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The relationship between economic growth and carbon dioxide emissions

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Abstract

English

The relationship between economic growth and carbon dioxide emissions.

This thesis will focus on the relationship between Gross Domestic Product and carbon dioxide emissions. There will be an analysis if the Environmental Kuznet Curve hypothesis created by Simon Kuznets (1955) holds for six different countries. The hypothesis tells us that when a country's Gross Domestic Product increases, the carbon dioxide emissions increase too. Eventually the pollution will reach a turning point and the environment will slowly start to recover. Moreover, this study has been carried out by doing a time series analysis and an estimation of each country's turning point where the carbon dioxide emissions will start to decrease while the Gross Domestic Product continues to increase. The countries examined are four developed countries Sweden, Denmark, the United Kingdom and France, and two developing countries India and Mexico. The data for the countries has been collected depending on availability and it varies between 119 to 194 observations. Our findings illustrate that the Environmental Kuznet Curve hypothesis holds for each of our selected countries, but the illustrations show a vague turning point for India and Mexico. To fight climate change, policymakers and the corporate world are the most responsible for decreasing the environmental footprint.

Keywords; Environmental Kuznets Curve, Carbon Dioxide, Gross Domestic Product

Español

La relación entre el crecimiento económico y las emisiones de dióxido de carbono.

Esta tesis se centrará en la relación entre el Producto Interno Bruto y las emisiones de dióxido de carbono. Se analizará si la hipótesis de la Curva Ambiental de Kuznet creada por Simon Kuznets (1955) se cumple para seis países diferentes. La hipótesis nos dice que cuando aumenta el Producto Interno Bruto de un país, aumentan también las emisiones de dióxido de carbono. Eventualmente, la contaminación alcanzará un punto de inflexión y el medio ambiente comenzará a recuperarse lentamente. Además, este estudio se ha llevado a cabo mediante un análisis de series temporales y una estimación del punto de inflexión de cada país donde las emisiones de dióxido de carbono comenzarán a disminuir mientras el Producto Interno Bruto continúa aumentando. Los países examinados son cuatro países desarrollados, Suecia, Dinamarca, Reino Unido

y Francia, y dos países en desarrollo, India y México. Los datos de los países se han recopilado en función de la disponibilidad y varía entre 119 y 194 observaciones. Nuestros hallazgos ilustran que la hipótesis de la curva ambiental de Kuznet se cumple para cada uno de nuestros países seleccionados, pero las ilustraciones muestran un punto de inflexión vago para India y México. Para luchar contra el cambio climático, los políticos y el mundo empresarial son los principales responsables de disminuir la huella ambiental.

Palabras clave; Curva de Kuznets Ambiental, Dióxido de Carbono, Producto Interno Bruto

Català

La relació entre el creixement econòmic i les emissions de diòxid de carboni.

Aquesta tesi se centrarà en la relació entre el Producte Interior Brut i les emissions de diòxid de carboni. S'analitzarà si la hipòtesi de la corba de Kuznet ambiental creada per Simon Kuznets (1955) és vàlida per a sis països diferents. La hipòtesi ens diu que quan augmenta el Producte Interior Brut d'un país, també augmenten les emissions de diòxid de carboni. Finalment, la contaminació arribarà a un punt d'inflexió i l'entorn començarà a recuperar-se a poc a poc. A més, aquest estudi s'ha realitzat fent una anàlisi de sèries temporals i una estimació del punt d'inflexió de cada país on les emissions de diòxid de carboni començaran a disminuir mentre el Producte Interior Brut continuï augmentant. Els països examinats són quatre països desenvolupats, Suècia, Dinamarca, Regne Unit i França, i dos països en desenvolupament, l'Índia i Mèxic. Les dades dels països s'han recollit en funció de la disponibilitat i varien entre 119 i 194 observacions. Les nostres troballes il·lustren que la hipòtesi de la corba de Kuznet ambiental és vàlida per a cadascun dels països seleccionats, però les il·lustracions mostren un punt d'inflexió inconcret per a l'Índia i Mèxic. Per lluitar contra el canvi climàtic, els responsables polítics i el món empresarial són els principals responsables de la disminució de la petjada ambiental.

Paraules clau; Corba de Kuznets Ambiental, Diòxid de Carboni, Producte Interior Brut

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1. Presentation

In this section we will introduce a presentation of this thesis. In addition, we will acknowledge people making this thesis possible.

This thesis is the completion of our year abroad in Spain at Universitat Rovira i Virgili obtaining a double degree in Economics. We are exchange students from University West in Sweden.

We have an interest in the environment and wanted to learn more about what factors affect it negatively hence the decision of writing about this subject. The environment is an important subject today because climate change is highly noticeable. With this thesis the purpose is to emphasize factors affecting the environment. We have ourselves noticed in our home country Sweden, which is a Nordic country, has developed a warmer and milder climate during the time we have lived. During the process studying this subject we have realized how large of an impact carbon dioxide emissions have on the environment and how the climate has reacted to these emissions.

We have written about a global issue where we have used econometric theory to examine how economic factors influence increased pollution. This guided us back to the Industrialization which was the beginning of increased pollution. There is a wide range of previous research related to the environment, where many researchers before us have contributed with their thoughts regarding environmental pollution. By studying what others have discovered we decided to use the Environmental Kuznets Curve hypothesis which according to previous literature is largely used and explains economic growth in relation to pollution. To apply this hypothesis, we chose six different countries since we wanted to compare the hypothesis in different economies.

We hope readers of this thesis will find it interesting and that it contributes to valuable knowledge about the relationship between economic growth and pollution. Perhaps it will be an eye opener to the reader and will provide for thoughtfulness of active choices related to air pollution.

Furthermore, we would like to thank our tutor professor Nektarios Aslanidis for your guidance throughout this work. You have provided us with inspiration for studying the Environmental Kuznets Curve hypothesis and the development of the model used. You

have helped us with the gathering of relevant data and made this thesis possible to finalize.

We would like to acknowledge professor Xiaoni Li for supporting us during this year abroad with all our questions regarding the academic life at the university and providing help when we needed it. Further, thanks to Elena Cruz Hidalgo and Ivette Gatell Terricabras, both students at URV who have helped us with the translation of the abstract in Spanish and Catalan.

This year has been challenging yet developing since we have lived abroad away from our families and friends. Therefore we would like to thank them for the support from afar in Sweden with encouragement when it has felt difficult. Although, working together on this thesis we have been able to support each other as well.

2. Introduction

In this section we will introduce the topic of the thesis. In addition, we will present some of the consequences a polluted environment contributes to.

It is commonly known today that the extensive emissions of greenhouse gasses are an issue around the world and cause harm to both humans, animals, and the environment. Greenhouse gasses already occur naturally in the Earth's atmosphere, although since the Industrialization anthropogenic emissions have largely increased. The industries provided production efficiency and work opportunities which benefitted the economic growth. To understand the environmental pollution many researchers have used the Environmental Kuznets Curve (EKC) hypothesis created by Simon Kuznets (1955). The model is used to reach an explanation and a connection related to economic growth and pollution. The hypothesis of the Environmental Kuznets Curve explains when a country's Gross Domestic Product (GDP) increases, the environmental pollution increases too. Eventually the pollution will reach a turning point and the environment will slowly start to recover.

Within the Earth's atmosphere greenhouse gasses such as carbon dioxide (CO_2) absorb heat radiation from the sun that heat up the planet which is vital for all life on Earth (Denchak, 2019). The natural balance occurs when the amount of radiation from the sun is equal to the amount of radiation to space (Hassler et al., 2020 p.41). Having higher levels of greenhouse gasses in the atmosphere results in a reduced cooling effect and creates an imbalance, hence a heating (Hassler et al., 2020 p.44-45). CO_2 accounts for 65 percent of all greenhouse gasses (United States Environmental Protection Agency [EPA], 2022). The enhanced greenhouse effect is proving to have major consequences for the Earth and its inhabitants. The increased emissions are released through population-and economic growth, thereby the use of energy, land, and technology (Denchak, 2019). Over the last 50 years CO_2 emissions have increased by approximately 90 percent (United States Environmental Protection Agency [EPA], 2022).

The world's fast growing population is further a contributor to the environmental decline. It affects Earth's ability to resist climate change and for it to absorb emissions deteriorates. The largest part of the emissions comes from the richest countries, primarily from the developed countries' industrial development and consumption patterns. If the people in the developing countries would have one fewer child, the long run effect on carbon dioxide emissions would have a significant decrease. By reducing the number of

newborns, the future carbon dioxide emissions would be smaller, since less population contributes to less pollution (Populationmatters, 2022).

Consequences related to climate change are intense and more frequent weathers, such as heat waves, hurricanes, droughts, and floods. These extreme weathers make wet regions wetter and dry regions drier (Denchak, 2019). The most sensitive ecosystem to climate change is the coral reefs. High temperatures in both the seas and oceans contribute to discoloration to corals (Hassler et al., 2020 p.84-85). There is a big range of sea species depending on coral reefs, when the reefs disappear it will contribute to large numbers of marine species getting extinct. Further negative effects related to the sea is the melting of glaciers which raises the sea levels and lead to an increase of ocean temperatures. When the ecosystems are being altered there is a shift in geographical ranges, migration patterns, freshwater and marine species (Denchak, 2019). It is not only marine life who gets affected from the pollution, also humans get affected. The CO_2 pollution affects people's health and causes large numbers of deaths every year (Hassler et al., 2020 p.82). When people are exposed to high air pollution the risks of getting respiratory infections, heart disease and lung cancer increases. The ones who are more prone to these health issues are elderly, children, and people with low income (World Health Organization [WHO], 2019).

Climate change affects countries in different ways, depending on if they are developed or developing. The countries suffering the most from climate change are developing, with more frequent and destructive natural disasters for each year. The reason for this effect is that the countries who contribute to most of the pollution are developed since their societies are more technical and industrial advanced (Ludwig et al., 2007). However, the developed countries are the ones having the ability to lower pollution since they obtain better economical resources and higher knowledge about how to create greener industries.

Developed countries have left agriculture for the most part and they have adapted to Industrialization. These countries have, in contrast to developing countries, higher income levels and higher GDP per capita. The unemployment rate is low in a developed country and the living standard for the population is good. According to the United Nations (2022) developed countries are mainly nations located in North America and Europe such as The United States, The United Kingdom and Sweden. A developing country is a low income country with a low GDP per capita and a high unemployment rate. These countries have not gone through Industrialization and are still in the

agricultural stage. Agriculture does not generate as much income for a country which keeps the economy poor. According to the United Nations (2022) developing countries are mostly located in Africa and South America such as Zimbabwe, Uganda and Colombia.

As global warming is an important topic all over the world, the United Nations (UN) implemented in 2015 the Paris Agreement which is a legally binding international treaty and came into effect one year later in 2016. The goal is to restrict global warming to two degrees celsius. This agreement is structured on a five year cycle where different actions to fight climate change are performed by the countries. In 2020 each country submitted their plans on how they should achieve these goals, called Nationally determined contributions (NDCs). While doing this, the agreement further states that developed countries should contribute with financial aid to countries who have less economic resources (United Nations Climate Change, 2022).

To fight climate, change the UN further created Sustainable Development Goals to improve the climate and living standards for the world's population. This contains 17 goals where all 193 member states of the UN are involved regardless of their stage of development, it is called Agenda 2030 (United Nations [UN], 2022). Goal number 13 is related to climate change and how it should be coped with (Regeringskansliet, 2022). The aim for this global goal is to fight natural disasters, poverty and contribute to sustainable development.

Pollution is a highly ongoing problem in today’s society and there are global goals trying to cope with this to save the planet and the population. The main purpose of this thesis is to examine the relationship between economic growth and CO_2 emissions while taking in consideration the Environmental Kuznets Curve. When a country has reached a certain level of GDP per capita, pollution per capita will start to decrease. To proceed the analysis a time series model will be carried out. We want to answer if the EKC hypothesis holds for different countries.

3. Literature review

In this section we will present research about the topic CO_2 emissions related to economic growth we found relevant and interesting for our thesis. Further, a summary of the literature will be presented.

a. Previous research

Research about economic growth and the environment is extensive. There is one hypothesis many researchers have studied called the Environmental Kuznets Curve (EKC) named after Simon Kuznets (1955). The EKC hypothesis illustrates an inverted U-shaped curve indicating different phases of the relationship between economic growth and pollution. The first phase is where low-income countries initiate a developing phase to an industrialized economy. In this phase the environment deteriorates. The turning point indicates a change where the countries initiate a post-industrial phase. It happens when the economy has developed and services have a larger part in the economy, where the environment improves (Agras & Chapman, 1999).

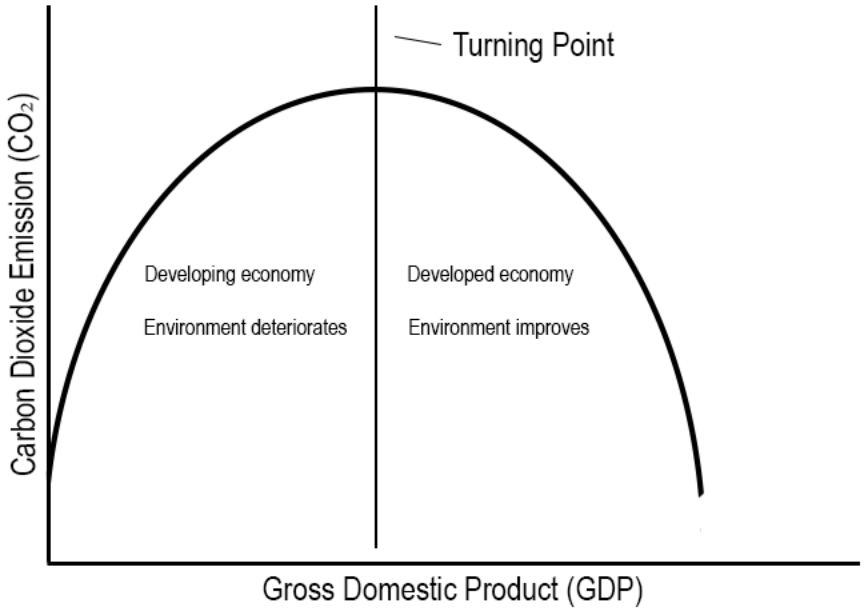

Figure 1: Illustration of the Environmental Kuznets Curve.

Grossman and Kreuger (1995) have examined the relationship between national GDP and indicators of local environmental conditions. No evidence is found that economic growth does unavoidable damage to the natural habitat. However, they do find increasing GDP in poor countries possibly has a connection with deteriorating environmental conditions. Once a certain level of income has been reached, air and

water quality seems to benefit. A turning point has been reached and they describe it as an inverted U-shaped relationship.

Even though economic growth has been associated with improving environmental conditions, Grossman and Kreuger (1995) argues that the process is not automatic. Instead it may have some explanations through improved technologies and stricter environmental policies in relation to economic growth. Grossman and Kreuger (1995) discuss that the inverted U-shape might take form as developed countries stop producing products generating much pollution and import the products instead from countries with less restrictive environmental policies. If this is the primary reason, it is not reliable in the future since there will eventually be a stop.

Kaika and Zervas (2013) explains that according to the EKC hypothesis economic growth will lead to a turning point in the environmental decline, suggesting that the relationship between environmental and economic growth has the form of an inverted U. Different factors other than income can affect the environmental decline and further lead to an EKC pattern. These can be international trade, structural changes and the institutional framework and governance and consumers preferences.

Urban & Nordensvärd (2018) finds that the EKC hypothesis holds for the Nordic countries except for Norway in terms of CO_2 emissions per capita. It is discussed it could be improvements in energy use, but the Nordic countries in general have low carbon energy and take advantage of natural resources which contribute to lower emissions related to economic growth. For a country to lower emissions, it is important to consider decreasing the dependence on oil-based products for transportation. Further, countries can learn from those countries that have already experienced a turning point, especially those countries who have similar natural resources to develop for example the hydropower. Urban & Nordensvärd (2018) discuss that it provides a source of inspiration for others and evidence shows that Sweden for instance can keep low carbon energy but still gain economic growth.

Beşe and Kalayci (2021) found no causal relationship between CO_2 and GDP when studying three developed countries. The EKC hypothesis was rejected, indicating that the economic growth itself of a country does not have any effect on emissions. In order to fight climate change other measures are required such as increasing the use of renewable energy and improving energy efficiency in transport, industry and households. Beşe and Kalayci (2021) continues to argue that authorities should invest in energy

conservation and policies for reducing emissions since they are not likely to have a negative effect on the economic growth of a country.

Panayotou (1993) explains that an environmental decline is inevitable, since the environment aims to become worse before it improves. The time it takes for the environment to improve depends on a country's environmental policy. Governments of developing countries can contribute to a flatter EKC by eliminating policy distortions, incorporating environmental costs to the activities creating them and further defining and enforcing property rights over natural resources Panayotou (1993) continues. With various financing mechanisms developed countries can support developing countries, this to protect the biodiversity and natural resources that can permanently be lost during the first phase of economic growth.

Dasgupta, et. al. (2002) argues that the international community has an important role in decreasing the EKC, this through financing of appropriate training related to environmental pollution, policy reforms and public environmental education. The authors continue by explaining that to avoid pollution it is crucial to support carefully aimed pollution control programs containing requirements that are possible for countries to execute.

Shi (2003) argues that the fast increase of CO_2 emissions has increased the concern for policymakers because of the feasible impact population growth has on the global CO_2 emissions. Further, the author finds evidence that population growth is one of the main forces related to increased CO_2 emissions globally during the last two decades. In addition, the impact of population growth on CO_2 emissions varies from country to country depending on their income levels. Which Shi (2003) describes is more noticeable in developing countries than developed countries.

Jayadevappa & Chhatre (2000) defines the importance that environmental problems come from bad developed policies. Further, the authors argue that some characteristics of the environment improve with trade and growth while others decline. For trade, policy reforms for environmental issues in a globalized world economy are problematic but necessary. It is crucial with policy coordination between developed and developing countries in order to minimize environmental costs Jayadevappa & Chhatre (2000) continues. Although, depending on which stage of development each country experiences they face different challenges. Developed countries need to reduce pollution while developing countries need to minimize it. Thus, both these options need

arrangements between the countries. It is an important challenge to make countries aware of the environment but also prevent them from raising new trade barriers. Jayadevappa & Chhatre (2000) further explains that countries need to have the ability to set their own policies and goals to amplify global environmental objectives.

Fang, et. al. (2019) found that CO_2 emissions increased in relation to both increased per capita income and trade openness. One suggestion in order to decrease emissions is to upgrade the quality of export baskets. However, as developing countries expand their trade openness, CO_2 emissions will continue to increase. The authors believe that developed countries should take more responsibility to ease CO_2 emissions. As long as developing countries have a rapid growth rate it will increase emissions, policymakers should take these factors into consideration while handling problems regarding CO_2 emissions (Fang, et.al, 2019).

Antweiler, Copeland & Taylor (2001) found in their research that countries who are open to international markets generate small changes in pollution because of changes in production of the country. Trade will have an increasing effect on both the value of national output and the income. These increases are estimated to decrease the pollution in approximately the same proportion. Concluding that trade has a small decreasing effect on pollution.

b. Summary of the literature

Each article focuses on economic growth and the environment. There are different perspectives and conclusions. Grossman and Kreuger (1995) found in their research that economic growth in developing countries has a relationship with environmental decline, and after a certain level of income has been reached the environment starts to benefit. Kaika & Zervas (2013) also suggest this, but not only income is the factor of a turning point in the EKC curve. Urban & Nordensvärd (2018) continues with their findings that the EKC hypothesis holds for almost all the Nordic countries.

On the other hand, Beşe and Kalayci (2021) rejected the EKC hypothesis when studying three developed countries, claiming that other factors are affecting the environment, which Dasgupta, et. al. (2002) agrees with. Shi (2003) found that one main factor for increasing CO_2 emissions was population growth. Continuously, Antweiler, Copeland &

Taylor (2001) discuss that opening up for the international market could have a small impact for decreasing the pollution.

Panayotou (1993) continues the research by explaining that environmental decline is inevitable either way, it will get worse before it improves and it all depends on the environmental policy. Jayadevappa & Chhatre (2000) agree with the importance of environmental policies to improve the environment, and each country needs their own customized policy. Further, Fang, et. al. (2019) discusses that while developing countries have rapid export growth, developed countries should take more responsibility regarding implementing environmental policies. This previous research raised our interest in continuing the thesis by testing the EKC hypothesis in different countries.

4. Methodology

In this section we will explain the econometric model we have chosen to analyze our purpose for this thesis. We will further present the variables and countries included in the study. In addition, our hypothesis about the data will be discussed.

a. Data

The purpose with this thesis is to examine the relationship between economic growth and the pollution of CO_2. The main variables will therefore be GDP per capita and CO_2 emissions per capita. The variables are opted from the Environmental Kuznets Curve by Simon Kuznets (1955). The data for GDP is gathered from the Maddison project Database (2018) and the data for CO_2 is from a National data gathering by Boden, Andres & Marland (2017). The observations are collected from six countries of our choice: Sweden, Denmark, United Kingdom, France, India and Mexico. The observations of the annual GDP per capita and CO_2 per capita begins during the 19th century and extends to the year 2014. The time interval is determined based on the availability of the data. It varies between 119 to 194 observations for each country as illustrated in Table 1. This will make it possible to examine the relationship between economic growth and emissions of CO_2.

Country	**Time period**	**Number of observations**
Sweden	1839 - 2014	175
Denmark	1843 - 2014	171
United Kingdom	1820 - 2014	194
France	1820 - 2014	194
India	1884 - 2014	130
Mexico	1895 - 2014	119

Table 1: Number of observations.

Sweden is our country of origin, making this our primary interest to study. In addition, it is a developed country and can thus give interesting results. It had a population of 10.35 million in 2020 (The World Bank, 2022). Further, Denmark was included since it is a part of Scandinavia and a neighboring country to Sweden. It had a population of 5.831 million

in 2020 (The World Bank, 2022). Continuously, Urban & Nordensvärd (2018) found in their research that the EKC hypothesis was true for Sweden and Denmark.

The United Kingdom (UK) was a clear choice when talking about the industrial revolution, since it was the country who started the Industrialization in the 18th century and spread it to other nations. The UK was populated with 67.22 million in 2020 (The World Bank, 2022). Further, France was chosen since they are a country that adopted the Industrialization a few years after it began. It was a strong country with a large growth during this time (Britannica, 2022). It had a population of 67.39 million in 2020 (The World Bank, 2022).

To obtain a perspective outside of Europe, one Asian and one North American country have been included in the study, these are India and Mexico. India is a large economy which holds many industries, the high air pollution in India is well known where the country has nine of the ten most polluted cities in the world (IndiaSpend, 2021). India was populated with 1.38 billion in 2020 (The World Bank, 2022). Mexico was an interesting country to choose since it was slower in adapting to industrialization and it did not start until the 19th century, where they then became a large producer for the national market (Haber, 1995 p.3). Mexico had a population of 128.9 million in 2020 (The World Bank, 2022). According to the United Nations (2022) Sweden, Denmark, France, and the UK are classified as developed countries. Mexico and India are classified as developing countries.

By choosing these six countries we believe interesting and useful results can be received for our thesis. We will be able to compare between the countries and interpret how industrialization has affected the countries in terms of CO_2 emissions and economic growth.

b. Variables in the model

The dependent variable is Carbon Dioxide (CO_2) emissions per capita. It will observe the general CO_2 emissions per capita for each selected country. When the data was collected it was expressed in thousand metric tons of carbon for each country. From the source of the data, it was suggested to multiply it by 3.667 to get units of carbon dioxide. Further, to fit our analysis it was calculated to units of carbon dioxide per capita. This by dividing CO_2 emissions per capita by the population of the country. The natural logarithm

of this variable will be used in the regressions to examine how CO_2 changes with the growth of GDP in percent.

The independent variable in the model is Gross Domestic Product (GDP) per capita. It is a measure within a country during a specific time period. The measure is a value of private consumptions, investments, government spending, and net exports. A higher and increasing GDP indicates a stronger and growing economy. This variable will observe the GDP per capita for each selected country. The data collected is measured in Real GDP per capita in 2011US$ benchmark for each country. In the regressions, the natural logarithm of this variable will be used to examine the economic growth in percent. Further, the quadratic of GDP per capita will be included in the regression to study the non-linear relationship. It will provide an estimation of how GDP per capita and CO_2 emissions change through time.

c. Econometric model

For the EKC analysis an Ordinary Least Square (OLS) regression will be used. This to be able to estimate how a dependent variable is impacted by an independent variable (Koop, 2013 p.56). The regressions will be executed with *IBM SPSS statistics 28*. There will be one regression for each selected county. The equation is a time series model inspired by Aslanidis (2009) and is as follows:

$$y_t = \alpha + \beta_1 x_t + \beta_2 x^2_t + \varepsilon_t \qquad t = 1,\ldots,T$$

In the equation, *t* indicates the year. The natural logarithm of CO_2 per capita is denoted by y, the natural logarithm of GDP per capita is denoted by x, and quadratic GDP per capita is denoted by x^2. Continuously, α is the intercept of CO_2 emissions at the first observed year, β indicates the changes in each independent variable, and ε is the error correction term. The results will tell how CO_2 per capita changes due to changes in GDP per capita. This model will be an estimation for each of the six countries.

The significance of β is of importance for a reliable result. Further, R square (R^2) is going to be observed. This will tell us how the variables fit the model. A value close to 1 indicates that the variables included are a good fit in the model, and values closer to 0 are thus worse (Koop, 2013 p.58).

Further, the next step in the EKC analysis is to find the turning point for each country. In Aslanidis (2009) research this following formula is used:

$$\textit{Turning point} = -\beta_1 \div (2\beta_2)$$

The turning point is where CO_2 emissions per capita will be at its maximum and thereafter start to decrease. This illustrates an approximation for at which level of GDP and what year CO_2 emissions per capita will start to decrease in each of the countries. As Kaika and Zervas (2013) argues, increasing economic growth will eventually reach a turning point in CO_2 emissions which suggests that the curve of the EKC hypothesis will acquire an inverted U-shape. By examining the turning point we can study the hypothesis and if it applies to the selected countries.

d. Our hypothesis

We expect an increasing GDP per capita to have an increasing impact on CO_2 emissions since economic growth would raise the production in a country. We believe this because for instance boosted investments would create possibilities for companies to produce more, and higher income would raise the demand for more products by consumers. In this case, β_1 will be positive. Further, we expect β_2 of quadratic GDP per capita to be negative since we do not believe CO_2 emissions per capita would continue to increase with further growth. Instead we believe it will increase in a larger magnitude at an earlier growth stage, since countries in an earlier stage of development have not yet reached advanced production techniques and economies of scale (Grossman and Kreuger, 1995). This is in accordance with the EKC hypothesis, if this is correct the relationship will take the shape of an inverted U. In conclusion, we expect β_1 to be positive (+) and β_2 to be negative (-). If the EKC hypothesis does not hold, the CO_2 emissions per capita will continue to increase as GDP per capita increases.

5. Results

In this section we will present the results of our data and illustrate relevant tables and graphs of our results. The results will be illustrated from OLS regressions.

The executed OLS regressions include both the dependent variable, CO_2 emission per capita, and the independent variable, GDP per capita. The results from the regressions will be summarized to examine how the CO_2 emissions change in relation to economic growth and how it has changed over the years. The Beta values will tell us if the EKC hypothesis holds. The turning point for each country will also be presented. The results from the regression made it possible to calculate at which level of GDP per capita the CO_2 emissions started to decline in each country. All interpretations of the results for the independent variable *ceteris paribus* apply, which indicates that the values of the Beta coefficients will apply when all other variables are constant.

	β_1	**β_2**	**Turning point**	**R^2**
Sweden	16.064 (<0.001)	-0.820 (<0.001)	9.795	0.900
Denmark	14.833 (<0.001)	-0.726 (<0.001)	10.216	0.968
United Kingdom	13.923 (<0.001)	-0.726 (<0.001)	9.589	0.911
France	17.323 (<0.001)	-0.899 (<0.001)	9.635	0.954
India	31.368 (<0.001)	-1.963 (<0.001)	7.990	0.831
Mexico	18.226 (<0.001)	-0.979 (<0.001)	9.308	0.587

Table 2: Regression results.

Table 2 illustrates the results of the regressions and the turning point for each country. R^2 is high for almost every country making the variables fit the model well at 90 percent or more. R^2 for India is slightly lower than the European countries at 83 percent which

still is a decent fit of the model. Mexico has the worst fit with 59 percent. Although, at a 5 percent significance level the results for all countries are statistically significant, making the results reliable.

β_1 is positive for all countries, indicating that an increase in GDP per capita has an increasing effect on CO_2 emissions per capita, this is what Grossman and Kreuger (1995) have found in their research. The results indicate that in Sweden a 1 percent increase in GDP per capita is estimated to increase CO_2 emissions per capita by 16 percent. This is consistent with Denmark, the UK, France, and Mexico. In these countries a 1 percent increase in GDP per capita is estimated to increase CO_2 emissions per capita in an interval of 14 percent to 18 percent. In the case of India, a 1 percent increase in GDP per capita is estimated to increase CO_2 emissions per capita by 31 percent. It is almost double that of the other countries.

Although, β_2 is negative indicating that the increasing effect on CO_2 emissions per capita will start to decrease over time. There could be an increase in a larger magnitude at an earlier stage in a developing economy. As time goes the CO_2 emissions per capita will start to decrease even if GDP per capita continues to increase. This can be illustrated with the turning points for each of the selected countries displayed in the following figures.

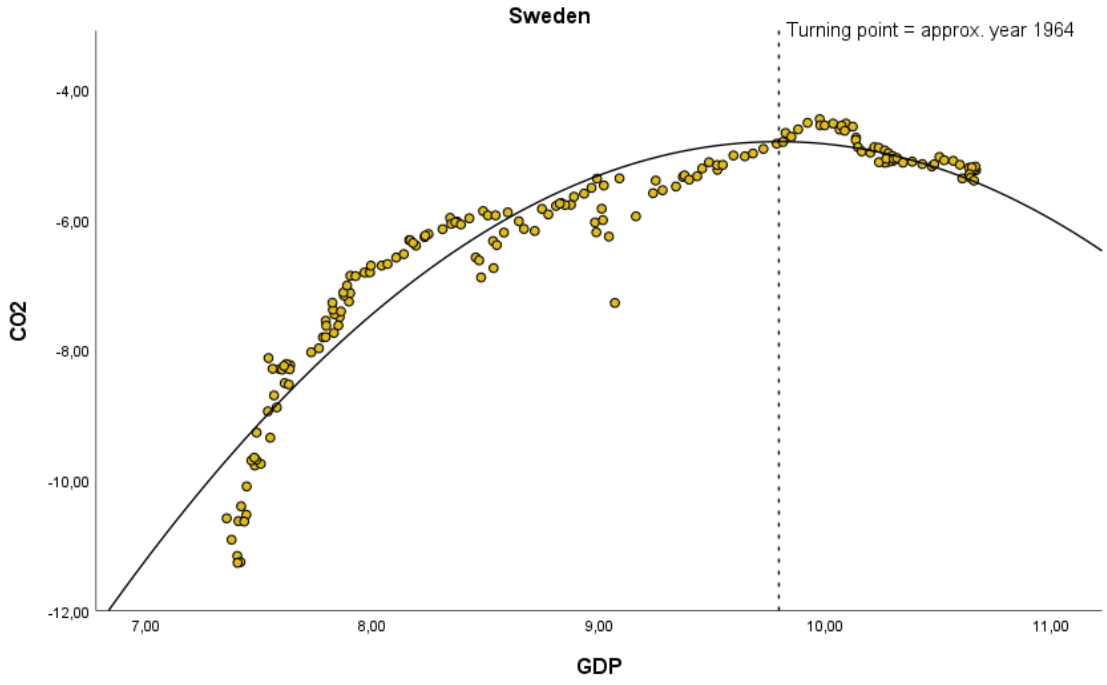

Figure 2: Estimate of the relationship between CO_2 emissions per capita and GDP per capita in Sweden.

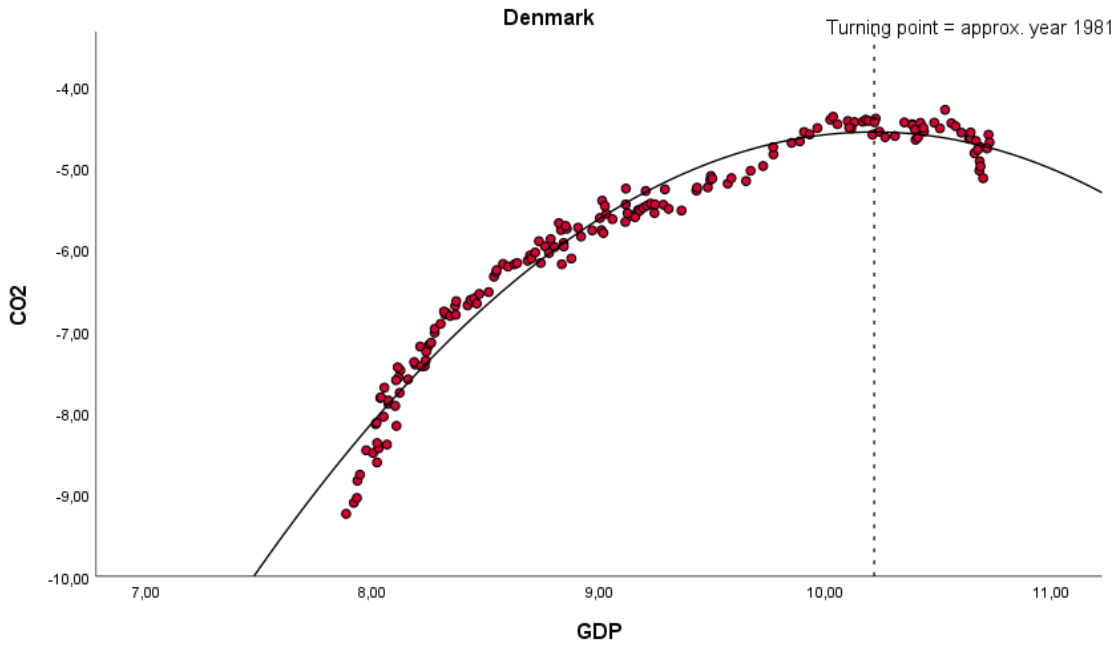

Figure 3: Estimate of the relationship between CO_2 emissions per capita and GDP per capita in Denmark.

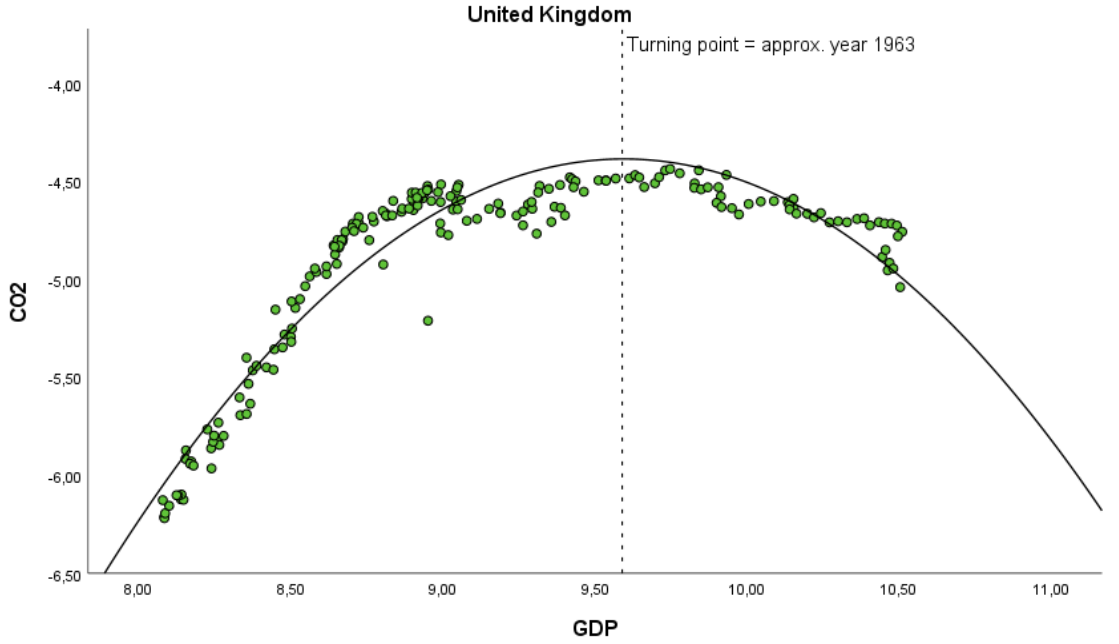

Figure 4: Estimate of the relationship between CO_2 emissions per capita and GDP per capita in the United Kingdom.

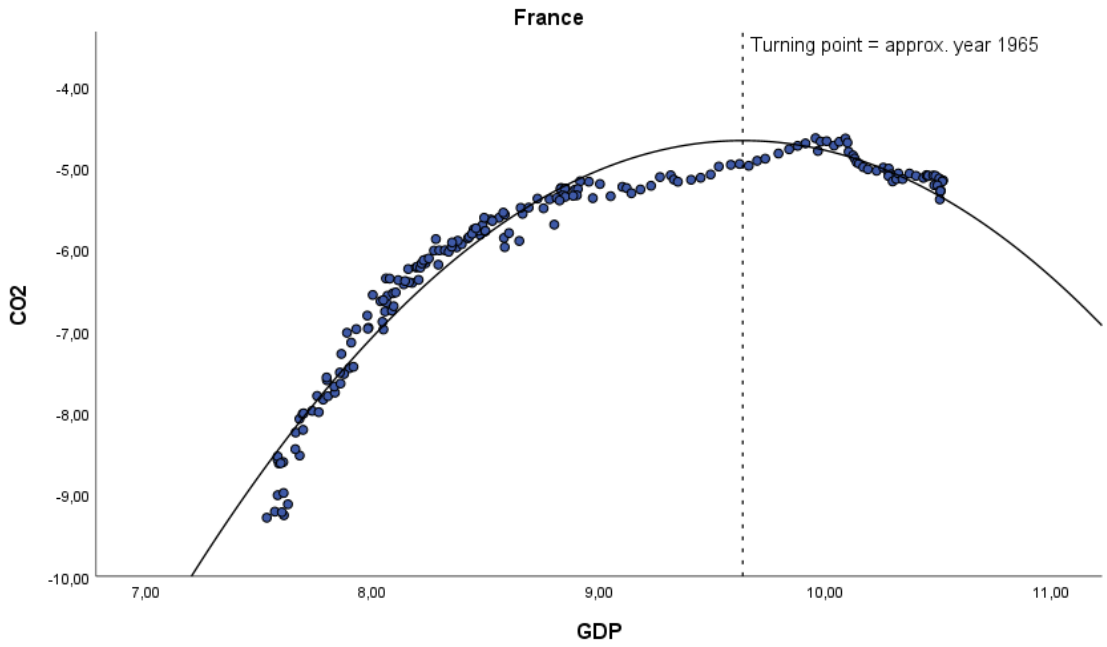

Figure 5: Estimate of the relationship between CO_2 emissions per capita and GDP per capita in France.

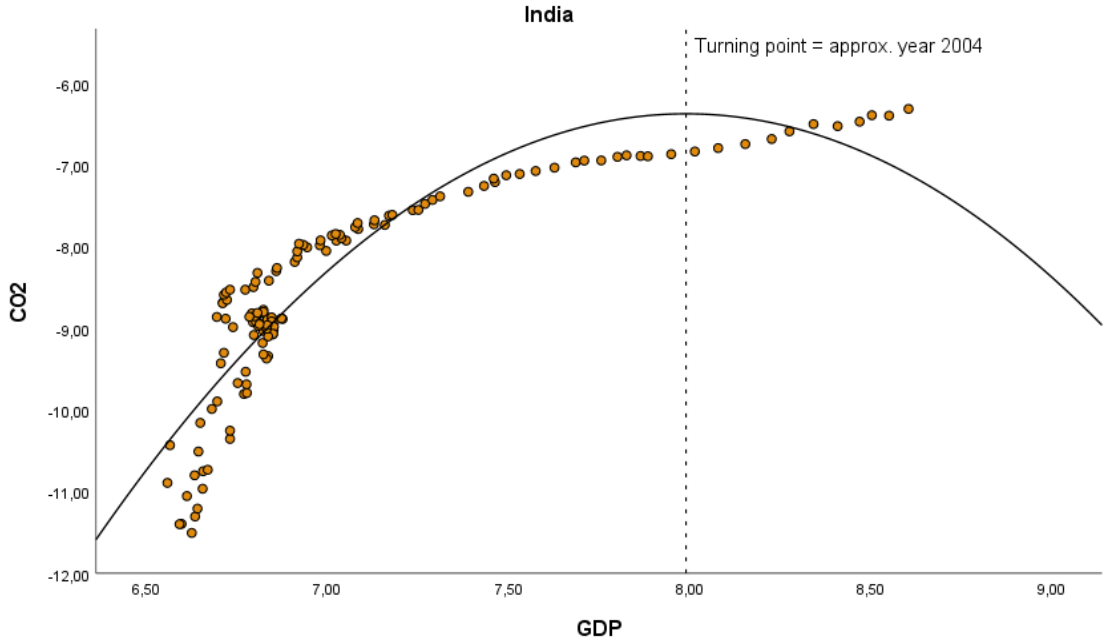

Figure 6: Estimate of the relationship between CO_2 emissions per capita and GDP per capita in India.

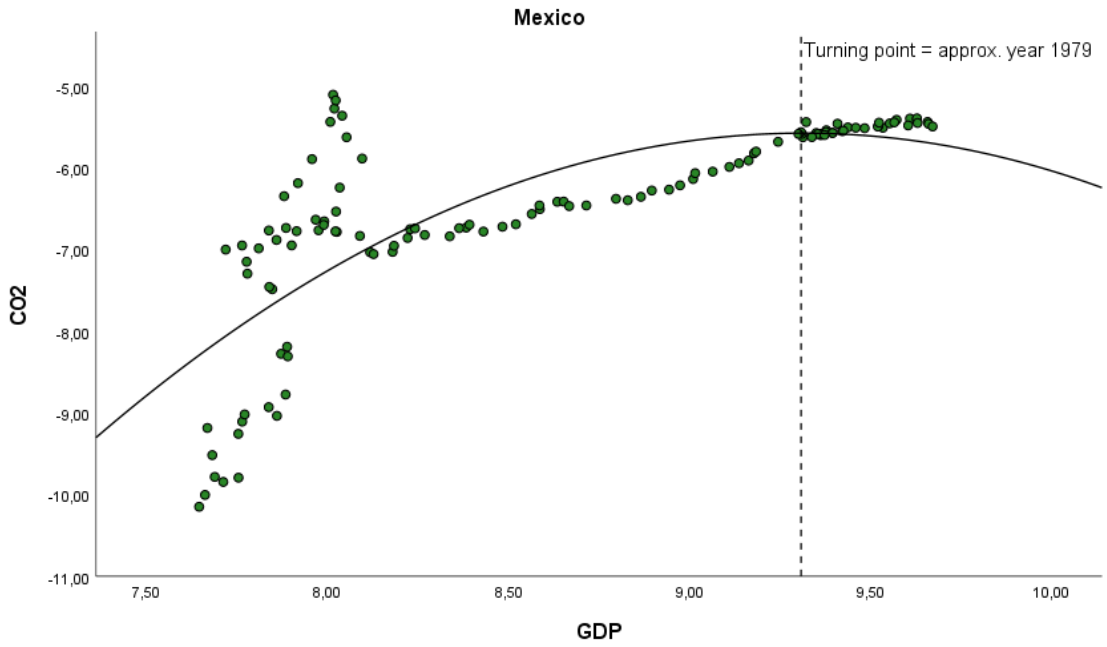

Figure 7: Estimate of the relationship between CO_2 emissions per capita and GDP per capita in Mexico.

The figures above illustrate the estimates of the relationship between CO_2 emissions per capita and GDP per capita. The values of the turning points are consistent through all countries where Sweden is at 9.795, Denmark at 10.216, the UK at 9.589, France at 9.635, India at 7.990 and Mexico at 9.308. The relationship has a clear shape of an inverted U for all our selected countries except for Mexico and India. In Mexico there is a hint of a decline, but not distinct. In India you can not detect a decline, but a continued increase is observed. According to our data they have not reached a turning point, and our results only show an estimate of when it could occur. The clear turning points occur in the late twentieth century.

6. Discussion

In this section we will have a discussion of our results and what factors may contribute to those. The results will further be compared to previous research.

The explanation for the relationship between economic growth and CO_2 emissions is well discussed. Grossman and Kreuger (1995) says economic growth generate improved technologies and environmental policies that will change the process of production at a developed income level. Meaning that developed countries instead will import products generating high pollution from countries with less policies. If a country at a developed stage were to stop producing high pollution generating products and import them instead will absolutely make the CO_2 emissions per capita decrease in that country. Our results are based on an analysis of mainly already developed countries, making this scenario possible. In the developed countries Sweden, Denmark, the UK and France the increase in CO_2 emissions per capita is consistent. For the same increase in GDP per capita CO_2 emissions per capita increase by approximately the same amount in these countries. In India, which is a developing economy, CO_2 emissions per capita increase almost double of that. This can thereby be because of the fact that India is still at a developing stage and a fast growing economy, and still produce high pollution generating products they are exporting to developed countries. Although, this is not a sustainable solution if all countries would continue like this because eventually there will be an end. It is only a selfish solution.

Beşe and Kalayci (2021) reject the EKC hypothesis, but they do have the same conclusion as other researchers that in order to improve the environment, policies are necessary, as well as renewable energy and authorities have a big role in financing this. Furthermore, as Jayadevappa & Chhatre (2000) discussed in their research, to actually help the environment, policies are important for all countries, both developed and developing. All countries face different challenges and because of that require policies suitable to their own needs. Developed countries need to minimize pollution as well as developing countries. Trade can generate economic growth for both parties, but it can also indicate a decline for the environment to countries if they must bear the burden of high pollution production with no further help. For the environment to improve, all countries need to contribute and have good relationships with each other. If countries used their comparative advantage in terms of using their already obtained resources and knowledge, and on the other hand having an openness and helpfulness towards each other, both countries and the environment could benefit in terms of economic growth and lower pollution. This relates to what Antweiler et al., (2001) explained in their research

that if a country opens up for international trade it can both generate economic growth but also decrease pollution.

Kaika and Zervas (2013) explains that other factors than income can affect the environment in a negative way and further illustrate an EKC pattern. In relation to this, Shi (2003) found in their research that the main source for CO_2 emissions is the fast growth of the population, thus this impact can vary depending on the income level for a country.

Our results illustrate that the turning point is higher in the countries where the population is lower. Looking at the countries with the highest and lowest population for our selection we have Denmark with a turning point at 10.216 and a population of 5.831 million, continuing with India that has a turning point at 7.990 with a population of 1.38 billion. The observations for Denmark started in 1843 while the observations for India started in 1884, making it 41 years of difference in obtained data. India is a country known for having large poverty indicating that a large number of India's population probably does not work in industries and contribute to the pollution related to the Industrialization. While Denmark was much earlier in adapting to Industrialization, and having a small population perhaps indicates that in Denmark the majority of the population have been involved in working in industries and contributing to a polluted environment. Since Denmark has a significantly smaller population than India this can indicate that Denmark's population might have had less poverty and higher income per capita. Thus, making it a richer country from the beginning.

Observed from our results the UK and France have similar populations and turning points. Where the UK has 67.22 million in population and a turning point of 9.589 and France has 67.39 million in population and a turning point of 9.635. The observations of the data for these two countries began in 1820. This indicates that the population growth is related to what level of GDP per capita there will be a turning point. Although, both Sweden and Mexico have similar turning points as the UK and France, and their population is not very similar. Making population not significantly important in terms of pollution, and it could instead depend on other aspects. Perhaps the fact that Sweden and Mexico have more developed environmental policies or they were faster in adapting greener industries because of better technologies. Mexico though, which is a developing country, illustrates similar values as the developed countries. However, Mexico's R^2 is much lower and is therefore less reliable.

Higher GDP indicates an increased value of private consumptions, investments, government spending, and net exports. The economy gets stronger, and at a certain stage, when the economy is developed our results indicate a turning point for the CO_2 emission per capita. An explanation of lower CO_2 emissions per capita could be increased investments. With increased investment new companies can be created. This would create competition in the market making companies want to try to improve. This brings innovation in areas such as technology and production. Today, awareness about the environment is vast. Companies must focus on the environment aspect and follow relevant regulations. Since the primary source of pollution comes from the industries the government has a very important role in this part. They must set regulations of how companies should operate, but also help to finance implemented policies. As Dasgupta, et. al. (2002) explains, to avoid pollution it is crucial for countries' governments to support and have finance programs related to environmental policies.

Consumers have a supporting role in society. With higher disposable income, consumers have the opportunity to make conscious choices such as buy eco-labeled products. In the long run this would eliminate the companies with a production process affecting the environment negatively. Although, there is a risk of higher income bringing overconsumption, that consumers buy more than they need. This has a negative effect on the environment as well. However, based on previous research we believe the government and companies have the primary responsibility regarding the production, marketing and policies.

Exports provide developing countries with economic growth. Although, increased exporting brings higher emissions because of increased transportation and production. Developing countries usually do not have the knowledge or the policies needed to reduce emissions. This is where developed countries could contribute with their environmental policies in order to keep emissions low but still let the developing countries increase their economy. As (Fang, et.al, 2019) indicated, developed countries should use their environmental policies and contribute to decreased CO_2 emissions. Further, Urban & Nordensvärd (2018) discuss the importance of decreasing the dependence of oil based transportation. This policymakers can take into consideration when choosing transport for exporting goods.

As long as humans exist on Earth they will produce pollution, it is unavoidable. Most research has stated that evolution in essentially every form such as economic growth and increased population, will cause pollution. It is humans who have constructed the

world to function like it does, and nothing can change that. What needs to be done from now on is to move forward and focus on what to do next in order to avoid an even more polluted world. Most agree that the pollution needs to be decreased and minimized. To find a sustainable solution to improve the Earth's environment and contribute to a sustainable life for future populations. Previous research discusses the same solutions, that environmental policies have a large effect on improving the environment and it needs to be implemented. As Panayotou (1993) explains, an environmental decline is inevitable; the environment needs to become worse before it improves. Now it depends on how a country's environmental policy is constructed. Thus, it is easier for developed countries to implement such regulations and policies since they have more resources and money to use. Our results illustrate that the developing countries have not yet reached a clear turning point and further no significant decline in CO_2 per capita. Support from developed countries could stimulate the process to decrease the CO_2 emissions. This is why good cooperation between countries is important. An openness, teamwork and trade can generate growth to everyone, even the environment could benefit in the long-run. All countries have an important role, both developing and developed, regardless of geographical location. This is a matter of supporting each other to find sustainable solutions.

Today, both national and global goals exist such as the Paris agreement and Agenda 2030. According to our study environmental policies are certainly important in order to have a diminishing effect on pollution. This indicates that the world is considering the environment and is trying to be better. Implementing these environmental goals for countries all around the world and being a part of them is a great example of an attempt of global cooperation which, even if a little bit successful, may be crucial for the future.

7. Conclusion

In this section we will finalize our thesis and conclude our results. Finally, our thoughts for future research will be discussed.

Our main purpose for this thesis was to examine if the Environmental Kuznets Curve hypothesis holds. We have chosen to apply it to six selected countries. Our obtained results indicate that the EKC hypothesis holds which also agrees with our hypothesis, but the illustrations show a vague turning point for India and Mexico. The CO_2 emissions per capita will increase in relation to a growth of GDP per capita. However, our results indicate that CO_2 emissions per capita will have a turning point after a certain amount of time when it has reached a certain level of GDP. After reaching the turning point the CO_2 emissions per capita will start to decrease even if GDP per capita continues to increase. This is in accordance with what Grossman and Kreuger (1995) have found in their research and describe this relationship as an inverted U-shape. This is what our results illustrate in Figure 2, 3, 4 and 5. That in an earlier stage in a developing economy it will generate unavoidable damage to the environment, but later it will improve as the economy has reached a developed level. Figure 6 and 7 supports that developing countries have not yet reached a clear turning point.

Finally we could claim that it is mostly in the hands of the policymakers and the corporate world to decrease the environmental footprint. Further, the average consumer could contribute in some ways by making conscious choices when consuming and buying products with eco-labels and produced from sustainable resources.

Since this research is based on mainly developed countries, future research related to this thesis could include more developing countries for instance from Africa and South America. It could possibly provide an interesting study since our results are not consistent regarding developing countries and the result of India differentiates considerably. To get a further in depth study, a comparison between developed and developing countries could be performed. To get perspective on what factors causing the environmental decline could be and which types of countries mostly contribute to it. Further, studying the difference and the effectiveness of the environmental policies between developed and developing countries could provide valuable information.

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