Figure 45. Impact of all factors in Brazil's CO_2 emissions over 1990-2011

Table 7 describes the impact of four factors on Brazil's CO_2 emissions in the first and second sub-periods.

Table 7. Shares of all factors in Brazil's CO_2 emissions over 1990-2011

Brazil	First Sub-period (1990–2000)	Second Sub-period (2000–2011)
Economic Activity	21 % (3rd major factor)	52.2 % (1st major factor)
Population	34.1 % (2nd major factor)	36.2 % (2nd major factor)
Energy Intensity	9.2 % (4th major factor)	2 % (4th major factor)
Carbon Intensity	35.6 % (1st major factor)	9.7 % (3rd major factor)
Total	100 %	100 %

6.1.2 Decomposition of CO_2 emissions in Russia

The decomposition analysis for Russia covers the period from 1992 to 2011 since the data of CO_2 emissions is not available for the country for 1990 and 1991. Between 1992 and 1998 Russia's economy has faced with recessions, therefore economic activity followed a decelerating impact on CO_2 emissions in the first sub-period. In 1992, the share of economic activity was equivalent to -153.3 %. However, at the end of first sub-period (in 2000) the share of economic activity increased to -68.7 %. Moreover, as a result of remarkable economic growth the economic activity effect started to accelerate Russia's CO_2 emissions in the second sub-period. At the end of second sub-period (in 2011), the share of economic activity has increased to 179.2 %. Six out of 19 years in research period economic activity followed a decreasing trend in CO_2 emissions in Russia and five of these years were in the first sub-period. Figure 46 describes the impact of economic activity on Russia's CO_2 emissions from 1992 to 2011.

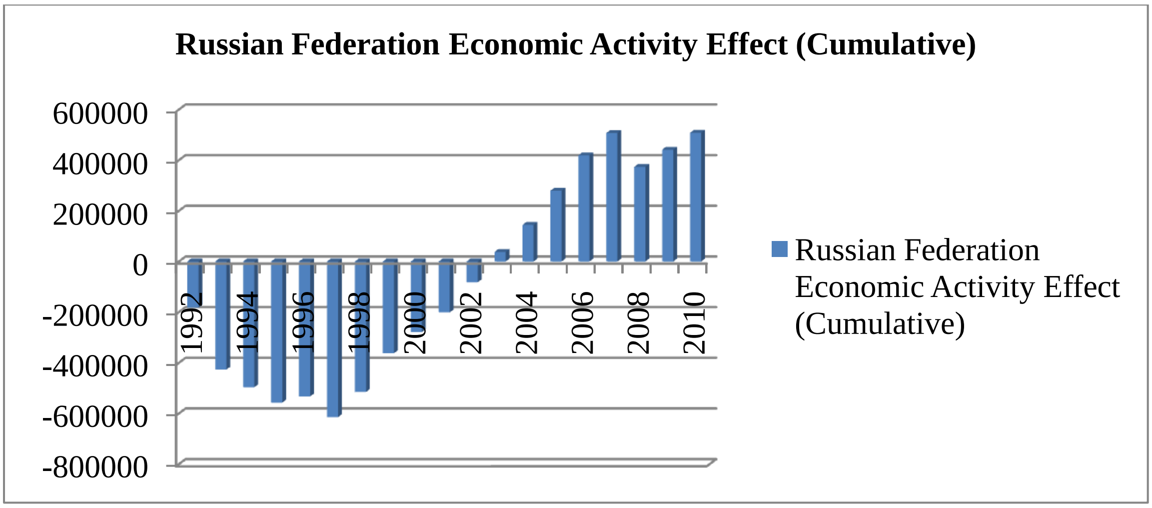

Figure 46. Impact of economic activity in Russia's CO_2 emissions over 1992-2011

Russia's population has decreased by 3.9 % from 1992 to 2011. Therefore, the population effect followed a reducing impact on CO_2 emissions in Russia. The share of population effect in Russia's CO_2 emissions was equivalent to -1.9 % in 1992. Since the population of Russia continued to decline during 1990s, the share of population effect decreased to -4.4 % at the end of first sub-period. Moreover, at the end of second sub-period (in 2011) the share of population effect in Russia's CO_2 emissions decreased to -22.1 %. In 16 out of 19 years the population effect followed a negative trend in Russia's CO_2 emissions. To sum up, Russia's population decline has reduced the carbon emissions in the entire study period. In addition Russia was the only country that experienced a population decline among the 9 countries. Figure 47 describes the impact of population effect in Russia's CO_2 emissions over 1992 – 2011.

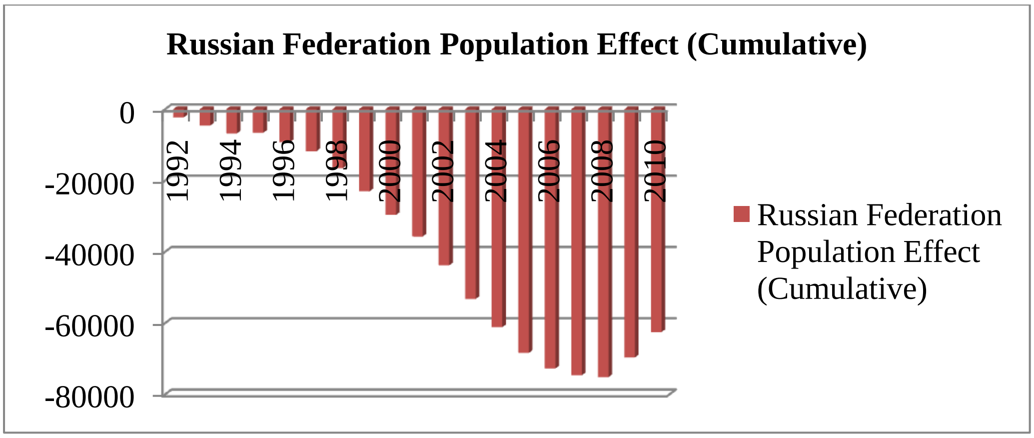

Figure 47. Impact of population effect in Russia's CO_2 emissions over 1992-2011

Between 1992 and 1999 energy intensity followed an accelerating impact in Russia's CO_2 emissions. In 1992, the share of energy intensity was equivalent to 56.6 %. However, for the first sub-period (from 1992 to 2000) we calculated the share of energy intensity as -15.4 %. Moreover, at the end of second sub-period, the share of energy intensity has decreased to -226.1 %. In 12 out of 19 years in study period energy intensity reduced Russia's CO_2 emissions. In addition, Russia's GDP increased by 38.6 % between 1992 and 2011, and its energy consumption has declined by -8.1 % in the same period (World Bank, 2015). The empirical results clearly indicate that Russia produced more with less energy in the study period. One can conclude that Russia (a high income country) achieved a remarkable success in its energy efficiency improvement. Figure 48 describes the impact of energy intensity in Russia's CO_2 emissions from 1992 to 2011.

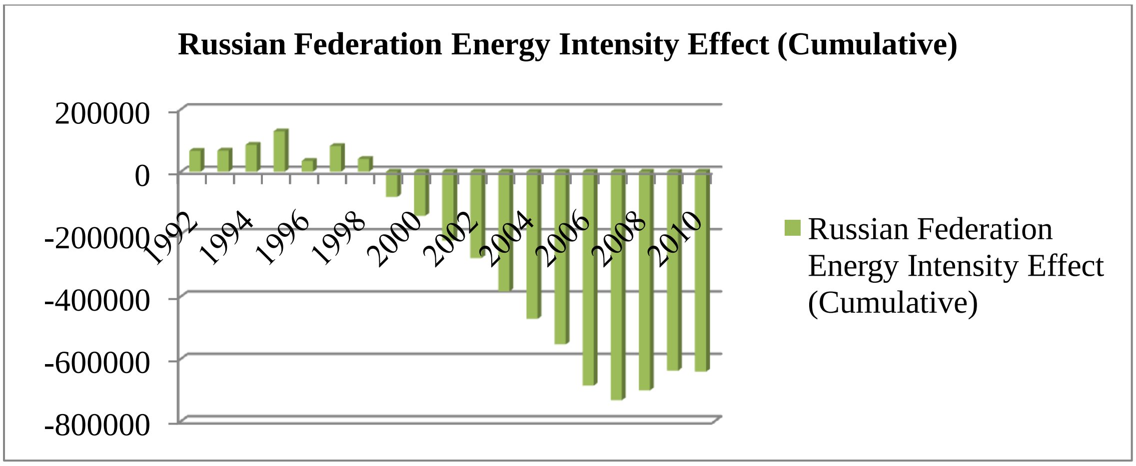

Figure 48. Impact of energy intensity in Russia's CO_2 emissions over 1992-2011

Carbon intensity effect has reduced the Russian CO_2 emissions during the study period. In 1992 (at the beginning of research period for Russia) the share of carbon intensity in CO_2 emissions was equivalent to -1.4 %. However, the decreasing impact of carbon intensity on Russia's CO_2 emissions became more visible during the study period. At the end of first sub period the share of carbon intensity in carbon dioxide emissions decreased to -11.6 %. Moreover, this value declined to -31.1 % at the end of second sub-period (in 2011). Russia's CO_2 emissions have decreased due to the improved carbon intensity. Improved carbon intensity is probably the result of declining consumption of oil sources in electricity production. The share of oil has decreased from 9.7 % (in 1992) to 2.6 % (in 2011) (World Bank, 2015). Moreover, the share of liquid fuel consumption in Russia's CO_2 emissions has decreased from 30.3 % (in 1992) to 20.7 % (in 2010) and the share of solid fuel consumption in CO_2 emissions has decreased from 28.8 % to 25.8 % in the same period (World Bank, 2015). On the other hand, the share of gaseous fuel consumption in Russia's CO_2 emissions has increased from 38.8 % (in 1992) to 50.4 % (in 2010) (World Bank, 2015). Since gas fuels are much cleaner than solid and liquid fuels, then the fuel mix in Russia became less carbon intensive. Figure 49 describes impact of carbon intensity on Russia's CO_2 emissions during 1992-2011 period.

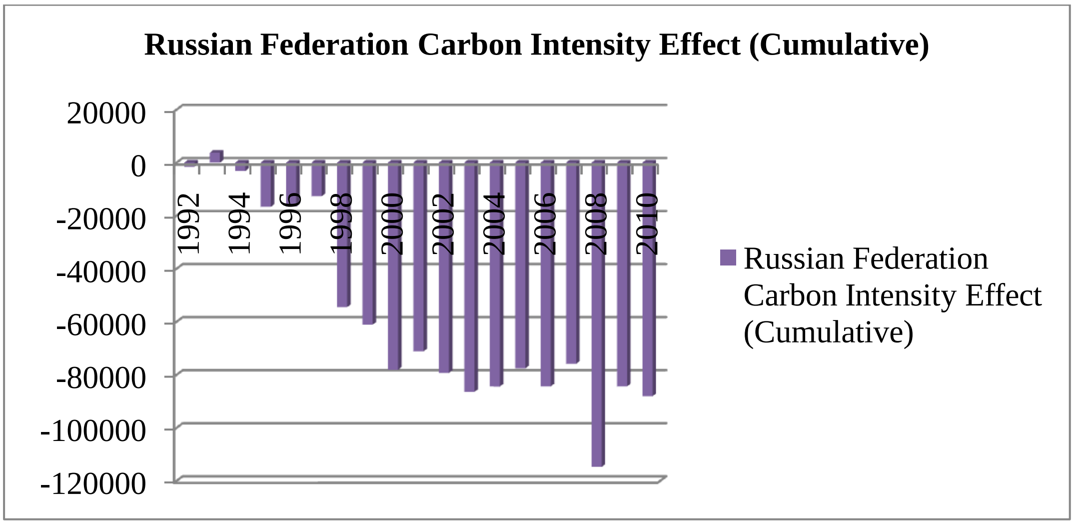

Figure 49. Impact of carbon intensity in Russia's CO_2 emissions over 1992-2011

It is possible to conclude that Russia's CO_2 emissions declined mainly due to the energy intensity improvement. In addition, population decrease and improvements in carbon intensity have also reduced the CO_2 emissions in Russia. Figure 50 describes the impact of all factors on Russia's CO_2 emissions during the research period.

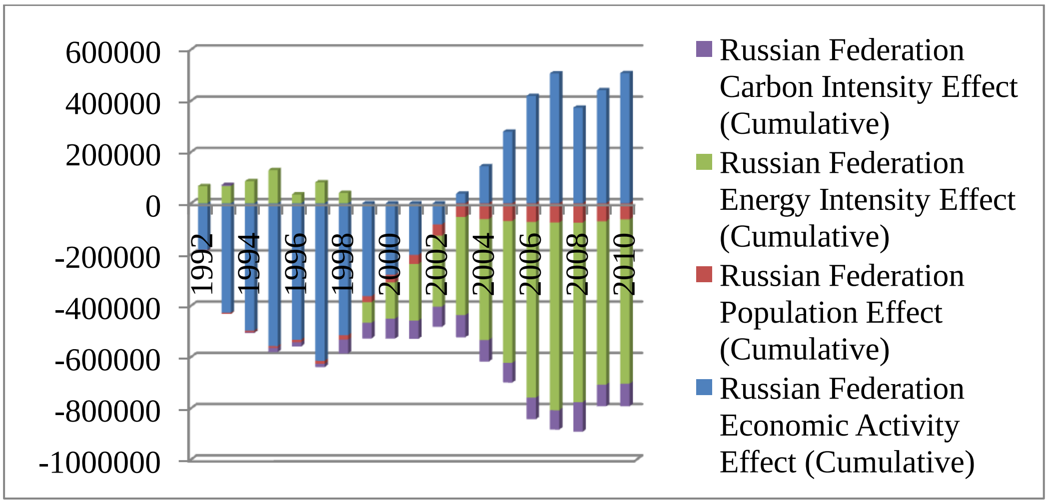

Figure 50. Impact of all factors in Russia's CO_2 emissions over 1992-2011

Table 8 summarizes the impact of four factors on Russia's CO_2 emissions between 1992 and 2011.

Table 8. Shares of all factors in Russia's CO_2 emissions over 1992-2011

Russia	First sub-period (1992-2000)	Second sub-period (2000-2011)
Economic Activity	-68.7 % (1st major factor)	179.2 % (2nd major factor)
Population Effect	-4.4 % (4th major factor)	-22.1 % (4th major factor)
Energy Intensity	-15.3 % (2nd major factor)	-226.1 % (1st major factor)
Carbon Intensity	-11.6 % (3rd major factor)	-31.1 % (3rd major factor)
Total	-100 %	-100 %

6.1.3 Decomposition of CO_2 emissions in India

India achieved a remarkable economic growth success during the study period. Country's real GDP has increased by 278.6 % from 1990 to 2011 (World Bank, 2015). As a result, the economic activity played an important role in India's carbon dioxide emissions changes. At the beginning of research period the share of economic activity effect in India's carbon dioxide emissions was equivalent to -14.2 %. However, starting in 1991, economic activity effect followed an accelerating impact on CO_2 emissions in India. Therefore, the share of economic activity has risen to 70.2 % at the end of first sub-period. Furthermore the share of economic activity effect continued to increase in the second sub-period and it reached to 97.4 % in 2011. India's sustained economic growth has accelerated its CO_2 emissions as it was expected. Figure 51 shows the impact of economic activity on India's CO_2 emissions from 1990 to 2011.

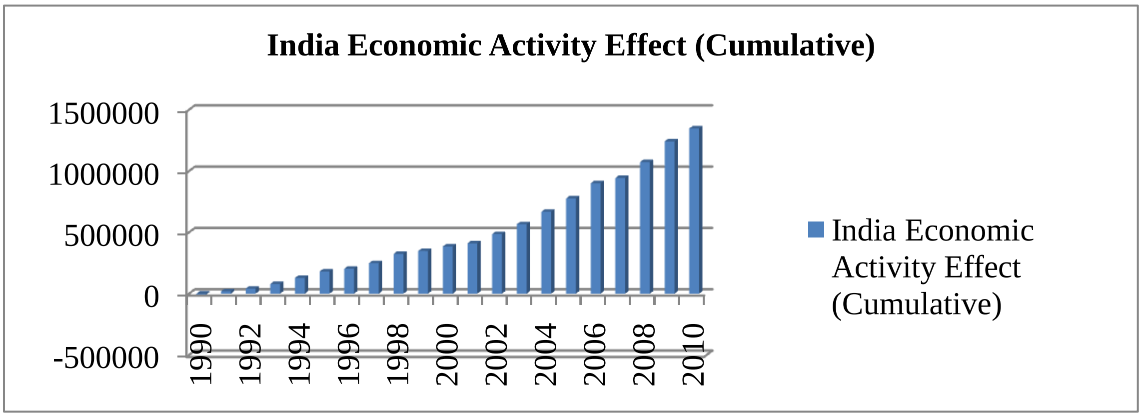

Figure 51. Impact of economic activity in India's CO_2 emissions over 1990-2011

India's population increased rapidly in the research period. Between 1990 and 2011, country's population has increased by 40.5 %. As a result, the population effect played an important role in India's CO_2 emissions. At the end of 1990s the share of population effect in CO_2 emissions was equal to 33.9 %. India's population growth has slowed down therefore the share of population effect in CO_2 emissions has declined to 29.6 % at the end of second sub-period (in 2011). India is the second most populous country in the world. However, the population growth rate is much greater than China; therefore, in the near future India's population is expected to surpass China's. Figure 52 shows the impact of population effect on India's CO_2 emissions from 1990 to 2011.

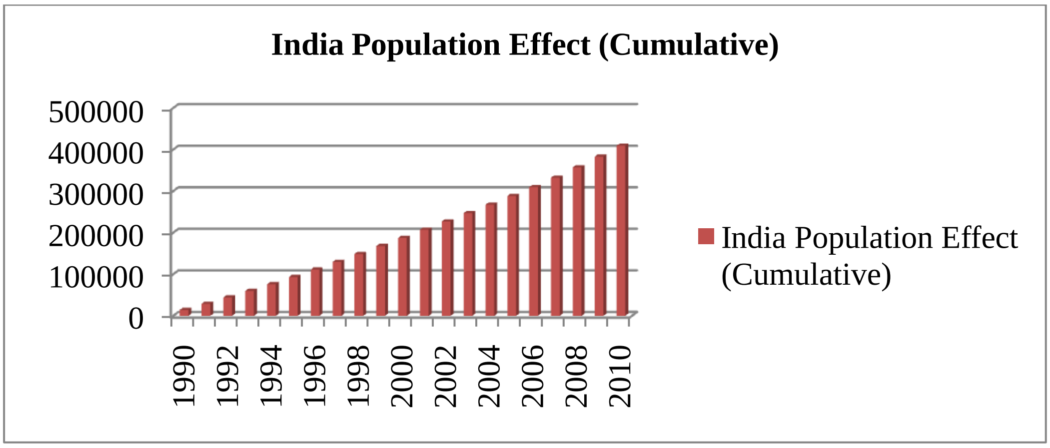

Figure 52. Impact of population effect in India's CO_2 emissions over 1990-2011

Energy intensity was another major determining factor in India's carbon dioxide emissions. At the beginning of study period the share of energy intensity was equivalent to 43.7 % in overall carbon emissions. However, starting from 1991, India's energy intensity followed a decreasing impact in country's CO_2 emissions. Therefore, at the end of first sub-period (in 2000) the share of energy intensity was equal to -35.4 %. Furthermore, the share has decreased to – 45 % at the end of second sub-period (in 2011). In 18 out of 21 years in research period, energy intensity has reduced the CO_2 emissions. India's GDP has increased by 278.7 % and its energy consumption has increased by 136.6 % in the study period. Similar to Russia, India becomes more productive using less energy. To sum up, our empirical findings clearly reveal that India achieved a considerable success to reduce the speed of CO_2 emissions by improving the energy intensity. Figure 53 shows the impact of energy intensity on India's CO_2 emissions.

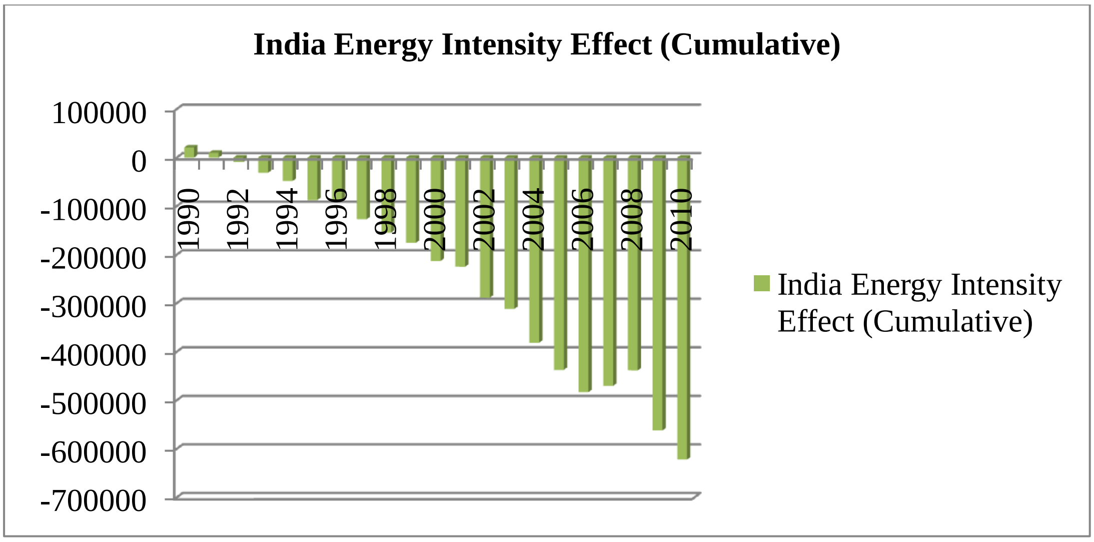

Figure 53. Impact of energy intensity in India's CO_2 emissions over 1990-2011

Carbon intensity also played a significant role in the changes of India's CO_2 emissions. At the beginning of research period its share was equivalent to 40.4 %.

Then the share decreased to 31.3 % and 18 % at the end of first and second sub-periods respectively. This is probably the result of declining oil and increasing natural gas consumption in electricity production in India. During the study period, share of oil has decreased from 3.5 % (in 1990) to 1.2 % (in 2011) where the share of natural gas has accelerated from 3.4 % (in 1990) to 10.3 % (in 2011) (World Bank, 2015). Together with this, the share of other renewable (excluding hydro) sources has increased from 0.01 % to 5 % between 1990 and 2011 in India's electricity production (World Bank, 2015). On the other hand, still coal sources accounted 68 % of India's electricity production in 2011; therefore carbon intensity considers accelerating India's carbon emissions. Negative carbon intensity is more preferable since it creates an opportunity to offset the increasing impacts of other factors. Figure 54 represents the impact of carbon intensity on India's carbon dioxide emissions from 1990 to 2011.

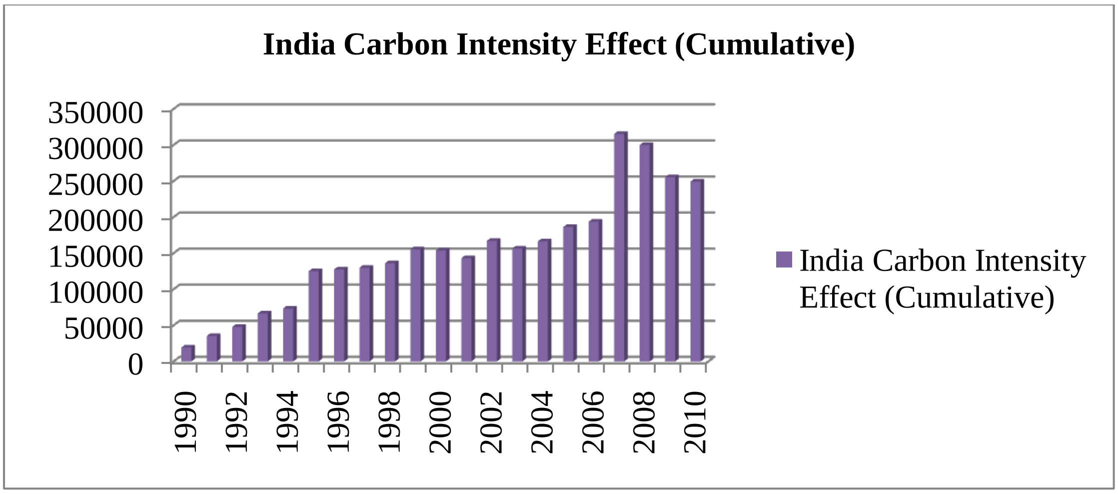

Figure 54. Impact of carbon intensity in India's CO_2 emissions over 1990-2011

To sum up, it is possible to conclude that a remarkable success achieved by India, in order to reduce its carbon emissions due to the improved energy efficiency. However, further steps are needed to decline the impact of carbon intensity and population effects. Figure 55 shows the impacts of four factors in India's CO_2 emissions from 1990 to 2011.

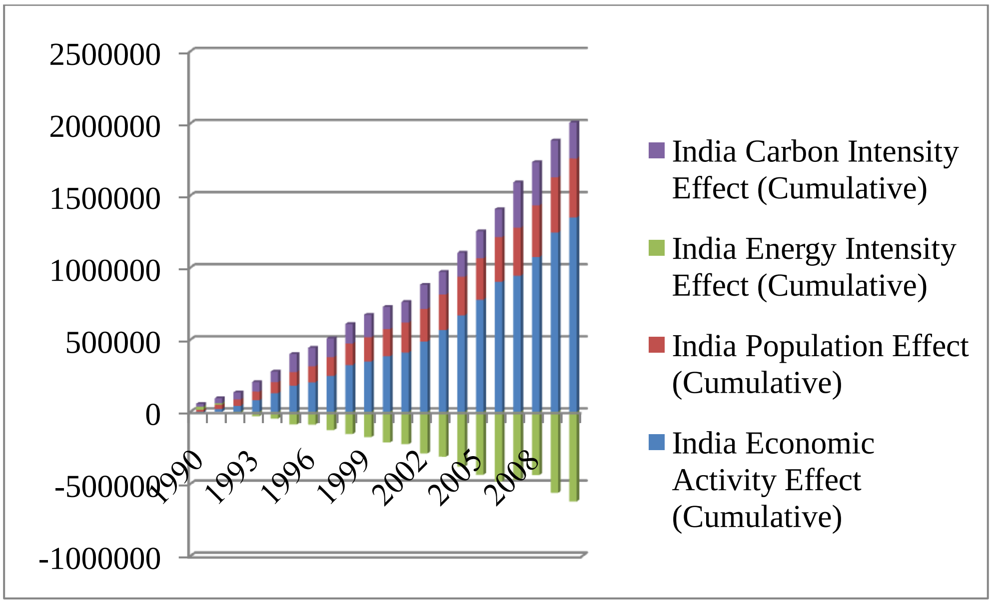

Figure 55. Impact of all factors in India's CO_2 emissions over 1990-2011

Table 9 summarizes the share of four factors in India's CO_2 emissions during the study period.

Table 9. Shares of all factors in India's CO_2 emissions over 1990-2011

India	First sub-period (1990 – 2000)	Second sub-period (2000 – 2011)
Economic Activity	70.2 % (1st major factor)	97.4 % (1st major factor)
Population	33.9 % (3rd major factor)	29.6 % (3rd major factor)
Energy Intensity	-35.4 % (2nd major factor)	-45 % (2nd major factor)
Carbon Intensity	31.3 % (4th major factor)	18 % (4th major factor)
Total	100 %	100 %

As table 9 indicates in the first sub-period, energy intensity successfully offset the accelerating impact of population. Furthermore in the second sub-period it is possible to conclude that energy intensity almost offset the accelerating impacts of population and carbon intensity.

6.1.4 Decomposition of CO_2 Emissions in China

China achieved the most spectacular economic growth in our times. The country's real GDP has increased by 698.9 % between 1990 and 2011. As a result, economic activity effect has followed the largest increasing impact on China's CO_2 emissions. At the beginning of study period the share of economic activity was equal to 151.4 %. Moreover, it has increased to 287.3 % at the end of first sub-period (in 2000). After 2000, the share of economic activity has gradually declined and it was equivalent to 134.9 % in 2011. However, economic activity effect is still the major determining factor in China's CO_2 emissions. Figure 56 presents the impact of economic activity on China's CO_2 emissions over 1990-2011.

Over its 1.3 billion individuals China is the most populous country in the world. However, from 1990 to 2011 the population of the country has only increased by 18.4 % (World Bank, 2015). If one compare with the second most populous country India, China's population growth could be considered as modest. India's population has increased by 40.5 % in the same period (World Bank, 2015). The share of population effect was equivalent to 34.5 % in China's CO_2 emissions at the end of 90's, however as a result of the slowdown in population the share has declined to 10.4 % in 2011. Figure 57 presents the impact of population effect on China's carbon emissions over 1990-2011.

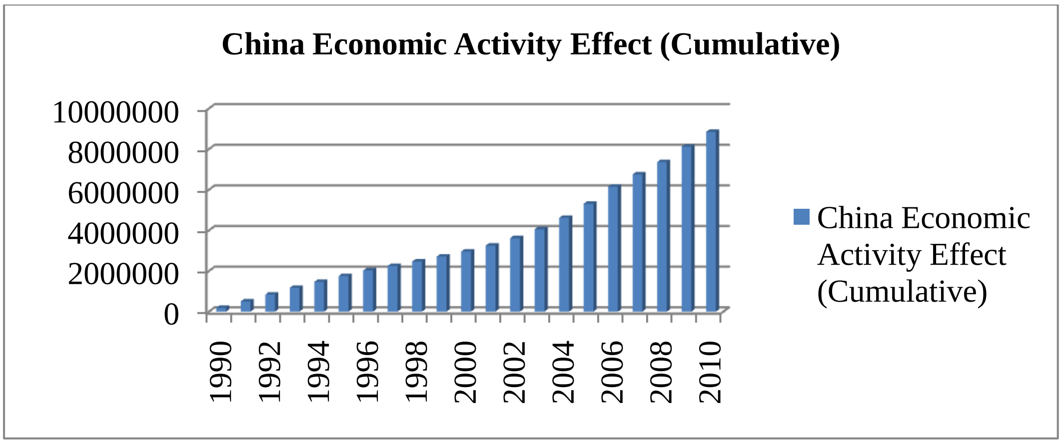

Figure 56. Impact of economic activity effect in China's CO_2 emissions over 1990-2011

China successfully improved its energy intensity during the study period. Country's energy consumption has increased by 213.3 % where the real GDP has increased by 698.9 % in the same period (World Bank, 2015). These values clearly indicate that China achieved its spectacular economic growth with relatively less energy consumption. As a result, the energy intensity has followed a negative trend in China's CO_2 emissions. The share of energy intensity was equivalent to -226.2 % at the end of first sub-period (in 2000). In addition, the share of energy intensity was calculated as -54.1 % at the end of second sub-period (in 2011). Except the years 2002 and 2003 (where a negative technological process was observed in China) energy intensity effect successfully reduced the Chinese CO_2 emissions. Figure 58 presents the impact of energy intensity on China's carbon emissions from 1990 to 2011.

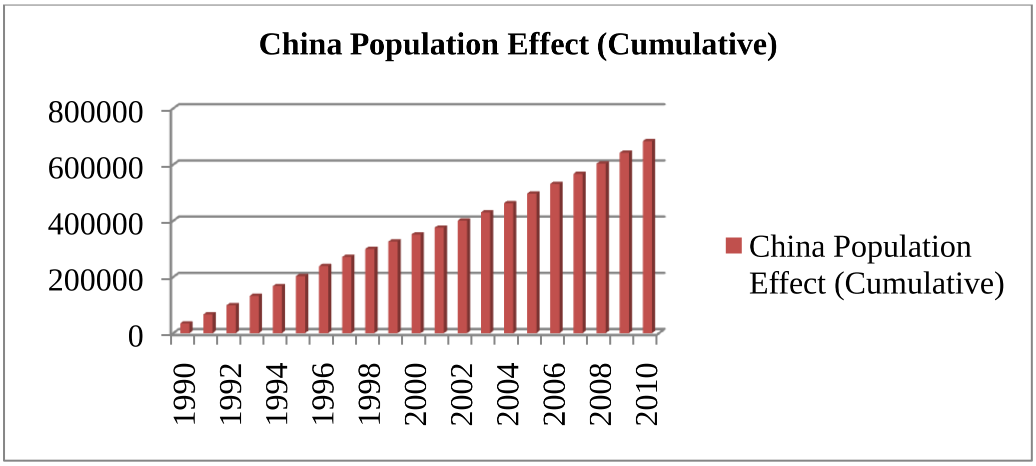

Figure 57. Impact of population effect in China's CO_2 emissions over 1990-2011

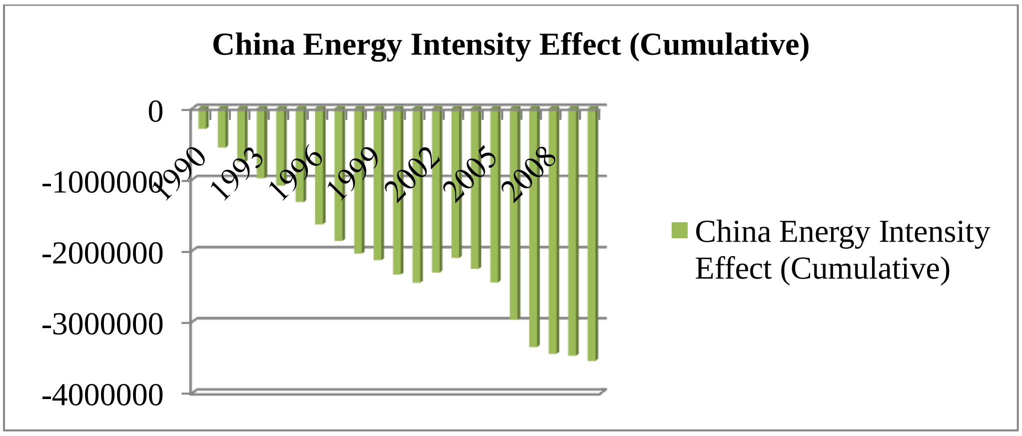

Figure 58. Impact of energy intensity in China's CO_2 emissions over 1990-2011

Between the years 1990 and 1996 carbon intensity has increased the CO_2 emissions in China. As a result the share of carbon intensity was equal to 4.4 % at the end of first sub-period. During the second sub-period, carbon intensity has increased China's CO_2 emissions except the years 2008 and 2010. Therefore, the share of carbon intensity in carbon emissions has increased to 8.8 % at the end of second sub-period. Increasing coal share (it has increased from 71.3 % to 79 % between 1990 and 2011 as World Bank's data indicates) and decreasing share of hydro sources (it has decreased from 20.4 % to 14.8 % between 1990 and 2011 as World Bank's data indicates) in electricity production are probably the main reasons of CO_2 accelerating carbon intensity. Figure 59 presents impact of carbon intensity on China's CO_2 emissions from 1990 to 2011.

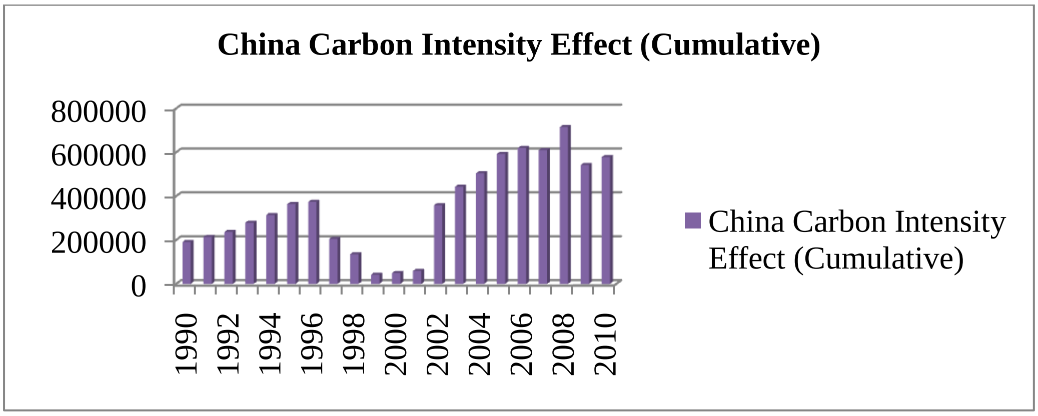

Figure 59. Impact of carbon intensity in China's CO_2 emissions over 1990-2011

To sum up, China improved its energy intensity and this improvement reduced the speed of carbon emissions in China, remarkably. Population effect had minor contributions to China's carbon emissions since China successfully reduced the population growth rate. Further emissions reduction is necessary since the carbon intensity is still increasing the carbon emissions in the country. Figure 60 presents the overall contributions of four different factors on China's carbon emissions between 1990 and 2011.

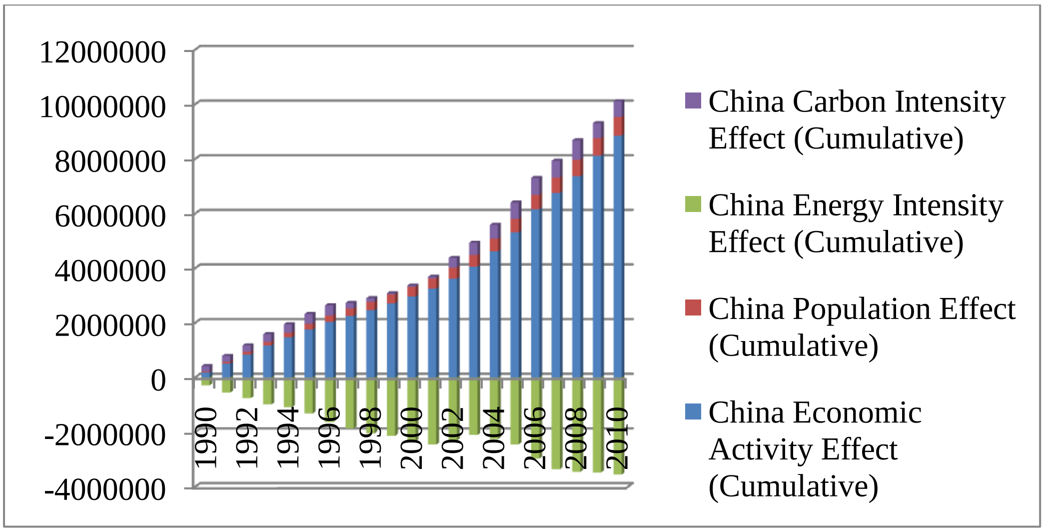

Figure 60. Impact of all factors in China's CO_2 emissions over 1990-2011

Table 10 summarizes the contribution of every factor to China's CO_2 emissions in terms of shares.

Table 10. Shares of all factors in China's CO_2 emissions over 1990-2011

China	First sub-period (1990-2000)	Second sub-period (2000-2011)
Economic Activity	287.3 % (1st major factor)	134.9 % (1st major factor)
Population Effect	34.5 % (3rd major factor)	10.4 % (3rd major factor)
Energy Intensity	-226.4 % (2nd major factor)	-54.1 % (2nd major factor)
Carbon Intensity	4.4 % (4th major factor)	8.8 % (4th major factor)
Total	100 %	100 %

As table 10 indicates, energy intensity effect almost successfully offset the accelerating impact of economic activity in the first sub-period. In the second sub-period the offsetting impact of energy intensity has decreased due to the negative technological progress that is observed in early 21st century in China. However, it is possible to state that China accomplished a considerable success to produce more with less energy.

6.2 Decomposition of CO_2 Emissions in MINTs

6.2.1 Decomposition of CO_2 emissions in Mexico

Mexico's real GDP has increased by 76.5 % during the research period (World Bank, 2015). As a result, economic activity effect played an important role in carbon emissions in Mexico. In early 1990s, the share of economic activity in carbon emissions was equivalent to 54.4 %. At the end of the first sub-period (2000) it has increased to 85.2 %. On the other hand, the share of economic activity has declined to 60.5 % in 2011. In 17 out of 21 years in the research period economic activity effect has increased Mexico's CO_2 emissions. Figure 61 depicts the impact of economic activity on Mexico's CO_2 emissions from 1990 to 2011.

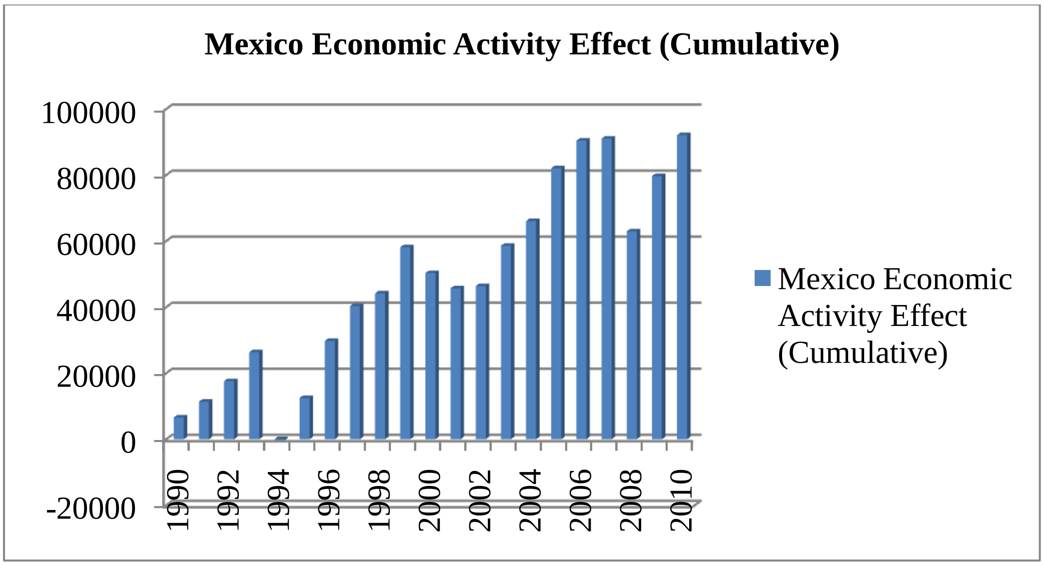

Figure 61. Impact of economic activity in Mexico's CO_2 emissions over 1990-2011

The population effect played a more significant role than the economic activity effect in Mexico's carbon dioxide emissions during the study period. In early 1990s the share of population effect was equivalent to 55.3 %. Furthermore, the share has increased to 94.9 % at the end of first sub-period (in 2000). On the other hand, it has showed a small decrease in CO_2 emissions in the second sub-period. The share of population effect was calculated as 81.8 % at the end of second sub-period (in 2011).

Despite this small decline, the population effect is still the major determining factor in country's carbon emissions. Mexico's population growth rate is very close to India. During the study period it has increased by 38.7 % (World Bank, 2015). Significant population growth brought significant carbon dioxide emissions increase in Mexico. Figure 62 depicts the changes in CO_2 emissions in Mexico resulted from the population changes.

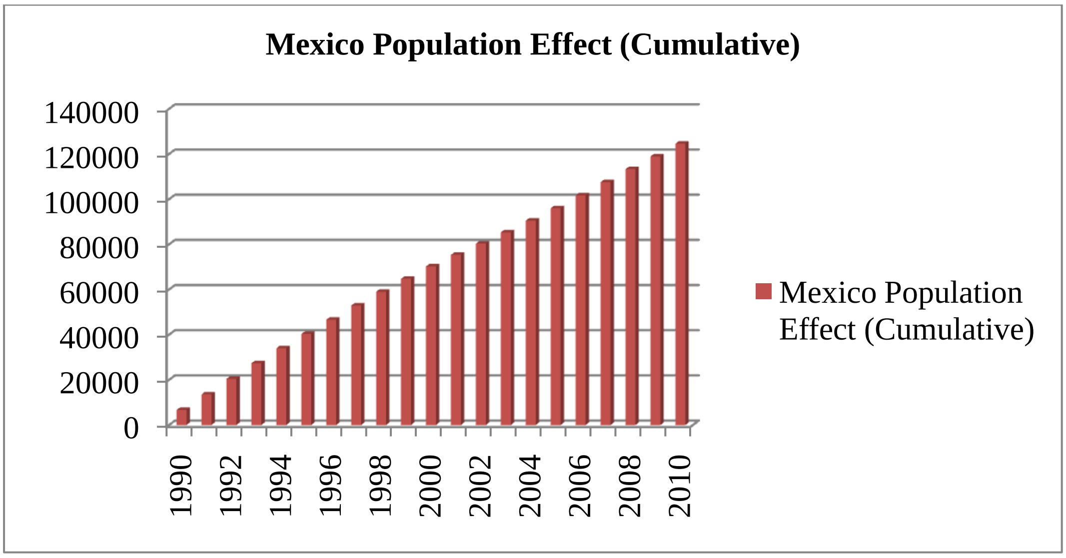

Figure 62. Impact of population effect in Mexico's CO_2 emissions over 1990-2011

Mexico's energy consumption has increased by 49.9 % between 1990 and 2011 (World Bank, 2015). In the same time interval, country's real GDP has risen by 76.5 % (World Bank, 2015). These values clearly indicate that Mexico improved its energy intensity similar to China and India. Thus, Mexico's energy intensity has followed a reducing impact on country's CO_2 emissions. At the end of first sub-period (in 2000) the share of energy intensity was equivalent to -95.5 %. On the other hand, the share of energy intensity was calculated as -38.4 % at the end of second sub-period. In 11 out of 21 years of the study period, energy intensity followed a decreasing trend in Mexico's CO_2 emissions. Figure 63 depicts the impact of energy intensity on Mexico's carbon emissions from 1990 to 2011.

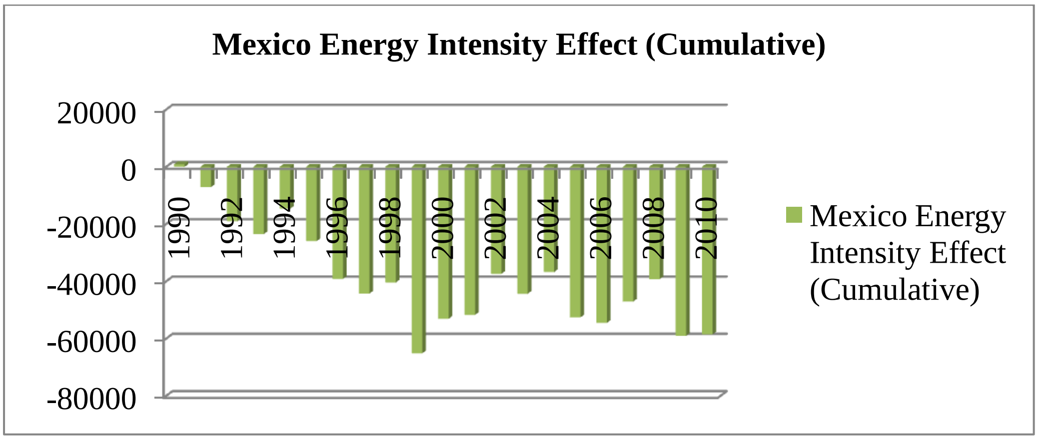

Figure 63. Impact of energy intensity in Mexico's CO_2 emissions over 1990-2011

In early 1990s, carbon intensity generally followed a negative trend in Mexico's carbon dioxide emissions. However, starting from 1994 carbon intensity has increased the amount of emissions remarkably. As a result, the share of carbon intensity in carbon emissions reached to 15.3 % at the end of first sub-period (in 2000). After 2001, share of carbon intensity has started to decrease. Thus, it has declined to -3.9 % at the end of second sub-period (in 2011). The share of natural gas in electricity production has increased from 15.5 % (in 1990) to 52.8 % (in 2011) and the share of renewable sources (excluding hydro) has increased from 1.4 % (in 1990) to 3.6 % (in 2011) (World Bank, 2015). Furthermore, the share of oil has decreased from 57.9 % (in 1990) to 16.4 % (in 2011), in electricity production (World Bank, 2015). These changes have helped to reduce the carbon intensity in Mexico during the study period. However, starting from 1991 Mexico started to use coal for electricity generation and in 2011, the share of coal has reached to 11.5 % (World Bank, 2015). Therefore the speed of obtaining a clean energy mix in Mexico has slowed down. Figure 64 depicts the changes in Mexico's CO_2 emissions resulted from carbon intensity effect from 1990 to 2011.

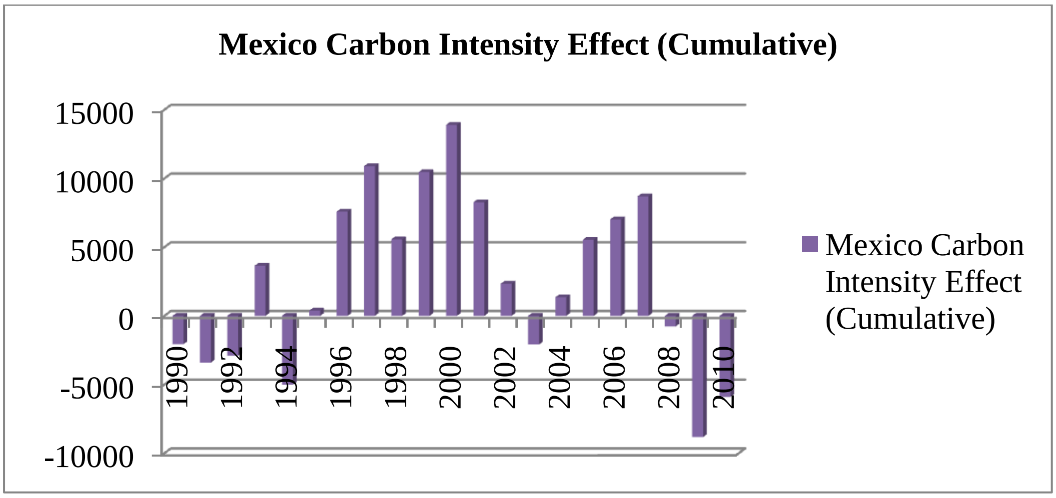

Figure 64. Impact of carbon intensity in Mexico's CO_2 emissions over 1990-2011

To sum up, it is possible to conclude that Mexico reduced its CO_2 emissions mainly due to the improvements achieved in energy intensity. Some improvements have also accomplished in carbon intensity. However, further improvements are necessary to reduce the carbon dioxide emissions. Figure 65 depicts the contribution of all factors on Mexico's CO_2 emissions between 1990 and 2011.

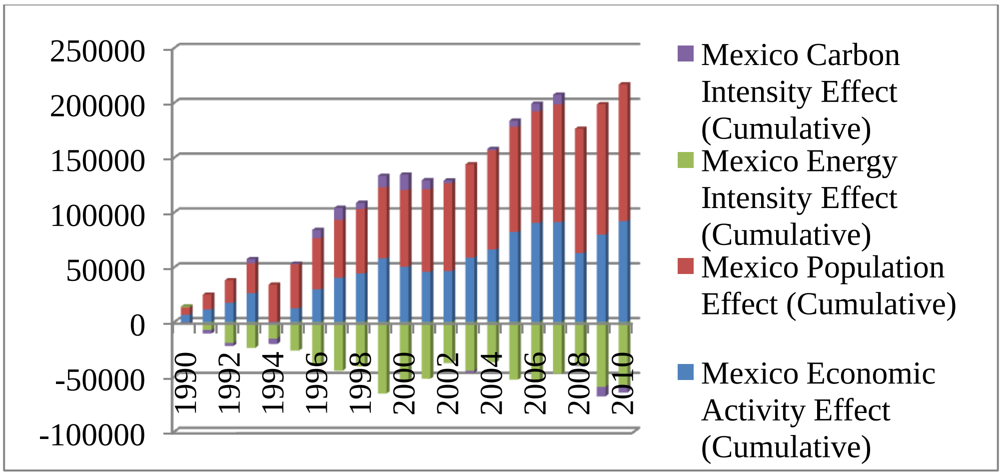

Figure 65. Impacts of all factors in Mexico's CO_2 emissions over 1990-2011

Additionally, table 11 presents the shares of four factors in Mexico's CO_2 emissions.

Table 11. Shares of all factors in Mexico's CO_2 emissions over 1990-2011

Mexico	First sub-period (1990-2000)	Second sub-period (2000-2011)
Economic Activity	85.2 % (3rd major factor)	60.5 % (2nd major factor)
Population Effect	94.9 % (2nd major factor)	81.8 % (1st major factor)
Energy Intensity	-95.5 % (1st major factor)	-38.4 % (3rd major factor)
Carbon Intensity	15.3 % (4th major factor)	-3.9 % (4th major factor)
Total	100 %	100 %

In the first sub-period, it is possible to state that energy intensity successfully offset the accelerating impact of population effect as table 11 indicates. However, in the second sub-period the capacity of energy intensity to offset the accelerating factors in Mexico's CO_2 emissions has declined.

6.2.2 Decomposition of CO_2 Emissions in Indonesia

Comprising the 37.1 % of overall emissions, the economic activity effect was the second largest determining factor in Indonesia's CO_2 emissions in early 1990s. Until the Asian crises (that is started in 1997), the economic activity followed an accelerating impact on CO_2 emissions in Indonesia. Therefore its share has increased to 44.5 % at the end of first period (in 2000). Moreover the share of economic activity has increased to 50 % at the end of second sub-period (in 2011). In 19 out of 21 years the economic activity has increased the CO_2 emissions in Indonesia. Between 1990 and 2011, Indonesia's real GDP has increased by 167.3 %; therefore a dominant increasing economic activity effect regarding country's CO_2 emissions was expected and it was observed. Figure 66 describes the changes in Indonesia's CO_2 emissions resulted from economic activity effect in the study period.

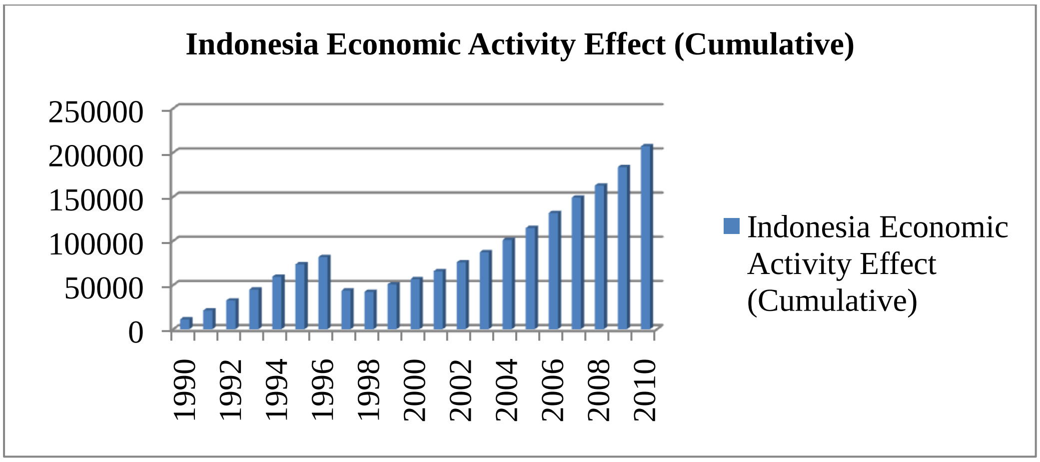

Figure 66. Impact of economic activity in Indonesia's CO_2 emissions over 1990-2011

Indonesia's population has increased by 36.5 % from 1990 to 2011 (World Bank, 2015). Therefore, the share of population effect has risen from 9.5 % to 30.6 % in the first sub-period. In the second sub-period annual population growth rate in Indonesia has slowed down, thus the share of population effect has decreased to 22 %. However, it is possible to state that the population effect is still a dominant factor in Indonesia's carbon emissions, due to the considerable population increase that is observed in the research period. Figure 67 describes the impact of population effect on Indonesia's CO_2 emissions over 1990-2011.

Energy intensity effect followed a reducing impact on Indonesia's CO_2 emissions until 1998. However, energy intensity has accelerated the CO_2 emissions during the Asia crises. Therefore, the share of energy intensity has increased to 13.3 % at the end of first sub-period (in 2000). In the second sub-period, 9 out of 11 years the energy intensity has followed a reducing impact on Indonesia's CO_2 emissions. Thus the share of energy intensity has declined to – 23.7 % at the end of second-sub period (in 2011). Indonesia's energy use has increased by 108.2 % between 1990 and 2011, while its real GDP has increased by 167.3 % in the same period (World Bank, 2015). As a result, we can conclude that Indonesia also achieved some energy intensity improvement during the study period. Although its energy improvement was better than Brazil's, it cannot be compared by the improvements of Mexico, India, China and Russia. Figure 68 describes the impact of energy intensity on Indonesia's carbon emissions over 1990-2011.

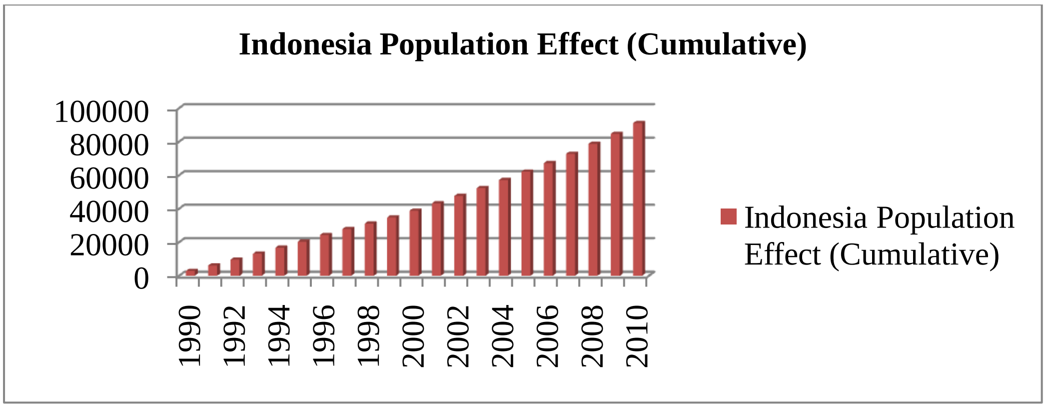

Figure 67. Impact of population effect in Indonesia's CO_2 emissions over 1990-2011

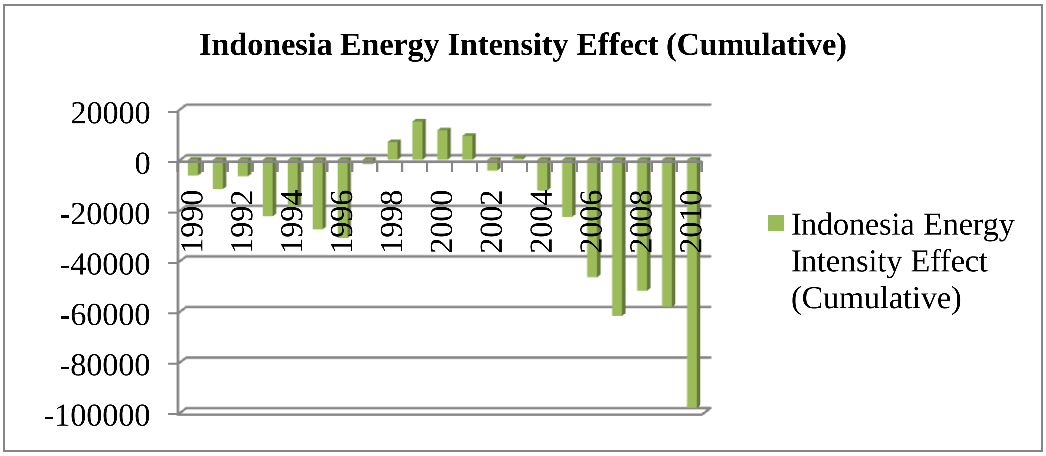

Figure 68. Impact of energy intensity in Indonesia's CO_2 emissions over 1990-2011

Between 1990 and 2000, the carbon intensity was the 4th largest determining factor in Indonesia's carbon emissions. It accounted the 11.6 % of changes in emissions. However, after 2000, a sharp increase has been observed in CO_2 emissions due to the carbon intensity. The share of carbon intensity has increased to 51.7 % in 2011 and it became the major determining factor of Indonesia's carbon emissions. In 14 out of 21 years in the research period, the carbon intensity has increased the amount of CO_2 emissions. The main reason of the accelerating carbon intensity was probably the accelerating coal consumption regarding electricity generation. The share of coal has risen from 29.9 % to 44.4 % between 1990 and 2011 (World Bank, 2015). In addition, the share of hydro sources in electricity generation has decreased from 17.5 % to 6.8 % from 1990 to 2011 (World Bank, 2015). On the other hand, the share of renewable energy sources (other than hydro) has increased from 3.4 % to 5.2 % in the same period (World Bank, 2015). Further increase in renewable energy sources implementation, may help to reduce the amount of carbon emissions that are resulted from the carbon intensity. Figure 69 describes the changes in Indonesia's carbon dioxide emissions due to the carbon intensity effect in the period 1990-2011.

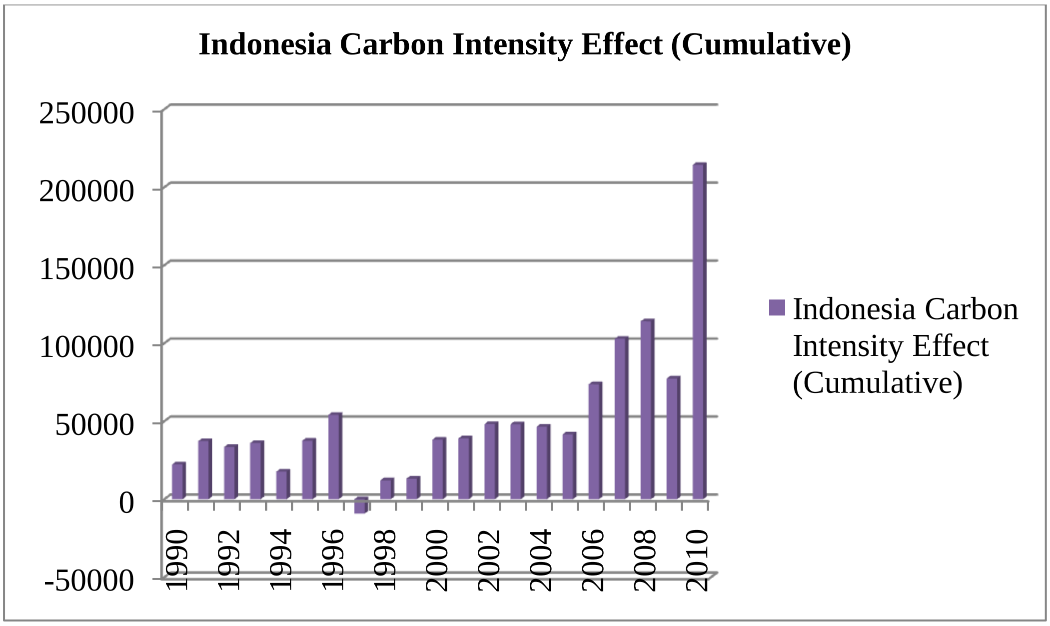

Figure 69. Impact of carbon intensity in Indonesia's CO_2 emissions over 1990-2011

Figure 70 describes the changes in Indonesia's CO_2 emissions due to the four different factors.

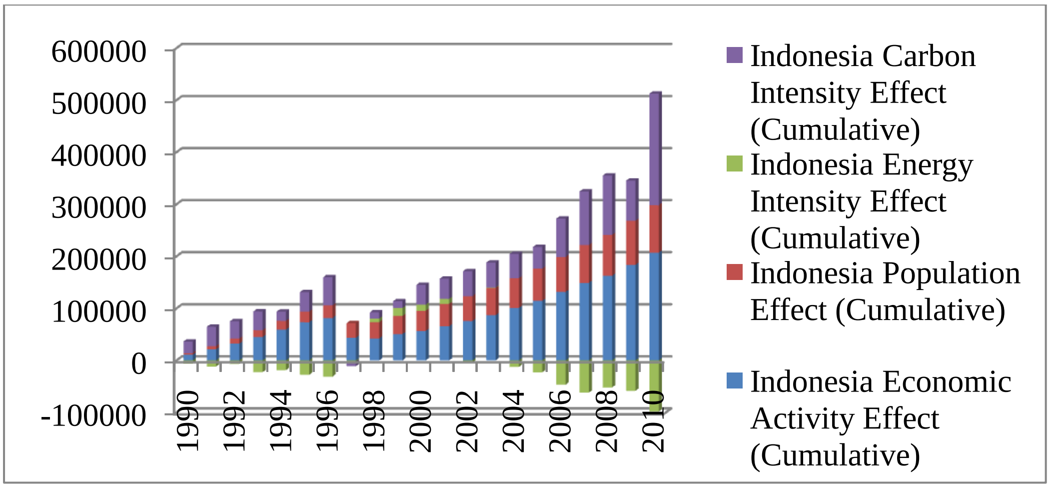

Figure 70. Impacts of all factors in Indonesia's CO_2 emissions over 1990-2011

Additionally, table 12 describes the shares of every factor in Indonesia's CO_2 emissions during the study period.

Table 12. Shares of all factors in Indonesia's CO_2 emissions over 1990-2011

Indonesia	First sub-period (1990-2000)	Second sub-period (2000-2011)
Economic Activity	44.5 % (1st major factor)	50 % (2nd major factor)
Population	30.6 % (2nd major factor)	22 % (4th major factor)
Energy Intensity	13.3 % (3rd major factor)	-23.7 % (3rd major factor)
Carbon Intensity	11.6 % (4th major factor)	51.8 % (1st major factor)
Total	100 %	100 %

Similar to Brazil, every factor followed an accelerating impact on Indonesia's carbon emissions in the first sub-period. However, in the second sub-period the contribution of energy intensity turned to negative. As one can check from the table, it is possible to state that energy intensity effect successfully offset the accelerating impact of population in the second sub-period in Indonesia. On the other hand, a sharp increase has observed in the share of carbon intensity, due to the increasing coal consumption.

6.2.3 Decomposition of CO_2 Emissions in Nigeria

Nigeria's real GDP has increased by 195.6 % between 1990 and 2011 (World Bank, 2015). However, during the 1990s real GDP per capita in Nigeria has decreased remarkably in 6 out of 10 years. Therefore, the share of economic activity effect was equal to – 6.8 % at the end of first sub-period. On the other hand, Nigeria's economy has expanded between 2000 and 2011. Hence economic activity effect has increased the CO_2 emissions in Nigeria, in the second sub-period. The share of economic activity has accelerated to 119.9 % at the end of second sub-period (in 2011). Figure 71 shows the impact of economic activity on Indonesia's CO_2 emissions over 1990-2011.

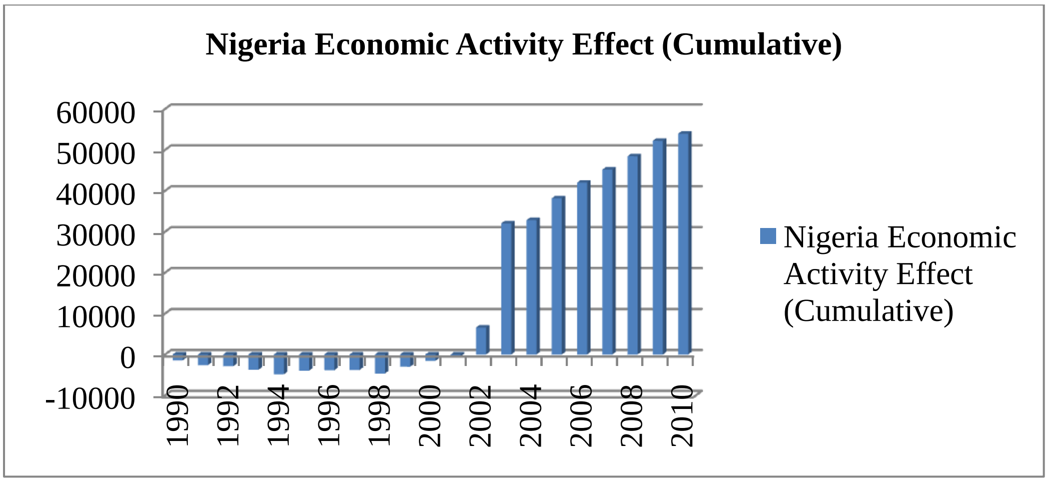

Figure 71. Impact of economic activity in Nigeria's CO_2 emissions over 1990-2011

Nigeria's population has increased by 71.7 % from 1990 to 2011. Therefore the population effect had a remarkable impact on CO_2 emissions in Nigeria. The share of population effect was equal to 27.2 % and 85.5 % at the end of first and second sub-periods respectively. Population effect was the second major determining factor in CO_2 emissions in Nigeria in the entire study period. Highest population growth was observed in Nigeria among the 9 research countries. Figure 72 shows the impact of population effect on Nigeria's CO_2 emissions over 1990-2011.

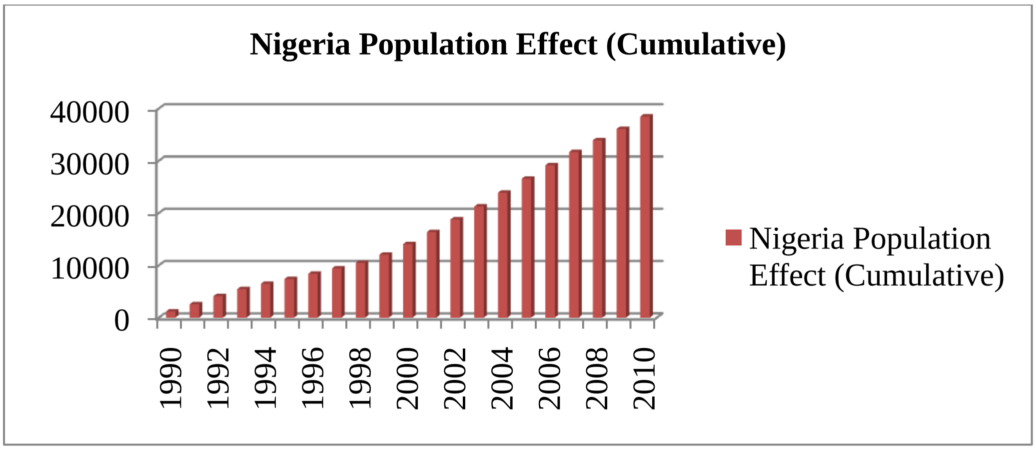

Figure 72. Impact of population effect in Nigeria's CO_2 emissions over 1990-2011

During the first sub-period Nigeria's energy intensity has increased the CO_2 emissions. The share of energy intensity was equal to 6.8 % at the end of first sub-period. However, Nigeria showed considerable energy efficiency improvements in the second sub-period. Hence the share of energy intensity has declined to -100.8 % in 2011. It is possible to state that Nigeria also produced more with less energy consumption. Country's real GDP has increased by 195.6 % while energy consumption has increased by 91.1 % between 1990 and 2011 (World Bank, 2015). Figure 73 shows the impact of energy intensity on Nigeria's carbon emissions in the study period.

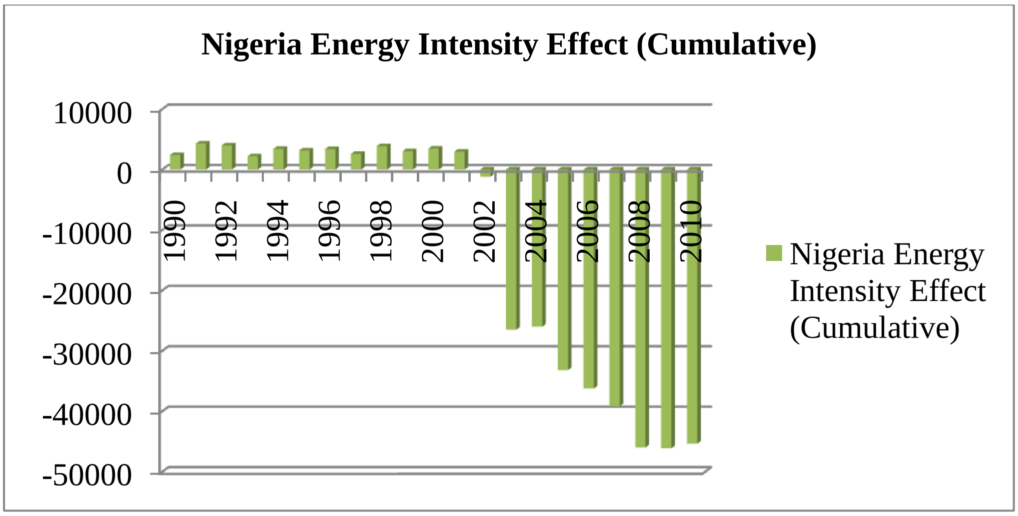

Figure 73. Impact of energy intensity in Nigeria's CO_2 emissions over 1990-2011

Carbon intensity was another major determining factor in Nigeria's CO_2 emissions and it followed generally an accelerating impact during the first sub-period. The share of carbon intensity was estimated as 72.7 %. However, the carbon intensity followed a negative trend in 8 out of 11 years in the second sub-period. Thus, its share has decreased to -4.6 % in 2011. Hence, it is possible to conclude that carbon intensity had minor contributions on Nigeria's carbon dioxide emissions in the second sub-period. The main reason of the carbon intensity decline was probably the increasing share of electricity production (it was equal to 53.7 % in 1990 and 63.3 % in 2011) (World Bank, 2015). Figure 74 shows the impact of carbon intensity on Nigeria's CO_2 emissions over 1990-2011.

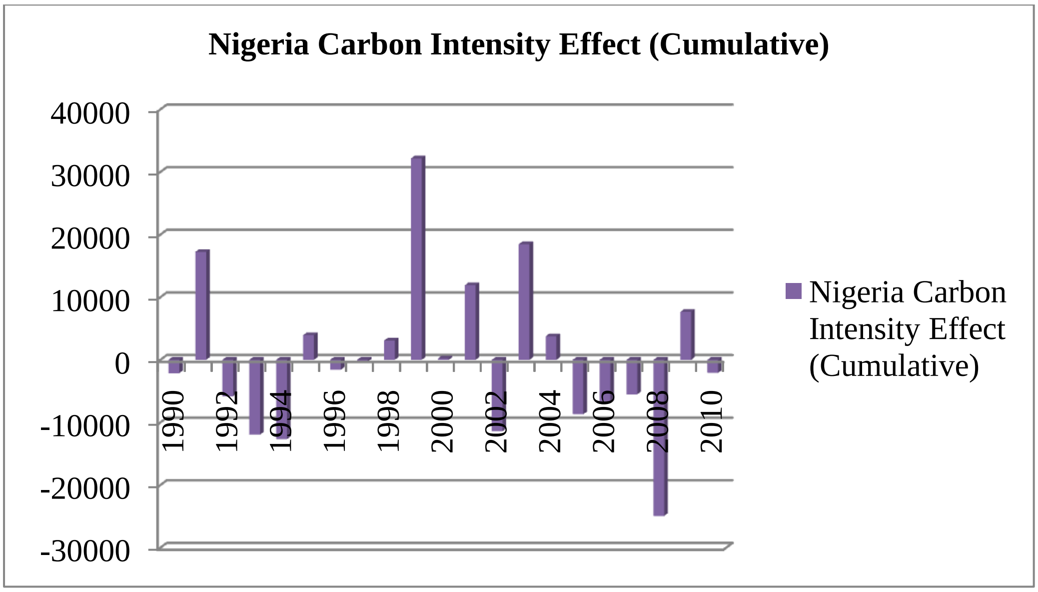

Figure 74. Impact of carbon intensity in Nigeria's CO_2 emissions over 1990-2011

Figure 75 shows the impact of four factors on Nigeria's CO_2 emissions from 1990 to 2011.

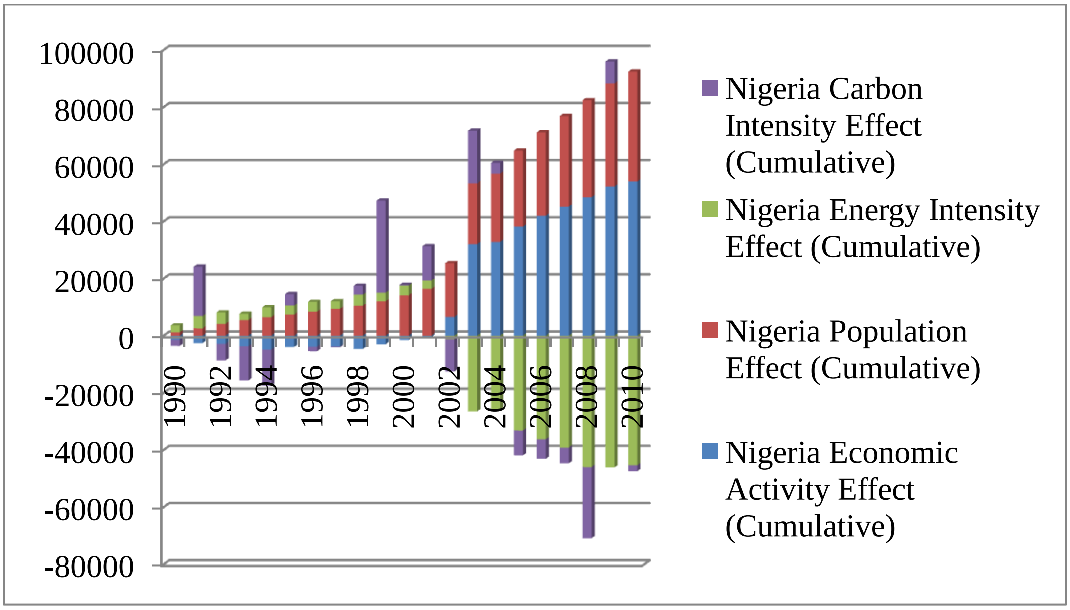

Figure 75. Impact of all factors in Nigeria's CO_2 emissions over 1990-2011

Furthermore, the shares of each factor in Nigeria's carbon emissions presented in the following table.

Table 13. Shares of all factors in Nigeria's CO_2 emissions over 1990-2011

Nigeria	First sub-period (1990-2000)	Second sub-period (2000-2011)
Economic Activity	-6.8 % (4th major factor)	119.9 % (1st major factor)
Population Effect	27.2 % (2nd major factor)	85.5 % (3rd major factor)
Energy Intensity	6.8 % (3rd major factor)	-100.8 % (2nd major factor)
Carbon Intensity	72.7 % (1st major factor)	-4.6 % (4th major factor)
Total	100 %	100 %

As one can check from the table, Nigeria's energy intensity effect successfully offset the whole of the accelerating impact of population effect and some part of the accelerating impact of economic activity effect in Nigeria's CO_2 emissions in the second sub-period.

6.2.4 Decomposition of CO_2 Emissions in Turkey

Turkey is one of the developing countries that achieved a sustained economic growth. Turkey's real GDP has increased by 127.1 % from 1990 to 2011 (World Bank, 2015). Hence the economic activity effect was the major determining factor in the research period. In 15 out of 21 years the economic activity has followed an accelerating impact on Turkey's CO_2 emissions. During the years of crises (1991, 1994, 1999, 2001, 2008, 2009) economic activity has followed a reducing impact in Turkish CO_2 emissions. At the end of first sub-period the share of economic activity was equal to 51.4 %. Moreover, the share of economic activity has increased to 68.7 % in Turkey's CO_2 emissions. Figure 76 presents the impact of economic activity regarding Turkish CO_2 emissions between 1990 and 2011.

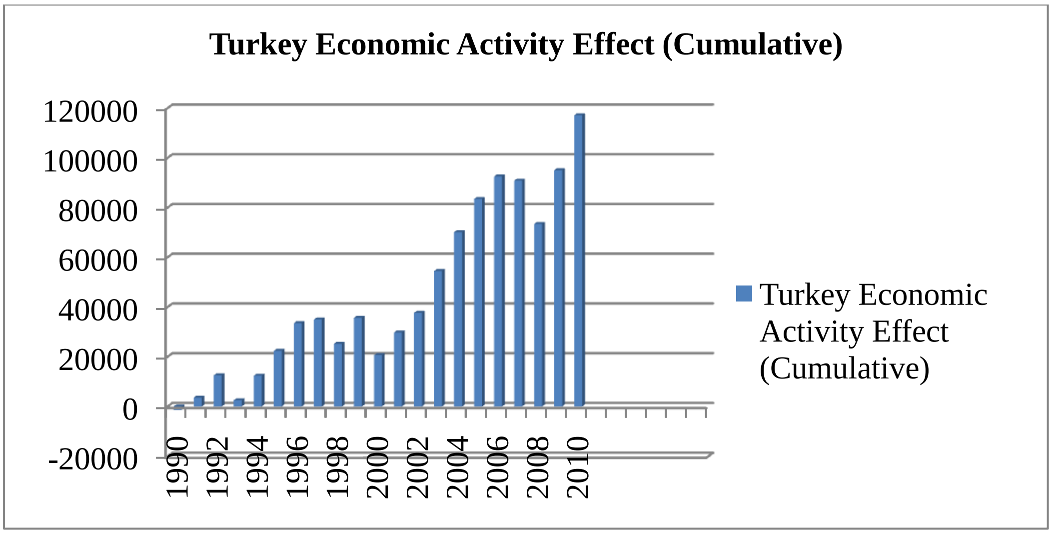

Figure 76. Impact of economic activity in Turkey's CO_2 emissions over 1990-2011

Between 1990 and 2011 Turkey's population has increased by 35.3 % (World Bank, 2015). Similar to Mexico and Nigeria, the population effect played an important role in Turkey's CO_2 emissions in the whole research period. It comprised 39.6 % and 37.3 % in CO_2 emissions at the end of first and second sub-periods respectively. Figure 77 presents the impact of population effect on Turkey's CO_2 emissions from 1990 to 2011.

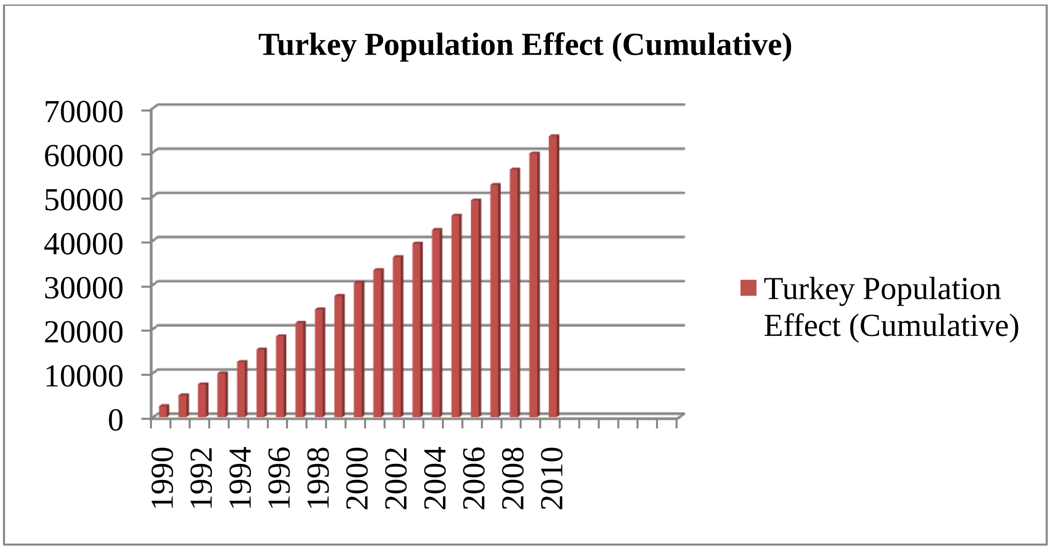

Figure 77. Impact of population effect in Turkey's CO_2 emissions over 1990-2011

Turkey's overall energy consumption has increased by 112.9 % in the research period while its real GDP has increased by 127.1 %. In 13 out of 21 years, energy intensity followed a negative trend in Turkey's carbon emissions. The share of energy intensity was equal to 3.3 % at the end of first sub-period (in 2000). Moreover, at the end of second sub-period (in 2011), share of energy intensity declined to -7.8 % in Turkish CO_2 emissions. The empirical findings indicate that Turkey also accomplished some energy efficiency however, the country's energy intensity improvement could not be considered as strong as China's, India's, Mexico's, Indonesia's, Russia's or Nigeria's improvements. Turkey clearly has a long way to improve its energy intensity. Figure 78 presents the impact of energy intensity on Turkey's carbon dioxide emissions from 1990 to 2011.

In 10 out of 21 years carbon intensity effect has followed a negative impact on Turkey's CO_2 emissions. The contribution of carbon intensity to Turkey's carbon emissions could be considered as a minor impact if one compare with impacts of economic activity and population effects. Carbon intensity constituted 5.7 % of overall carbon emissions in Turkey at the end of first sub-period (in 2000). Moreover its share has decreased to 1.8 % at the end of second sub-period (in 2011). Turkey's carbon intensity has decreased since the share of natural gas in electricity has increased from 17.7 % (in 1990) to 45.4 % (in 2011) (World Bank, 2015). Together with this, the share of renewable energy sources (other than hydro) has increased from 0.1 % to 2.5 % between 1990 and 2011 (World Bank, 2015). The increase in renewable energy sources in electricity production has also helped to reduce the carbon intensity during the study period. On the other hand, the share of coal still comprised 28.9 % of electricity production in Turkey in 2011; therefore carbon intensity is still increasing the amount of emissions. Figure 79 presents the impact of carbon intensity on Turkey's CO_2 emissions from 1990 to 2011.

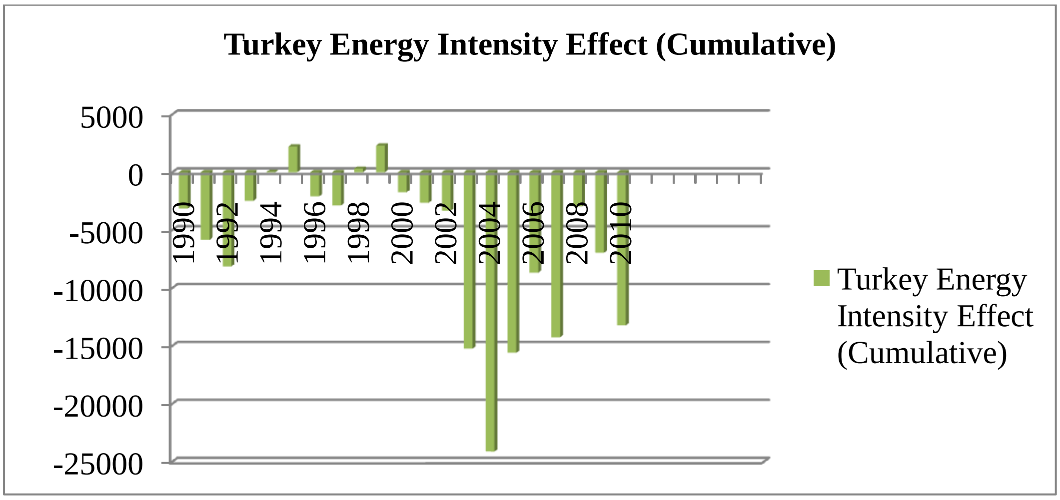

Figure 78. Impact of energy intensity in Turkey's CO_2 emissions over 1990-2011

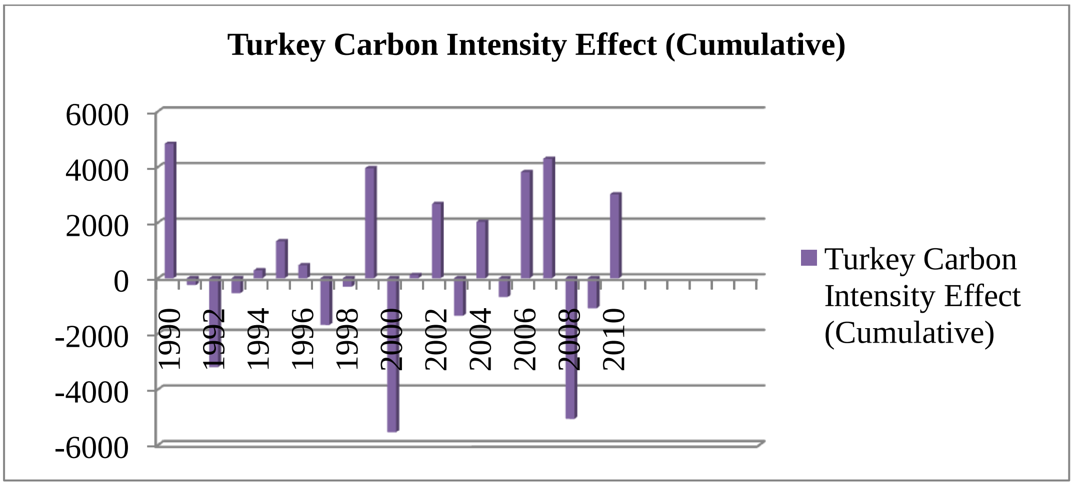

Figure 79. Impact of carbon intensity in Turkey's CO_2 emissions over 1990-2011

Figure 80 presents the aggregated contribution of four factors on Turkey's CO_2 emissions in the study period.

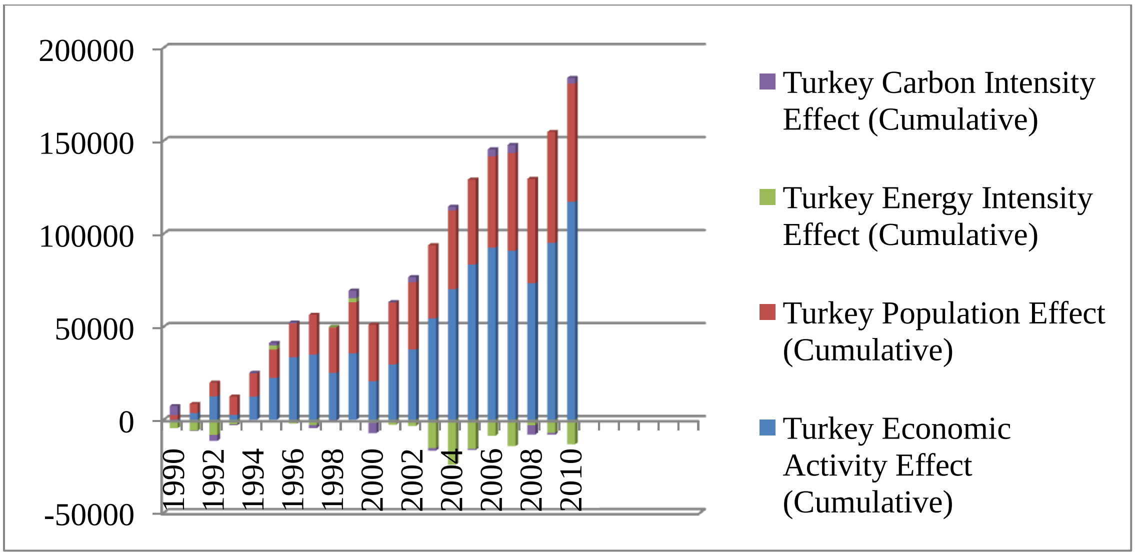

Figure 80. Impact of all factors in Turkey's CO_2 emissions over 1990-2011

Finally the following table presents the shares of four factors in Turkey's CO_2 emissions.

Table 14. Shares of all factors in Turkey's CO_2 emissions over 1990-2011

Turkey	First sub-period (1990-2000)	Second sub-period (2000-2011)
Economic Activity	51.4 % (1st major factor)	68.7 % (1st major factor)
Population Effect	39.6 % (2nd major factor)	37.3 % (2nd major factor)
Energy Intensity	3.3 % (4th major factor)	-7.8 % (3rd major factor)
Carbon Intensity	5.7 % (3rd major factor)	1.8 % (4th major factor)
Total	100 %	100 %

As table 14 indicates every factor in Turkey's carbon emissions followed an accelerating trend similar to Brazil and Indonesia. In the second period some efficiency have been observed in carbon intensity and energy intensity, however, empirical findings clearly showed that Turkey has a long way to reduce its CO_2 emissions.

6.3 Decoupling Factor Calculations

The decoupling term is firstly used in environmental studies in early 2000s by Zhang (2000). In 2002, it is presented as an environmental indicator by OECD. The term is based on the dilemma between economic prosperity and environmental degradation (Freitas & Kaneko, 2011). Therefore, we use the term 'decoupling' in environmental studies to characterize the link between economic activity and environmental damage. OECD uses the terminology such as 'decoupling is the link between economic goods and environmental bads'. The OECD (2002) develops two modalities of decoupling. The first one is the 'absolute decoupling'. In this case, the decoupling effect occurs when the environmentally relevant variable shows a stable or decreasing trend over time while the economic activity grows. On the other hand, 'relative decoupling' occurs when the environmental relevant variable follows a positive growth rate, but the growth of economic activity is higher. Hence, the decoupling ratio can be calculated as the ratio of carbon dioxide emissions and real GDP at the end and the beginning of selected periods. Although absolute decoupling is the ideal case, relative decoupling is seen in the reality. Therefore;

$$Relative\ Decoupling\ Ratio = \frac{(\frac{CO_{2t}}{GDP_{t}})}{(\frac{CO_{2t-1}}{GDP_{t-1}})} \quad (9)$$

Regarding interpretation, the reference value for the result of this ratio is 1. Values less than 1 present the existence of decoupling in the selected period whereas on the contrary values greater than 1 present the occurrence of coupling. OECD defined the decoupling factor as difference between decoupling ratio and 1. In this case, if the value of decoupling factor is positive then decoupling exists, and if it is negative or zero there is no occurrence of decoupling. The decoupling ratios of BRIC countries are presented in the table below.

Table 15. Decoupling ratios in BRICs over 1990-2011

Years	Brazil	Russia	India	China
90-91	1.03		1.06	0.96
91-92	1.01		1.01	0.91
92-93	1.00	1.02	0.99	0.94
93-94	1.00	1.00	1.00	0.94
94-95	1.02	1.00	0.99	0.98
95-96	1.08	1.03	1.01	0.95
96-97	1.02	0.93	1.00	0.92
97-98	1.04	1.03	0.97	0.89
98-99	1.02	0.96	0.98	0.93
99-00	0.98	0.92	1.00	0.95
00-01	1.02	0.95	0.97	0.95
01-02	0.96	0.95	0.98	0.97
02-03	0.96	0.96	0.97	1.11
03-04	0.99	0.93	0.97	1.06
04-05	1.00	0.95	0.96	0.98
05-06	0.96	0.96	0.98	0.98
06-07	0.99	0.92	0.98	0.93
07-08	1.02	0.98	1.07	0.94
08-09	0.95	1.00	1.01	1.00
09-10	1.06	1.06	0.90	0.97
10-11	1.01	1.00	1.00	1.00
Average	1.00	0.98	0.99	0.96

The decoupling factors for BRICs are presented in the table below.

Table 16. Decoupling factors in BRICs over 1990-2011

Years	Brazil	Russia	India	China
90-91	0.03 (D)		-0.06	0.04 (D)
91-92	0.01 (D)		-0.01	0.09 (D)
92-93	0.00	-0.02	0.01 (D)	0.06 (D)
93-94	0.00	0.00	0.00	0.06 (D)
94-95	0.02 (D)	0.00	0.01 (D)	0.02 (D)
95-96	0.08(D)	-0.03	-0.01	0.05 (D)
96-97	0.02 (D)	0.07 (D)	0.00	0.08 (D)
97-98	0.04 (D)	-0.03	0.03 (D)	0.11 (D)
98-99	0.02 (D)	0.04 (D)	0.02 (D)	0.07 (D)
99-00	-0.02	0.08 (D)	0.00	0.05 (D)
00-01	0.02 (D)	0.05 (D)	0.03 (D)	0.05 (D)
01-02	- 0.04	0.05 (D)	0.02 (D)	0.03 (D)
02-03	-0.04	0.04 (D)	0.03 (D)	-0.11
03-04	-0.01	0.07 (D)	0.03 (D)	-0.06
04-05	0.00	0.05 (D)	0.04 (D)	0.02 (D)

05-06	-0.04	0.04 (D)	0.02 (D)	0.02 (D)
06-07	-0.01	0.08 (D)	0.02 (D)	0.07 (D)
07-08	0.02 (D)	0.02 (D)	-0.07	0.06 (D)
08-09	-0.05	0.00	-0.01	0.00
09-10	0.06 (D)	-0.06	0.10 (D)	0.03 (D)
10-11	0.01 (D)	0.00	0.00	0.00
Average	0.00	0.02	0.01	0.04
Number of decoupling	11 out of 21	11 out of 19	13 out of 21	17 out of 21

Regarding BRICs, the highest decoupling between GDP and carbon dioxide emissions occurred in China during the study period. In 17 out of 21 periods the decoupling factor was calculated as positive for the country. China has been followed by Russia and India in this respect. In Russia, 11 out of 19 and in India 12 out of 21 periods, the decoupling factor was positive. Finally, in Brazil 11 out of 21 periods the decoupling factor was calculated as positive.

The decoupling rations of MINT countries in the research period are presented in the table below.

Table 17. Decoupling ratios in MINTs over 1990-2011

Years	Mexico	Indonesia	Nigeria	Turkey
90-91	1.00	1.10	1.00	0.99
91-92	0.97	1.05	1.43	1.02
92-93	0.97	1.01	0.91	1.04
93-94	1.01	0.94	0.77	0.97
94-95	1.00	0.94	0.75	0.98
95-96	0.98	1.05	1.10	0.98
96-97	0.98	1.05	0.97	1.02
97-98	1.00	0.87	0.97	1.01
98-99	1.00	1.14	1.11	0.99
99-00	0.95	1.04	1.68	0.97
00-01	1.04	1.08	1.01	1.05
01-02	0.99	1.00	1.13	1.00
02-03	1.02	0.99	0.86	0.99
03-04	0.97	1.01	0.78	1.06
04-05	1.03	0.96	1.04	1.03

05-06	0.97	0.96	0.87	0.97
06-07	1.00	1.02	0.91	0.96
07-08	1.02	1.04	0.92	1.00
08-09	1.00	1.05	0.72	0.98
09-10	0.94	0.91	1.10	1.02
10-11	1.01	1.22	0.98	1.01
Average	0.99	1.02	1.00	1.00

The decoupling factors of MINT countries from 1990 to 2011 are presented in the table below.

Table 18. Decoupling factors in MINTs over 1990-2011

Years	Mexico	Indonesia	Nigeria	Turkey
90-91	0.00	-0.10	0.00	0.01 (D)
91-92	0.03 (D)	-0.05	-0.43	-0.02
92-93	0.03 (D)	-0.01	0.09 (D)	-0.04
93-94	-0.01	0.06 (D)	0.23 (D)	0.03 (D)
94-95	0.00	0.06 (D)	0.25 (D)	0.02 (D)
95-96	0.02 (D)	-0.05	-0.10	0.02 (D)
96-97	0.02 (D)	-0.05	0.03 (D)	-0.02
97-98	0.00	0.13 (D)	0.03 (D)	-0.01
98-99	0.00	-0.14	-0.11	0.01 (D)
99-00	0.05 (D)	-0.04	-0.68	0.03 (D)
00-01	-0.04	-0.08	-0.01	-0.05
01-02	0.01 (D)	0.00	-0.13	0.00
02-03	-0.02	0.01 (D)	0.14 (D)	0.01 (D)
03-04	0.03 (D)	-0.01	0.22 (D)	-0.06
04-05	-0.03	0.04 (D)	-0.04	-0.03
05-06	0.03 (D)	0.04 (D)	0.13 (D)	0.03 (D)
06-07	0.00	-0.02	0.09 (D)	0.04 (D)
07-08	-0.02	-0.04	0.08 (D)	0.00
08-09	0.00	-0.05	0.28 (D)	0.02 (D)
09-10	0.06 (D)	0.09 (D)	-0.10	-0.02
10-11	-0.01	-0.22	0.02 (D)	-0.01
Average	0.01	-0.02	0.00	0.00
Number of Decoupling	9 out of 21	7 out of 21	12 out of 21	10 out of 21

Regarding MINTs the highest decoupling was observed in Nigeria. Twelve out of 21 periods the decoupling between carbon emissions and GDP was observed. Turkey, Mexico and Indonesia have followed Nigeria in this regard. The decoupling periods were calculated as 10, 9 and 7 out of 21, for these countries respectively.

Chapter 7

CASE STUDY: DECOMPOSITION OF THE CO_2 EMISSIONS IN IRAN OVER 1990-2011

Utilizing the refined Laspeyres index (RLI) method a decomposition analysis for the CO_2 emissions in BRICs and MINTs over 1990-2011 is presented in chapter 6. The RLI method is accepted as a perfect decomposition method since it does not leave any residual term after the analysis conducted. In this chapter our aim is to decompose the CO_2 emissions in Iran over the same period using both refined Laspeyres index method and logarithmic mean Divisia index (LMDI) method. The LMDI method is another perfect decomposition technique and similar to the RLI method it does not leave any residual term after the computation of decomposition analysis.

We analyze Iran in this chapter since energy plays a more significant role in its economy and country's economic structure, energy market and environmental dynamics are quite different than the BRICs and MINTs. Utilizing both RLI and LMDI methods for the same country also creates an advantage to compare two decomposition methods.

7.1 Overview of Iran's Economy, Energy Market and CO_2 Emissions

Iran is a Middle East country which always plays a significant role in world's political, economic, and historical agenda. Iran's economy has expanded remarkably in the study period. The country's real GDP has increased from 101.5 billion US$ (in

1990) to 248.9 billion US$ (in 2011) where this change corresponds to 145.2 % increase (World Bank, 2015). In addition, annual real GDP growth for Iran was calculated as 4.4 % on average, in this period. Consequently, real GDP per capita has increased from $1807.4 to $3310.5 between 1990 and 2011.

Iran's GDP structure has also changed in the study period. The share of agriculture has declined from 12.8 % (in 1990) to 5.9 % (in 2011), where the share of services has also declined from 53.7 % to 47.6 % in the same period. On the other hand, the share of industry has increased from 33.5 % to 46.4 % between 1990 and 2011 (World Bank, 2015). In most of the developed and developing countries the shares of agriculture and industry sectors have remarkably decreased in this period where the share of services in GDP has increased. However, in Iran the share of industry has increased considerably in real GDP where the shares of agriculture and services sectors have decreased. Therefore, it is possible to conclude that Iran's economic structure is quite different than most of the other countries.

Iran's economy is largely dependent to energy exports. In 2011, as World Bank's data indicates natural gas rents and oil rents respectively accounted 4.8 % and 25.1 % of overall GDP. Iran's one of the major economic problem is the international sanctions which are targeting the energy sector. Besides international sanctions the Iranian economy fights with high inflation and unemployment problems. During the study period the inflation rate was equivalent to 22.9 % and unemployment rate was equivalent to 11.7 % on average (World Bank, 2015).

Iran’s population has increased by 33.9 % from 56.2 million individuals to 75.2 million individuals between 1990 and 2011. According to World Bank (2015) the urban population rate has increased from 56.3 % to 71.2 % in the same period.

Following Venezuela, Saudi Arabia, and Canada, Iran has the 4th largest crude oil reserves in the world. As the EIA (2015) states, the country accounted 10 % of world’s crude oil reserves. However, after 2011, due to the sanctions of US and EU Iran’s oil production followed a substantial decline. Together with rich oil reserves, Iran has the 2nd largest natural gas reserves in the world just after Russia. According to the EIA (2015) the country constitutes 15 % of world’s natural gas reserves.

Iran’s energy consumption has increased from 69.3 thousand KT of oil equivalent to 212.4 thousand KT of oil equivalent and this change corresponds to 206.3 % increase. As a result, per capita energy consumption has increased from 1234.4 kg of oil equivalent to 2825.1 kg of oil equivalent in the same period (World Bank, 2015). Natural gas and oil respectively accounted 60 % and 38 % in Iran’s energy consumption. Overall 99.4 % of Iran’s energy is still generated from fossil fuels. Iran’s per capita electricity consumption has also remarkably increased from 944.2 KWH to 2661.9 KWH between 1990 and 2011 (World Bank, 2015). In 2011, as World Bank’s data indicated natural gas accounted 66.8 % of electric power production. It was followed by oil (27.8 %), hydro (5 %), coal (0.2 %), renewable (0.1 %), and nuclear (0.1 %) sources, in this respect. Finally, Iran’s electricity transmission and distribution losses are increasing; they have increased from 10.3 % to 14.6 % during the study period.

Iran's CO_2 emissions have increased by 177.8 % from 211.1 thousand KT to 586.6 thousand KT. As a result, the country became the 8th largest CO_2 emitting country in the world. Correspondingly, per capita CO_2 emissions have increased from 3.8 tons to 7.8 tons (World Bank, 2015). In 2011, electricity and heat production was the main factor and it accounted 32.3 % in CO_2 emissions in Iran. It was followed by residential buildings and commercial & public services (23.3 %), transport (22.3 %), manufacturing and construction (19.8 %) and other sectors (2.2 %) in this respect (World Bank, 2015).

7.2 Logarithmic Mean Divisia Index Method

If the aggregate to be analyzed is denoted by Y, m the number of factors, and K_i an attribute of the aggregate then the general index decomposition analysis identity provided by Ang (2005) is:

$$Y = \sum_i Y_i = \sum_i K_{1,i}, K_{2,i}, \dots, K_{n,i} \qquad \text{i=0,1,2,……n.} \tag{10}$$

In a multiplicative decomposition the changes in aggregate from Y^0 to Y^t during the period 0 to T can be calculated as

$$D_{tot} = \frac{Y^T}{Y^0} = D_{k1} D_{k2} \dots D_{kn} \tag{11}$$

In an additive decomposition analysis the changes in aggregate from 0 to T can be calculated as

$$\Delta C_{tot} = \Delta C_{ea} + \Delta C_{pop} + \Delta C_{eng} + \Delta C_{car} + \Delta C_{rsd} \tag{12}$$

where ΔC_{tot} represents the change in CO_2 emissions; ΔC_{ea} represents the change in economic activities; ΔC_{pop} represents the change in population effect; ΔC_{eng} represents the change in energy intensity and ΔC_{car} represents the change in carbon intensity. Finally ΔC_{rsd} is the residual term.

The LMDI method has been developed from the arithmetic mean Divisia index (AMDI) method and this method leaves a residual term after conducting the decomposition analysis. However, the LMDI method captures the changes in CO_2 emissions completely and therefore no residual term arises. The equations for the additive LMDI technique can be given as:

$$\Delta C_{ea} = \sum_{i=1}^{n} \frac{CO_{2i,T} - CO_{2i,0}}{LN\left(\frac{CO_{2i,T}}{CO_{2i,0}}\right)} * LN\left(\frac{EA_T}{EA_0}\right) \tag{13}$$

represents the economic activity effect.

$$\Delta C_{pop} = \sum_{i=1}^{n} \frac{CO_{2i,T} - CO_{2i,0}}{LN\left(\frac{CO_{2i,T}}{CO_{2i,0}}\right)} * LN\left(\frac{POP_T}{POP_0}\right) \tag{14}$$

represents the population effect.

$$\Delta C_{eng} = \sum_{i=1}^{n} \frac{CO_{2i,T} - CO_{2i,0}}{LN\left(\frac{CO_{2i,T}}{CO_{2i,0}}\right)} * LN\left(\frac{EN_T}{EN_0}\right) \tag{15}$$

represents the energy intensity effect.

$$\Delta C_{car} = \sum_{i=1}^{n} \frac{CO_{2i,T} - CO_{2i,0}}{LN\left(\frac{CO_{2i,T}}{CO_{2i,0}}\right)} * LN\left(\frac{CN_T}{CN_0}\right) \tag{16}$$

represents the carbon intensity effect. As an additional note $EA = \frac{GDP}{POP}$ (per capita GDP), $EN = \frac{ENG}{GDP}$ (energy intensity of the economic activity), $CN = \frac{CO2}{ENG}$ (carbon intensity of the energy use), and POP represents the number of individuals in the country.

7.3 Empirical Findings

In this chapter we utilized both refined Laspeyres index (RLI) and logarithmic mean Divisia index (LMDI) methods to examine the factors which are affecting Iran's carbon dioxide emissions. The empirical findings of the analysis are presented below.

7.3.1 Economic Activity Effect

As we mentioned before, the economic activity effect reflects the changes in CO_2 emissions resulted from the changing activity levels. In the times of recession, the economic activity effect follows a reducing impact in CO_2 emissions or vice versa. In 19 out of 21 periods, the economic activity effect has followed an increasing impact; therefore it was the major determining factor in Iran's CO_2 emissions. In the first sub-period (1990-2000) it accounted 34.1 % in overall CO_2 emissions according to RLI and LMDI methods. Furthermore in the second sub-period (2000-2011) the share of economic activity has risen to 64.9 % again according to both methods.

7.3.2 Population Effect

The population effect shows the changes resulted from the increases and decreases which are observed in the number of individuals. Iran's population has increased remarkably during the study period. Therefore this population increase has also raised the CO_2 emissions. At the end of first sub-period the share of population effect was calculated as 27.5 % and 27.4 % by RLI and LMDI methods respectively. During the first sub-period the population effect was the 3rd major determining factor in Iran's CO_2 emissions. At the end of second sub-period the share of population effect was calculated as 28.8 % according to both of the methodologies and it became the second major determining factor in Iran's CO_2 emissions.

7.3.3 Energy Intensity Effect

A decline in energy intensity implies that a country becomes less energy intensive and it is able to produce more output with lower energy consumption. Moreover, a negative energy intensity effect starts to offset the CO_2 emissions accelerating impact of any other factors. In Iran, energy intensity was the second largest CO_2 emissions accelerating factor in the first sub-period. It accounted 31.4 % in Iran's CO_2 emissions according to both of the methods. However, in the second sub-period as

RLI and LMDI decomposition results indicate the share of energy intensity has decreased to 13.6 %. This results show that Iran achieved some success to reduce its energy intensity. However, the impact of energy intensity is still increasing the CO_2 emissions.

7.3.4 Carbon Intensity Effect

Carbon intensity effect analyzes the impact of fuel mix in a country's changing CO_2 emissions. If we replace the conventional (fossil) energy sources with renewable energy sources then this will led to a decrease in carbon dioxide emissions which are resulted from the carbon intensity. At the end first sub-period the share of carbon intensity was equal to 7.1 % and 7.2 % as decomposition results of RLI and LMDI methods showed. However, in the second sub-period carbon intensity effect followed a negative trend in Iran's CO_2 emissions. Its share was calculated as -7.3 % for RLI method and -7.2 % for LMDI method. This is probably the result of declining oil use and increasing natural gas use in Iran's energy consumption mix. Since the natural gas is relatively cleaner than oil, then this replacement helps to reduce the CO_2 emissions resulted from the carbon intensity.

As one can conclude, both RLI and LMDI methods decompose the changes in factors affecting the carbon dioxide emissions without a residual term. The empirical findings of both methods are very close to each other, however, the LMDI method is easier to implement. Figure 81 and 82 show the decomposition results of RLI and LMDI methods in Iran over 1990-2011, respectively.

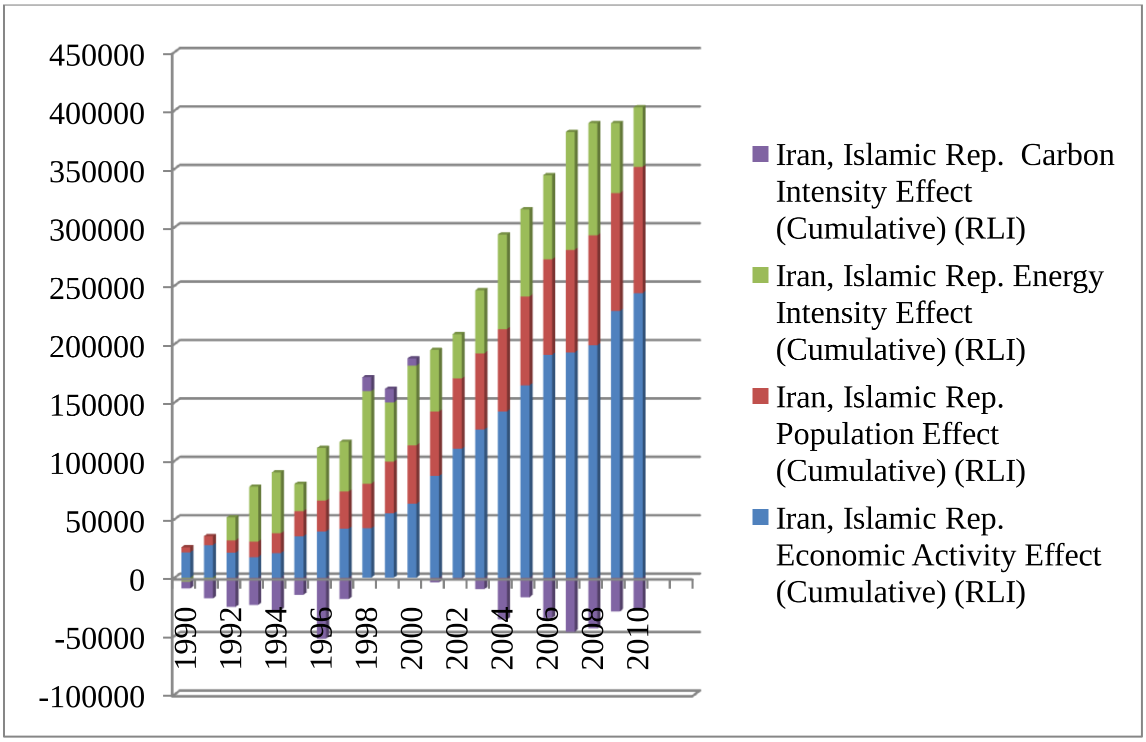

Figure 81. Decomposition of Iran's CO_2 emissions over 1990-2011 (RLI method)

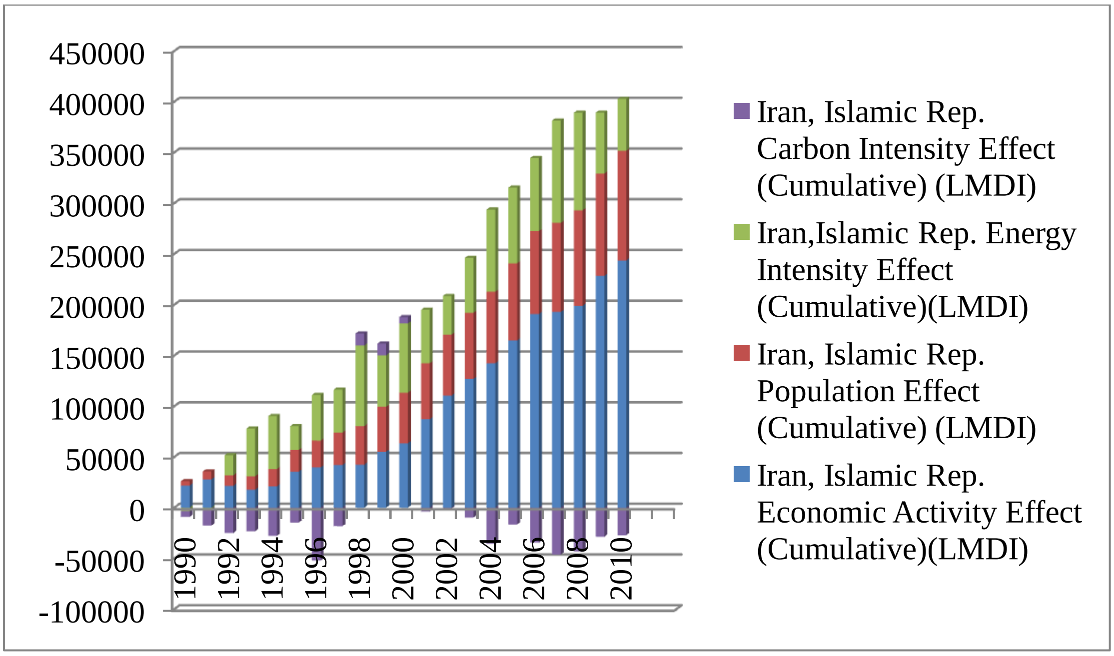

Figure 82. Decomposition of Iran's CO_2 emissions over 1990-2011 (LMDI method)

The decoupling ratios and decoupling factors have also calculated for Iran for the research period. In Iran, the decoupling between economic growth and environmental degradation was observed in 10 out of 21 periods. The decoupling factor was calculated as – 0.01 for Iran, in the study period on average. The decoupling ratios and factors are presented in the table below.

Table 19. Decoupling ratios and decoupling factors in Iran over 1990-2011

Years	Decoupling Ratio	Decoupling Factor
90-91	0.96	0.04 (D)
91-92	0.97	0.03 (D)
92-93	1.05	-0.05
93-94	1.14	-0.14
94-95	1.00	0.00
95-96	0.95	0.05 (D)
96-97	0.96	0.04 (D)
97-98	1.12	-0.12
98-99	1.21	-0.21
99-2000	0.92	0.08 (D)
00-01	1.05	-0.05
01-02	0.93	0.07 (D)
02-03	0.96	0.04 (D)
03-04	1.02	-0.02 (D)
04-05	1.01	-0.01
05-06	1.03	-0.03
06-07	0.94	0.06 (D)
07-08	1.04	-0.04
08-09	1.00	0.00
09-10	0.96	0.04 (D)
10-11	0.99	0.01 (D)
Average	1.01	-0.01
Decoupling years		11 out of 21

Chapter 8

CONCLUSIONS AND POLICY IMPLICATIONS

In this thesis we decomposed the carbon dioxide emissions in BRIC (Brazil, Russia, India, and China) and MINT (Mexico, Indonesia, Nigeria, and Turkey) countries for the period 1990-2011. The refined Laspeyres index method (RLI) utilized and the impacts of four important factors namely the economic activity, population effect, energy intensity, and carbon intensity considered. We divided the study period into two sub-periods where the first sub-period includes the years between 1990 and 2000, and the second sub-period includes the years between 2000 and 2011.

For each of these countries various interesting results have observed. In Brazil economic activity was the major determining factor in CO_2 emissions at the end of the second sub-period. If one compare with the first sub-period it is obvious that the share of economic activity has increased in Brazil's CO_2 emissions between 2000 and 2011. Population effect was the second major determining factor in Brazil's CO_2 emissions in both sub-periods and its share showed only minor changes. The contribution of energy intensity to CO_2 emissions in Brazil decreased remarkably in the latter period if we compare with the former one. Furthermore the contribution of carbon intensity to Brazil's CO_2 emissions showed more substantial decrease if we compare with the energy intensity. Although both factors (energy intensity and carbon intensity) presented the sign of improvement, their impact is still accelerating the CO_2 emissions in Brazil which is not a desirable result.

Due to the existence of abundant hydro sources, Brazil has the highest renewable energy share in energy mixes of BRICs and MINTs. As Pereira et al. (2012) states renewable sources constituted 47.2 % of the primary energy production. Moreover as World Bank's (2015) data indicates renewable sources accounted 87.1 % of the secondary energy (electricity) production in 2011. In order to reduce the energy intensity Brazil should follow some technological advancement. Implementing the energy saving policies the country could accomplish the energy efficiency target and may reduce the energy imports. In addition, a successful reduction in CO_2 emissions could also be achieved as a result of improved energy intensity.

Natural resources which become sources of energy production have strategic advantages for the countries. First of all, these natural resources reduce the dependence on energy imports. In addition, natural resources increase the stability of the supply of a service which is highly important for a society in its economic and social development. Natural resources can produce either conventional or renewable energy. Renewable energy is clean and sustainable and it creates an alternative way to tackle the fossil fuel depletion and related negative environmental impacts. Brazil has large amount of natural sources of renewable energy, including solar, hydro, wind, biodiesel and ethanol (Pereira et. al, 2012). Solar energy is the largest available energy resource on the planet and it can be used both direct (for solar radiation) and indirect (for wind, biomass, and hydraulic) ways of energy production. In Brazil, solar energy is used in both ways for heating and lighting. As Pereira et al. (2012) states the majority of PV systems are not connected to the electricity grid in Brazil. Brazilian people generally use this technology for pumping systems, for solar home systems and for small public & commercial services.

Wind power is another important natural resource of energy. There are certain advantages in wind power such as, the wind resources are renewable, widely distributed in world, clean, generate energy which has zero CO_2 emissions and have low implementation costs. In countries which have limited hydro sources the wind power may be a considerable clean alternative for energy production. In Brazil, which has large hydro sources, the wind power is again an important alternative since it does not use water (a resource that has depletion risk). In 2010, Brazil was the 22nd largest wind power producer in the world and the country comprised 0.3 % of world's wind power market (Pereira et al., 2012).

If a country has considerable hydro potential then it could have two major advantages. First, the cost of hydro supply is relatively lower than other sources such as uranium, coal, natural gas, and oil. Second, the hydro sources do not produce CO_2 emissions. Brazil constituted 12.1 % in world's hydroelectricity production and the country is the second largest hydraulic energy producer in the world, just after China (Pereira et al., 2012). Small hydroelectric plants are also important for Electricity Regulatory Agency (ANEEL) for power generation in Brazil.

Bio-fuels are derived from renewable biomass which is an alternative for combustion engines or other fuels derive from natural gas and oil. There are two main bio-fuels such as ethanol (extracted from sugarcane) and biodiesel (produced from either vegetable oil or animal fat and added to petroleum diesel in different proportions). Accounting 3.2 % of the overall biodiesel production Brazil was the 4th largest producer in the world market after Germany, US, and France.

Ethanol is another liquid fuel which is used as a substitute for light oil derivatives. Ethanol is a bio-fuel which is produced from sugarcane. It is either directly used in combustion engines (E100 or flex fuel engines) or as an addition to gasoline up to 25 % of volume. The Brazilian government has implemented some measures (for instance the Brazilian ethanol program) to benefit from the advantages of ethanol. As Pereira et al. (2012) states Brazil was the second largest ethanol producer in the world after US. In 2010, it comprised 32.5 % of world's ethanol market.

Consumption of oil, coal and natural gas is expected to increase in the whole world, and therefore the CO_2 emissions resulted from these burning fuels. As EIA (2015) states, the consumption of fossil fuels are not sustainable and cannot be maintained in the long run from environmental, social and economic point of view, nowadays. As a result of the consolidation efforts in Brazil's internal energy market, especially in ethanol and hydro sectors, the country achieved a significant success in terms of producing clean energy. Brazil also accomplished some scale advantages with cost reduction and productivity increase together with technological development and other positive factors. Besides remarkable success achieved in Brazil for implementation of relatively cheaper hydro and ethanol, still a vigorous action is required to benefit from the other renewable sources. Furthermore, Brazil has some targets to reduce its GHG emissions between 36 % and 39 % by 2020, compared with the emissions level in 1990.

Brazil has high wind power potential in its North East region and, a remarkable solar potential in Amazonia, however these technologies are still costly. Since the renewable energy costs have showed tendency to decrease and the marginal costs of conventional energy sources are raising, then it is expected that renewable sources will be competitive in the near future. Brazil should focus on some policies which are both economically and environmentally sustainable. Brazil should also struggle with its certain deforestation problem in its Amazon region.

Brazil’s annual population growth rate has decreased from 1.7 % (in 1990) to 0.9 % (in 2011) where world’s annual population growth rate has decreased from 1.6 % to 1.2 % in the same period (World Bank, 2015). Population growth rate substantially decreased in Brazil; however the share of population effect is still considerably high in country’s CO_2 emissions.

In Russia, a successful reduction in CO_2 emissions is achieved during the study period mainly due to the improved energy intensity. In addition, population effect and carbon intensity have also reduced Russia’s CO_2 emissions because of the decreasing population and relatively cleaner energy mix. Russia has significant coal reserves but it produces limited amount of coal and this is a remarkable contribution from Russia to have an environmentally sustainable world. Russia was the only country which experienced CO_2 emissions decline among the nine research countries. Further CO_2 emissions reduction is possible for Russia since the Northwest region of the country has high wind power potential. This potential also creates some benefits for EU countries due to the geographic proximity. As Boute & Willems (2012) state an EU – Russian cooperation in renewable energy field which includes exporting green energy (including hydro, biomass and wind) from Russia to EU creates two main opportunities. First, this cooperation helps to decarbonizes EU’s electricity supply with a low cost. Second, Russia could start to develop a national renewable energy sector without increasing the energy prices for domestic consumers.

India achieved a remarkable success to reduce the speed of CO_2 emissions due to the improved energy intensity. On the other hand, the increasing contributions of population effect and carbon intensity on India's CO_2 emissions are still considerably high. India's annual population growth rate has decreased from 2 % (in 1990) to 1.3 % (in 2011) however; this value is still higher than world's average population growth rate. Declining population growth in India may contribute to emissions reduction further. To reduce the carbon intensity further India could increase its renewable energy capacity. India already shows a substantial effort to improve its renewable capacity in order to provide solutions to the long term energy problems. The country is increasingly implementing renewable energy techniques and taking positive steps for cleaning the air and achieving a more sustainable future (Kumar et al., 2010).

Recently there is an observed increase in the use of biomass as an energy source and related estimations have showed that 15 – 50 % of the world's primary energy consumption could be generated from biomass by the year 2050. The main advantage of biomass is, it is a form of renewable energy and it does not add CO_2 emissions if one compare with conventional sources. Biomass resources include a wide range of materials, such as firewood collected in farmlands, forestry and agricultural crops grown especially for energy generation and natural woods. India has a considerable biomass capacity and has a potential of 2700 MW energy recovery from waste, 5000 MW of bagasse cogeneration and 16881 MW of plantations and agro-residues (Kumar et al., 2010).

Hydropower is another renewable energy source which produces mechanical energy from the kinetic or potential energy of water for watermills and textile machines.

Moreover the hydropower is widely used in electricity production. As Kumar et al. (2010) state India has the fifth largest hydro potential in the world. In addition India has the fifth largest wind power capacity just after US, Germany, Spain and China in 2010. The total annual solar radiation is approximately 7500 times greater than world's overall annual primary energy use. India's most regions receive 4 – 7 KWh of solar radiation per square meter in every day and there are more than 250 sunny days in a year in the country (Kumar et al., 2010). Further focus on development and implementation for solar energy will help India to accomplish its sustainable environment targets.

Despite its economic boom which is started since 1978, China accomplished a spectacular success to decrease the speed of CO_2 emissions by its successfully improved energy intensity. Simply, it is possible to state that China produced more with less energy. Furthermore, among BRIC countries China's success in energy efficiency is better than India and Brazil; however it is worse than Russia's. Besides it is the most populous country in the world, China's annual population growth rate has decreased from 1.4 % to 0.5 % between 1990 and 2011 (World Bank, 2015). These values are quite smaller than world's average. Hence, the impact of population effect on China's CO_2 emissions was lower than India's and Brazil's population effects. On the other hand, the impact of carbon intensity has increased because China still produces more than 80 % of its electricity from the coal sources. In order to reduce its carbon intensity China also follows the same way with India and the country shows substantial efforts to improve its renewable capacity.

China is blessed with significant solar resources and the country generally utilizes the solar energy for urban and rural domestic energy consumption and the power supply for remote areas. As Peidong et al. (2009) states the photovoltaic power generation is expected to reach $1.8 * 10^6$ KW in 2020 where the area which is installed by solar water heater is expected to reach $3 * 10^8\ m^2$ in the same year. China's wind energy reserves mainly distributed in south eastern and in north eastern regions of the country. China manufactured its first small wind energy water pumping generators in 1958. According to the wind power programs the installed capacity in China is expected to reach $3 * 10^7$ KW in 2020. Domestic garbage, firewood, crop stalks, foul wastes, waste water, industrial organic waste residue are the main biomass energy resources of China. The biological chemical transition (fuel alcohol and marsh gas), biomass gasification (thermal power co-production or power production) and direct burning are all the activities which comprised the biomass energy in China. Until 2020, as Peidong et al. (2009) state the production of biodiesel is expected to reach $2 * 10^{10}$t where the production of biological solid fuel, fuel alcohol and biomass energy power generation are expected to reach $5 * 10^7 t, 1 * 10^7 t\ and\ 3 * 10^7 kW,$ respectively in that year. Additionally mash gas amount is expected to increase $4 * 10^{10} m^3$ until 2020. China also has remarkable amount of small hydropower and geothermal energy sources. Furthermore, due to its geographic location China has abundant ocean energy sources such as tidal energy, oceanic flow energy, wave energy, salt difference energy, temperature difference energy; however, China's oceanic energy production unfortunately has started very late.

In Mexico, population effect was the major determining factor in CO_2 emissions for both first and second sub-periods. The annual population growth rate in Mexico has decreased from 2.1 % (in 1990) to 1.3 % (in 2011), however, it is still higher than the world average. A reduction in population growth rate could reduce the speed of CO_2 emissions further. Similar to India and China, Mexico also accomplished a successful energy intensity improvement especially in the first sub-period. The impact of carbon intensity has also decreased in Mexico's CO_2 emissions during the study period.

Renewable energy sources comprised the 3 % of the Mexico's energy mix and as Escobedo et al. (2014) emphasizes the US bordering Mexico, including California, Arizona, New Mexico and Texas states have remarkable wind power potential. Therefore the authors analyzed the potential wind power in Northern Mexico. They calculated the wind speed, wind power density, power output & useful hours and daily pattern for Northern Mexico. The analysts also provided maps for the speed of wind in Northern Mexico. Escobedo et al. (2014) reported that the wind speed increases from 4 pm to 6 am the following day. They also concluded that the Northern states of Mexico have 1700 useful hours where the speed of wind is more than 3 m/s. recently, Mexico focused more to the renewable energy. Hence increasing the current potential would create an opportunity for the country to improve its carbon intensity and then reduce the carbon dioxide emissions.

In Indonesia, all of the factors followed an accelerating impact on carbon dioxide emissions at the end of the first sub-period. However, in the second sub-period the country accomplished some energy intensity improvements. Population effect played a significant role in Indonesia's CO_2 emissions during the study period. The annual population growth rate has decreased from 1.8 % to 1.3 % between 1990 and 2011 (World Bank, 2015). Indonesia's population growth rate is also higher than world's average. Therefore a decline in population growth rate may be helpful to reduce the impact of population effect on Indonesia's CO_2 emissions. In Indonesia carbon intensity showed a significant increase due to the increasing coal consumption in the research period. Indonesia's energy consumption is largely dependent to coal, crude oil and natural gas and hence the CO_2 emissions are increasing rapidly in the country.

The Indonesian government aims to diversify the energy sources to ensure a more sustainable environment. As Hasan et al. (2011) states renewable energy accounts only 3 % of Indonesia's energy mix. Indonesia has remarkable renewable energy potential including hydro, geothermal, biomass, solar and wind power due to the its geographic location and natural conditions. A certain action is expected from public, government, and non-government agencies to use renewable energy in order to accomplish the sustainability goal (Hasan et al., 2011). However, the major challenge is that, Indonesia is a lower middle income country and renewable energy sources (especially solar and wind power) may be costly for the country. Focusing on energy intensity improvement and reduction of coal consumption are probably the appropriate short term goals for Indonesia.

Empirical findings reveal that in Nigeria carbon intensity and population effect were the major determining factors in CO_2 emissions in the first sub-period. In the second sub-period Nigeria achieved a valuable energy intensity improvement. As a result energy intensity followed a reducing impact on Nigeria's CO_2 emissions. Nigeria's population growth rate was quite higher than other seven countries. Thus, in the second sub-period the impact of population in Nigeria's CO_2 emissions has become more visible. The annual population growth rate in Nigeria has increased from 2.6 % (in 1990) to 2.8 % (in 2011) (World Bank, 2015). The annual population growth rate is quite larger than the annual world average. Hence, a reduction in population growth rate would be a remarkable step towards to decrease the Nigeria's CO_2

emissions. In the second sub-period carbon intensity effect followed a decreasing trend in CO_2 emissions.

However, Nigeria has certain energy problems. Almost 50 % of the public is lack of electricity. As Mohammed et al. (2013) states more than 25 % of human population experiences an energy crisis in the world. Majority of these people are living in the rural areas in developing countries and mainly sub-Saharan Africa, like Nigeria. According to Mohammed et al. (2013) almost 80 % of Nigerians use combustible biomass, generally forest food and its charcoal derivatives for primary energy use. Nigeria has considerable renewable and non-renewable energy sources. Regarding renewable sources, Nigeria utilized only the traditional bio-energy sources. Mohammed et al. (2013) analyzed the potential of Nigeria's renewable sources including hydro, biomass, solar, and wind. They clearly stated that the potential which is estimated from crop residue, animal waste, municipal solid waste were equivalent to 697.2 TJ, 455.8 PJ and 442 MW respectively. The authors also stated that solar radiation in Nigeria changes between 4 KW h/m^2 and 7 KW h/m^2 and these values are sufficiently larger than the threshold average value for 2.3 KW h/m^2 which is necessary for the operation of simple domestic load in rural areas. In addition, the wind speed in country changes from 1 m/s to 8 m/s and the hydro potential of Nigeria is equivalent to 12950 MW according to Mohammed et al. (2013). Nigeria has abundant renewable sources however the country is a lower middle income country and it has certain poverty problems. Hence the installation of renewable sources especially solar and wind power might be very expensive for Nigeria, mainly for the people who live in rural areas.

In Turkey, the population effect played a significant role in CO_2 emissions in both of the sub-periods. Following economic activity the population effect was the second major determining factor in Turkish CO_2 emissions. Empirical findings reveal that Turkey accomplished some energy and carbon intensity improvements. However these improvements are not at the desirable level. Turkey should focus on energy saving policies and technological advancements to improve the energy intensity and reduce the CO_2 emissions. Among 8 research countries Turkey has the lowest amount of energy resources.

As Capik et al. (2012) states Turkey has a remarkable potential of hydro, wind and geothermal energy resources. Each of these resources comprised approximately 14800 MW, 1000 MW, and 94 MW in Turkey's energy mix, respectively. Turkey is very rich in terms of hydro sources. In addition, due to its geographic location Turkey has solar energy potential and country's biomass potential is also remarkable. Turkey's government also plans to implement nuclear power plants for energy production and to reduce the dependence of Turkey in world's energy market.

Beyond all these advantages of renewable energy sources we should keep in the mind that except Russia (which is a high income country) all the other countries are developing countries. Hence, the implementation of renewable sources (Duro & Padilla, 2006) may not be very costly for the upper middle income countries (including China, Brazil, Turkey, and Mexico) however; most probably this attempt would be costly for the lower middle income countries (such as India, Indonesia and Nigeria) since these countries have poverty problem especially in their rural regions. On the other hand, despite it has many shortcomings in terms of poverty alleviation, India’s effort for installing renewable energy sources regarding sustainable energy generation is invaluable.

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