Hacettepe University Graduate School of Social Sciences

Economics Department

Economics Master's Programme

DETERMINANTS OF GREENHOUSE GAS EMISSIONS IN TURKISH MANUFACTURING INDUSTRY

Nurten İpek TAŞTAN

Master's Thesis

Ankara, 2019

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ACCEPTANCE AND APPROVAL

The jury finds that Nurten İpek TAŞTAN has on the date of 24/05/2019 successfully passed the defense examination and approves her Master's Thesis titled "Determinants of Greenhouse Gas Emissions in Turkish Manufacturing Industry".

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ABSTRACT

TAŞTAN, Nurten İpek. *Determinants of Greenhouse Gas Emissions in Turkish Manufacturing Industry*, Master's Thesis, Ankara, 2019.

Ever since the onset of the first Industrial Revolution in the United Kingdom, the world has experienced a rapid change in climate, and the surface and ocean temperatures have been increasing at unprecedented levels. The climate change, which has been predominantly caused by anthropogenic greenhouse gas emissions, has been receiving increasing attention from the major international institutions related to economic development from the beginning of 1990s.

There is widespread consensus among the economics literature that the GHG emissions are the primary cause of the increase in global average temperatures. Considering the close relation between industrial activities and the GHG emissions, determining the causes of emissions is required in order to form policies to tackle climate change. Determining the causes of the GHG emissions for the Turkish manufacturing industry, therefore, can assist the Turkish government for forming effective policies in order to attain its sustainable development goals.

This study makes two panel data estimations for the periods of 2003-2016 and 2009-2016 in order to determine the causes of GHG emissions for the Turkish manufacturing industry. The results indicate that production value, capacity usage, capital intensity, and operating at medium-low technology levels increase the total emission levels, while environmental taxes, productivity, and R&D expenditures reduce GHG emissions. The results point out that taxing sectors with high emission levels and subsidizing R&D expenditures with the tax revenues can be an effective mean to decrease greenhouse gas emissions generated by the manufacturing industry of Turkey.

Keywords

Climate Change, Greenhouse Gas Emissions, Turkish Manufacturing Industry

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LIST OF ABBREVIATIONS

CFC: Chlorofluorocarbon

CH_4: Methane

CLRTAP: Convention on Long-Range Transboundary Air Pollution

CO_2: Carbon Dioxide

EKC: Environmental Kuznets Curve

EU: European Union

FGLS: Feasible Generalized Least Squares

GDP: Gross Domestic Product

GHG: Greenhouse Gases

GISS: Goddard Institute of Space Studies

GK: Geary-Khamis Dollar

H_2O: Water Vapor

IIED: International Institute for Environment and Development

INDC: Intended Nationality Determined Contributions

IPCC: Intergovernmental Panel on Climate Change

IUNC: International Union for Conservation of Nature

NACE: General Industrial Classification of Economic Activities within the European Communities

NASA: National Aeronautics and Space Administration

N_2O: Nitrous Oxide

O_3: Ozone

OECD: Organization for Economic Co-operation and Development

Ppm: Parts per Million

R&D: Research and Development

TL: Turkish Lira

TURKSTAT: Turkish Statistical Institute

UN: United Nations

UNEP: United Nations Environment Programme

UNESCO: United Nations Educational, Scientific and Cultural Organization

UNFCCC: United Nations Framework Convention on Climate Change

WCED: World Commission on Environment and Development

WWF: World Wildlife Fund

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INTRODUCTION

The Industrial Revolution and the following developments presented humans an opportunity to utilize natural resources in a way like never before. Seizing this opportunity, humanity has reached to a level of prosperity beyond the imagination of a pre-capitalist state of mind. Bolt, Inklaar, de Jong, and van Zanden (2018) shows that the income per capita level in the United Kingdom is roughly 25 times greater than that of 1650's, while the income level has not changed much between the period 1-1650[1]. However, this unprecedented growth came with its costs. The Industrial Revolution, and following expansion of the world population brought about an increasing demand for industrial production and accommodation. Most of the production activities resulted in an immense environmental degradation, through waste and the use of energy. Moreover, the rapid output growth caused substantial problems in the social life such as distribution, access to resources and equity. The problems arising in different dimensions, and increasing awareness led people to question the consequences of their economic activities. As a result, the discussions on economic development started to revolve around its sustainability.

One of the main problems that sustainability discussions address is the support systems of the earth being under threat (UNESCO, 1996). However, the environmental and economic concerns coincide with each other. (Munda, 1997). Positive or negative developments in each dimension directly affect one another, and the initial effect generates a spillover effect among both dimensions. Meadows and Randers (2012) argues that economic development, in terms of increasing the output level, adversely effects the natural environment through increased input and energy usage and at extreme levels, leads to environmental degradation. Environmental degradation, in turn, adversely effects production in several sectors (e.g., agriculture) through the contamination of resources (inputs). The fact that both dimensions affect each other calls for policy actions that address both dimensions simultaneously

[1]According to Bolt et al. (2018), the income per capita levels of the U.K. on years 1, 1650, and 2010 respectively corresponds to 600, 925, and 23,777 Geary-Khamis (GK) dollars.

(Pawłowski, 2008). Achieving a sustainable environment, therefore, has become a major concern of economists and policymakers, especially at the onset of the 21st century.[2]

Climate change is one of the major environmental problems arose as a result of economic activities. The International Panel on Climate Change (IPCC) released an assessment report in 2007 which demonstrates the adverse effects of climate change on all living beings. The increase in temperature through the increased industrial activities caused the snows and glaciers to melt, the sea levels to rise and ocean temperatures to increase (Ramanathan & Feng, 2009). The effects of the change in environment shifted the habitats of land and sea animals and plants in several regions (IPCC, 2007). The climate change's effects are also observable in the economic dimension, with the most prominent effect being on the agricultural and food production (Fischer, Shah and van Velthuzien, 2002; Schlenker and Lobell, 2010; Müller, Cramer, Hare and Lotze-Campen, 2011; Bindi and Olesen, 2011; Calzadilla et al., 2013). Some other authors further argue that the adverse and potentially irreversible effects of climate change calls for immediate attention on identifying its causes and taking policy actions (Solomon, Plattner, Knutti and Friedlingstein, 2009; Hoegh-Guldberg and Bruno, 2010; Clark et al., 2016; O'Neill et al., 2017; Pecl et al., 2017).

IPCC (2007) underlines that the primary factor causing the climate change was most likely to be anthropogenic greenhouse gas (GHG) emissions. There are different types of GHG's; such as methane (CH_4), nitrous oxide (N_2O), and ozone (O_3), water vapor (H_2O), chlorofluorocarbons (CFCs), and carbon dioxide (CO_2). The increased concentration of GHG's on world's atmosphere causes the average world temperature to increase,[3] sea and ocean levels to rise, and change the precipitation and evaporation patterns of some regions.

CH_4, N_2O, and CO_2 are of particular interest among all other GHG's because their concentrations in the atmosphere are rapidly increasing. These gases are found to be effecting the ecosystem more than other GHG's, and are mainly anthropogenic. Especially CO_2 emissions are held responsible for the majority of the climate change after the Industrial

[2] see e.g. Lin and Zheng (2016) for a survey.
[3] An overall increase in world temperature does not necessarily mean that the average temperature will rise in all geographical regions. The average temperature may not change in some regions.

Revolution, even though, all three GHG's have increased substantially after 1750, and have contributed to the increase in average global temperature.

Regardless of the fact that governments, to some degree, aim to tackle the climate change through their own incentives, some international treaties seek to induce an external pressure to achieve global goals on preventing hazardous anthropogenic effects on the environment.[4]

Turkey has taken several steps to tackle the climate change by joining the international movement seeking to preserve natural resources and the environment. In 2004, Turkey has joined *United Nations Framework Convention on Climate Change* (UNFCCC), which is an international treaty aiming to stabilize the GHG emissions to prevent hazardous levels of climate change, as an Annex I party.[5] However, UNFCCC has a non-binding mechanism and is more of a voluntary contribution than a compulsory one. Another important commitment of Turkey was the ratification of the *Kyoto Protocol* in 2009. Kyoto Protocol was first enacted in 2005 and is the very first agreement that requires joined parties to limit GHG emissions and requires achieving several targets on a time interval. The joint interest of Turkish policymakers' and the requirements of the Kyoto Protocol points out that the GHG emissions need to be reduced to sustainable levels. The last major international agreement that Turkey has participated in is the Paris Agreement. Turkey has signed the Paris Agreement in 2016, but has not ratified it yet. Unlike the Kyoto Protocol, the Paris Agreement does not have binding forces and allows its participants to determine their goals and targets domestically. However, Turkey has not reported a mitigation pledge yet, and remains the only OECD country to do so for 2020 (OECD, 2019).

In order to reduce GHG emissions, determining their source is an important step. IPCC (2014) shows that the manufacturing sector accounts for 21% of the global GHG emissions. Additionally, Diakoulaki and Mandaraka (2007) shows that the manufacturing industry is the major source in the European Union (EU) that affect the GHG emissions. The strong

[4] Alongside GHG emissions some of the adverse effects of human activities on the environment include, but not limited to, depletion of natural sources such as air, soil or water, ecosystem destructions and the extinction of wildlife, garbage disposals and pollution.

[5] Annex I parties consist of OECD member countries and countries with economies in transition (EIT).

association of GHG emissions with the manufacturing sector points out that policies aiming to reduce GHG emissions by regulating the manufacturing industry are likely to be the most effective ones. Therefore, identifying the determinants of GHG's for the manufacturing industry, is essential in order to cope with climate change.

Turkey's rapid energy demand growth after the 1990's brought an equivalently rapid GHG emission growth during the corresponding period. Akbostancı, Tunç, and Türüt-Aşık (2011) show that even though Turkey has the lowest per capita CO_2 emissions among all OECD countries, has the highest increase for the period 1990-2004. OECD (2019) further shows that Turkey's GHG emissions have been increasing both in absolute and in per capita terms since 1990. As for the total GHG intensities, Turkey's per capita GHG intensity is approximately the half of the remaining OECD countries'. However, the relatively high growth rates are alarming for the Turkish Economy.

Various estimations and datasets, namely those of Tunç, Türüt-Aşık, and Akbostancı (2007) and (OECD, 2019), have demonstrated the part that manufacturing industry plays on Turkey's total GHG emissions. The decomposition analysis of Tunç et al. (2007) estimates that the manufacturing industry accounted for the 27% of the total CO_2 emissions of the Turkish Economy in 1996. A more recent analysis by OECD (2019) shows that the GHG emissions of Turkey are mainly generated by the energy production and the industrial sector-mostly manufacturing industry, followed by the transportation sector. As a result, the manufacturing industry is on the forefront regarding Turkey's policies aiming to limit GHG emissions.

Turkey's intervention to the energy sector is limited. Turkey needs to achieve this goal primarily through measures taken on the industry sector. Therefore, the determinants of GHG emissions in the manufacturing industry is of utmost importance for these policies. Through accurately identifying these causes, precise policies can be conducted to achieve sustainability for the environmental dimension.

The main aim of this study is to identify the determinants of GHG emissions in the Turkish manufacturing industry. In order to do so, two different panel datasets are compiled for the periods of 2003-2016 and 2009-2016. The variables assumed to affect the emission levels are production value, output per worker, average firm size, openness to trade, environmental tax per enterprise, capacity usage, research and development expenditures, capital intensity and technology levels. Feasible Generalized Least Squares and Prais-Winsten panel data regressions are used for the estimation.

Section 1.1 of this study elaborates the discussions on environmental concerns and climate change. Section 1.2 discusses Turkey’s current situation in GHG Emissions. Section 1.3 summarizes the related literature. Section 1.4 introduces the empirical analysis, data, methodology, findings and discussions, policy implications and limitations of the study. Then, the thesis concludes by summarizing the main findings and their implications.

CHAPTER 1
DETERMINANTS OF GREENHOUSE GAS EMISSIONS IN TURKISH MANUFACTURING INDUSTRY

1.1. ENVIRONMENTAL CONCERNS AND CLIMATE CHANGE

The notion of sustainability, although never being addressed separately, can be traced back to the writings of classical economists.[6] Even though the emergence of neoclassical economics prevented it from being a central issue of the economics literature, especially the emergence of development economics reignited the discussions on sustainability.[7] The initial salient efforts of international institutions, with some notable ones being the foundation of the International Institute for Environment and Development (IIED), United Nations Environment Programme (UNEP) and the Organization of Economic Co-operation and Development's (OECD) efforts that link environment to economic issues, was the outcome of the increasing environmental awareness during the 1970's.[8]

After the increasing importance given on environmental and social issues over a decade, the term "sustainable development" gained widespread recognition in 1987 as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987, p. 24).[9] Barbier (1987, p. 103) further stressed that economic, social and environmental dimensions are integrated and cannot be regarded as separate issues by stating that "poor people often have no choice but to opt for immediate economic benefits at the expense of the long-run sustainability of their livelihoods." Further

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[6]For example, Malthus (1872)'s discussions on the "*Malthusian Trap*" are built upon Britain's (in)ability to sustain high rates of population growth with finite arable land.
[7] For instance, Meadows, Randers, Meadows, and Behrens III (1972) stressed the *fear of running out of nonrenewable sources*.
[8] IIED' foundation was an effort to maintain economic progress without damaging the environment, while OECD's work was a concrete step towards integrating the environment and economics.
[9] Robert, Parris, and Leiserowitz (2005) provides an extensive survey of the evolution of the definition of sustainable development, and the relative position of the environmental sphere for the concept.

definitions made during the late 1980s and 1990s underlining the crucial role that the environment plays on human life are; "improving the quality of human life while living within the carrying capacity of supporting ecosystems" by IUNC, UNEP, and WWF (1991, p. 10), "focus(ing) on natural capital assets […] that […] should not decline through time", "the ideal of a harmonization or simultaneous realization of economic growth and environmental concerns" and "an economic-ecological integration […] above all in terms of resource use and pollution emissions" (Munda, 1997, pp. 215-216).

After the late 1990's the emphasis of the economic literature slightly shifted towards the social dimensions, in particular reducing global inequality. Especially after the 2008-2009 crisis, the social dimension, through distributional issues, became the primary focus of the economists.[10] However, the environmental dimension of development stayed far from being neglected. In September 2015, The United Nations (UN) have agreed on and published *Transforming our World: 2030 Agenda for Sustainable Development.* With an emphasis on bolstering the three fundamental pillars of *sustainable development*, namely those of the environmental, economic, and social pillars, UN (2015) designated 17 goals to achieve until 2030. The agenda's primary focus on the environmental dimension is to fight-off climate change, sustain natural resources, and prevent environmental degradation. The primary focus that UN puts on environmental issues inclines that, roughly 250 years after the Industrial Revolution, humanity has reached to a point where the natural environment is nearing to a point of no return.

Of all the topics discussed on the environmental dimension of sustainable development, climate change is the most mentioned one in the recent years. Its widespread effects and causes being related to a myriad of economic activities, climate change is "the mother of all externalities" (Tol, 2009, p. 29). The scientific community agree upon the fact that the temperature rises over the last 50 years are mainly due to human activities (McCarthy, Canziani, Leary, Dokken, & White, 2001). Being mostly the consequence of economic activities, climate change also have effects on economic activities as well, which underlines

[10] See, e.g. Kumhof, Rancière, and Winant (2015).

the need for policies to address climate change for the better functioning of economic activities.[11] In addition, the observable effects of human-related activities on the atmosphere increasingly raised public awareness, which is another factor that influences policymakers to put further emphasis on climate change[12].

National Aeronautics and Space Administration's (NASA) Goddard Institute of Space Studies (GISS) estimates that the mean temperature of the Earth surface has increased 0.8ºC roughly within the last 140 years, with approximately two thirds of the increase occurring after 1980. The resulting climate change due to the increase in average surface temperatures have profound effects on the life on earth. According to IPCC (2007), climate change causes the glaciers, ices and snow to rapidly melt, which further alters the average surface and ocean heat. Consequently, the melting ice and glaciers rise up the sea level. These rises endanger the habitable areas on sea level. The increase in average temperatures and the changes in precipitation and evaporation rates shifts the habitats of both land and sea animals and plants in several regions and also, higher temperatures negatively affect human life through increasing heat-related mortality and altering the infectious diseases (IPCC, 2007).

The vast majority of the economies around the world are aware of the potential dangers of the changes in the climate over the last decades, and have been taking measures to slow down, or suppress human intervention to the climate. The adoption of the Kyoto Protocol in 1997 is the first international legislative measure to prevent climate change through adoption of policies limiting GHG emissions. As of 2019, there are a total of 192 parties that have ratified the Kyoto Protocol, which shows the degree of international cooperation to prevent climate change. One major party that has yet to ratify the protocol, the United States, have pledged to cut its GHG emissions to 26-28% below its 2005 levels by 2025, and participated in the global movement to prevent climate change (Lin & Zheng, 2016).

[11] See Tol (2009) for a survey.
[12] See, e.g., Lorenzoni and Pidgeon (2006) for a survey on public awareness and climate change.

1.1.1. Causes of GHG Emissions

One particular assessment of IPCC (2007) was that the primary factor causing the climate change was most likely to be greenhouse gas (GHG) emissions. The increased concentration of GHG's in World's atmosphere creates a greenhouse effect which in turn traps heat within the earth surface and the atmosphere, causing the average temperature level to rise. There is a consensus on GHG emissions being one of the prime reasons of the global climate change since they cause relatively rapid melting of the glaciers and rises in sea levels (Ramanathan & Feng, 2009). There are different types of GHG's in the world's atmosphere; with the most notable ones being methane (CH_4), nitrous oxide (N_2O), and ozone (O_3), water vapor (H_2O), chlorofluorocarbons (CFCs), and carbon dioxide (CO_2). Especially CH_4, N_2O, CFCs and CO_2 emissions are closely related to various human activities.

According to IPCC (2014), the anthropogenic GHG emissions have increased more rapidly for the period of 2000-2010 (annually 2.2%) compared to the period of 1970-2000 (annually 1.3%). Figure 1 shows the world GDP and world total CO_2 emissions.

The human-related activities causing CH_4 and N_2O are mainly agricultural ones and burning biomass fuels. Waste management and energy use also generate significant amounts of both of the two GHG's. CFCs are mainly emitted from industrial activities and the usage of various consumer products. CO_2 emissions are mostly related to energy consumption and heating, agricultural activities, manufacturing, transportation, and construction.

1.1.1.1. CO_2 Emissions

IPCC (2007)'s estimates show that the atmospheric concentration of CO_2 is around 379 parts per million (ppm) which far exceeds the pre-industrial approximations of 260-270 ppm (Wigley, 1983). IPCC (2007) further shows the annual CO_2 emissions grew around 80% from 1970 to 2004. CO_2's rate of increase far exceeds those of the other anthropogenic GHG's.

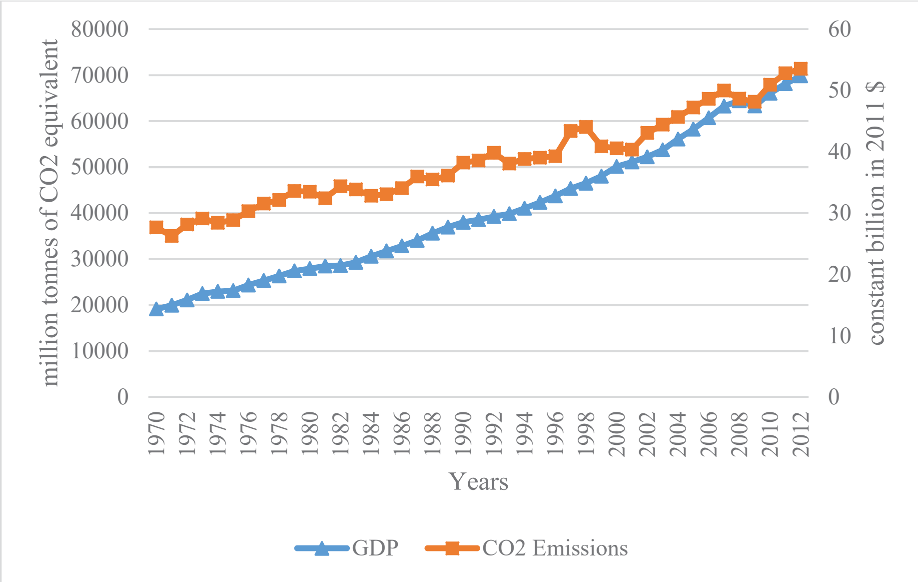


Figure 1: World GDP and CO2 Emissions for the period of 1970-2012

Source: World Development Indicators Database

The majority of the GHG emissions comes from the CO_2 emissions from fossil fuel combustions and industrial activities. Of all anthropogenic GHG's, CO_2 is especially important because even though it is not the most abundant GHG in the atmosphere, its concentration is growing rapidly. Particularly, CO_2 emissions constitute the majority of the anthropogenic GHG's with accounting for 76% of all emissions since 1970, according to 2010 estimates of IPCC (2014).The fact that CO_2 is relatively easy to control compared to other GHG's generates an additional focus on CO_2 emissions and its determinants.

1.1.1.2. CH_4 Emissions

According to IPCC (2007), CH_4's concentration in the atmosphere is around 1779 ppm, while the preindustrial approximations are only around 715 ppm. (Richter, 2008). However, the increase in CH_4 is in a decreasing trend since 1990's, and its concentration in the atmosphere is becoming relatively stable. (IPCC, 2014; Scheehle and Krueger, 2006).

IPCC (2014) shows that approximately 16% of global anthropogenic GHG emissions originate from CH_4. The main sources of CH_4 emissions after the industrial revolution are predominantly those of agricultural activities, energy production and waste management. Especially agriculture and energy sectors have relatively more influence on CH_4 emission growth. The fact that these two factors result in more CH_4 emission explains the higher CH_4 growth rates in developing economies through rapid industrialization and population growth (Scheehle & Kruger, 2006).

1.1.1.3. N_2O Emissions

The approximations of Richter (2008) shows that the global N_2O concentration in 2005 is 319 ppm, which is above the preindustrial level of 270 ppm. Compared to CH_4, N_2O's growth has been steadily increasing after the industrial revolution, and the increase is expected to continue over next century (IPCC, 2014).

IPCC (2014)'s estimates show that the 6.2% of global GHG emissions in 2010 are caused by N_2O emissions. N_2O is emitted predominantly by the agricultural sector, followed by energy production. Industrial sector and waste management also generate relatively mild levels of N_2O.

1.2. TURKEY'S CURRENT SITUATION IN GHG EMISSIONS

Turkey's growing population, economy and urbanization creates a pressure for GHG emissions to increase. However, Turkey is still in a relatively impressive position among the OECD. The per capita GHG intensity in Turkey is 6.2 tons of CO_2 equivalent per capita, while the combined level for the OECD countries' is 12 tons per capita (OECD, 2019). Furthermore, Turkey's GHG emissions per GDP is significantly lower than the OECD average.[13] However, Turkey's GHG emission's growth have been the highest among the OECD countries since 1990's (Akbostancı et al., 2011). The increase in GHG's is potentially

[13] Turkey's GHG emissions per GDP is 0.27 tons of CO_2 equivalent, while the OECD average is 0.32 tons.

due to the rapid increase in energy demand, as Turkey; heavily depends on imported energy, has a relatively higher ratio of fossil fuels in her energy mix compared to the OECD average, and has one of the highest energy demand growth rates among the OECD countries (OECD, 2019).[14] Even though Turkey's relative position among the OECD is impressive, the GHG emission growth rates are alarming for Turkey and points out an urgent need to take action. Figure 2 shows Turkey's GHG emissions for the period of 1995-2016.

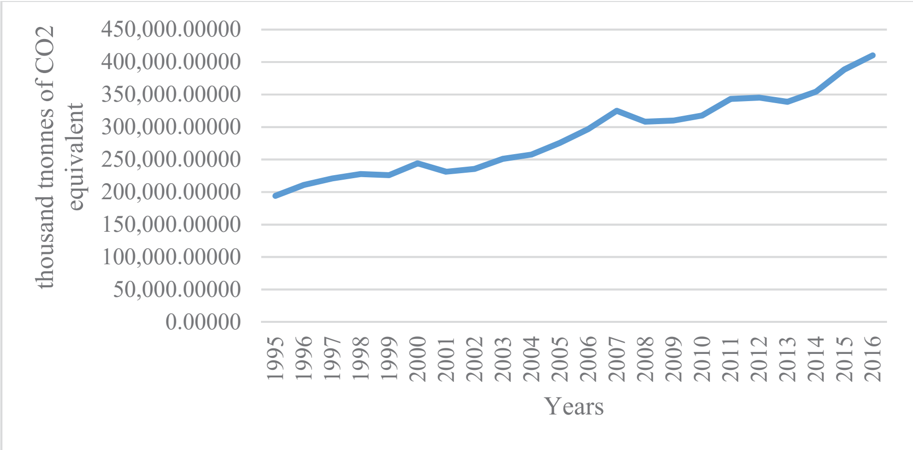


Figure 2: Turkey's GHG Emissions

Source: EUROSTAT's Air Emissions Account

There are different estimations of the sources of economic activities that promote GHG emissions of Turkey. Figure 3 shows Turkish manufacturing industry's total GHG emissions. Some notable ones of these estimations are the ones that Tunç et al. (2007), and OECD (2019) make. A common finding of these estimations are that the manufacturing industry plays a substantial role in Turkey's GHG emissions. For example, Table 1 shows the manufacturing industry's percentage share of Turkey's GDP and total GHG emissions. As of 2016, the manufacturing industry constitutes of 16.6% of Turkey's GDP and emits 30.11% of the total GHG. Considering the relative size of the manufacturing industry and its part in total emissions, identifying the underlining causes of GHG emissions in the manufacturing

[14] 88% of Turkey's energy mix is composed of fossil fuels while the OECD average for fossil fuels is 80%.

industry is an important starting-point for any policy to be conducted to reduce GHG emissions to the desired levels of both Turkey, and the international standards.

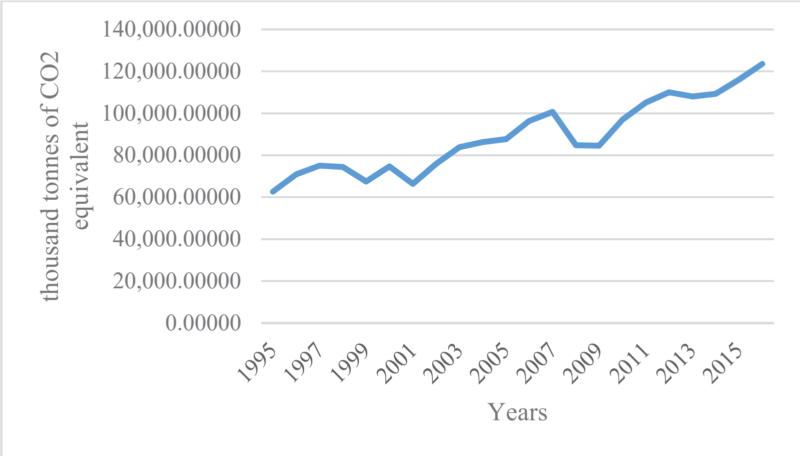


Figure 3: Turkish Manufacturing Industry's Total GHG Emissions

Source: EUROSTAT's Air Emissions Account

The most GHG emitting sectors of Turkish manufacturing industry in terms of total emissions are C23 - manufacture of other non-metallic mineral products, and C24 - manufacture of basic metals. These sectors are characterized by medium-low technology and their energy-mix mostly contain coal and fossil fuels. The lowest GHG emitting sectors are; C18 - printing and reproduction of recorded media, C21 - manufacture of basic pharmaceutical products and pharmaceutical preparation, and C26 - manufacture of computer, electronic and optical products. C21 and C26 are characterized by high technology levels while C18 is a low-technology sector. See Figures 5-6-7 in Appendix 1 for the GHG emission levels of sectors C16-30 for 1995-2016. While the data represented in Appendix 1 are based on total emission levels, Yeni (2018) shows that the most GHG emitting sectors in terms of GHG intensity are characterized by low and medium-low technology, while the least emitting sectors have medium-high and high technology.

Table 1: Manufacturing Industry's Percentage Share in Turkey's GDP and Total Emissions for the period of 1998-2016

Years	% share of the GDP	% share of the GHG Emissions
1998	22.3	32.70
1999	20.1	29.87
2000	18.8	30.60
2001	17.8	28.72
2002	16.9	32.18
2003	17.1	33.39
2004	16.9	33.48
2005	16.9	31.83
2006	17.1	32.46
2007	16.8	30.99
2008	16.3	27.49
2009	15.2	27.26
2010	15.1	30.52
2011	16.5	30.63
2012	15.9	31.87
2013	16.2	31.86
2014	16.8	30.83
2015	16.7	29.89
2016	16.6	30.11

Source: TURKSTAT and EUROSTAT

Turkish government have been extensively addressing the issues related to environmental protection since the 6th 5-year Development Plan in 1996 and have been conducting policies and issuing laws in accordance with its environmental goals. A significant force that influenced the Turkish government's approach to the environmental dimension have been the European Union (EU) membership criteria. Turkey has taken, and still takes, several legislative actions to comply with the environmental standards of the EU. For instance, Turkey adopted a national Climate Change Strategy and a National Climate Change Action Plan with short and long-term objectives to mitigate GHG emissions respectively in 2010 and 2011. Turkish policymakers' increasing attention to environmental objectives is reflected through the contents of the development plans, with increasing importance given to the environmental goals with each preceding plan.

Turkey’s participation in international agreements regarding the preservation of the environment further shows that the Turkish government is well aware of the need of action to prevent climate change. Of all the steps that Turkey has taken, two of them are relatively important especially internationally. The first one of these actions is Turkey’s participation to the UNFCCC as an Annex I party in 2004. Joining to UNFCCC shows that Turkish government is aware of the need to stabilize the GHG emissions, even if the treaty, by the very nature of the UNFCCC, is not a compulsory one and has no binding elements in it. The second important action of Turkey was ratifying and enacting the Kyoto Protocol in 2009. Unlike UNFCCC, the Kyoto Protocol has binding elements such as bringing constrains to the existing emission levels of its participant parties, and requires the goals to be achieved within specified time periods. The Kyoto Protocol requires the Annex II parties to reduce their emission levels at least 18% below the 1990 level until 2020. Yet, Turkey does not have any quantitative obligations to reduce her emission levels as an Annex I party. Another international agreement that Turkey has signed is the Paris Agreement. Unlike the Kyoto Protocol, the Paris Agreement does not have binding regulations for the participating parties. Instead, it allows for voluntary contribution by determining and reporting Intended Nationality Determined Contributions (INDC). INDC requires Turkey to determine several emission targets some of which are; baseline scenario targets (business-as-usual (BaU) and official plans scenario), and intensity and trajectory targets in order to achieve lower emission rates. The targets of Turkey can be summarized as

- reducing the GHG emissions by 25% of the BaU scenario by 2030,
- attaining a downward trend in net GHG emissions by 2026, and
- achieving a carbon intensity (GHG emissions/GDP) reduction of 40% for 2013-2030.

Although Turkey has signed the Paris Agreement in 2016, it still have not ratified it. As of 2019, Turkey remains the only OECD country that has yet to pledge a mitigation goal yet for 2020 (OECD, 2019). Similar to the case with the Kyoto Protocol, the Paris Agreement does not impose any binding elements on Turkey’s policies. With no legal obligations to reduce GHG emissions, the emission levels of Turkey have not declined. Figure 4 shows the emission per GDP trends of Turkey, OECD countries and the World.

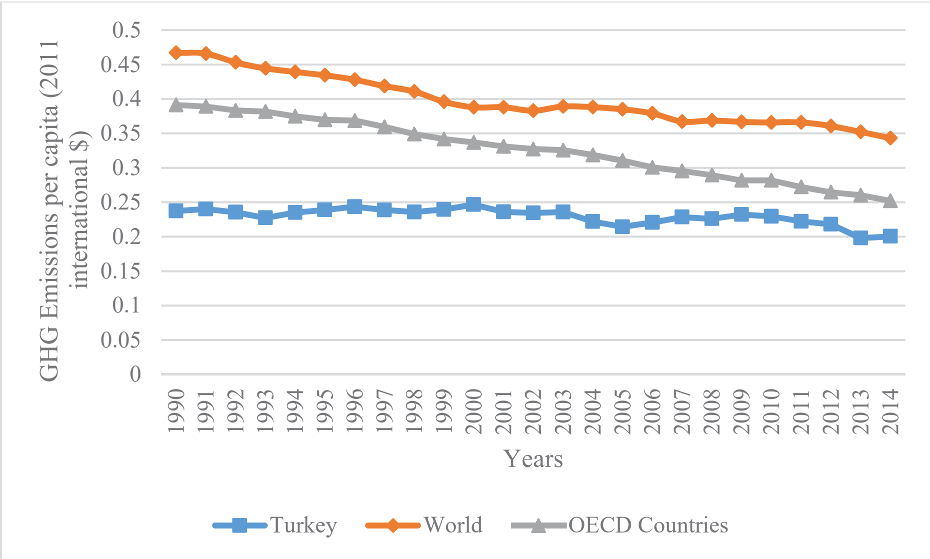


Figure 4: Turkey, OECD, World GHG Emissions per capita

Source: World Development Indicators' Database

1.3. LITERATURE SURVEY

This section provides a brief survey of the related literature. The related literature is mostly composed on the works that investigate the determinants of GHG emissions, and forms the theoretical basis of the elements of the analysis in the following section.

There is a grand strand of literature investigating the sources of GHG emissions and the factors that increase or decrease emission levels. A major source investigated by the literature is the demographics of the subjective country. Dietz and Rosa (1994), York, Rosa, and Dietz (2003), Dietz, Rosa, and York (2007), Lankao, Tribbia, and Nychka (2009), Rosa, Diekmann, Dietz, and Jaeger (2010), Jorgenson and Clark (2010), Wood (2009) found that the population size positively affects the GHG emissions. MacKellar, Lutz, Prinz, and Goujon (1995), Shi (2003), Martínez-Zarzoso and Maruotti (2011) shows that the effect of the population size is more severe in least developed countries. However, despite the positive effects of the population size are agreed to be significant, the findings on the effects of the age structure of the population, i.e. the relative size of the non-dependent population, are mixed. For example, York et al. (2003) finds that the relative size of the non-dependent population significantly affects the GHG emissions, while Dietz et al. (2007)and Jorgenson and Clark (2010) could not find sufficient evidence on the effect of the age structure. Aside from the size and the age structure of the population, MacKellar et al. (1995), Cramer (1996), Cramer (1998), Liu, Daily, Ehrlich, and Luck (2003), and Knight and Rosa (2012) shows that larger households also cause higher levels of emissions. Furthermore, Dietz, Gardner, Gilligan, Stern, and Vandenbergh (2009) identified household consumption as a major source of GHG emissions, and asserted that the desired decrease in GHG emissions can be achieved through the actions of the households. Dietz et al. (2009) above, Bolt et al. (2018) and Brizga, Feng, and Hubacek (2014) obtained similar findings and showed that household consumption growth has a significant impact on GHG emissions in the Baltic States. Wood (2009) shows that another aspect of population that significantly increases GHG emissions is consumer affluence, via increasing the total demand (especially for the production of goods with high GHG emission levels).

The size and the structure of the population though, is not the only aspect of demographics that is found to effect emissions. Especially through the increased energy usage, York et al. (2003), Dietz et al. (2007), Jorgenson (2007a), Bengochea Morancho, Martinez-Zarzoso, and Morales-Lage (2006), Jorgenson (2009), Jorgenson, Clark, and Kentor (2010), Jorgenson, Dick, and Shandra (2011) and Bengochea Morancho et al. (2006), showed that urbanization increases the rates of GHG emissions. Glaeser and Kahn (2010) and the UNFPA (2007) further investigates the effects of urbanization, and shows that urbanization through increased accommodation in suburbs spurs emissions while the increase in core urban population have negative effects.

It is plausible to assume that the population size is proportional to the economic activities within an economy. Therefore, its effects on emissions may be reflected through the effects of economic activities. Another strand of the literature investigates the effects of economic activities and emission levels. Being at the center of the economic-activity related discussions, the Environmental Kuznets Curve (EKC), or equivalently the ecological modernization, has been tested in several studies. The basic idea of this hypothesis is that, environmental degradation is expected to decrease at the later stages of development, after an initial increase during the take-off of an economy. The hypothesis is formed after the seminal work on Kuznets (1955), arguing that the same procedure applies for income inequality and economic development.

The EKC hypothesis, just like the original hypothesis of Kuznets (1955), is a highly controversial one with no consensus among economists on the issue. A large variety of works have conducted tests aiming to determine whether the EKC has any empirical validity or not. However, mixed results have been found with regards to its validity Spaargaren and Mol (1992), Shafik (1994), Selden and Song (1994), Grossman and Krueger (1995), J. A. List and Gallet (1999), and Redclift and Woodgate (2010) found empirical evidence in support of the EKC. In contrast, Cavlovic, Baker, Berrens, and Gawande (2000), Azomahou, Laisney, and Van (2006), Aslanidis and Iranzo (2009), Jalil and Mahmud (2009), and Carson (2009) could not find any evidence for the validity of the hypothesis. Another line of work linking the discussions on economic growth and the convergence debate to environmental issues, J. List and Strazicich (2003); Lee and List (2004); Bulte, List, and Strazicich (2007) have provided evidence for a convergence in CO_2 emissions through utilizing panel data of industrialized countries. Referring to their findings, Brock and Taylor (2010) constructed a *green Solow model* to support the convergence in emission levels alongside the existence of an EKC.

One particular argument that the EKC literature puts forward is that increased economic activity, which can be reflected by an increase in the production value of the manufacturing sector, significantly affects the amounts of emissions in an economy. A broad literature tests the validity of this argument for the industrial sectors of different countries with different structures through conducting decomposition analyses for the respective industries of each country. Some notable studies in this literature are those of Ren, Yin, and Chen (2014), Guan, Hubacek, Weber, Peters, and Reiner (2008)'s, M. Wang and Feng (2017) and Q. Wang, Chiu, and Chiu (2015) for the Chinese industry, De Freitas and Kaneko (2011) for the Brazilian industry, Casler and Rose (1998) and Tol, Pacala, and Socolow (2006) for the United States' industry, Wood (2009) for the Australian industry, Lim, Yoo, and Kwak (2009)'s for the South Korean industry, Diakoulaki, Mavrotas, Orkopoulos, and Papayannakis (2006)'s for

Greek industry, Das and Paul (2014) for the Indian industry, and González, Landajo, and Presno (2014) for the EU. The common finding of these works is that increased economic activity, economic growth, or an increase in production value results in an increase in GHG emissions. Their findings indicate that the total production value is an important determinant of the emissions in the manufacturing industry.

There are also several works investigating the effects of openness to trade or globalization.[15] Cole (2003), Cole (2004), Cole (2006), Kellenberg (2009), Bu, Lin, and Zhang (2016), Cole, Elliott, and Okubo (2014), Bu et al. (2016) finds that trade liberalization, through the mechanism of the pollution haven hypothesis, increases GHG emissions in underdeveloped countries while decreasing emissions in their more developed peers. On the other hand, Christmann and Taylor (2001), Andonova (2003) and Albornoz, Cole, Elliott, and Ercolani (2009) argue that increased trade relations with the developed countries promote eco-friendly technology in the developing world, which in turn reduces GHG emissions. However, Jorgenson (2007a), Jorgenson (2007b) and Jorgenson (2009) finds that foreign direct investment and GHG emissions in underdeveloped countries are positively correlated, indicating that the openness to trade may cause higher levels of GHG emissions even if underdeveloped countries acquire new technologies through foreign direct investment.[16]

There are also contrasting findings on the literature regarding the effects of international trade for the GHG emissions in developed countries. For example, the decomposition analysis of Yamakawa and Peters (2011), analyzing the Norwegian industry, showed that the production of exports account for the vast majority of the GHG emissions, indicating a possible positive relation between international trade and climate change. Wood (2009) also shows that increase in exports substantially promote GHG emissions in the Australian industry. Guan et al. (2008) finds that, alongside consumption and capital investment, increase in exports is (and will be) the driving force of the Chine industry's emission levels. Lim et al. (2009) also illustrates that the GHG emission levels of the South Korean industry is also positively

[15] see, e.g., Copeland and Taylor (2004) for a survey.
[16] There is another literature investigating whether environmental regulations influence the FDI decisions through environmental control costs (ECC). Erdogan (2014) summarizes several influential works and their main findings in this literature.

affected by the level of exports. The mixed results on how globalization, or international trade, affects the GHG emissions in both underdeveloped (or developing) and developed economies indicate that there is no consensus within the economics literature about the effects of international trade on GHG emissions. The lack of such consensus indicates that whether international trade promotes GHG emissions or not may be heavily sensitive to some other characteristics of the country (e.g., industry's structure, production technology, etc.) and motivates researchers to investigate its effects specifically for each country.

The energy intensity and the energy mix (i.e., the mix of the sources of energy that are being used during the production process) are also the sources that are discussed among the literature as the determinants of the GHG emissions for the industrial activities. There is a consensus among the literature that energy intensity and GHG emissions are positively related. Ren et al. (2014) shows that a decrease in the energy intensity of the industrial production substantially decreases GHG emissions in the Chinese industry while Q. Wang et al. (2015) shows that the energy intensity and mix come right after the economic performance as the primary factor of China's GHG emissions. Lim et al. (2009) for South Korea, Hatzigeorgiou, Polatidis, and Haralambopoulos (2008) for Greece, Andreoni and Galmarini (2012) for Italy, Rafaj, Amann, Siri, and Wuester (2015) for the European countries and Hamilton and Turton (2002) for the OECD countries find similar results on the significance of energy intensity on the GHG emissions. Akbostancı et al. (2011); Kumbaroğlu (2011); and Tunç, Türüt-Aşık, and Akbostancı (2009) finds that these results also hold for the Turkish manufacturing industry.

The production technology, especially for the manufacturing sector, is a widely investigated source of GHG emissions among the economics literature. Some works argue that innovations in the energy sector aiming to develop cleaner and more sustainable energy sources are crucial to tackle the adverse effects of the production process on the atmosphere (Bosetti, Carraro, Massetti, Sgobbi, & Tavoni, 2009). Aside from the other benefits of research and development (R&D) on better energy sources (such as increased production at lower costs), developments in the energy sector are argued to be favorable in that they reduce the future costs of mitigation efforts according to Blanford (2009), Margolis and Kammen (1999), Bosetti, Carraro, Massetti, and Tavoni (2008) and Garrone and Grilli (2010).

Aside from the technological growth in the energy sector, invention and adaptation of more productive production technologies are also argued to play substantial roles in reducing GHG emissions. Arto and Dietzenbacher (2014), for example, illustrates that better technology in the production process, even though not having strong enough effects to offset the opposing effects of growth in consumption and population, reduce the level of GHG emissions. Another line of work with some notable ones being Bosetti et al. (2008), Fernández, López, and Blanco (2018), Fisher-Vanden and Wing (2008) argue that R&D expenditures, through the technological developments, influence the GHG emissions, especially in underdeveloped and developing economies. There are two opposing effects here, as argued by Fisher-Vanden and Wing (2008), which are closely related to the discussions on the EKC: Better technology can result in an increase in industrial production which in turn causes higher levels of GHG emissions, or better technology can cause a shift to cleaner technologies which reduces the GHG emissions. The empirical literature on the effects of technology indicate a strong relationship between the level of technology and the level of emissions. However, this effect can be analyzed through two closely related but distinct forces: the level of technology and the amount of R&D expenditures.

The ways to tackle climate change through mitigating the adverse effects of GHG emissions have been widely addressed in the literature. Aldy, Krupnick, Newell, Parry, and Pizer (2010) provides an extensive survey on the climate mitigation policies. One particular policy, which is widely accepted by the environmental economics literature as a major regulation that governments can apply in order to prevent GHG emissions; is *environmental taxes* (or, carbon taxes). For instance, Muller (1996) discussed the carbon tax policies and tax schemes of several countries and argued on the part that environmental taxes play on achieving sustainable development. Their findings illustrate the effectiveness of fiscal policies on the environmental sphere in mitigating the climate change, and suggest immediate action to be taken especially by the developed countries which still do not take sufficient action against the issue. Environmental taxes are highly regarded as policy instruments against climate change because of the “double dividend hypothesis”, i.e., the hypothesis that argues that environmental taxes reduce negative externalities through achieving the socially optimum production and generating tax revenue for the government (through replacing highly distortive taxes).[17]

Some other widely accepted tools that governments can use on reducing GHG emissions are; the *green government spending* (e.g., Diamond and Mirrlees (1971); Stiglitz and Dasgupta (1971); Atkinson and Stern (1974)), i.e. the provision of green goods by the government, and *emission quotas* (e.g., Zhang, Wang, and Da (2014); Ishikawa and Kiyono (2006); Chichilnisky and Heal (1995); Starkey and Anderson (2005). Even though these measures are argued to be effective means to tackle climate change, this study particularly focuses on the effects of environmental taxes as policy instruments due to the availability of data and includes the level of environmental taxes to the analysis.

1.4. EMPIRICAL ANALYSIS

1.4.1. Data, Variables and Methodology

This section of the study initially defines the data and the variables used for the analyses, followed up by the methodology under which the preceding analysis is made.

1.4.1.1. Data and Variables

This subsection introduces the data used for the analysis of this study. It first introduces the data, variables and their abbreviations. Then, it shows where each data is acquired, and how they are generated.

[17] See, e.g., Fullerton and Metcalf (1997), Goulder (1994), Bovenberg and Goulder (2002), Parry (1998) and Hanson and Sandalow (2006) for discussions about the validity of this hypothesis; and Parry and Bento (2000) for a review on the subject.

The study seeks to analyze each sector within the Turkish manufacturing industry through constructing a panel data within these sectors. The data on the manufacturing industry consists of 15 distinct sectors, excluding (i) manufacture of food products (ii) manufacture of beverages (iii) manufacture of tobacco products (iv) manufacture of textiles (v) manufacture of wearing apparel (vi) manufacture of leather and related products (vii) manufacture of furniture (viii) other manufacturing (ix) repair and installation of machinery and equipment sectors. The sector classifications are made according to the NACE revision 2 sectoral classification in 2-digits. Table 2 presents detailed information on each sector and their codes.

The dependent variable in the analysis is the GHG emissions of each sector within the Turkish manufacturing industry. The explanatory variables seeking to explain the changes in the dependent variable are; the production value (PV) of each sector, average firm size (EMPENT), capacity usage (CAPUSE), productivity level (PVEMP), environmental tax per enterprise (ENVENT), openness to trade (OTT), research and development expenditures (LAG1RDEXP), and capital intensity of each sector (CAPITALPV), and technology level of each sector (LOW, MEDLOW, MEDHIGH, HIGH). Table 3 presents explanations of variables used in the analysis and their units of measures.

Due to the unavailable data for some variables for the 2003-2009 period we constructed two panel datasets. First model analyzes the period 2003-2016 for the variables production value, productivity, average firm size, openness to trade and technology levels. Second model analyzes the period 2009-2016 for the variables environmental tax, productivity, capacity usage, capital intensity, openness to trade, R&D expenditure and technology levels. The reasons and implications of the exclusion of certain explanatory variables from the datasets are discussed later when the limitations to the analysis are discussed.

The data for GHG emissions, are acquired from EUROSTAT's Air Emissions Account Database. The data represents the sum of CO_2 emissions and the CO_2 equivalents of the N_2O and CH_4 emissions of each sector within the manufacturing industry. The data is in the form of thousand tons of CO_2 equivalents and is available from 2003 to 2016 for all the sectors without any missing data. EUROSTAT compiles this data annually from the national emission inventories, i.e. Convention on Long-Range Transboundary Air Pollution (CLRTAP) and UNFCCC, and from energy statistics and balances. $N_2O^{CO_2}$ and $CH_4^{CO_2}$ denote the CO_2 equivalents of N_2O and CH_4 respectively. The GHG data then is simply

$$GHG \equiv CO_2 + N_2O^{CO_2} + CH_4^{CO_2} \tag{1}$$

The variable GHG represents the amount of GHG emissions to the atmosphere made by each sector in the manufacturing industry.

Production value data (PV) are gathered from TURKSTAT's "Annual Industry and Service Statistics" database. It is based on the sold amount of units', stock changes' and the resold goods and services' monetary values. The entries in the original data are nominal TL. In order to cancel the price effects, the data is deflated using the Producer Price Index obtained from TURKSTAT. The adjusted data is in real form, based on 2003 TL. The data reflects the total value of the goods produced and sold by each sector, indicating the monetary value of production. It measures the economic activity in the respective sector.

This study, therefore, seeks to analyze whether the previous findings on the effects of industrial production are analogous to the Turkish case, i.e. whether the production value of the Turkish manufacturing sector is a determinant of the GHG emissions.

Average firm size (EMPENT) is calculated through using two distinct data from TURKSTAT's "Annual Industry and Service Statistics" database, namely those of the number of employees and the number of firms at sectoral level. The average firm size is basically obtained by dividing the number of employees to the number of firms, as in

$$EMPENT \equiv \frac{\text{number of employees}}{\text{number of enterprises}} \tag{2}$$

The data on the number of employees represents the number of contracted workers, i.e., the workers who receive some form of payment in exchange of their labor. The number of enterprises consists of all the active units in each sector during each period.

Table 2: Manufacturing Sectors According to NACE Rev. 2 Classification

Code of the Sector	Name of the Sector
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
C17	Manufacture of Paper and Paper Products
C18	Printing and Reproduction of Recorded Media
C19	Manufacture of Coke and Refined Petroleum Products
C20	Manufacture of Chemicals and Chemical Products
C21	Manufacture of Basic Pharmaceutical Products and Pharmaceutical Preparations
C22	Manufacture of Rubber and Plastic Products
C23	Manufacture of Other Non-Metallic Mineral Products
C24	Manufacture of Basic Metals
C25	Manufacture of Fabricated Metal Products except Machinery and Equipment
C26	Manufacture of Computer, Electronic and Optical Products
C27	Manufacture of Electrical Equipment
C28	Manufacture of Machinery and Equipment n.e.c.
C29	Manufacture of Motor Vehicles, Trailers and Semi-trailers
C30	Manufacture of Transport Equipment

Source: EUROPA List of NACE Codes

Capacity usage (CAPUSE) data are gathered from Central Bank of Turkey's Electronic Data Delivery System. It represents the actual capacity usage of enterprises operating in the manufacturing sector compared to their physical capacity. The data are in the form of percentage rates. The Central Bank of Turkey monthly collects and publishes this data. The equation characterizing CAPUSE is simply

$$\text{CAPUSE} \equiv \frac{\text{total capacity used}}{\text{total physical capacity}} \tag{3}$$

CAPUSE basically takes values between 0 and 1, with 1 representing that the sector is operating at full capacity. The variable basically represents how efficiently each sector undergoes the production process. Smaller values of the variable indicate that the sector lacks efficiency, while larger values indicate that the sector operates as efficiently as possible given the existing level of technology.

Table 3: Abbreviations and the Variables

Variables	**Description**	**Units or Measures**	**Model 1**	**Model 2**
GHG	Greenhouse gas emissions	Thousand tonne of CO_2 equivalent	✓	✓
PV	Production value	Real TL (based on 2003 TL)	✓	✗
ENVENT	Environmental Tax per enterprise	Real TL (based on 2003 TL)	✗	✓
PVEMP	Output per worker (Productivity)	Real TL (based on 2003 TL)	✓	✓
EMPENT	Average Firm Size	Employee per enterprise	✓	✗
OTT	Openness to Trade	(Total imports +exports) / PV	✓	✓
CAPUSE	Capacity Usage	% of the total psychical capacity	✗	✓
LAG1RDEXP	Research and Development Expenditure	Real TL (based on 2003 TL)	✗	✓
CAPITALPV	Capital Intensity	Capital per output	✗	✓
LOW	Sectors with low technology levels	Number of firms	✓	✓
MEDLOW	Sectors with medium-low technology level	Number of firms	✓	✓
MEDHIGH	Sectors with medium-high technology level	Number of firms	✓	✓
HIGH	Sectors with high technology levels	Number of firms	✓	✓

Defining the productivity level (PVEMP) is through utilizing two different data from TURKSAT, namely those of the total output per sector and the number of employees. The output data is of million TLs. Each data is annually collected by TURKSAT. The equation defining PVEMP can be simply written as

$$\text{PVEMP} \equiv \frac{\text{total output}}{\text{number of employees}} \tag{4}$$

The reason of the inclusion of output per worker is to capture the effects of productivity of each sector.

The environmental tax data (ENVENT) is gathered from EUROSTAT. The data is the sum of 4 taxes levied on the firms, divided by the number of enterprises in the economy. These taxes are the following: pollution taxes, energy taxes, transportation taxes, and resource taxes. ENVENT can be defined by the following equation:

$$\text{ENVENT} \equiv \frac{\text{PTAX} + \text{ETAX} + \text{TTAX} + \text{RTAX}}{number\ of\ enterprises} \qquad (5)$$

Where PTAX ETAX TTAX and RTAX represent the pollution, energy, transportation, and resource taxes respectively.

An important note on ENVENT here is the fact that Turkey does not implement a pollution tax to the polluting firms. As a result, the values of PTAX are equal to zero for each sector. So, ENVENT comprises of the remaining 3 tax values. It represents how the environmental tax imposed by the government affects each firm on average.

The openness to trade data (OTT) is calculated from the data on the total imports and the total exports from TURKSTAT's "Foreign Trade Statistics" report, alongside PV. The OTT is defined by the fraction of the sum of the total imports and the total exports divided by the production value of each sector, or is equivalently

$$\text{OTT} \equiv \frac{\text{total imports} + \text{total exports}}{\text{PV}} \qquad (6)$$

OTT is an indicator of the degree of globalization of each sector, i.e. how integrated to international trade they are. Higher values of OTT indicate that the sector is more open to international trade while lower values mean that the sector operates more domestically. This study, aims to analyze the effects of openness to international trade on the Turkish manufacturing industry's GHG emissions.

The R&D expenditure data is acquired from TURKSTAT's "Research and Development Statistics". Similar to PV, the data is originally in the form of nominal TL, but then deflated using Producer Price Index and in the analysis used in the form of real (based on 2003 values) TL. Since most R&D activities do not have immediate effects, the lagged values of the data are used in order to capture the delayed effects of R&D expenditures. The lagged R&D expenditure data LAG1RDEXP is

$$\mathrm{LAG1RDEXP} \equiv \mathrm{R\&D_t} - \mathrm{R\&D_{t-1}} \tag{7}$$

for a single period of lag. The lagged values of R&D expenditure (hereby referred to as R&D expenditure) captures the effects of the research expenditures of each sector.

Capital intensity (CAPITALPV) is calculated through several steps by using the "Gross Investment in Machinery and Equipment" data from TURKSTAT's "Annual Industry and Service Sectors Statistics" report. The data is calculated through applying the "Perpetual Inventory Method" to the data, following the guidelines from Kaplan, Ozturk, and Kalyoncu (2011), Karadağ, Deliktaş, and Önder (2004) and Yeni (2014)'s works. The capital data for each sector and each period is calculated through

$$\mathrm{K_0} = \mathrm{I_n}\,\frac{1 - (1 - \delta)^{\mathrm{n}}}{\delta} \tag{8}$$

Where $\mathrm{K_0}$ denotes the initial capital stock, $\mathrm{I_n}$ denotes the n-year average investment, and δ represents the depreciation rate of capital. The depreciation rate of capital, as it is the most commonly used rate among the literature, is taken as %10.

After calculating $\mathrm{K_0}$, the capital stock for the remaining periods are found through

$$\mathrm{K_t} = \mathrm{I_{t-1}} + (1 - \delta)\mathrm{K_{t-1}} \tag{9}$$

Finally, the CAPITALPV is calculated via dividing the capital stock to PV as in

$$\mathrm{CAPITALPV} \equiv \frac{\mathrm{K}}{\mathrm{PV}} \tag{10}$$

Based on the findings of the existing literature on the significance of the energy mix and intensity on the GHG emissions, and especially on the findings of Akbostancı et al. (2011); Kumbaroğlu (2011) and Tunç et al. (2009), this study includes energy intensity via a proxy, capital intensity.

The technology data is gathered from EUROSTAT's "High Tech Classification of the Manufacturing Sectors". There are four levels of technology defined in the data, which are low, medium-low, medium-high, and high technology levels. Each level is introduced to the model by utilizing dummy variables. Table 4 shows the technology levels of the sectors.

This study seeks to analyze whether these variables e.g. the technology levels of the firms, production value, productivity, average firm size, R&D expenditures, capital intensity, environmental tax, openness to trade, capacity usage affect the GHG emissions of the Turkish manufacturing industry. These factors, if their effects are significant, are of critical importance since they can have direct implications on government policies.

Lastly, in order to summarize the data Table 5 and 6 show the descriptive statistics of the analyses and the hypothesized signs of the variables.

1.4.1.2. Methodology

This subsection of the study defines the methodology. Then, the results of the analyses and the discussions of the findings are reviewed in the following subsections.

There are three main types of data that econometric analyses are based upon. The first one, cross-section data, is characterized by the data of a cross-section of variables for a single time period. Analyzing cross-section data is particularly useful when one seeks to analyze the variations among units, i.e., how each unit differ from one another. However, the analyses based on this type of data are limited when the analyzed effects are expected to vary in time. In addition, econometric analyses with cross-sectional data usually draw a heteroscedasticity problem, where the error terms vary among observations (Cameron & Trivedi, 2010).

In contrast with cross-sectional data, time series data which is the second type of data consists of data collected in different periods. However, the collected data is only limited to the observations on one unit only. Using time series data in econometric analyses is useful when can show the changes in observations for a certain time period but it cannot account for the variations among different units. Econometric analyses with time series data, unlike cross-sectional analyses, usually exhibits an autocorrelation problem in which the error terms of different time periods are correlated (Cameron & Trivedi, 2010).

Table 4: Technology Levels of the Sectors

Code of Sector	Sector Name	Technology Level	Number of Firms (2016)
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	Low	23,207
C17	Manufacture of Paper and Paper Products	Low	3,479
C18	Printing and Reproduction of Recorded Media	Low	11,620
C19	Manufacture of Coke and Refined Petroleum Products	Medium-Low	289
C20	Manufacture of Chemicals and Chemical Products	Medium-High	5,408
C21	Manufacture of Basic Pharmaceutical Products and Pharmaceutical Preparations	High	385
C22	Manufacture of Rubber and Plastic Products	Medium-Low	18,362
C23	Manufacture of Other Non-Metallic Mineral Products	Medium-Low	16,733
C24	Manufacture of Basic Metals	Medium-Low	5,466
C25	Manufacture of Fabricated Metal Products except Machinery and Equipment	Medium-Low	62,369
C26	Manufacture of Computer, Electronic and Optical Products	High	1,421
C27	Manufacture of Electrical Equipment	Medium-High	9,876
C28	Manufacture of Machinery and Equipment n.e.c.	Medium High	16,707
C29	Manufacture of Motor Vehicles, Trailers and Semi-trailers	Medium-High	4,726
C30	Manufacture of Transport Equipment	Medium-High	1,145

Source: EUROSTAT's High Tech Classification for NACE Rev. 2 Sectors

Table 5: Descriptive Statistics of 2003-2016 Analysis and the Hypothesized Signs of the Variables

Variables	Mean	Standard Deviation	Minimum	Maximum	Hypothesized Signs
GHG	5758.077	13540.59	219.4243	74919.96	
PV(billion TL)	15,100	10,200	1,460	57,000	(+)
PVEMP	498258.3	933068.2	79393.8	5274997	(-)
EMPENT	27.28603	33.07452	1.078071	185.5503	(-)
OTT	0.9576633	0.6773328	0.013082	3.392151	(+)
LOW	0.2	0.4009558	0	1	(-)
MEDLOW	0.333333	0.4725309	0	1	(+)
MEDHIGH	0.333333	0.4725309	0	1	(+)

Table 6: Descriptive Statistics of 2009-2016 Analysis and the Hypothesized Signs of the Variables

Variables	Mean	Standard Deviation	Minimum	Maximum	Hypothesized Signs
GHG	6374.089	15626.63	219.4243	74919.96	
ENVENT	77766.74	168821.5	878.5036	1187048	(-)
PVEMP	602722.6	1075683	111165.6	5274997	(-)
CAPUSE	75.78636	5.649553	55.50196	87.94445	(+)
OTT	0.9934506	0.7228571	0.0150891	3.392151	(+)
LAG1RDEXP(billion TL)	155	197	1.025946	1040	(-)
CAPITALPV	0.2807878	0.1317538	0.0259483	.7613618	(+)
LOW	0.2	0.4016772	0	1	(-)
MEDLOW	0.333333	0.4733811	0	1	(+)
MEDHIGH	0.333333	0.4733811	0	1	(+)

Panel data is the final type of data and is the combination of the two types of data mentioned above. It is characterized by the observations of different units across multiple time periods. However, as useful as it is for econometric analyses, panel data has its drawbacks since one can encounter the common problems of both the cross-sectional and the time-series analyses can suffer from, namely those of heteroscedasticity and autocorrelation problems. Panel data analysis is a widely used econometric method in social sciences. Panel data consists of both cross-sectional data with N number of cross-sectional units and times series data with T periods. Therefore, the data has a total of N×T number of observations.

This study forms two different analyses with both being based on two different panel datasets. The first dataset consists of a larger time frame (2003-2016) but there are fewer dependent variables, which are PV, EMPENT, OTT and technology levels. The second dataset includes fewer years (2009-2016) but there are more variables that can explain the emission levels which are ENVTAX, OTT, EMPENT, LAG1RDEXP, CAPUSE, CAPITALPV and technology levels of the sector.

Both of the two datasets have 15 sectors (N) operating within the manufacturing industry. For the first and second datasets, there are 14 and 8 years of observations respectively. Therefore, the first dataset has a total of 210 observations and the second dataset have a total of 120.

Gathering the data that we discussed in the previous section we can write our econometric models as follows:

$$\mathrm{GHG}_{it} = \beta_{0it} + \beta_{1it}\mathrm{PV} + \beta_{2it}\mathrm{PVEMP} + \beta_{3it}\mathrm{EMPENT} + \beta_{4it}\mathrm{OTT} + \alpha_{1i}\mathrm{LOW} + \alpha_{2i}\mathrm{MEDLOW} + \alpha_{3i}\mathrm{MEDHIGH} + e_{it} \quad (11)$$

Where i denotes the manufacturing sectors i = (16, 17, ……, 30) and t denotes the year t = (2003, 2004, …., 2016).

$$\mathrm{GHG}_{it} = \gamma_{0it} + \gamma_{1it}\mathrm{ENVENT} + \gamma_{2it}\mathrm{PVEMP} + \gamma_{3it}\mathrm{CAPUSE} + \gamma_{4it}\mathrm{OTT} + \gamma_{5it}\mathrm{CAPITALPV} + \theta_{1i}\mathrm{LOW} + \theta_{2i}\mathrm{MEDLOW} + \theta_{3i}\mathrm{MEDHIGH} + u_{it} \quad (12)$$

Where i denotes the sectors i = (16, 17, …, 30) and t denotes the time

t = (2009, 2010, …, 2016).

Since the analysis is based upon a panel data, it is highly likely that it has one of the characteristic problems that one can encounter when working with panel data econometrics.

Autocorrelation problem or also known as serial correlation problem happens when the error terms of an estimated model are dependent to their lagged values. This type of error is encountered especially in models investigating different time periods. When the error terms contain some meaningful information, this is expected to continue over time, resulting in a correlation between the error terms. The presence of a correlation between error terms generates unbiased and unreliable estimators.

The analyses are based on a panel data, for which it is very common to encounter with an autocorrelation problem. In order to check whether both of the estimated models have such an error, Wooldridge (2003)'s test is applied to each models. The null hypothesis being that there is no first-degree autocorrelation the test results are shown in Table 7.

Table 7: Autocorrelation Test Results

Models	P-value	Significance level
2003-2016 analysis	0.0000	0.95
2009-2016 analysis	0.0417	0.95

Rejecting the null hypothesis, the test results show that both of the models have an autocorrelation problem.

Heteroscedasticity problem occurs when the variances of the error terms of an estimated model differ across observations. The difference in the variance of error terms is mostly encountered when dealing with cross-section data where the dependent variable of each observation is likely to be affected by different factors. The presence of a heteroscedasticity problem adversely affects the efficiency of the estimated parameters.

The panel data analysis of this thesis is likely to encounter such a problem since the GHG emissions in each manufacturing sectors are presumably affected by different factors.

Heteroscedasticity occurs when the variance of the error is not constant (Wooldridge, 2009). Using Breusch-Pagan/Godfrey method we found that there is evidence that both of the models have heteroscedasticity. Table 8 shows the heteroscedasticity test's results for H_0 : $var(e_{it}) \neq k$.

A cross-sectional dependence may occur can arise “due to spatial or spillover effects, or could be due to unobserved (or unobservable) common factors (Baltagi & Hashem Pesaran, 2007, p. 229). This type of error is mostly encountered in panel data econometrics.

Table 8: Heteroscedasticity Test Results

Models	P-value	Significance level
2003-2016 analysis	0.0000	0.95
2009-2016 analysis	0.0000	0.95

In order to determine whether both models have a cross-sectional dependence problem or not, the cross sectional dependence test developed by Pesaran (2004), is used. Table 9 shows the results of the cross sectional dependence test.

Table 9: Cross- Sectional Dependence Test Results

Models	P-value	Significance level
2003-2016 analysis	0.0000	0.95
2009-2016 analysis	0.2500	0.95

The null hypothesis is that there is no cross sectional dependence. From the results table we can say that at 95% significance level the first model has cross sectional dependence while the second model does not.

For 2009-2016 data we used Feasible Generalized Least Squares method introduced by Parks (1967) and corrected the autocorrelation and heteroscedasticity problem that are present in our panel data. When corrected for autocorrelation and heteroscedasticity FGLS estimator (also known as Weighted Least Squares Estimator) yields better results than OLS estimator.

For the 2003-2016 model we couldn’t use FGLS because in order to correct the cross-sectional dependence problem the panel data need to be balanced. Since, our panel data is unbalanced we used Prais-Winsten regression model developed by Beck and Katz (1995) which corrects for cross sectional dependence when the data is unbalanced.

1.4.2. Results

1.4.2.1. Estimation Results of Model 1 and Model 2

This subsection presents the results of the estimated model 1 introduced in the previous section. The results presented here are those of the corrected models. Tables 10 and 11 present the results for the models from year 2003 to 2016 and from year 2009 to 2016 respectively.

Table 10: Estimation Results for the Period of 2003-2016

Explanatory Variables	Coefficient	Z	P>|Z|
PV	0.000000185*** (0.000000037)	5.50	0.000
PVEMP	-0.0007048** (0.0002666)	-2.64	0.008
EMPENT	-16.22822** (6.226257)	-2.61	0.009
OTT	-24.3399 (397.283)	-0.06	0.951
LOW	-925.5157 (1074.998)	-0.86	0.389
MEDLOW	7395.763*** (1414.591)	5.23	0.000
MEDHIGH	-806.8416 (831.3967)	-0.97	0.332
CONS.	726.0976 (1322.148)	0.55	0.583

Notes*: This table demonstrates the estimation results for estimating the model where GHG is the dependent variable, while PV, PVEMP, EMPENT, OTT, LOW, MEDLOW, and MEDHIGH are explanatory variables. The high technology's (HIGH) effects are embedded in the constant, CONS. The method used for estimation is FGLS. The estimation period ranges from 2003 to 2016, and the observations are yearly. The total number of observations is 208. P>|Z| represents the significance level where the null hypotheses for each variable are rejected. ***, **, and * represent significance levels of 0.001, 0.01, and 0.05, respectively.*

1.4.2.2. Discussions of the Findings

The results of Model 1 shows that the production value is a significant factor that affects the GHG emissions of the Turkish manufacturing industry. According to the estimation, 1 million TL worth of production causes 0.185 tons of CO_2-equivalent emissions. Considering the total atmospheric concentration of GHGs, such an amount is non-negligible.

The vast majority of the economics literature have already recognized the impact of increasing industrial production on the GHG emissions. This thesis' results, furthermore, shows that the production value is the prime determinant of the Turkish manufacturing industry's GHG emissions from 2003 to 2016. This finding is analogous to those of Tunç et al. (2009) and Akbostancı, Tunç, and Türüt-Aşık (2018)'s, as they argue that the economic activity is the primary force that increases GHG emissions. The impact of production value being this profound have important policy implications which will be discussed later in this section.

The effects of productivity are significant and negative for both Model 1 and Model 2. Model 1's results show that one-unit increase in the average firm size reduces the GHG emissions by 0.7 tons, while Model 2's results show that one-unit increase in the average firm size reduces emissions by 0.8 tons. The results indicate that increase in productivity, in terms of less employees producing more valuable goods, reduces the total GHG emissions.

This result supports the discussions on the GHG emissions reducing effects of technological advancements. Alongside the previous result on the effects of the production value, this result indicates that producing more valuable goods and the production technology have opposing effects. Such finding may support the arguments of Fisher-Vanden and Wing (2008) on the two opposing effects that better technology causes: an increase in GHG via increase in industrial production, represented by the production value in this case, and a decrease in GHG emissions via a shift to cleaner technologies, which relates to the effects of productivity. Productivity's significant effect is another important factor that can be helpful in forming environmental policies. The implications of productivity will be discussed later.

The average firm size's effects are negative and significant as well. Model 1's results show that one-unit increase in the average firm size reduces 16,228 tons of GHG emissions. Therefore, larger firms in the manufacturing industry significantly reduce the emission levels.

Table 11: Estimation Results for the Period of 2009-2016

Explanatory Variables	Coefficient	Z	P>|Z|
ENVENT	-0.0025995** (0.0008686)	-2.99	0.003
PVEMP	-0.000842*** (0.0002164)	-3.89	0.000
CAPUSE	39.67752** (15.3539)	2.58	0.010
OTT	-315.2013 (279.7917)	-1.13	0.260
CAPITALPV	2472.952* (1160.823)	2.13	0.033
LOW	-1034.372 (851.4386)	-1.21	0.224
MEDLOW	9183.494*** (1210.358)	7.59	0.000
MEDHIGH	-65.00796 (565.6839)	-0.11	0.909
CONS.	-2096.643 1260.181	-1.6	0.096

***Notes**: This table demonstrates the estimation results for estimating the model where GHG is the dependent variable, while ENVENT, PVEMP, CAPUSE, OTT, CAPITALPV, LOW, MEDLOW, and MEDHIGH are explanatory variables. The high technology's (HIGH) effects are embedded in the constant, CONS. The method used for estimation is FGLS. The estimation period ranges from 2009 to 2016, and the observations are yearly. The total number of observations is 115. ***, **, and * represent significance levels of 0.001, 0.01, and 0.05, respectively.*

Not surprisingly, environmental taxes decrease the amount of GHG emitted to the atmosphere with the Model 2's results indicating that 1 TL increase in the environmental tax per enterprise results in a reduction of 2.6 tons of emissions. This result is completely analogous to the literature on public finance and environmental economics, and proposes further proof the effectiveness to a role that environmental taxes can play on climate mitigation.

In both models, openness to trade’s effect on the GHG emissions is found to be insignificant. This is in line with the mixed result found among the literature.

The rate of capacity usage is found to be significantly increasing the GHG emissions for the 2009-2016 period. The results show that 1 percentage share increase in the capacity usage increases GHG emissions by 39,678 tons. In other words, the GHG emissions increase with higher capacity usage of manufacturing sectors.

Though the results indicate that a reduction in capacity usage can reduce GHG emissions, this contradicts with economic rationale. However, this result may indicate that higher levels of capacity require exponentially higher amounts of energy to operate, i.e. the energy required to use production facilities may increase with the higher levels of capacity to be used. A more efficient energy structure for each firm can result in suppressing the adverse effects of increased levels of capacity usage.

Since there is no data on the R&D of sectors 19 and 20 (the manufacture of coke and petroleum products, and the manufacture of chemicals and chemical products, respectively), and taking its lagged value results in the loss of data for one year (hence, to further restrict the number of observations), a distinct model for 2009-2016 with the inclusion of the lagged R&D expenditures is estimated in order to capture the potential link between R&D and GHG emissions. Table 12 summarizes the findings of the model we conducted to estimate R&D expenditure. The results show that 1 TL increase in manufacturing firms’ R&D reduces 0.05 tons of GHG emissions.

The results show that the effects of the R&D expenditures of the manufacturing industry on the GHG emissions are significant and negative. One possible explanation of this result is the fact that R&D expenditures enable firms to employ more efficient technologies. These technologies, in turn, reduce the input (and energy) used per output and produce less emissions for a given level of output compared to less efficient technologies. However, more productive technologies naturally result in an output growth. The net effect in the emission levels in this case depends on the magnitudes of each counteracting forces. When the emission-reducing effects of more efficient technologies are not strong enough to offset the increase in emissions resulting from the output growth, as in Arto and Dietzenbacher (2014), the net effect can be an increase in the total emission level, and *vice versa*.

Table 12: Estimation Results of the Variable LAG1RDEXP in 2009-2016 Analysis

Explanatory Variable	Coefficient	z	P>|z|
LAG1RDEXP	**-0.00000458*** (0.0000012)**	**-3.82**	**0.00000693**
ENVENT	-0.011749 (0.0054798)	-2.14	0.032
PVEMP	0.016399 (0.0013079)	12.54	0.000
CAPUSE	43.34835 (40.33923)	1.07	0.283
OTT	-561.0082 (542.7296)	-1.03	0.301
CAPITALPV	14091.87 (2633.637)	5.35	0.000
LOW	-4141.914 (1507.74)	-2.75	0.006
MEDLOW	1748.695 (1268.65)	1.38	0.168
MEDHIGH	-873.5855 (949.2143)	-0.92	0.357
CONS	-7667.475 (2945.975)	-2.60	0.009

*Note: ***, **, and * represent significance levels of 0.001, 0.01, and 0.05, respectively.*

The analysis for the period 2009-2016 shows that capital intensity significantly increases the GHG emissions. According to the results of Model 2, an increase of one unit of capital intensity increases the GHG emissions by 2,472,952 tons. That an enterprise operates is more capital intensive means that the total energy usage of the enterprise is accordingly high as well. In other words, there will be more machines, which require substantial energy to operate, compared to raw labor, therefore more energy is used during the production process. Therefore, a positive relationship between capital intensity and GHG emissions indicate a positive effect of energy usage on the total emissions as well.

This result is in accordance with that of Akbostancı et al. (2011); Kumbaroğlu (2011); and Tunç et al. (2009)'s on the importance of energy usage and Turkish manufacturing industry's

GHG emission levels. The strong tie between energy and GHG emissions directly indicate the need of transition to more energy-efficient technologies.

The effects of technology levels are analyzed using dummy variables in both models. The results of the estimations for both 2003-2016 and 2009-2016 estimations indicate that the low, medium-high, and high technology levels' effects are insignificant. On the other hand, medium-low technology is found to significantly promote GHG emissions, with operating at medium-low technology increasing GHG emissions by 7,395,763 tons according to Model 1's results, and by 9183.494 tons according to Model 2's results.

The sectors with medium-low technology are: the manufacture of (i) coke and refined petroleum products, (ii) rubber and plastic products, (iii) other non-metallic products, and (iv) basic metals. A common characteristic of these sectors is that their input mixes are mostly composed of inputs that relatively emit more GHG's, namely those of fossil fuels and coal. This dirty material use is the main determinant of the emission level. That the technology level of a sector being medium-low enhancing the total GHG emissions is, then, is a natural income of its input mix. Promoting different input mixes via introduction of new production technologies to these sectors can result in a reduction of GHG emissions.

1.4.2.3. Policy Implications

The findings of the estimations indicate that; the factors that increase the GHG emissions in the Turkish manufacturing sector are

- production value (the total value of the goods produced),
- capacity usage (the level that firms operate divided by their total physical capacity),
- capital intensity (the ratio of capital to production value, which is considered to be a proxy for energy usage), and
- a medium-low technology level

while the factors that reduce the GHG emissions are

- productivity (or average firm size),
- environmental taxes (per firm), and
- R&D expenditures (on-year-lagged).

These results have two major policy implications. First, the significant effect of environmental taxes on reducing emissions indicate that green taxes can be an efficient mean in reducing the emission levels. Furthermore, basing these taxes on the production value and the usage of relatively hazardous inputs (e.g. fossil fuel and coal) can significantly offset the GHG enhancing effects of production value and the medium-low technology. Aside from the fact that these taxes can result GHG emission levels, they can generate double dividends, as argued by the literature.[18]

A second policy implication can be based on the GHG emission reducing effects of productivity and R&D expenditures. Government policies subsidizing R&D expenditures aiming to integrate more efficient technologies to each sector and increase the efficiency of the existing technologies (mostly through reducing the energy usage rates) can be another policy to achieve a more eco-friendly manufacturing sector. Moreover, financing these subsidies via the environmental taxes imposed within the manufacturing sector can promote the usage of cleaner technologies alongside providing incentives for technological developments without any additional burden on the government budget. Furthermore, simultaneously promoting more efficient technologies with green taxes can mitigate possible increases in output levels due to more efficient technology. This can prevent overproduction since green taxes can keep the manufacturing sector's production level situated close to the socially optimum level (i.e., the optimum level of production considering the social costs of production, instead of the private costs of firms).

[18] See Bovenberg (1999) and Goulder (1995) for further discussions.

The main results of this study are in line with the findings of Yeldan and Voyvoda (2015). They argue that taxing carbon emissions and investing the revenues on renewable energy production is an effective environmental policy for Turkey. In other words, they point out a double dividend for taxing carbon emissions. According to their estimation, Turkey can achieve GHG emissions 23% less than the BaU projection provided with Turkey's INDC by implying such policy.[19]

1.4.2.4. Limitations

This subsection briefly discusses the limitations of the analysis.

The biggest limitation that constrains the analysis is the limited availability of data on the amount of energy used and the sources of energy that Turkish manufacturing industry uses. Numerous studies have shown that sources related to energy consumption and the types of energies consumed are the most vital factor to a country's GHG emissions. However, the data for energy sources and energy usage for NACE Rev 2 sectoral classification is only available for the period after 2014. Such a time frame (2014 to 2016) is a limited time to draw reliable conclusions through an econometric analysis with a relatively small number of cross-sectional units. Therefore, energy sources and energy usage is excluded from the present analysis.

A second important limitation is related to the number of observations of the data that this analysis is based on. The reliability of an analysis like the one conducted in this study increases substantially with a higher number of observations. Even though we can obtain GHG emissions data from EUROSTAT for the period of 1995-2016, the earliest observation in TURKSTAT's Annual Industry and Service Statistics database in NACE Rev. 2 sectoral classification is from 2003. Therefore, the estimation period is limited with the length of TURKSTAT's data. The number of observations are sufficiently high to conduct an analysis but, more observations for a longer period of time could have presented more reliable results.

[19] See Yeldan and Voyvoda (2015, p. 37) for the baseline scenarios.

Another limitation related to the number of observations is caused by some missing data. The data on the R&D expenditures for C19 and C20 sectors are missing, resulting in a loss of 2 sectors for 1 year. Additionally, the utilization of the lagged values of R&D expenditures, although being particularly useful for the analysis as they capture the effects of R&D expenditures better than those of the same period, results in a loss of one year of data. These problems result in the further limiting to the already small number of data, and to some extent reduces the reliability of the results.

Some sectors in the manufacturing industry are left out of the analysis due to the unavailability of the data. The excluded sectors are C10 – Manufacture of Food Products, C11 – Manufacture of Beverages, C12- Manufacture of Tobacco Products, C13 – Manufacture of Textile Products, C14- Manufacture of Wearing Apparel, C15 - Manufacture of leather and related products, C31 - Manufacture of furniture, C32- Other manufacturing and C33 - Repair and installation of machinery and equipment.

A final limitation is the strong correlation between some explanatory variables, especially the one between the environmental tax and the production value. The presence of such relation adversely affects the reliability of the results of a model where both variables are present as explanatory variables, and forces this thesis' analysis to leave one behind despite there is available data for both variables.

CONCLUSION

In accordance with the World Bank's sustainable development goals, achieving environmental stability through mitigating climate change requires identifying the major causes that adversely affect the atmosphere. There is widespread consensus in the literature that the sharp increase in anthropogenic GHG emissions after the Industrial Revolution has been the primary source of climate change for the last 250 years. Moreover, the adverse effects of GHG emissions, especially those of CO_2 emissions, have been accelerating for the last few decades. The increases in the global averages in both surface and ocean temperatures are pointing out immediate action to be taken in order to prevent the environment from passing a point of no return.

Analogous to the World Bank's concerns, Turkey is determined to tackle global which can be seen through its national goals and strategies and commitments. The Turkish government, alongside the sustainable development goals of the World Bank, have determined some sustainable development goals of itself which include environmental stability in both land and water. The goals include integrating measures on climate change to national policies and strategies, and predict an increased weight of environmental policies in national planning. In addition, even if Turkey does not have any commitments to fulfill, the ratification of the Kyoto Protocol further demonstrates Turkey's devotion to achieve environmental sustainability.

One major source that is argued to have a substantial part on the GHG emissions is the industrial sector, with the significant contribution of the manufacturing activities. For the case of the Turkish Economy, OECD (2019)'s Environmental Performance Reviews displays the profound effects of the manufacturing industry on Turkey's total GHG emissions. Since Turkey, among all the OECD countries, have the highest increase in GHG emissions over the last decades, the country's specific characteristics that cause the emissions need to be identified.

The manufacturing industry plays a particularly important part on the emission of three specific GHG's; namely those of CO_2, N_2O, and CH_4. These gasses are found to be at their historical highest levels today, with their concentration in the atmosphere increasing in each day. An effective way to mitigate the climate change then is through controlling the sources in manufacturing industry which cause the emissions of these gasses. This can be done through identifying the channels from which the manufacturing industry emits GHG's. Hence, determining the factors that cause the GHG emissions in the manufacturing industry, and form policies based on these findings that seek to reduce emissions and take the economy back to sustainable levels of emissions.

This thesis sought to investigate the determinants of GHG emissions for the Turkish Manufacturing Industry. Two panel datasets for 2003-2016 and 2009-2016 are constructed for the estimation process. The main findings suggest that; production value (the total value of the goods produced), capacity usage (the level that firms operate divided by their total physical capacity), capital intensity (the ratio of capital to production value, which is considered to be a proxy for energy usage) significantly increase the GHG emissions. On the other hand; productivity (or average firm size), environmental taxes (per firm) and R&D expenditures (on-year-lagged) significantly reduce emission levels. The effects of technology levels (low, medium-low, medium-high, and high) are insignificant, except for the positive effect of medium-low technologies for which firms mostly use inputs that cause harmful emissions.

The main findings of the thesis have several policy implications. First of all, the significant impact of environmental taxes on reducing emissions, alongside the positive effect of production values, indicate that environmental taxes are effective means to mitigate climate change. Moreover, the effectiveness of environmental taxes points out a possible double dividend in green taxes, as in Yeldan and Voyvoda (2015).

Another policy implication can be made on the effects of new technologies. That the level of GHG emissions decrease in R&D expenditures and productivity creates a rationale to subsidize R&D investments and investments for more efficient technologies in order to promote an eco-friendly manufacturing sector. Moreover, these subsidies can be financed through taxing industries with technologies that stimulate GHG emissions through the predominant usage of dirty inputs, such as coal and fossil-fuels. Integrating environmental taxes and subsidies can jointly reduce the emission levels of the Turkish manufacturing industry, and according to our findings, their effect can significantly contribute Turkey on its way to achieve its goals for sustainable development.

This research, though, has certain limitations which mostly stem from the unavailable data. A more comprehensive analysis could have been made if NACE Rev. 2 data on energy sources and usage of the manufacturing sector become available. In addition, the time interval of the data used for the analysis (which is again due to unavailable data) prevents its results from being conclusive. This study provides valuable information on the determinants of GHG emissions for the Turkish manufacturing industry which is the first step for more detailed future analysis of the issue.

BIBLIOGRAPHY

Akbostancı, E., Tunç, G. İ., & Türüt-Aşık, S. (2011). CO2 emissions of Turkish manufacturing industry: A decomposition analysis. *Applied Energy, 88*(6), 2273-2278. doi:10.1016/j.apenergy.2010.12.076

Akbostancı, E., Tunç, G. İ., & Türüt-Aşık, S. (2018). Drivers of fuel based carbon dioxide emissions: The case of Turkey. *Renewable and Sustainable Energy Reviews, 81*, 2599-2608. doi:10.1016/j.rser.2017.06.066

Albornoz, F., Cole, M. A., Elliott, R. J., & Ercolani, M. G. (2009). In search of environmental spillovers. *World Economy, 32*(1), 136-163. doi:10.1111/j.1467-9701.2009.01160.x

Aldy, J. E., Krupnick, A. J., Newell, R. G., Parry, I. W., & Pizer, W. A. (2010). Designing climate mitigation policy. *Journal of Economic Literature, 48*(4), 903-934. doi:10.1257/jel.48.4.903

Andonova, L. B. (2003). Openness and the environment in Central and Eastern Europe: Can trade and foreign investment stimulate better environmental management in enterprises? *The Journal of Environment & Development, 12*(2), 177-204. doi:10.1177/1070496503012002003

Andreoni, V., & Galmarini, S. (2012). Decoupling economic growth from carbon dioxide emissions: A decomposition analysis of Italian energy consumption. *Energy, 44*(1), 682-691. doi:10.1016/j.energy.2012.05.024

Arto, I., & Dietzenbacher, E. (2014). Drivers of the growth in global greenhouse gas emissions. *Environmental science & technology, 48*(10), 5388-5394. doi:10.1021/es5005347

Aslanidis, N., & Iranzo, S. (2009). Environment and development: is there a Kuznets curve for CO2 emissions? *Applied Economics, 41*(6), 803-810. doi:10.1080/00036840601018994

Atkinson, A. B., & Stern, N. H. (1974). Pigou, taxation and public goods. *The Review of Economic Studies, 41*(1), 119-128. doi:10.2307/2296403

Azomahou, T., Laisney, F., & Van, P. N. (2006). Economic development and CO2 emissions: a nonparametric panel approach. *Journal of Public Economics, 90*(6-7), 1347-1363. doi:10.1016/j.jpubeco.2005.09.005

Baltagi, B. H., & Hashem Pesaran, M. (2007). Heterogeneity and cross section dependence in panel data models: theory and applications introduction. *Journal of Applied Econometrics, 22*(2), 229-232. doi:10.1002/jae.955

Barbier, E. B. (1987). The concept of sustainable economic development. *Environmental conservation, 14*(2), 101-110. doi:10.1017/S0376892900011449

Beck, N., & Katz, J. N. (1995). What to do (and not to do) with time-series cross-section data. *American political science review, 89*(3), 634-647. doi:10.2307/2082979

Bengochea Morancho, A., Martinez-Zarzoso, I., & Morales-Lage, R. (2006). *The Impact of Population on Co2 Emissions: Evidence from European Countries*. Retrieved from https://ssrn.com/abstract=902703

Bindi, M., & Olesen, J. E. (2011). The responses of agriculture in Europe to climate change. *Regional Environmental Change, 11*(1), 151-158. doi:10.1007/s10113-010-0173-x

Blanford, G. J. (2009). R&D investment strategy for climate change. *Energy Economics, 31*, S27-S36. doi:10.1016/j.eneco.2008.03.010

Bolt, J., Inklaar, R., de Jong, H., & van Zanden, J. L. (2018). *Rebasing 'Maddison': new income comparisons and the shape of long-run economic development*. Retrieved from

Bosetti, V., Carraro, C., Massetti, E., Sgobbi, A., & Tavoni, M. (2009). Optimal energy investment and R&D strategies to stabilize atmospheric greenhouse gas concentrations. *Resource and Energy Economics, 31*(2), 123-137. doi:10.1016/j.reseneeco.2009.01.001

Bosetti, V., Carraro, C., Massetti, E., & Tavoni, M. (2008). International energy R&D spillovers and the economics of greenhouse gas atmospheric stabilization. *Energy Economics, 30*(6), 2912-2929. doi:10.1016/j.eneco.2008.04.008

Bovenberg, A. L. (1999). Green Tax Reforms and the Double Dividend: an Updated Reader's Guide. *International Tax and Public Finance, 6*(3), 421-443. doi:10.1023/a:1008715920337

Bovenberg, A. L., & Goulder, L. H. (2002). Environmental taxation and regulation. In *Handbook of public economics* (Vol. 3, pp. 1471-1545): Elsevier.

Brizga, J., Feng, K., & Hubacek, K. (2014). Drivers of greenhouse gas emissions in the Baltic States: A structural decomposition analysis. *Ecological Economics, 98*, 22-28. doi:10.1016/j.ecolecon.2013.12.001

Brock, W. A., & Taylor, M. S. (2010). The Green Solow Model. *Journal of Economic Growth, 15*(2), 127-153. doi:10.1007/s10887-010-9051-0

Bu, M., Lin, C. T., & Zhang, B. (2016). Globalization and climate change: new empirical panel data evidence. *Journal of Economic Surveys, 30*(3), 577-595. doi:10.1111/joes.12162

Bulte, E., List, J. A., & Strazicich, M. C. (2007). Regulatory federalism and the distribution of air pollutant emissions. *Journal of Regional Science, 47*(1), 155-178. doi:10.1111/j.1467-9787.2007.00504.x

Calzadilla, A., Rehdanz, K., Betts, R., Falloon, P., Wiltshire, A., & Tol, R. S. (2013). Climate change impacts on global agriculture. *Climatic change, 120*(1-2), 357-374. doi:10.1007/s10584-013-0822-4

Cameron, A. C., & Trivedi, P. K. (2010). *Microeconometrics using stata* (Vol. 2): Stata press College Station, TX.

Carson, R. T. (2009). The environmental Kuznets curve: seeking empirical regularity and theoretical structure. *Review of Environmental Economics and Policy, 4*(1), 3-23. doi:10.1093/reep/rep021

Casler, S. D., & Rose, A. (1998). Carbon dioxide emissions in the US economy: a structural decomposition analysis. *Environmental and Resource Economics, 11*(3-4), 349-363. doi:10.1023/A:1008224101980

Cavlovic, T. A., Baker, K. H., Berrens, R. P., & Gawande, K. (2000). A meta-analysis of environmental Kuznets curve studies. *Agricultural and Resource Economics Review, 29*(1), 32-42. doi:10.1017/S1068280500001416

Chichilnisky, G., & Heal, G. (1995). *Markets with tradable CO2 emission quotas: principles and practice*. Retrieved from https://mpra.ub.uni-muenchen.de/id/eprint/8486

Christmann, P., & Taylor, G. (2001). Globalization and the environment: Determinants of firm self-regulation in China. *Journal of International Business Studies, 32*(3), 439-458. doi:10.1057/palgrave.jibs.8490976

Clark, P. U., Shakun, J. D., Marcott, S. A., Mix, A. C., Eby, M., Kulp, S., . . . Plattner, G.-K. (2016). Consequences of twenty-first-century policy for multi-millennial climate and sea-level change. *Nature Climate Change, 6*, 360. doi:10.1038/nclimate2923

Cole, M. A. (2003). Development, trade, and the environment: how robust is the Environmental Kuznets Curve? *Environment and development economics, 8*(4), 557-580. doi:10.1017/S1355770X0300305

Cole, M. A. (2004). Trade, the pollution haven hypothesis and the environmental Kuznets curve: examining the linkages. *Ecological economics, 48*(1), 71-81. doi:10.1016/j.ecolecon.2003.09.007

Cole, M. A. (2006). Does trade liberalization increase national energy use? *Economics letters, 92*(1), 108-112. doi:10.1016/j.econlet.2006.01.018

Cole, M. A., Elliott, R. J., & Okubo, T. (2014). International environmental outsourcing. *Review of World Economics, 150*(4), 639-664. doi:10.1007/s10290-014-0193-6

Copeland, B. R., & Taylor, M. S. (2004). Trade, growth, and the environment. *Journal of Economic Literature, 42*(1), 7-71. doi:10.1257/002205104773558047

Cramer, J. C. (1996). A demographic perspective on air quality: conceptual issues surrounding environmental impacts of population growth. *Human Ecology Review, 3*(2), 191-196. Retrieved from https://www.jstor.org/stable/24707216.

Cramer, J. C. (1998). Population growth and air quality in California. *Demography, 35*(1), 45-56. doi:10.2307/3004026

Das, A., & Paul, S. K. (2014). CO2 emissions from household consumption in India between 1993–94 and 2006–07: a decomposition analysis. *Energy Economics, 41*, 90-105. doi:10.1016/j.eneco.2013.10.019

De Freitas, L. C., & Kaneko, S. (2011). Decomposition of CO2 emissions change from energy consumption in Brazil: challenges and policy implications. *Energy Policy, 39*(3), 1495-1504. doi:10.1016/j.enpol.2010.12.023

Diakoulaki, D., & Mandaraka, M. (2007). Decomposition analysis for assessing the progress in decoupling industrial growth from CO2 emissions in the EU manufacturing sector. *Energy Economics, 29*(4), 636-664. doi:10.1016/j.eneco.2007.01.005

Diakoulaki, D., Mavrotas, G., Orkopoulos, D., & Papayannakis, L. (2006). A bottom-up decomposition analysis of energy-related CO2 emissions in Greece. *Energy, 31*(14), 2638-2651. doi:10.1016/j.energy.2005.11.024

Diamond, P. A., & Mirrlees, J. A. (1971). Optimal taxation and public production I: Production efficiency. *The American Economic Review, 61*(1), 8-27. Retrieved from https://www.jstor.org/stable/1910538.

Dietz, T., Gardner, G. T., Gilligan, J., Stern, P. C., & Vandenbergh, M. P. (2009). Household actions can provide a behavioral wedge to rapidly reduce US carbon emissions. *Proceedings of the National Academy of Sciences, 106*(44), 18452-18456. doi:10.1073/pnas.0908738106

Dietz, T., & Rosa, E. A. (1994). Rethinking the environmental impacts of population, affluence and technology. *Human Ecology Review, 1*(2), 277-300. Retrieved from http://www.jstor.org/stable/24706840.

Dietz, T., Rosa, E. A., & York, R. (2007). Driving the Human Ecological Footprint. *Frontiers in Ecology and the Environment, 5*(1), 13-18. doi:10.1890/1540-9295(2007)5[13:DTHEF]2.0.CO;2

Erdogan, A. M. (2014). Foreign Direct Investment and Environmental Regulations: A Survey. *Journal of Economic Surveys, 28*(5), 943-955. doi:10.1111/joes.12047

Fernández, Y. F., López, M. F., & Blanco, B. O. (2018). Innovation for Sustainability: The Impact of R&D Spending on CO2 Emissions. *Journal of cleaner production, 172*, 3459-3467. doi:10.1016/j.jclepro.2017.11.001

Fisher-Vanden, K., & Wing, I. S. (2008). Accounting for quality: Issues with modeling the impact of R&D on economic growth and carbon emissions in developing economies. *Energy Economics, 30*(6), 2771-2784. doi:10.1016/j.eneco.2007.04.002

Fullerton, D., & Metcalf, G. E. (1997). *Environmental taxes and the double-dividend hypothesis: did you really expect something for nothing?* Retrieved from https://www.nber.org/papers/w6199

Garrone, P., & Grilli, L. (2010). Is there a relationship between public expenditures in energy R&D and carbon emissions per GDP? An empirical investigation. *Energy Policy, 38*(10), 5600-5613. doi:10.1016/j.enpol.2010.04.057

Glaeser, E. L., & Kahn, M. E. (2010). The greenness of cities: carbon dioxide emissions and urban development. *Journal of Urban Economics, 67*(3), 404-418. doi:10.1016/j.jue.2009.11.006

González, P. F., Landajo, M., & Presno, M. J. (2014). Tracking European Union CO2 emissions through LMDI (logarithmic-mean Divisia index) decomposition. The activity revaluation approach. *Energy, 73*, 741-750. doi:10.1016/j.energy.2014.06.078

Goulder, L. H. (1994). Energy taxes: traditional efficiency effects and environmental implications. *Tax policy and the economy, 8*, 105-158. doi:10.1086/tpe.8.20061820

Goulder, L. H. (1995). Environmental taxation and the double dividend: A reader's guide. *International Tax and Public Finance, 2*(2), 157-183. doi:10.1007/bf00877495

Grossman, G. M., & Krueger, A. B. (1995). Economic growth and the environment. *The Quarterly Journal of Economics, 110*(2), 353-377. doi:10.2307/2118443

Guan, D., Hubacek, K., Weber, C. L., Peters, G. P., & Reiner, D. M. (2008). The drivers of Chinese CO2 emissions from 1980 to 2030. *Global Environmental Change, 18*(4), 626-634. doi:10.1016/j.gloenvcha.2008.08.001

Hamilton, C., & Turton, H. (2002). Determinants of emissions growth in OECD countries. *Energy Policy, 30*(1), 63-71. doi:10.1016/S0301-4215(01)00060-X

Hanson, C., & Sandalow, D. B. (2006). *Greening the tax code*. Washington, DC: Brookings Institution.

Hatzigeorgiou, E., Polatidis, H., & Haralambopoulos, D. (2008). CO2 emissions in Greece for 1990–2002: a decomposition analysis and comparison of results using the

Arithmetic Mean Divisia Index and Logarithmic Mean Divisia Index techniques. *Energy, 33*(3), 492-499. doi:10.1016/j.energy.2007.09.014

Hoegh-Guldberg, O., & Bruno, J. F. (2010). The impact of climate change on the world's marine ecosystems. *Science, 328*(5985), 1523-1528. doi:10.1126/science.1189930

IPCC. (2007). *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Cambridge: Cambridge University Press.

IPCC. (2014). *Climate Change 2014: Mitigation of Climate Change*. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

Ishikawa, J., & Kiyono, K. (2006). Greenhouse-Gas Emission Controls in an Open Economy. *International Economic Review, 47*(2), 431-450. doi:10.1111/j.1468-2354.2006.00384.x

IUNC, UNEP, & WWF. (1991). *Caring for The World. A Strategy for Sustainable Living* Gland, Switzerland

Jalil, A., & Mahmud, S. F. (2009). Environment Kuznets curve for CO2 emissions: a cointegration analysis for China. *Energy Policy, 37*(12), 5167-5172. doi:10.1016/j.enpol.2009.07.044

Jorgenson, A. K. (2007a). Does foreign investment harm the air we breathe and the water we drink? A cross-national study of carbon dioxide emissions and organic water pollution in less-developed countries, 1975 to 2000. *Organization & Environment, 20*(2), 137-156. doi:10.1177/1086026607302153

Jorgenson, A. K. (2007b). The effects of primary sector foreign investment on carbon dioxide emissions from agriculture production in less-developed countries, 1980-99. *International Journal of Comparative Sociology, 48*(1), 29-42. doi:10.1177/0020715207072158

Jorgenson, A. K. (2009). The transnational organization of production, the scale of degradation, and ecoefficiency: A study of carbon dioxide emissions in less-developed countries. *Human Ecology Review, 16*(1), 64-74. Retrieved from https://www.jstor.org/stable/24707737.

Jorgenson, A. K., & Clark, B. (2010). Assessing the temporal stability of the population/environment relationship in comparative perspective: a cross-national panel study of carbon dioxide emissions, 1960–2005. *Population and Environment, 32*(1), 27-41. doi:10.1007/s11111-010-0117-x

Jorgenson, A. K., Clark, B., & Kentor, J. (2010). Militarization and the environment: a panel study of carbon dioxide emissions and the ecological footprints of nations, 1970–2000. *Global Environmental Politics, 10*(1), 7-29. doi:10.1162/glep.2010.10.1.7

Jorgenson, A. K., Dick, C., & Shandra, J. M. (2011). World economy, world society, and environmental harms in less-developed countries. *Sociological Inquiry, 81*(1), 53-87. doi:10.1111/j.1475-682X.2010.00354.x

Kaplan, M., Ozturk, I., & Kalyoncu, H. (2011). Energy consumption and economic growth in Turkey: cointegration and causality analysis. *Romanian Journal of Economic Forecasting, 2*(31), 31-41. Retrieved from http://roinocomp.ipe.ro/rjef/rjef2_11/rjef2_2011p31-41.pdf.

Karadağ, M., Deliktaş, E., & Önder, A. Ö. (2004). The effects of public capital on private sector performance in Turkish regional manufacturing industries. *European Planning Studies, 12*(8), 1145-1156. doi:10.1080/0965431042000289269

Kellenberg, D. (2009). An empirical investigation of the pollution haven effect with strategic environment and trade policy. *Journal of International Economics, 78*(2), 242-255. doi:10.1016/j.jinteco.2009.04.004

Knight, K. W., & Rosa, E. A. (2012). Household dynamics and fuelwood consumption in developing countries: a cross-national analysis. *Population and Environment, 33*(4), 365-378. doi:10.1007/s11111-011-0151-3

Kumbaroğlu, G. (2011). A sectoral decomposition analysis of Turkish CO2 emissions over 1990–2007. *Energy, 36*(5), 2419-2433. doi:10.1016/j.energy.2011.01.027

Kumhof, M., Rancière, R., & Winant, P. (2015). Inequality, leverage, and crises. *American Economic Review, 105*(3), 1217-1245. doi:10.1257/aer.20110683

Kuznets, S. (1955). Economic growth and income inequality. *The American Economic Review, 45*(1), 1-28. Retrieved from https://www.jstor.org/stable/1811581.

Lankao, P. R., Tribbia, J. L., & Nychka, D. (2009). Testing theories to explore the drivers of cities' atmospheric emissions. *AMBIO: A Journal of the Human Environment, 38*(4), 236-245. doi:10.1579/0044-7447-38.4.236

Lee, J., & List, J. A. (2004). Examining trends of criteria air pollutants: are the effects of governmental intervention transitory? *Environmental and Resource Economics, 29*(1), 21-37. doi:10.1023/B:EARE.0000035427.22165.3b

Lim, H.-J., Yoo, S.-H., & Kwak, S.-J. (2009). Industrial CO2 emissions from energy use in Korea: a structural decomposition analysis. *Energy Policy, 37*(2), 686-698. doi:10.1016/j.enpol.2008.10.025

Lin, B. C. a., & Zheng, S. (2016). A New Direction in Environmental Economics. *Journal of Economic Surveys, 30*(3), 397-402. Retrieved from https://onlinelibrary.wiley.com/doi/epdf/10.1111/joes.12166. doi:10.1111/joes.12166

List, J., & Strazicich, M. (2003). *Are CO2 Emission Levels Converging Among Industrial Countries?* Retrieved from https://ideas.repec.org/p/feb/natura/00508.html

List, J. A., & Gallet, C. A. (1999). The environmental Kuznets curve: does one size fit all? *Ecological Economics, 31*(3), 409-423. doi:10.1016/S0921-8009(99)00064-6

Liu, J., Daily, G. C., Ehrlich, P. R., & Luck, G. W. (2003). Effects of household dynamics on resource consumption and biodiversity. *Nature, 421*(6922), 530-533. Retrieved from https://doi.org/10.1038/nature01359. doi:10.1038/nature01359

Lorenzoni, I., & Pidgeon, N. F. (2006). Public views on climate change: European and USA perspectives. *Climatic change, 77*(1-2), 73-95. doi:10.1007/s10584-006-9072-z

MacKellar, F. L., Lutz, W., Prinz, C., & Goujon, A. (1995). Population, households, and CO2 emissions. *Population and Development Review, 21*(4), 849-865. doi:10.2307/2137777

Malthus, T. R. (1872). *An Essay on the Principle of Population*. Edinburgh: Ballantyne and Company

Margolis, R. M., & Kammen, D. M. (1999). Underinvestment: the energy technology and R&D policy challenge. *Science, 285*(5428), 690-692. doi:10.1126/science.285.5428.690

Martínez-Zarzoso, I., & Maruotti, A. (2011). The impact of urbanization on CO2 emissions: evidence from developing countries. *Ecological Economics, 70*(7), 1344-1353. doi:10.1016/j.ecolecon.2011.02.009

McCarthy, J. J., Canziani, O. F., Leary, N. A., Dokken, D. J., & White, K. S. (2001). *Climate change 2001*. Cambridge, United Kingdom: Cambridge University Press.

Meadows, D., & Randers, J. (2012). *The limits to growth: the 30-year update*: Routledge.

Meadows, D., Randers, J., Meadows, D. L., & Behrens III, W. W. (1972). *The limits to growth: a report for the club of rome's project on the*

predicament of mankind. New York: Universe Books.

Muller, F. (1996). Mitigating climate change: The case for energy taxes. *Environment: Science and Policy for Sustainable Development, 38*(2), 13-43. doi:10.1080/00139157.1996.9933459

Munda, G. (1997). Environmental economics, ecological economics, and the concept of sustainable development. *Environmental Values, 6*(2), 213-233. doi:10.3197/096327197776679158

Müller, C., Cramer, W., Hare, W. L., & Lotze-Campen, H. (2011). Climate change risks for African agriculture. *Proceedings of the National Academy of Sciences, 108*(11), 4313-4315. doi:10.1073/pnas.1015078108

O'Neill, B. C., Oppenheimer, M., Warren, R., Hallegatte, S., Kopp, R. E., Pörtner, H. O., . . . Yohe, G. (2017). IPCC reasons for concern regarding climate change risks. *Nature Climate Change, 7*, 28. Retrieved from https://doi.org/10.1038/nclimate3179. doi:10.1038/nclimate3179

https://www.nature.com/articles/nclimate3179#supplementary-information

OECD. (2019). *OECD Environmental Performance Reviews: Turkey 2019*.

Parks, R. W. (1967). Efficient Estimation of a System of Regression Equations when Disturbances are Both Serially and Contemporaneously Correlated. *Journal of the American Statistical Association, 62*(318), 500-509. doi:10.1080/01621459.1967.10482923

Parry, I. W. H. (1998). *The double dividend: when you get it and when you don't.* Paper presented at the Proceedings. Annual Conference on Taxation and Minutes of the Annual Meeting of the National Tax Association.

Parry, I. W. H., & Bento, A. M. (2000). Environmental policy, tax deductions and the double dividend hypotheses. *Journal of Environmental Economics and Management, 39*, 67-96. doi:10.1006/jeem.1999.1093

Pawłowski, A. (2008). How many dimensions does sustainable development have? *Sustainable Development, 16*(2), 81-90. doi:10.1002/sd.339

Pecl, G. T., Araújo, M. B., Bell, J. D., Blanchard, J., Bonebrake, T. C., Chen, I.-C., . . . Evengård, B. (2017). Biodiversity redistribution under climate change: Impacts on ecosystems and human well-being. *Science, 355*(6332), eaai9214. doi:10.1126/science.aai9214

Pesaran, M. H. (2004). *General diagnostic tests for cross section dependence in panels.* Retrieved from https://ssrn.com/abstract=572504

Rafaj, P., Amann, M., Siri, J., & Wuester, H. (2015). Changes in European greenhouse gas and air pollutant emissions 1960–2010: decomposition of determining factors. In *Uncertainties in Greenhouse Gas Inventories* (pp. 27-54): Springer.

Ramanathan, V., & Feng, Y. (2009). Air pollution, greenhouse gases and climate change: Global and regional perspectives. *Atmospheric Environment, 43*(1), 37-50. Retrieved from https://www.sciencedirect.com/science/article/pii/S1352231008008583. doi:10.1016/j.atmosenv.2008.09.063

Redclift, M. R., & Woodgate, G. (2010). *The international handbook of environmental sociology*. Cheltenham, UK; Northampton MA, USA: Edward Elgar Publishing.

Ren, S., Yin, H., & Chen, X. (2014). Using LMDI to analyze the decoupling of carbon dioxide emissions by China's manufacturing industry. *Environmental Development, 9*, 61-75. doi:10.1016/j.envdev.2013.11.003

Richter, C. A. (2008). *Ozone production in the atmosphere simulation chamber SAPHIR* (Vol. 2): Forschungszentrum Jülich.

Robert, K. W., Parris, T. M., & Leiserowitz, A. A. (2005). What is sustainable development? Goals, indicators, values, and practice. *Environment: Science and Policy for Sustainable Development, 47*(3), 8-21. doi:10.1080/00139157.2005.10524444

Rosa, E. A., Diekmann, A., Dietz, T., & Jaeger, C. C. (2010). *Human footprints on the global environment: Threats to sustainability*: MIT Press.

Scheehle, E. A., & Kruger, D. (2006). Global anthropogenic methane and nitrous oxide emissions. *The Energy Journal*, 33-44. doi:10.5547/ISSN0195-6574-EJ-VolSI2006-NoSI3-2

Schlenker, W., & Lobell, D. B. (2010). Robust negative impacts of climate change on African agriculture. *Environmental Research Letters, 5*(1), 014010. Retrieved from https://iopscience.iop.org/article/10.1088/1748-9326/5/1/014010/pdf. doi:10.1088/1748-9326/5/1/014010

Selden, T. M., & Song, D. (1994). Environmental quality and development: is there a Kuznets curve for air pollution emissions? *Journal of Environmental Economics and Management, 27*(2), 147-162. doi:10.1006/jeem.1994.1031

Shafik, N. (1994). Economic development and environmental quality: an econometric analysis. *Oxford Economic Papers, 46*(4), 757-774. doi:10.1093/oep/46.supplement_1.757

Shi, A. (2003). The impact of population pressure on global carbon dioxide emissions, 1975–1996: evidence from pooled cross-country data. *Ecological Economics, 44*(1), 29-42. doi:10.1016/S0921-8009(02)00223-9

Solomon, S., Plattner, G.-K., Knutti, R., & Friedlingstein, P. (2009). Irreversible climate change due to carbon dioxide emissions. *Proceedings of The National Academy of Sciences, 106*(6), 1704-1709. doi:10.1073/pnas.0812721106

Spaargaren, G., & Mol, A. P. (1992). Sociology, environment, and modernity: Ecological modernization as a theory of social change. *Society & Natural Resources, 5*(4), 323-344. doi:10.1080/08941929209380797

Starkey, R., & Anderson, K. (2005). *Domestic Tradable Quotas: A policy instrument for reducing greenhouse gas emissions from energy use*. Retrieved from https://www.teqs.net/Tyndall2005.pdf

Stiglitz, J. E., & Dasgupta, P. (1971). Differential taxation, public goods, and economic efficiency. *The Review of Economic Studies, 38*(2), 151-174. Retrieved from https://www.jstor.org/stable/2296778.

Tol, R. S. (2009). The economic effects of climate change. *Journal of Economic Perspectives, 23*(2), 29-51. doi:10.1257/jep.23.2.29

Tol, R. S., Pacala, S. W., & Socolow, R. (2006). *Understanding long-term energy use and carbon dioxide emissions in the USA*. Retrieved from FEEM Working Paper No. 107.06: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=927741

Tunç, G. I., Türüt-Aşık, S., & Akbostancı, E. (2007). CO2 emissions vs. CO2 responsibility: an input–output approach for the Turkish economy. *Energy Policy, 35*(2), 855-868. doi:10.1016/j.enpol.2006.02.012

Tunç, G. I., Türüt-Aşık, S., & Akbostancı, E. (2009). A decomposition analysis of CO2 emissions from energy use: Turkish case. *Energy Policy, 37*(11), 4689-4699. doi:10.1016/j.enpol.2009.06.019

UN. (2015). *Transforming our world : the 2030 Agenda for Sustainable Development*. Retrieved from https://www.refworld.org/docid/57b6e3e44.html

UNESCO. (1996). *Population, environment and development linkages*.

UNFPA. (2007). *Unleashing the Potential of Urban Growth* (978-0-89714-807-8). Retrieved from

Wang, M., & Feng, C. (2017). Decomposition of energy-related CO2 emissions in China: an empirical analysis based on provincial panel data of three sectors. *Applied energy, 190*, 772-787. doi:10.1016/j.apenergy.2017.01.007

Wang, Q., Chiu, Y.-H., & Chiu, C.-R. (2015). Driving factors behind carbon dioxide emissions in China: A modified production-theoretical decomposition analysis. *Energy Economics, 51*, 252-260. doi:10.1016/j.eneco.2015.07.009

WCED, S. W. S. (1987). World commission on environment and development. *Our common future*.

Wigley, T. (1983). The pre-industrial carbon dioxide level. *Climatic Change, 5*(4), 315-320. doi:10.1007/BF02423528

Wood, R. (2009). Structural decomposition analysis of Australia's greenhouse gas emissions. *Energy Policy, 37*(11), 4943-4948. doi:10.1016/j.enpol.2009.06.060

Wooldridge, J. M. (2003). Further results on instrumental variables estimation of average treatment effects in the correlated random coefficient model. *Economics letters, 79*(2), 185-191. doi:10.1016/S0165-1765(02)00318-X

Wooldridge, J. M. (2009). On estimating firm-level production functions using proxy variables to control for unobservables. *Economics letters, 104*(3), 112-114. doi:10.1016/j.econlet.2009.04.026

Yamakawa, A., & Peters, G. P. (2011). Structural decomposition analysis of greenhouse gas emissions in Norway 1990–2002. *Economic Systems Research, 23*(3), 303-318. doi:10.1080/09535314.2010.549461

Yeldan, E., & Voyvoda, E. (2015). *Low Carbon Development Pathways and Priorities for Turkey*. Retrieved from https://www.wwf.de/fileadmin/fm-wwf/Publikationen-PDF/Low_Carbon_Development_Pathways_for_Turkey_October_2015_FullStudy.pdf

Yeni, O. (2014). Technical Efficiency of the Manufacturing Industry in Turkey: 2003-2008. *International Journal of Arts and Commerce, 3*(3), 17-26. Retrieved from https://s3.amazonaws.com/academia.edu.documents/33553486/3.pdf?AWSAccessKeyId=AKIAIWOWYYGZ2Y53UL3A&Expires=1558962913&Signature=Kb50e2oSEYzL5vy2icBfu4q6l%2B0%3D&response-content-disposition=inline%3B%20filename%3DTechnical_Efficiency_of_the_Manufacturin.pdf.

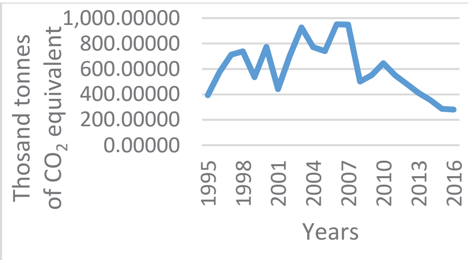
Yeni, O. (2018). 12 A sectoral analysis of greenhouse gas emissions and output growth in Turkey. In *The Dynamics of Growth in Emerging Economies: The Case of Turkey* (pp. 283). London and New York: Routlegde.

York, R., Rosa, E. A., & Dietz, T. (2003). Footprints on the earth: The environmental consequences of modernity. *American Sociological Review, 68*(2), 279-300. Retrieved from http://www.jstor.org/stable/1519769.

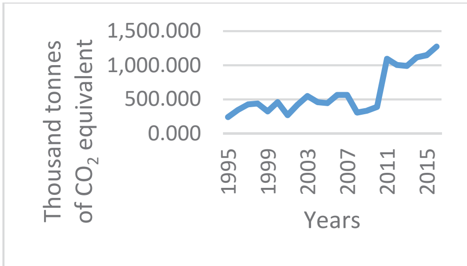
Zhang, Y.-J., Wang, A.-D., & Da, Y.-B. (2014). Regional allocation of carbon emission quotas in China: Evidence from the Shapley value method. *Energy Policy, 74*(11), 454-464. doi:10.1016/j.enpol.2014.08.006

APPENDIX 1

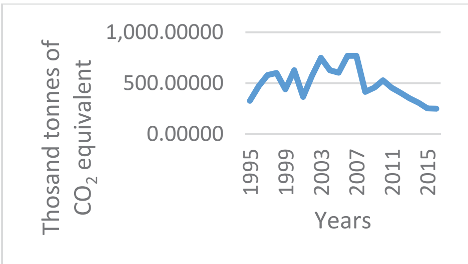
GHG EMISSON LEVELS OF SECTORS C16-30



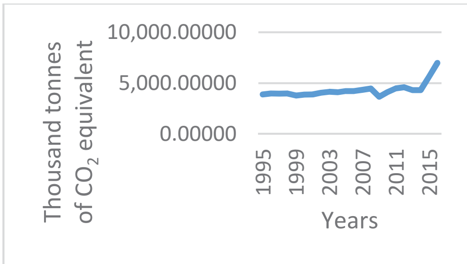
C16- Manufacture of wood and of products of wood and cork



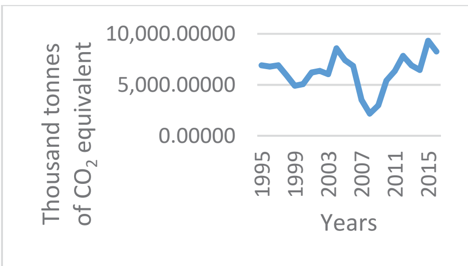
C17- Manufacture of paper and paper products



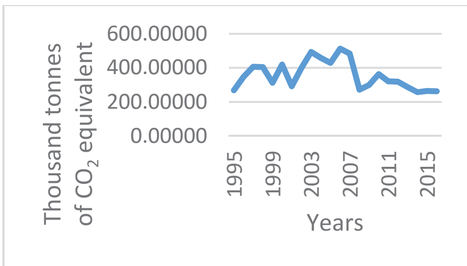
C18- Printing and reproduction of recorded media



C19- Manufacture of coke and refined petroleum products



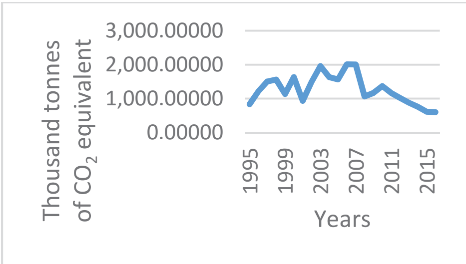
C20- Manufacture of chemicals and chemical products



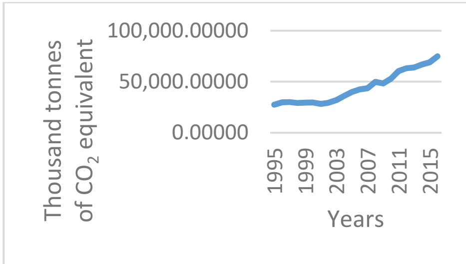
C21- Manufacture of basic pharmaceutical products and pharmaceutical preparation

Figure 5: Manufacturing sectors C16, C17, C18, C19, C20, C21's emission levels for the period 1995-2016

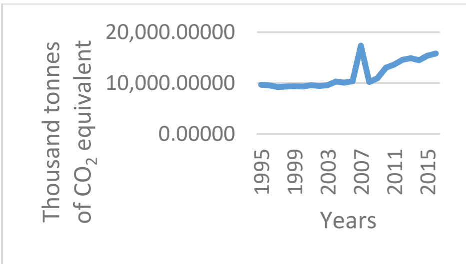
Source: EUROSTAT's Air Emission Accounts



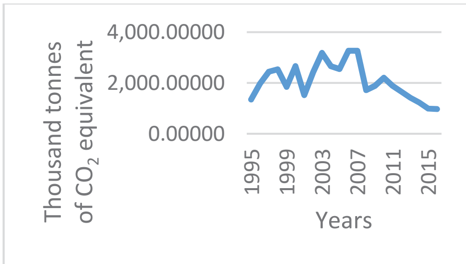
C22- Manufacture of rubber and plastic products



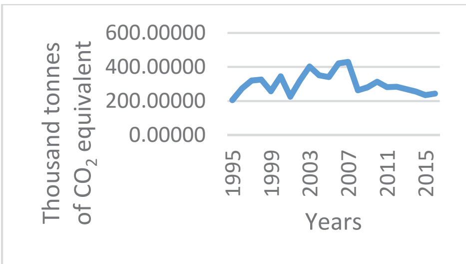
C23- Manufacture of other non-metallic mineral products



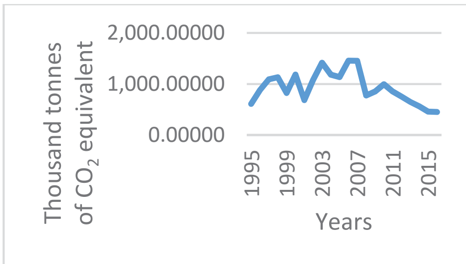
C24- Manufacture of basic metals



C25- Manufacture of fabricated metal products, except machinery and equipment



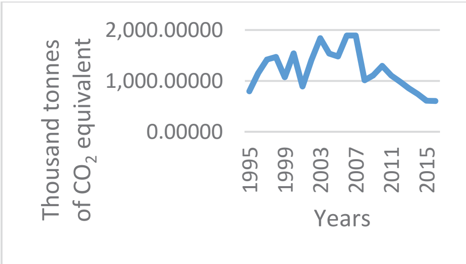
C26- Manufacture of computer, electronic and optical products



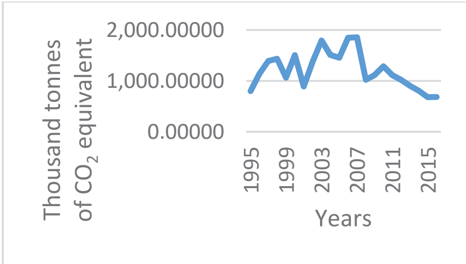
C27- Manufacture of electrical equipment

Figure 6: Manufacturing sectors C22, C23, C24, C25, C26, C27's GHG Emissions for the period of 1995-2016

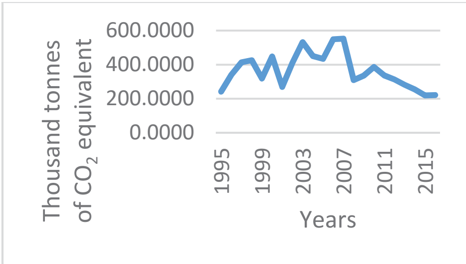
Source: EUROSTAT's Air Emissions Account



C28- Manufacture of machinery and equipment n.e.c.



C29- Manufacture of motor vehicles, trailers and semi-trailers



C30- Manufacture of other transport equipment

Figure 7: Manufacturing sectors C28's, C29's and C30's GHG Emissions for the period of 1995-2016

Source: EUROSTAT's Air Emissions Account

APPENDIX 2
ORIGINALITY REPORT

HACETTEPE UNIVERSITY
GRADUATE SCHOOL OF SOCIAL SCIENCES
MASTER'S THESIS ORIGINALITY REPORT

HACETTEPE UNIVERSITY
GRADUATE SCHOOL OF SOCIAL SCIENCES
ECONOMICS DEPARTMENT

Date:12/06/2019

Thesis Title : Determinants of Greenhouse Gas Emissions in Turkish Manufacturing Industry

According to the originality report obtained by myself/my thesis advisor by using the Turnitin plagiarism detection software and by applying the filtering options checked below on 12/06/2019 for the total of 47 pages including the a) Title Page, b) Introduction, c) Main Chapters, and d) Conclusion sections of my thesis entitled as above, the similarity index of my thesis is 8 %.

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1. ☒ Approval and Decleration sections excluded
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I declare that I have carefully read Hacettepe University Graduate School of Social Sciences Guidelines for Obtaining and Using Thesis Originality Reports; that according to the maximum similarity index values specified in the Guidelines, my thesis does not include any form of plagiarism; that in any future detection of possible infringement of the regulations I accept all legal responsibility; and that all the information I have provided is correct to the best of my knowledge.

I respectfully submit this for approval.

12/06/2019
Date and Signature

Name Surname:	Nurten İpek Taştan
Student No:	N15225270
Department:	Economics
Program:	Economics Master's Programme

ADVISOR APPROVAL

APPROVED.

Asst. Prof. Onur YENİ

APPENDIX 3

ETHICS BOARD WAIVER FORM

HACETTEPE UNIVERSITY
GRADUATE SCHOOL OF SOCIAL SCIENCES
ETHICS COMMISSION FORM FOR THESIS

HACETTEPE UNIVERSITY
GRADUATE SCHOOL OF SOCIAL SCIENCES
ECONOMICS DEPARTMENT

Date: 12/06/2019

Thesis Title: Determinants of Greenhouse Gas Emissions in Turkish Manufacturing Industry

My thesis work related to the title above:

1. Does not perform experimentation on animals or people.
2. Does not necessitate the use of biological material (blood, urine, biological fluids and samples, etc.).
3. Does not involve any interference of the body's integrity.
4. Is not based on observational and descriptive research (survey, interview, measures/scales, data scanning, system-model development).

I declare, I have carefully read Hacettepe University's Ethics Regulations and the Commission's Guidelines, and in order to proceed with my thesis according to these regulations I do not have to get permission from the Ethics Board/Commission for anything; in any infringement of the regulations I accept all legal responsibility and I declare that all the information I have provided is true.

I respectfully submit this for approval.

12/06/2019
Date and Signature

Name Surname: Nurten İpek Taştan
Student No: N15225270
Department: Economics
Program: Economics Master's Programme
Status: ☒ MA ☐ Ph.D. ☐ Combined MA/ Ph.D.

ADVISER COMMENTS AND APPROVAL

Asst. Prof. Onur YENİ