Decomposition Analysis of CO_2 Emissions for Turkey and Iran over 1990-2010

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Abstract

There exists an important awareness for reduction of CO2 emissions to obtain a sustainable world. Together with this, there is a great deal of interest for decomposition analysis to see the accelerating and decelerating factors of CO2 emissions. The aim of this project is to decompose CO2 emissions in economic sectors for the two superpowers of Middle East, Iran and Turkey, over the time period between 1990 and 2010, for Turkey obtained a rapid growth performance in recent years and Iran which is the energy superpower of the world. Refined Laspeyres Index decomposition method and a consistent data gathered from the World Bank's and UN's databases have been used during the analysis. Five main sectors (agriculture, manufacturing, transportation, construction and other service sectors) and four main impacts (scale effect, composition effect, energy intensity effect and carbon intensity effect) have been considered to see the increasing and decreasing factors of CO2 emissions. Various interesting results are observed for both of the countries, for each of the economic sectors. Generally scale effect and energy intensity effect are the dominant impacts for all sectors of both countries. However composition effect and carbon intensity effect are also important contributors for economic activities of these two countries. Overall, our analysis showed that these two countries should pay attention for energy intensity and sustainable economic growth.

1 Introduction

Environmental sustainability has been one of the most important issues on the world's agenda since the universe started to give the destruction signal. World population doubled in only 50 years. In 1960, it was around 3 billion; however, in 2005 it exceeded 6.5 billion. The world population increases, thus the need for water, food, energy supply and technical supply will also continue to increase. It is expected, by the end of 21st century world population will reach to 15 billion. Together with the rapid population growth, urbanization and industrialization will continue to increase. Therefore if serious environmental measures are not taken into consideration, it is possible to state that sustainability of the world will be in danger.

Together with the urbanization, energy demand will also continue to rise. In 2030, world electricity need expected to double as compared with today. Seventy eight percent of electricity consumption of the world still is generated by fossil fuels (WB, 2011). Fossil fuels are pollutant to environment and they are increasing the amounts of CO_2 emissions. CO_2 emissions are the main reason of global warming and the global warming is the greatest environmental problem of the world which creates danger for all living organisms.

Since the economic growth, environmental sustainability and energy efficiency are connected subjects, some of the developed countries being aware about this connection and they began to make huge investment on renewable energy sources. Despite, most of the developing countries still ignore the environmental sustainability. These countries are not voluntary to interrupt their economic growth by using renewable energy sources. Since renewable energy sources are relatively expensive than the fossil fuels, countries do not prefer to use them. Some of the developing countries (for instance, Iran) are very rich in terms of liquid and gas fuels and they use these fuels for their energy demand. However, some of the developing countries (for instance, Turkey) are located on the transition hub of these energy sources and they use these types of fuels, since these fuels are relatively cheaper than the renewable sources and they are also portable.

The cases of Iran and Turkey are quite interesting since Iran is an energy superpower in the world and carefully monitored by other countries. Furthermore, Turkey is located on the energy transition hub between Europe and Middle East and Caspian Region. Both of the countries obtained remarkable growth performance in the last two decades. For instance, Iranian GDP is 4.4 times greater than in 2011 ($514 billion) as compared with 1990 level ($116 billion). Correspondingly, Turkey's GDP is 5.1 times greater in 2011 ($774 billion) as compared 1990 level ($150 billion). During the last twenty years both the countries showed rapid population growth. In 2011, Iran's and Turkey's population reached to 75.4 million and 73 million, respectively. Another important basic economic indicator is GDP per capita and it is approximately equivalent to $6800 and $10600 for Iran and Turkey, in 2011, respectively.

Iran is a huge energy consumer, located at position 12 of World Bank's energy consumption ranking. According to the same database, the recent overall energy consumption of country is approximately 211 thousand kt of oil equivalent and this value is 3 times greater than 1990 consumption level. On the other hand, Turkey is located at position 23 of World Bank's energy consumption ranking. Turkey's overall energy consumption is estimated around 105 thousand kt of oil equivalent in 2011. This energy consumption amount is almost twice if one compare with 1990 level. Both Iran and Turkey are certain electricity consumers of Middle East. Iranian electricity production is estimated as 233 billion kwh and electricity consumption is estimated as 196 billion kwh (WB, 2010). For Turkey, overall electricity production and consumption values are estimated as 211 billion kwh and 180 billion kwh, respectively. Iran is able to meet its domestic electricity demand and also exports electricity to its neighbor countries. The customers of Iranian electricity are Armenia, Iraq, Afghanistan, Pakistan and Turkey. Approximately 95 percent of electricity in Iran is generated from thermal electricity sources and remaining 5 percent is generated from hydro and renewable sources. Seventy four percent of electricity in Turkey is generated from thermal electricity sources and remaining 26 percent is generated from hydro and renewable sources (WB, 2010). In the light of this information CO_2 emissions are on an incredible level, especially for Iran. In 2010, overall CO_2 emissions of Iran are more than 571 thousand kt and country located at position 7 in the world CO_2 emissions ranking. For Turkey, in the same year overall CO_2 emissions are estimated as 298 thousand kt and the country is located at position 21 in the same ranking. Accordingly, CO_2 emissions metric ton per capita is equivalent to 7.67 and 4.13 for Iran and Turkey, respectively. Overall, it is possible to state that Iran is a serious pollutant for the world. Turkey is not at the same level but its environmental damage is also increasing.

Iranian economy suffers from the sanctions of the world countries. However, external dynamics are not the only problems of Iranian economy. Internally, country has a serious energy efficiency and wastage problem. Together with this, high subsidies on energy sources create problems on Iran. Iran is a very rich country in terms of energy sources, however plenty number of years it had to import sources from other countries in order to meet high energy demand. Energy prices (especially for gasoline) are generally subsidized and this resulted the over use of energy sources. For the next following years government plans to decrease the amount of subsidies to discourage wage. Reduction of subsidies contains both petroleum and natural gas.

Turkey’s importance in the energy markets is growing, both as a regional energy transit hub and as a growing consumer. Turkey’s energy demand has increased rapidly over the last few years and likely will continue to grow in the future (EIA). During the recent years Turkey showed fastest increase in energy demand in OECD countries. Turkish economy has avoided from the long stagnation that affected negatively the European OECD countries. Real GDP growth rate for Turkey is estimated as 9.2%, 8.5% and 2.6% for the years 2010, 2011 and 2012, respectively. In the last two decades Turkey suffered from four different economic crises. These crises happened in the years 1994, 1999, 2001 and 2008 respectively. Turkey’s energy use is still relatively low, despite it is growing at a very fast pace. Since the domestic energy sources are very limited Turkey mostly relies to the imports of these sources. Turkish government is voluntary to use nuclear sources to reduce the dependence of country. However, there is a debate about the nuclear sources since the sources are risky.

For the internal energy and related CO_2 emissions dynamics, doing a decomposition analysis might be helpful in terms of environmental sustainability and efficient energy use. Both of the countries have the potential to solve their energy over use problems and reduce the CO_2 emissions. This type of decomposition analysis will also emphasize the energy intensive and carbon intensive sectors of Iran and Turkey. A decomposition analysis also gives valuable insights for solving the energy concerned issues of these two countries.

In this project the main purpose is making a decomposition analysis for Iran and Turkey between 1990 and 2010, according to five main economic sectors, agriculture, manufacturing, construction, transportation and other services. Refined Laspeyres Index decomposition method and a consistent data set gathered from World Bank and United Nations energy databases have been used. Four main effects have been considered to see the accelerating and decelerating factors of CO_2 emissions. These effects are, scale effect, composition effect, energy intensity effect and carbon intensity effect.

2 Literature Review

For the concern of decomposition analysis, researchers generally followed two different ways. Some of them either did a comparison analysis between the decomposition methods or they computed some extensions according to available methods to minimize the residual terms and obtain a better approach. Furthermore, in the second category, some researchers used the available decomposition techniques to analyze the increasing and decreasing factors of CO_2 emissions of countries according to economic activities.

Ang et al. (2003) discussed the perfect decomposition techniques for energy and environmental issues. The authors clearly stated that they extended the work of Albrecht et al. (2002) by giving a more complete and up to date overview of perfect decomposition techniques and their role in energy demand and related analysis. The main reason behind of their work is there has been a great deal of interest in decomposition analysis in energy policy studies.

Ang et al. (2004) obtained a general Fisher index approach to energy decomposition analysis by extending the conventional two-factor fisher index decomposition approach to n factors. After their work the authors obtained a complementary approach for the current methodology. The new approach possesses some desirable properties and it may used for some important analysis in energy studies. The authors also emphasized that the new formula is more complicated than the other commonly used Index Decomposition Analysis (IDA) approaches.

Liu (2006) did a comparison analysis for methodologies related with the decomposition approach based on energy consumption. Considering the size of residual term as a comparison tool, Liu concluded the adaptive weighting Divisia index method and simple average Divisia index method show the most robust and smallest residual term.

Paul & Bhattacharya (2003) analyzed the factors that are accelerating or decelerating CO_2 emissions emitted from the energy use of India between 1980 and 1996. The authors used decomposition method and they analyzed four main impacts such as, pollution coefficient, energy intensity, structural changes and economic activity to describe the changes in CO_2 emissions. Using the decomposition method authors proved that economic growth has the largest positive impact on CO_2 emissions change, for all important economic activities. There exists a decline for CO_2 emissions obtained from industrial sectors and transportation because of the increasing energy efficiency and fuel switching. The authors also emphasized the decrease due to the pollution coefficient and energy intensity effect for agriculture can be ignored. They finally concluded that the energy intensity has had a greater impact on energy induced CO_2 emissions compared with the pollution coefficient.

Comille & Frankhauser (2004) decomposed the energy data to determine the main factors (contributors) behind the improvements in energy intensity. They concluded that energy prices and progress in enterprise restructuring are two more important factors for more efficient energy use. The authors also emphasized that the economies of Central and Eastern Europe and the former Soviet Union countries are very energy intensive. They also clearly stated that there exists a decline for energy intensity during the period of transition. However, the transition countries are still highly energy intensive.

Kawase et al. (2005) examined the long-term scenarios for other countries and the medium-term scenarios for Japan in order to construct Japan's long-term climate stabilization scenario. Using the extended Kaya Identity the authors decomposed the CO_2 emissions according to following indexes: CO_2 capture and storage, carbon intensity, energy efficiency, energy intensity and economic activity. They also evaluated a Reduction Balance Table for CO_2 emissions. The authors also calculated the necessary improvement for energy intensity and carbon intensity decline to reach the goal, i.e. obtaining 60-80 percent reduction for CO_2 emissions.

Ma & Stern (2007) used the logarithmic mean Divisia index method to analyze the factors related with changing energy intensity trends of China for the time period between 1980 and 2003. They reported that the technological change is the major factor for decreasing energy intensity. Together with this the structural change for industry sector increased the energy intensity during the same period. Structural change considers shifts of production between sub-sectors and it represents a declining trend for energy intensity. They also stated that the reason of increasing energy intensity after the year 2000 is the negative technological progress. Finally, the inter-fuel substitution is a small factor for changes in energy intensity.

Vinuya et al. (2010) decomposed the CO_2 emissions growth in US according to states between the years 1990 and 2004. The authors used the logarithmic mean Divisia index (LMDI) method to decompose the emissions according to five impacts. These effects are emissions per unit of fossil fuel, share of fossil fuel in total energy consumption, energy intensity, gross state product per capita and population. Their analysis proved that, during the research period there is an increase in energy efficiency. Together with this, lowering the share of fossil fuels in overall energy consumption and lowering the emissions intensity, balances the increasing impact of GDP per capita and population growth on carbon emissions for US.

Kumbaroglu (2011) made a decomposition analysis about CO_2 emissions for Turkey for time period 1990-2007 according to main economic activities, agriculture, manufacturing, electricity, residential buildings and transportation. The author analyzed four main impacts on CO_2 emissions by using the refined Laspeyres index method (RLI). The analyzed impacts are, scale effect, composition effect, energy intensity effect and carbon intensity effect. The author clearly stated that various interesting results on the underlying effects of economic activities emission data are found. Kumbaroglu also stated that valuable insights that are gained into CO_2 impacts of sector policies including energy and emission intensities, fuel switching and activity changes.

The purpose of this study is to analyze the major and minor impacts of CO_2 emissions for Iran and Turkey between 1990 and 2010 according to five main economic sectors. These sectors are agriculture, manufacturing, construction, transportation and other services. Four main effects, namely, the scale effect, energy intensity effect, composition affect and the carbon intensity effect will be considered. For the decomposition analysis Refined Laspeyres Index Method and a consistent data that is gathered from World Bank's and United Nation's databases will be used.

3 Data and Methodology

Structural Decomposition Analysis (SDA) and Index Decomposition Analysis (IDA) are the two widely used methods for decomposing the indicator changes according to sectors. SDA is related with the input output model of quantitative economics and its theoretical foundations and major properties are discussed by Rose and Casler (Kumbaroglu, 2011). For decomposition analysis IDA methods are generally used. Because of this it is possible to apply IDA methods for any data at any level of aggregation. The well known Laspeyres index method isolates the impact of a variable by letting that specific variable to change between two years while holding other variables constant at their base year values (Kumbaroglu, 2011). Various methods have been developed and employed under IDA methodology (Kumbaroglu, 2011). In 2000, Ang and Zhang provided a survey about the index decomposition analysis. Refined Laspeyres Index (RLI) method is derived from Laspeyres Index Method by Ang and Zhang. The main feature of method is, it distributes the residual term evenly to each variable. The RLI method has some advantages such that, it is not difficult to apply and understand. Ang and Zhang did some comparison about the IDA methods and they stated that RLI method is time reversal, factor reversal and it also passes from the zero value robustness test. For this study we used the RLI method to decompose the CO2 emissions of Iran and Turkey. The method is based on the Kaya Identity, which is mainly used to analyze the role of different factors, which also influences the CO2 emissions. The Kaya Identity defines carbon emissions (C) as the multiplication of four different effects: population (POP), carbon intensity of energy use (C/E), energy intensity of production (E/P) and per capita production (P/POP). Mathematically, it is represented as,

$$C = POP * \frac{C}{E} * \frac{E}{P} * \frac{P}{POP}$$

For this study our aim is to show the impacts at subsectors level, therefore, CO_2 emissions are represented as the multiplication of the sub-sectored total of four effects such that:

$$CO_{2i}^t = P_i^t * \sum_j \frac{CO_{2j}^t}{E_j^t} * \frac{E_j^t}{P_j^t} * \frac{P_j^t}{P_i^t}$$

where $\frac{CO_{2j}^t}{E_j^t}$ shows the carbon intensity of energy use in subsector j at time t, $\frac{E_j^t}{P_j^t}$ is the energy intensity of production in subsector j at time t, and $\frac{P_j^t}{P_i^t}$ is the share of subsector j within sector i, at time t and it is possible to denote the carbon intensity by CI, the energy intensity by EI and the sectors share by SS. Then the previous equation can be written as;

$$CO_{2i}^t = P_i^t * \sum_j CI_j^t * EI_j^t * SS_j^t$$

The effect of changes in production activity which is referred to as scale effect and it can be calculated as:

Scale Effect (P_i^t)

$$= \Delta P(i) \sum_j \left\{SS(j)EI(j)CI(j) + \frac{1}{2} * \left(\Delta SS(j)EI(j)CI(j) + SS(j)\Delta EI(j)CI(j) + SS(j)EI(j)\Delta CI(j)\right)\right\} + \Delta P(i) \sum_j \{\frac{1}{3} * (\Delta SS(j)\Delta EI(j)CI(j) + \Delta SS(j)EI(j)\Delta CI(j) + SS(j)\Delta EI(j)\Delta CI(j)) + 1/4 * (\Delta SS(j)\Delta EI(j)\Delta CI(j))\}$$

First effect is the scale effect and it shows the change in CO_2 emissions are resulted from the changing activity levels. According to the scale effect, the increase of activity levels increases the amount of CO_2 emissions and the decrease of activity levels decreases the amount of CO_2 emissions.

Composition Effect (SS_j^t)

$$= \sum_j \Delta SS(j)\{P(i)EI(j)CI(j) + \frac{1}{2} * (\Delta P(i)EI(j)CI(j) + P(i)\Delta EI(j)CI(j) + P(i)EI(j)\Delta CI(j))\} + \sum_j \Delta SS(j)\{\frac{1}{3} * (\Delta P(i)\Delta EI(j)CI(j) + \Delta P(i)EI(j)\Delta C(i) + P(i)\Delta EI(j)\Delta CI(j)) + 1/4 * (\Delta P(i)\Delta EI(j)\Delta CI(j))\}$$

Composition effect shows the change of emissions resulted from the changes in the composition of sector. A structural change toward less carbon intensive subsectors decreases CO_2 emissions and a structural change toward more carbon intensive subsectors increases CO_2 emissions.

Energy Intensity Effect (EI_j^t)

$$= \sum_j \Delta EI(j)\{P(i)SS(j)CI(j) + \frac{1}{2} * (\Delta P(i)SS(j)CI(j) + P(i)\,\Delta SS(j)CI(j) + P(i)SS(j)\Delta CI(j))\} + \sum_j \Delta EI(j)\{\frac{1}{3} * (\Delta P(i)\Delta SS(j)CI(j) + \Delta P(i)SS(j)\Delta CI(j) + P(i)\Delta SS(j)\Delta CI(j)) + 1/4 * (\Delta P(i)\Delta SS(j)\Delta CI(j))\}$$

Energy intensity effect suggests an indication for efficiency of energy process, conversion technologies and energy conservation. Energy saving activities, reducing the use of fossil fuels and use of renewable technologies increases the energy efficiency. Energy efficiency will reduce the amount of CO_2 emissions.

Carbon Intensity Effect (CI_j^t)

$$= \sum_j \Delta CI(j) \left\{ P(j)SS(j)EI(j) + \frac{1}{2} * \left(\Delta P(i)SS(j)EI(j) + P(i)\Delta SS(j)E(j) + P(i)SS(j)\Delta EI(j) \right) \right\} +$$

$$\sum_j \Delta CI(j) \{ \frac{1}{3} * (\Delta P(i)\Delta SS(j)E(j) + \Delta P(i)SS(j)\Delta EI(j) + P(i)\Delta SS(j)\Delta EI(j)) + \frac{1}{4} * (\Delta P(i)\Delta SS(j)\Delta EI(j)) \}$$

Carbon intensity effect is used to show the impact of fuel substitution on CO_2 emissions. For instance, if the share of renewable resources increases or if people use natural gas instead of coal, there will be a certain decline in overall CO_2 emissions. The change of CO_2 emissions between two time periods is the sum of these four effects.

$$\Delta CO_2(i) = Scale\ Effect\ (i) + Composition\ Effect\ (i) + Energy\ Intensity\ Effect\ (i) + Carbon\ Intensity\ Effect\ (i)$$

For the detailed analysis about the RLI method it is appropriate to follow the work of Ang and Zhang, called Methodological Issues in Cross-Country/Region Decomposition of Energy and Environment Indicators.

4 Empirical Results for Iran

4.1 Agriculture

For the agriculture sector of Iran, the most determining effect appears to be the scale effect. In the early 1990s scale effect shows a negative impact for overall agricultural emissions. Because of this, there was a decline on overall GDP of country, just after the Iraq war. After 1993, generally the scale effect shows a positive impact on CO_2 emissions. Around 2009 and 2010, scale effect shows a declining trend because there are heavy sanctions on Iranian economy. Energy use for agriculture sector, increased rapidly during the research period. In 2010 the total energy use in agriculture is 4.4 times greater than 1990 level. Energy intensity generally declines for agriculture while scale effect increases. However, on average energy intensity is positive for agriculture. Carbon intensity effect generally shows a negative trend for agriculture.

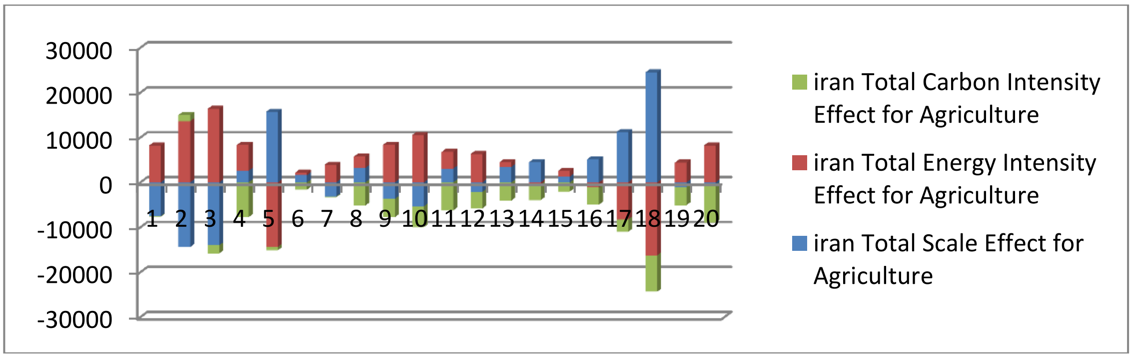

Figure 1. *The decomposition of agriculture sector for Iran between 1990 and 2010*

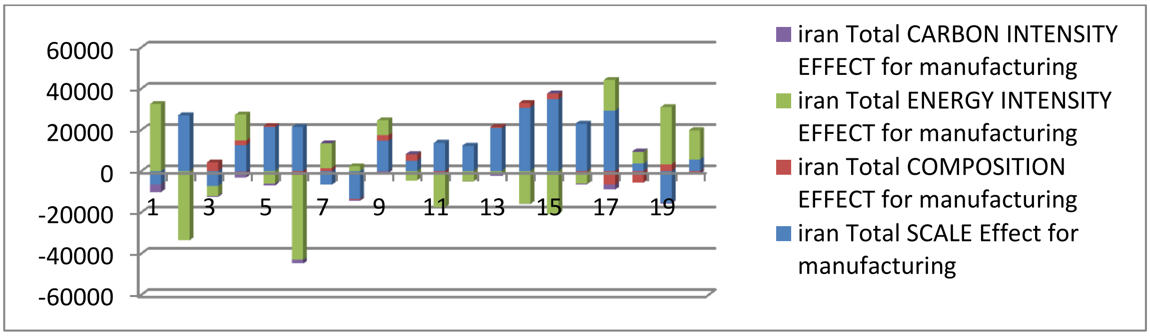

Figure 2. *The decomposition of manufacturing sector of Iran between 1990 and 2010*

4.2 Manufacturing

For manufacturing, scale effect and energy intensity effects are the two major impacts that are affecting CO_2 emissions. Scale effect generally shows a positive impact on emissions except the years 1991, 1993, 1997, 1999 and 2009. Manufacturing GDP of Iran increased by 114% during the research period. Energy intensity effect is on the opposite direction with scale effect. On average it shows a negative impact on emissions. Despite its slow growing technology, negative energy intensity impact implies that Iran obtained some energy intensity. Composition effect is a minor positive contributor of emissions, since the share of manufacturing GDP increased slightly in secondary industry. The negative minor impact of Carbon intensity effect for manufacturing also can be ignored.

4.3 Construction

The scale effect shows a positive impact on overall emissions, except the years 1991, 1993, 1997, 1998, 2000 and 2009. Overall construction GDP declined in these years. However, on average, scale effect is positive. Construction GDP is almost 4.1 times greater than 1990 level, in 2010. Energy intensity effect is negative for construction sector. However, it is positive on the years when GDP for construction decreased. Despite the energy use of construction sharply increased, it is possible to state that in the periods of recession, the resource management is also a problem for country. Carbon intensity effect is also an important contributor of CO_2 emissions for construction and it shows a negative trend on average. The share of construction GDP slightly decreased in secondary industry; however the small implication of composition effect can be neglected.

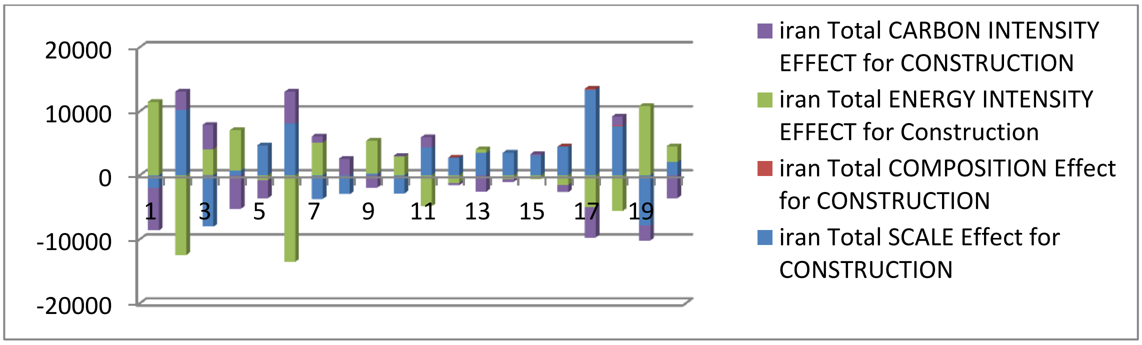

Figure 3. *The decomposition of construction sector for Iran between 1990 and 2010*

4.4 Transportation

During the twenty years of research, scale effect has a positive trend for transportation. This result is not a surprising result, since the GDP for transportation 4 times greater than its 1990 level, in 2010. Energy intensity effect is negative on average. However in most of the years the impact of energy intensity is positive, since the overall energy use of transportation sector is 12.4 times greater than 1990 level, as of today. Transportation is one of the most energy intensive sectors of Iranian economy. Carbon intensity effect is a minor determinant of the sector. Therefore its relatively small negative impact can be ignored. The share of transportation GDP increased between 1990 and 2010 through tertiary industry, thus the composition effect is positive for the sector.

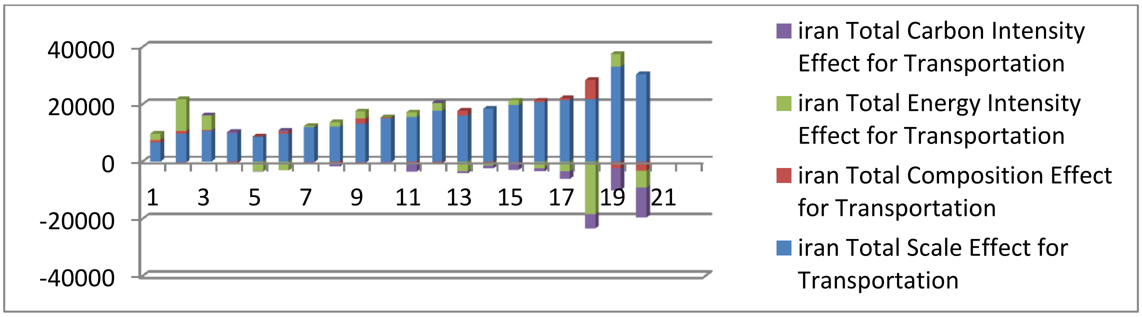

Figure 4. *The decomposition of transport sector for Iran between 1990 and 2010*

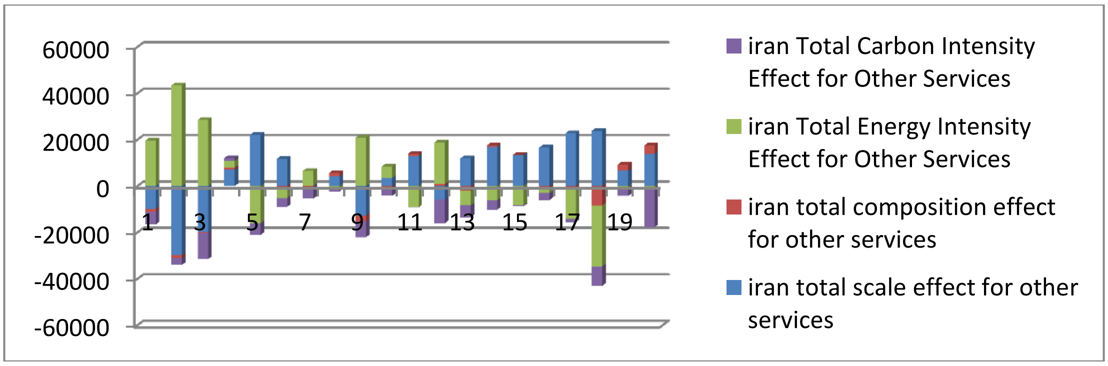

Figure 5. *The decomposition of other services for Iran between 1990 and 2010*

4.5 Other Services

For the service sector, energy intensity effect and scale effect are the main determinants of increasing CO_2 emissions and they are both positive on average. GDP of other services is 2.3 times greater in 2010 as compared with the 1990 level. Overall energy use increased amazingly during the research period. It increased by 792 percent between the years 1990 and 2010. This is due to the huge consumption of electricity and heating in residential buildings in Iran. Carbon intensity effect shows a remarkable negative impact on overall emissions and it has a negative trend almost in every year of last two decades. There is a small negative composition effect of other services since the share of sector slightly decreased in tertiary industry.

5 Empirical Results for Turkey

5.1 Agriculture

For the agriculture sector of Turkey, dominant effects are the energy intensity effect and scale effect. Scale effect (also we can call it as GDP effect) is generally a positive contributor for CO2 emissions of agriculture, except the years 1994, 1997, 1999, 2001 and 2009. In these years there exists a decline on agricultural GDP. These years are also the years that country faced with recession. Therefore a negative scale effect is expected and it is consistent. Energy intensity effect is generally positive for agriculture during the first decade. Energy Intensity effect is negative except only some of the years of the second decade. However, on average energy intensity effect is positive. Carbon Intensity effect has some minor contributions to overall estimated CO2 emissions, if one compare with the other effects and these contributions are mostly negative during the research period. There is no composition effect since we considered the agriculture sector as a whole of primary industry.

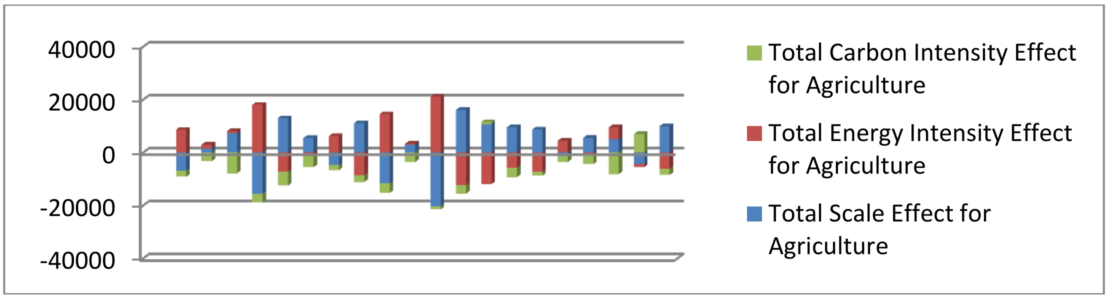

Figure 6. *The decomposition of agriculture for Turkey between 1990 and 2010*

5.2 Manufacturing

Since Turkey has a great manufacturing capacity, then a positive and huge scale effect is not a surprising result. Except the years of crises (1994, 1999, 2001 and 2009) Turkey's manufacturing GDP just increased in every year between 1990 and 2010. Therefore, a positive scale effect from manufacturing is expected and it is consistent. Overall; the manufacturing GDP is almost 4 times greater in 2010, as compared to 1990 level. Energy Intensity is the second dominant factor for manufacturing emissions. However, on average, it shows a negative trend during the last two decades. Especially on these years that scale effect is positive, then energy intensity has a negative impact on overall emissions. Overall energy consumption for manufacturing industries is approximately 3 times greater in 2010, as compared with 1990 level. Therefore it is possible to state that GDP increased with a faster pace if we compare with energy increase for manufacturing. Compared with the total energy use of manufacturing, CO_2 emissions increased with a slower pace. Especially in the second decade, Turkey began to use gas fuels with an increasing rate, thus, Carbon Intensity effect generally shows a negative impact on CO_2 emissions. Since the share of manufacturing showed a small decrease in secondary industry, a minor negative composition effect is expected and it is observed.

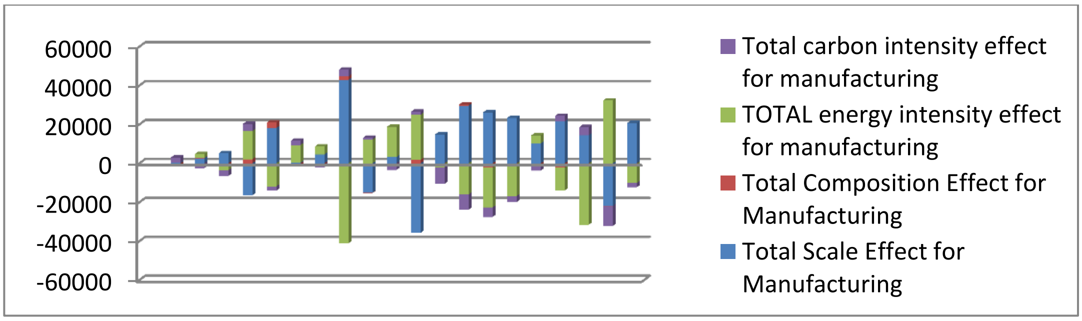

Figure 7. *The decomposition of manufacturing for Turkey between 1990 and 2010*

5.3 Construction

During the last two decades, construction GDP of Turkey, showed a remarkable increase and in 2010 it is estimated at 4.26 times greater than 1990 level. Generally, the scale effect has a positive contribution to overall emissions, except the years of crises. Recessions showed their negative impact on construction sector profoundly. Although energy intensity is mostly negative, in the years of crises (when GDP decreases, sharply) there exists a positive energy intensity effect. The positive energy intensity effect also proves that in recession periods certain energy wastage occurs. For construction a positive composition effect has been observed during the studies. Because of this the share of sector increased in secondary industry. Finally the carbon intensity effect has some negative minor impacts on emissions for construction sector of Turkey.

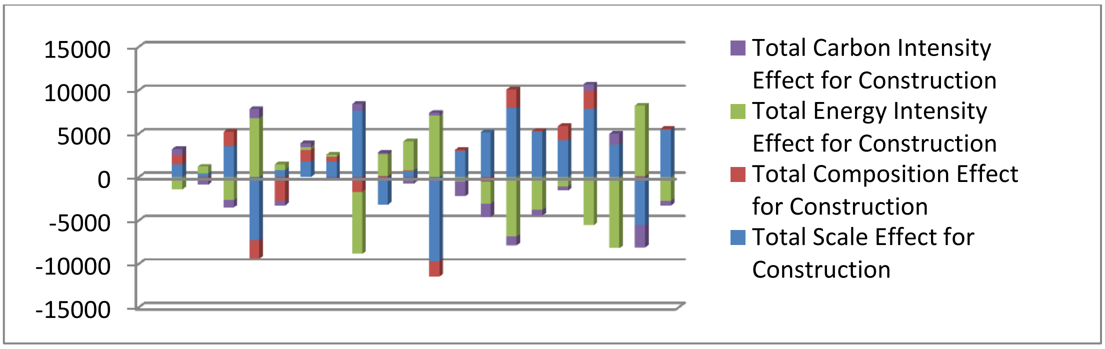

Figure 8. *The decomposition of construction for Turkey between 1990 and 2010*

5.4 Transportation

Scale effect represents a positive contribution to CO_2 emissions derived from transportation, since the GDP for transport sector in 2010, is nearly 6.6 times greater than its 1990 level. Only in some years (1994, 2001 and 2009) scale effect for transportation is negative because these years country faced with crises. The other economic activities affected negatively in 1999 crises, because in that year an earthquake happened. However, the earthquake did not affect transportation sector abnormally. Energy intensity effect is generally negative, because people started to use more economic cars as technology improved. Another main reason for negative energy intensity is that as the gasoline and diesel prices increased rapidly, people started to use alternative ways of transportation especially in the large cities. Carbon intensity effect is generally negative since people started to use less consuming LPG cars. Finally composition effect is small and positive for transportation, since the share of this sector increased in tertiary industry, especially in the first decade.

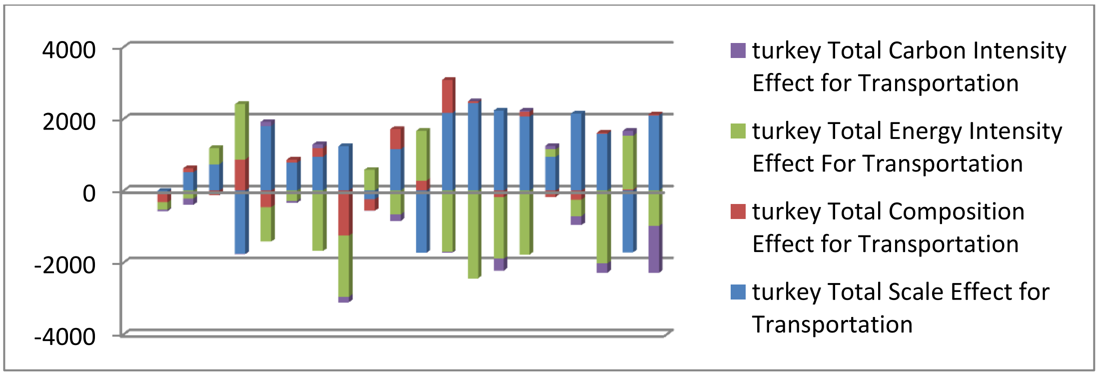

Figure 9. *The decomposition of transportation for Turkey between 1990 and 2010*

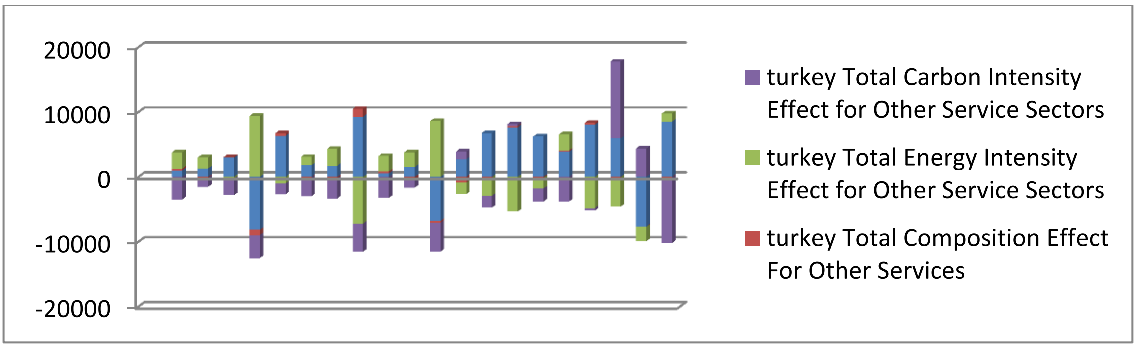

Figure 10. *The decomposition of other services for Turkey between 1990 and 2010*

5.5 Other Services

Scale effect is positive for other services, on average. This is not a surprising result since the GDP for other services is 6.3 times greater in 2010 if one compare with the 1990 level. GDP declined in the years 1994, 2001 and 2009 therefore in those years scale effect is negative. Second dominant contributor is the carbon intensity effect. Because by starting mid 90s Turkey began to use natural gas instead of coal for domestic heating purpose. Carbon Intensity is negative on average, since natural gas is relatively a cleaner fuel than coal. Energy Intensity is the third greatest contributor to emissions obtained from other services, and it is positive on average. This also proves that country has some energy wastage issues on service sector. Finally there exists a minor contribution from composition effect of service sector to emissions, which can be ignored.

6 Conclusion

For this project, the CO_2 emissions of two super powers of the Middle East, Iran and Turkey, are decomposed according to five main economic activities, namely, agriculture, manufacturing, construction, transportation and other services. Four main impacts (scale effect, composition effect, energy intensity effect and carbon intensity effect) and refined Laspayres index method has been considered during the analysis. Various interesting results and remarkable insights are observed.

Iran is an upper middle income developing country and at the same time it is the energy superpower of the world. The country relies on the revenue that gathers from energy sources. However, international sanctions show their negative impact on country's energy sector and after 2008 Iranian economic growth slowed down. Moreover, in 2012 country faced with a recession. Despite external problems, Iran has a certain energy wastage problem. Since the huge amount of energy is subsidized by government, then the overall energy use of Iran is high and this lead to an increase on CO_2 emissions. Together with this, country is very rich in terms of energy sources; therefore the citizens are not voluntary to use renewable energy sources. In the winter months, the natural gas demand reaches its peak and in order to meet with this high demand Iran imports natural gas from its neighbors. Iran also has a controversial nuclear energy program.

Turkey obtained a significant economic growth performance especially in the last decade. Therefore country's energy use increased very rapidly. Since the domestic energy sources are very limited, Turkey is a huge importer of oil and natural gas. Mainly, Turkey imports its energy from Russia and Iran. However, Turkish government plans to reduce the energy dependence of Turkey, therefore the new aim is generating electricity from nuclear sources. Furthermore, there is a debate on Turkish public about the riskiness of nuclear energy. Instead of nuclear energy most of the authorities suggest renewable energy sources such as wind and sun. Especially Turkey has some wind and solar energy potentials as a result of its geographic location.

Our study showed that scale effect and energy intensity effect generally plays an important role of emissions decomposition, for both of the countries, almost for all the economic activities. Since the GDP of both countries showed a remarkable increase, a dominant scale effect and energy intensity effect are expected. Carbon intensity effect plays a minor role for decomposition of emissions. The composition effect also plays a minor role about the decomposing the emissions for secondary and tertiary industries. Manufacturing, transportation and other services are the sectors that have leadership about the huge scale effect and energy intensity effect. Therefore, increasing energy efficiency (i.e. being more productive with less energy) in manufacturing, fuel switching for transportation (i.e. using electricity cars instead of gasoline and diesel cars) and generating residential electricity from sun and wind instead of natural gas and coal will be an efficient energy policies to reduce the carbon emissions. For Iran, it will be also beneficial if the government reduces the energy subsidies.

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