Is there a relationship between economic growth and carbon dioxide emissions?

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Abstract

This study examines the relationship between per capita GDP and per capita emissions of the greenhouse gas carbon dioxide (CO_2) in order to observe the possible influence of economic growth on environmental degradation. The study is conducted on 69 industrial countries as well as 45 poor countries using cross-sectional data. Several theories with different views on the possible impact of economic growth on environmental degradation are studied. All studies conclude there is a relationship between economic growth and environmental degradation, the impact of this relationship is however different. The empirical result of the cross-sectional study implies there is in fact a relationship between per capita GDP and per capita carbon dioxide emissions. The correlation is positive, which suggests growing per capita GDP leads to increasing carbon dioxide emissions. No turning point is found at which emissions start to decrease when reaching a high enough GDP, as some theories claims. Market economy mechanisms are according to the result not enough to lower the emissions and thus legal regulations are needed to avoid further environmental degradation.

Keywords

Gross Domestic Product (GDP), Economic growth, Environmental degradation.

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1. Introduction

The issue of environmental degradation is one of the greatest challenges of our time. The consequences of the heavy pollution that has been going on for many years are horrendous both in the short and long run as well as on a local and global scale. From a local perspective, pollutants being emitted in the air as well as in streams and lakes contaminate the drinking water and affect the local ecosystems directly. When changing the dynamic of an ecosystem, the balance of organisms that provides us with the clean air we breathe and the food we eat gets disrupted. This could have disastrous effects on all parts of society, including poverty, starvation, unemployment, living situations and general health of the population (Watson & Albritton, 2001). In fact, emissions from manufacturing plants and other polluting establishments affects humans directly by causing sickness including different types of cancers, inflammations and heart diseases (Pope & Dockery, 2006).

Environment degradation is a big problem not only for local areas but for the whole planet on a global scale. As pollutants accumulate in our atmosphere, the so-called greenhouse effect causes global warming. As the global temperature increases, the arctic ice melts more rapidly, which rises the sea level (McMichael, et al., 2006). Many high populated cities all over the world are situated in coastal areas and are threatened to get flooded. Another unwanted effect of global warming is the increased drought in already badly affected areas, making it almost impossible to live in areas close to the equator (Dai, 2013). The issue of pollution and climate change, both locally and globally, is not merely a question of moral and respecting nature. It is also a question of human survival, and the world as we know it.

Economic growth is often pointed out to be the cause of environmental issues based on the notion that increased production equals increased pollution. However, some hypothesise that the relationship between economic growth and environmental degradation is more complex than that. Some even argue that economic growth could improve the environment (Dinda, 2004). In a world where economies continue to develop and production constantly grows, it is important to understand the relationship between economic status and environmental degradation.

The environmental consequences of economic growth have been studied many times before with varying results. The objective of this study is to investigate if there is a relationship between economic growth and carbon dioxide (CO_2) emissions. Will a richer economy worsen the environmental quality even further due to increased emissions, or will an increase in per capita GDP not only increase the living standards but also contribute to a better, less polluted planet?

The level of environmental degradation is quantified as per capita carbon dioxide (CO_2) emissions. It is well known that CO_2 is one of the worst pollutants contributing to environmental issues (Houghton, 1996). Other pollutants causing environmental degradation are not included in this study, however, the theories used in this study could be applied for other pollutants as well. When measuring the economic status of a country, per capita gross domestic product (GDP) is normally used, as is the case in this study. GDP is defined as the market value of all final goods and services produced in one period (Lequiller & Blades, 2006). The research question of this study is as follows: Is there a relationship between per capita GDP and per capita CO_2 emissions?

In order to try to answer the research question at hand, previous studies and theories are investigated. An empirical study is performed, focusing on industrial countries but also including poor countries for comparison reasons. The results are then analysed and compared to the relevant theories.

2. Theory

The theoretical ground on the subject of economic growth and environmental degradation is presented in this chapter. The three most common theories used to describe the relationship between economic growth and environmental damage are examined, followed by a comment on the problematisation of cross-sectional studies. The chapter is concluded with a theoretical summary.

2.1 The three curves of environmental degradation and economic growth

The Environmental Kuznets Curve

The Environmental Kuznets Curve (EKC) first got recognized in the World Development Report (1992) as the relationship between ambient concentrations of sulphur dioxide and per capita GDP in 47 cities distributed over 31 countries. The EKC follows an inverted U-shape where per capita income and sulphur dioxide concentration are positively correlated to a certain point at which the trend turns and the opposite relationship can be observed. The name of the EKC is inspired by the similar relationship between income inequality and economic growth proposed by Kuznets (1955). The EKC was later applied to not only sulphur dioxide concentrations and urban areas but to general environmental degradation worldwide. The empirical support for this generalization is scarce and has been criticized by many (Stern, 2004). Still, the hypothesis of an inverted U-shaped relationship between per capita income and environmental issues lives on.

The theory of the EKC is based on the effects of the transition from agricultural production in rural areas to industrial production in urban areas. As the industrial production becomes more intensive, pollution increases. With time, and higher income levels, the industrial-heavy production is phased out in favour of a more high-technological and service-centralized production. This development is thought to counteract the increase in pollution and eventually cause the pollution levels to drop. The effects of a high-technological and production-effective economy is thought to contribute to the decrease in pollution, as well as a higher demand for a clean climate from consumers and higher political interests in the wellbeing of the environment (Dinda, 2004).

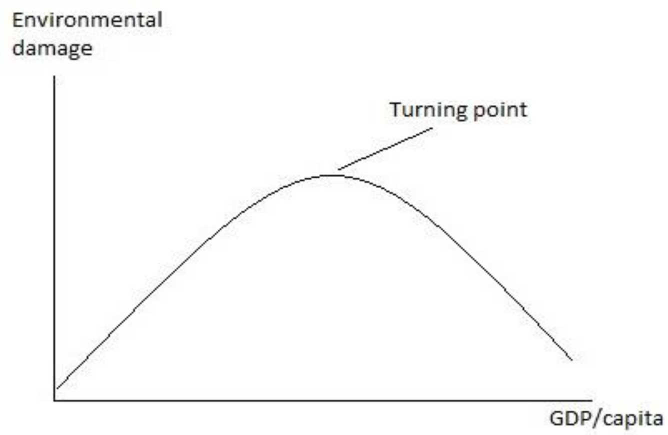

Figure 1. The Environmental Kuznets Curve (EKC). Per capita GDP is represented on the x-axis and environmental damage on the y-axis.

For a more in-depth view of the mechanisms behind the shape of the EKC, one must define the different aspects of the EKC hypothesis. The initial increase in environmental degradation as economies grows is called *the scale effect*. Economic growth implies increased pollution levels simply due to increased output. Increased output requires increased input and thus more natural resources are used and pollution levels rise. The pollution is thought to increase to scale with economic growth (Grossman & Krueger, 1991).

The shape of the EKC indicates the existence of other mechanisms offsetting the scale effect. These mechanisms added together acts as the decreasing effect of environmental degradation as economies grow. The mechanisms thought to counteract the scale effect and ultimately offsetting it completely are described as the technological effect, the composition effect, effects of international trade, increased demand for a clean environment and strengthened regulations.

The technological effect describes the effects of technological improvements and a more effective production. The incentives for new technology is usually not based on environmental concerns on firm-level, but the environmental benefits of a more effective production can still be utilized. As basic economic theory tells us, a competitive market puts pressure on firms to sell products and services at a low price. In order to maximize profits, firms try to make production cheaper by investing in both existing effective technology and in developing new technology internally. Richer countries can afford investments in R&D and thus technological development goes hand in hand with economic development (Komen, et al., 1997). A more effective production requires less input, which is thought to create a diminishing effect on pollution levels.

When an industry-heavy economy moves towards a more service-intensive economy, the relative change in the composition of goods and services produced is called *the composition effect*. Governments and firms increase their consumption in services when the economy grows, which could be explained by the increased need for R&D as mentioned previously, as well as an increased need for practices of the law, teachers, doctors and other professions essential in a modern society. The population increase their consumption of household related services as their income increases as well. These are examples of actions that increase per capita GDP without increasing pollution levels. In other words, the pollution levels may not increase to scale with economic growth if the composition of output is changed (Vukina, et al., 1999).

When richer countries invest more in R&D, use high-technology equipment and operate in a more service-centralized economy, it creates large differences in the preconditions of *trade* between developed and developing countries. Basic trade theory implies economies specialize in products they are relatively effective producers of, in other words have a comparative advantage in. As developed countries have a high-technology intensive production and developing countries have a low-technology intensive production, the results of international trade divides the global production into “dirty” production with high pollution levels in developing countries and “green” production with lower pollution levels in developed countries (Jänicke et al., 1997; Stern et al., 1996). The displacement hypothesis describes this displacement of dirty industries from developed to developing countries. The pollution is not thought to decrease globally; its intensity is simply moved from one part of the world to another. Additional underlying factors behind the creation of “Pollution Havens” are the differences in regulations and costs of production (Dinda, 2004). Another effect of international trade is the increase in market size. As mentioned previously – as the market increases in size, so does the competitive pressure to increase investments in R&D. This could have a decreasing effect on pollution levels. However, another point made about the greater market is that there is nothing you cannot buy – the availability for all kinds of goods increase and people might buy more unnecessary products, which increases the production volume and thus the pollution (Dinda, 2004).

Another mechanism argued to play a role in the decrease of environmental degradation is *the increased demand for a clean planet*. As income increases, so does the willingness to pay for a clean environment. At some point, the willingness to pay for a clean planet increases relatively more than the increase in income (Roca, 2003). Consumers express this through choices of less environmentally damaging products, donations to environmental organizations and voting for environmentally friendly political parties. The income elasticity of environmental quality demand is discussed by many and is proposed to play an important role in figuring out the mechanisms behind the EKC (Beckerman, 1992; McConnell, 1997).

Hettinge et al. (2000) states pollution grows unless *environmental regulation* is strengthened. Different types of regulations that is used to decrease pollution levels include emission charges and subsidies, emission standards and property rights (Cunningham & Sinclair, 1998). Regulations are decided by politicians, and so the question is if economic growth motivates politicians to introduce additional environmental regulations. Since people have a higher demand for a clean environment when income grows, the median voter theorem could shed some light to our case (given the state in question is a democracy). The median voter theorem, introduced by Black (1948), states politicians adopting their politics to the median voter should maximize the number of votes in their favour. This could explain why politicians in countries with growing incomes tend to strengthen environmental regulations - to gain voters.

The Brundtland curve hypothesis

The Environmental Kuznets Curve is not the only hypothesized curve used to describe the environmental effects of economic development. The WCED report (World Commission on Environment and Development) from 1978 named “Our future”, also known as the Brundtland report, presents another view of the relationship between GDP and environmental damage. The authors of the report argue that poor countries cause high levels of environmental degradation initially, followed by a decrease in environmental degradation when the economies grow until a turning point is reached, at which environmental degradation increases. Contrary to the EKC, the Brundtland curve is U-shaped.

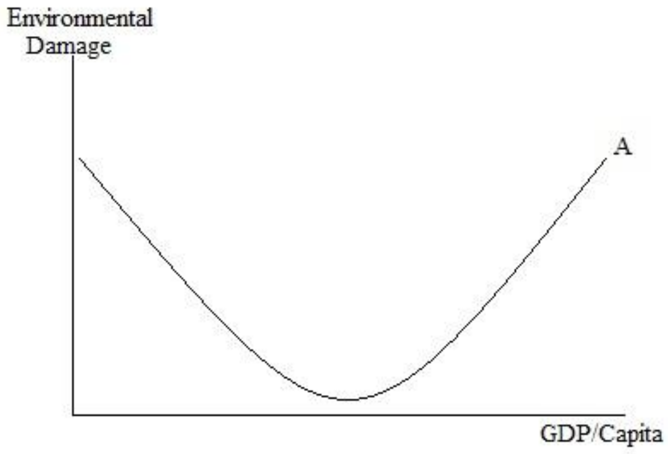

Figure 2. The Brundtland Curve. Per capita GDP is represented on the x-axis and environmental damage on the y-axis. The level of environmental damage follows a U-shaped curve (A), where the lowest environmental damage is caused by middle-income economies.

According to the Brundtland Curve hypothesis, countries in poverty cause high damage to the environment due to the lack of ability to prioritize environmental wellbeing. High levels of deforestation and overexploitation of sensitive land are necessary for citizens living in high poverty in order to make a living (Larsson, et al., 2011). As the economy grows, environmental damage decreases (mainly due to the mechanisms holding the level of environmental damage high is alleviated, that is, poverty decreases). When the turning point is reached, the pollution is thought to increase with economic growth and eventually get as high as originally. The positive trend in environmental degradation is according to the Brundtland Curve hypothesis caused by increased consumption which leads to increased production. The environmental damage caused by increased production is as damaging to the environment as the problems caused by poverty according to the theory (Field & Field, 2013).

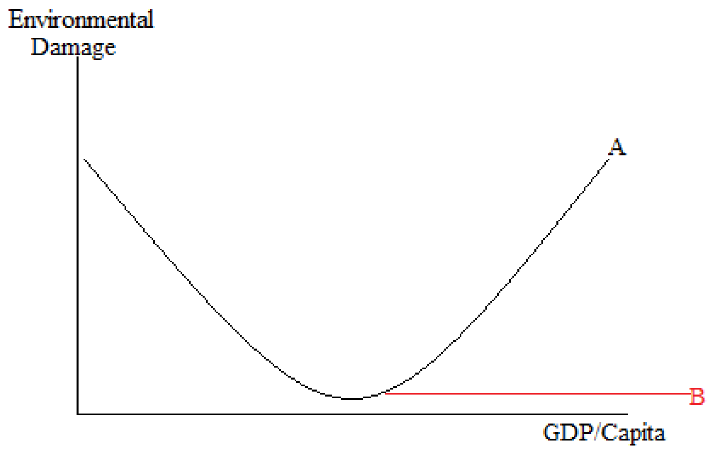

Figure 3. The alternative Brundtland Curve. Per capita GDP is represented on the x-axis and environmental damage on the y-axis. The alternative path (B) implies a stagnation in the level of environmental damage instead of an increase in environmental degradation as the U-shaped Brundtland curve (A).

The Brundtland curve might make the future seem dark, but the curve includes an alternative prediction. This path, marked (B) in the figure above, suggests a possibility for a stagnation of the level of environmental damage at the turning point. This path, at very low levels of environmental damage, is only possible if green technology and development is of high priority. Wealthy countries could invest in green, innovative production in order to counteract the increasing pollution levels (Bratt, 2012). Depending on how creative high-income countries are willing to get in the context of environmental friendly technology, wealth could have a positive effect on the environment. One of the mechanisms allowing for green development is increased willingness to pay for a clean environment. (Larsson, et al., 2011; Field & Field, 2013).

The environmental Daly curve hypothesis

In 1973 the ecological economist Daly writes "Toward a steady state economy" where he describes the relationship between economic growth and environmental damage. Daly argues that today's economy driven by increased production is doomed and a steady-state type of economy could be the alternative (Daly, 1973). Daly writes about the subject again in 2004 in "Ecological Economics: Principles and Applications", where Daly questions the impact of human creativity and innovation and argues that the incentives for green technology is not enough to lower pollutions. Some natural resources are non-renewable, and others are being used at a higher pace than what is required in order to keep a sustainable amount. Daly argues that green development is not enough to offset the usage of scarce natural resources and the overall environmental damage. Daly states that although the incentives for a better, high quality environment might occur when a country reaches a particular point of wealth, the damage will already be too severe. The attempts to create a green production and a sustainable consumption will not be good enough to decrease the environmental damage. The environmental damage will increase as the economic status grows in a country, no matter the willingness of the citizens and policymakers (Daly & Farley, 2004). The environmental Daly curve hypothesis suggests that an increase in per capita GDP will lead to higher environmental damage. The environmental degradation will increase with per capita GDP due to increased production. The Daly curve does not indicate a turning point at any level of wealth, such as the EKC and the Brundtland Curve (Bratt, 2012).

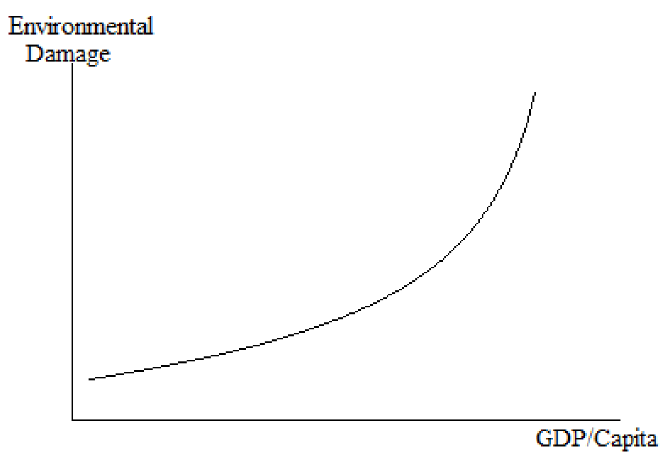

Figure 4. The Environmental Daly Curve. Per capita GDP is represented on the x-axis and environmental damage on the y-axis. The environmental damage increases with economic growth.

2.2 The problematisation of theories based on cross-sectional studies

The theories mentioned above are either based on, or empirically supported by cross-sectional studies, which only includes data that differ in space and not in time. This implies that we assume all countries follow the same curve of environmental degradation with a growing economy. Instead of only using cross-sectional data, time-series studies are requested by many (Ray, 1998; Dinda, 2004). The problem is that time-series studies require data from a long period of time, which in the case of carbon dioxide emissions or environmental degradation in general is non-existent. Ray (1998) states, when describing income inequality, cross-sectional based graphs cannot describe the hypothesized correlation in each country separately, the shape of the inverted U is to some extent a product of the statistical methodology used. The individual country's slope at the time the data was obtained does not necessarily have to be tangent with the slope of the cross-sectional curve where this country is placed. This concept might seem difficult to grasp and therefore shown graphically below.

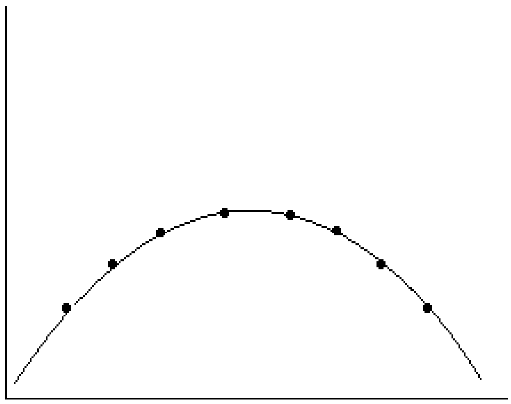

Figure 5. The dots represent different countries along a curve based on cross-sectional data.

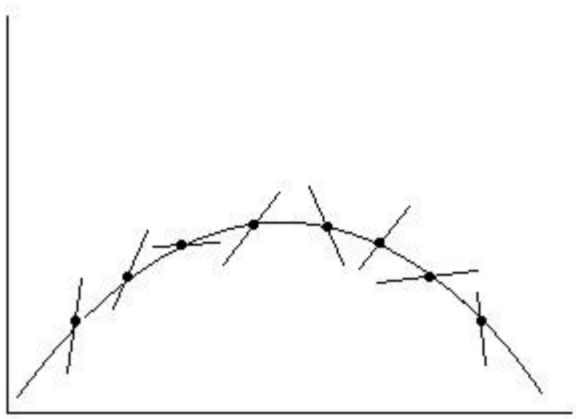

Figure 6. The dots represent different countries along a curve based on cross-sectional data. The slopes for each individual country is not tangent to the slope of the cross-sectional curve at that particular point.

Ray also points out that, when measuring income inequality, the economies situated at the top of the curve (at the turning point) are all Latin American. This could imply that the shape of the inverted U is only an artefact of Latin American countries having higher per capita GDP and higher income inequality for structural reasons only, not due to per capita income. This problematisation could be applied to all kinds of inverted U-shaped curves supported by cross-sectional data and thus theories on environmental degradation as well.

2.3 Theoretical summary

The relationship between economic growth and the environment is a relatively new subject in economics and due to this, there are not many established theories on the area. However, the most extensive theory is the EKC theory which has theoretical roots in classical economic topics such as income elasticity, trade and competitive markets. The EKC follows an inverted U-shape where the environmental damage initially increases with a growing economy to later decrease after a certain point of wealth. The opposite trend can be observed for the Brundtland curve hypothesis, where environmental damage initially decreases to later increase, or potentially stagnate, after a certain point of economic growth. The similarities between these two curves is the existence of a turning point as well as the theoretical explanation behind the increase in environmental damage. Even though it might not be called the scale effect in the Brundtland curve theory, the mechanism is the same. The reason for the decrease in environmental damage however differs between the two theories. For the EKC theory, it is the effective production, international trade and increased demand for a clean planet that mainly drives down environmental damage at the later stages of economic growth. According to the Brundtland curve hypothesis, the reduced poverty creates possibilities to prioritize the environment, which drives down the environmental damage at an early stage of economic growth. The two contradicting theories are accompanied by a third, the Daly theory, that does not include any type of turning point. According to the Daly theory, the environmental damage increases with economic growth unless the very principles of the modern world economy changes. Again, the scale effect is responsible for the increase in environmental damage and is the common denominator for the three most acknowledged theories on the subject. The results of the empirical part of this study will be compared to the theories examined and the possible similarities and differences will be discussed.

3. Previous studies

There are several previous studies addressing the consequences of economic growth on the environment. In order to get the whole picture, both literature and empirical studies are presented below. The studies are presented one by one and summarised at the end of the chapter.

Three Totally Different Environmental/GDP Curves (2012)

In this paper Bratt compares three different theories explaining the connection between environmental degradation and GDP. The theories discussed are the Environmental Kuznets curve (EKC), the Brundtland curve and the Daly curve. All three hypotheses recognize that the level of GDP affect the environmental degradation, but in different ways. The EKC hypothesis argues that an increasing level of GDP would initially increase pollution until a certain level of GDP, at which the level of pollution starts to decrease. The relationship between environmental degradation and economic growth is in the case of the EKC graphically shown as an inverted U-shape. The Brundtland curve theory provides another picture, where the graphical form is the opposite, U-shaped, which implies the poorest and wealthiest countries to have the highest levels of pollution. The Daly curve theory suggests increasing levels of pollution with an increasing GDP that keeps on going, without any turning point. Bratt points out that the three different environmental/GDP curves deals with different aspects of environmental degradation. The EKC hypothesis could be used when measuring emissions or concentration. The Brundtland curve could be used when measuring production and the Daly curve when measuring consumption. Bratt's final conclusion is that even though either curve could be true, the most possible scenario seems to be a positive, monotonic relationship between environmental degradation and GDP.

Environmental Kuznets Curve Hypothesis: A Survey (2004).

In this survey Dinda review the methods, explanations and results of some of the previous studies that have found empirical evidence for the EKC hypothesis. Dinda starts off by summarizing the most important parts of the theory behind the EKC. These are described as the income elasticity of environmental quality demand, the scale effect, the technological and composition effects, international trade, the market mechanism and legal regulations. Dinda suggests that the important question is whether or not economic growth could be a solution instead of the reason for environmental degradation. Empirical studies are reviewed as well as the critiques that have followed the EKC hypothesis. Dinda concludes that there are mixed evidence for the EKC and there is no specific per capita income level that represents the turning point at which the environmental degradation starts to decrease. This makes it impossible for policy makers to agree on one single policy that reduces pollution levels with a growing economy. Dinda suggests further studies examining the dominant mechanism behind the EKC and to include more time-series analysis for individual economies. The author also urges for caution concerning unknown pollutants when developing new industrial technology.

Economic Growth and Environmental Degradation: The Environmental Kuznets Curve and Sustainable Development (1996)

Stern et al. discuss the relationship between economic growth and environmental degradation in this literature review, where the concept of the Environmental Kuznets Curve (EKC) is critically examined. The study contains a number of empirical studies concerning economic growth and environmental degradation previously published. Stern et al. found that in some cases economic growth affects the environment in a way consistent with the EKC, and in other cases there was no consistency with the EKC hypothesis at all. The authors suggest the difference in outcome could be due to differences in the incentives to preserve the environment. Stern et al. conclude that the EKC cannot be applied in reality without strong incentives from policymakers and a general willingness from the civilians to reduce environmental degradation.

Environmental Quality and Development: Is There a Kuznets Curve for Air Pollution Emissions? (1994)

Selden & Song investigate the correlation between air pollution and economic growth for four airborne emissions, Sulphur dioxide (SO2), Nitrogen oxide (NO2), suspended particulate matter (SPM) and Carbon monoxide (CO). Both time-series and cross-sectional data are collected from the World resources (WRI 1991). Decreasing levels of emissions at high-income levels was found for all tested emissions except CO. The study shows an effect similar to the EKC where a sufficiently high-income level could reduce emission levels for some pollutants (SO2, NO2 and SPM), however, the authors state that the turning point where the emissions starts to decrease is higher than originally thought. Given the current per capita GDP levels of the low-income economies of the world, there is a long way to go before global emission levels starts to decrease.

On the relationship between energy consumption, CO_2 emissions and economic growth in Europe (2010)

Acaravci & Ozturk examine the relationship between economic growth, carbon dioxide (CO_2) emissions and energy consumption in European countries. In the study the authors use a cointegration test in nineteen countries distributed over Europe to observe the possible connection between the three variables. Acaravci & Ozturk state that the empirical analysis show evidence of a long-run positive relationship between the variables for some of the countries tested, however, there was no evidence of a positive long-run relationship for others; therefore, the study does not provide a unanimous result. Acaravci and Ozturk conclude that the EKC hypothesis cannot be seen as valid for most of the European countries.

STOKING THE FIRES? CO_2 Emissions and Economic Growth (1992)

Holtz-Eakin & Selden address the topic of global warming, using panel data from 130 countries to estimate the possible relationship between per capita income and carbon dioxide emissions. The authors use the results received from the study to forecast the global carbon dioxide emissions. The study shows four major results. The first result is a diminishing propensity to emit CO_2 emissions as the economies develop, which cannot be detected when using cross-sectional data only. The second result is that although the marginal propensity to emit is diminishing with a growing economy, the accumulative CO_2 emissions will globally increase at an annual rate. This outcome is thought to be caused by the fact that countries with the highest marginal propensity to emit CO_2 are also the countries with the highest economic and population growth (low-income economies). The fourth major result is that the pace of economic growth does not dramatically alter the future levels of carbon dioxide emissions when performing a sensitivity analysis.

Summary of previous research

Previous studies presented in this chapter show a parted view of how economic growth affects environmental degradation. All authors conclude that there is in fact a connection between economic growth and environmental degradation, but the outcomes of the studies differ. Some of the studies show a tendency of decreasing emissions when the economy grows. However, some studies conclude that increases in GDP should cause further increases in emissions. The EKC hypothesis is the theory most frequently studied concerning environmental degradation and economic growth and thus naturally take more focus than other theories in this chapter.

4. Empirical analysis

The empirical part of the study is presented in this chapter. The regression models and the variables used are explained followed by a presentation of the results. The results are described and compared to prior expectations. Firstly, the relationship between per capita GDP and per capita CO_2 emissions is tested for industrial countries (regression model 1). Because of a much larger availability of data for industrial countries compared to poor countries, a more extensive model is used when studying industrial countries. Therefore, the regression model for poor countries (regression model 2) includes fewer variables and countries. The form of regression used is Ordinary Least Squares (OLS) for both models.

Regression model 1

CO_2 emissions = $\beta_0 + \beta_1 GDP/Capita - \beta_2 (GDP/Capita)^2 - \beta_3 Renewable\ Electricity + \beta_4 Electricity\ Coal + \beta_5 Livestock\ Production\ Index + \varepsilon$

Regression model 2

CO_2 emissions = $\beta_0 + \beta_1 GDP/Capita - \beta_2 (GDP/Capita)^2 + \varepsilon$

Explanation of variables

β_0 = Constant for the regression model

β_x = Coefficient for variable x

CO_2 emissions = Carbon dioxide (CO_2) emissions measured in tons per capita.

$GDP/Capita$ = GDP per capita in current US dollars (2016).

$(GDP/Capita)^2$ = GDP per capita squared in current US dollars (2016).

$Renewable\ Electricity$ = The share of electricity generated by renewable power plants of total electricity generated by all types of power plants, in percent.

$Electricity\ Coal$ = The share of electricity produced from coal-sources of total electricity production, in percent.

$Livestock\ Production\ Index$ = Index of the value of livestock produce (the prices used are weighted average international prices in 2004-2006), including commodities such as food, fibre and skins.

ε = Error term

Data and specifications for chosen variables

The data used in the regression analyses are provided by the World Bank database and represents the year of 2012. This is due to lack of relevant data in the more recent years. The countries included in regression model 1 are industrial countries, which in this case is defined as countries with a HDI *(Human Development Index)* over 0.5. The HDI is a measurement of a country's living conditions as well as the economic and social standards. The HDI measurement combines GDP, the level of education and the life expectancy among other variables in order to estimate the general well-being of a country (Sagar & Najam, 1998). The HDI value of 0.5 is often used as a criterion for an industrialized country (Wolff, et al., 2009). The sample is chosen based on HDI values from the Human Development Report 2013 (Malik, 2013). Countries included in the regression analyses using regression model 2 is made up of three samples. The poor sample includes countries defined as "low development countries" by the UN, based on HDI values in 2013 (Malik, 2013). The sample for industrial countries are the same as in regression model 1 and the third sample is made up by all countries with available data worldwide. The statistical software used for all regressions performed is Gretl© (Cottrell & Lucchetti, 2016).

The dependent variable Carbon dioxide ($\mathrm{CO_2}$) emissions is expressed in tons $\mathrm{CO_2}$ emitted per capita for one period. $\mathrm{CO_2}$ is one of the pollutants with greatest contribution to global warming as well as local environmental degradation (Solomon, et al., 2009). It is crucial to understand what affects CO_2 emissions in order to make decisions regarding the wellbeing of the environment.

The gross domestic product (GDP) is a measurement of the market value of all goods and services produced in one period. The data used in this study represents the GDP/capita in 2012, measured in 2016 years US dollars' value. The variable GDP/capita is very commonly used to measure economic status as is the case for previous research in the field of environmental economics. The expected outcome varies with different theories.

To test for polynomial form, the variable GDP/capita squared is included in this model. This variable tells us if the EKC or the Brundtland curve is possible as they are of polynomial form. The signs of the coefficients tell us if the curve is potentially U-shaped as the Brundtland curve or the opposite as in the EKC.

The energy sector is the greatest contributor to CO_2 emissions globally and thus energy output is a relevant variable in the regression model. The variable Renewable Electricity is the share of electricity generated by renewable power sources, in percent. Renewable electricity production emits less CO_2 than non-renewable electricity production, therefore the expected correlation between renewable electricity output and carbon dioxide emissions should be negative.

Unlike renewable electricity, the electricity production made from coal-sources should have a positive effect on the CO_2 emission level. Producing electricity from coal-sources is still common, despite the high levels of CO_2 being emitted. The variable Electricity Coal measures the share of electricity produced from coal-sources, in percent.

Livestock production demands a high amount of natural resources and contributes to the environmental degradation by emitting out greenhouse gases, such as CO_2 (Thornton & Herrero, 2010). The livestock index measures the value of the production of commodities such as food, fibre and skins. A higher livestock index is expected to increase CO_2 emissions.

Expected outcome

Variable	Description	Source	Expected Outcome
CO_2 emissions	The amount of carbon dioxide (CO_2) emitted, in tons per capita in 2012.	World Bank database	Dependent Variable
$GDP/Capita$	The GDP per capita in 2012, measured in 2016 value US dollars.	World Bank database	+/-
$GDP/Capita^2$	The variable GDP/capita squared.	World Bank database	+/-
Renewable Electricity	Renewable electricity output in percent of total electricity output, year 2012.	World Bank database	-
Electricity Coal	Electricity production from coal-sources in percent of total electricity production, year 2012.	World Bank database	+
Livestock Production	Index of livestock production, such as food and skins, year 2012.	World Bank database	+

Table 1. Table of regression variables, data sources and expected outcome.

4.1 Regression results for industrial countries

Dependent variable CO_2 emissions					
Models	**1a**	**1b**	**1c**	**1d**	**1e**
Independent variable	Estimated Coefficient (Standard Error)	Estimated Coefficient (Standard Error)	Estimated Coefficient (Standard Error)	Estimated Coefficient (Standard Error)	Estimated Coefficient (Standard Error)
Constant	−0.159771 (2.75976)	3.18246 *** (0.828846)	1.17512 (2.91617)	−1.27620 (2.85723)	3.03509 *** (0.755046)
GDP/Capita	0.000228978 *** (5.09626e-05)	0.000201951 *** (4.65197e-05)	0.000237729 *** (5.44037e-05)	0.000242500 *** (5.31112e-05)	0.000235249 *** (5.28430e-05)
$GDP/Capita^2$	−1.49158e-09 ** (6.26902e-010)	−1.24755e-09 ** (5.99522e-010)	−1.57005e-09 ** (6.69687e-010)	−1.87876e-09 *** (6.38915e-010)	−1.92398e-09 *** (6.63186e-010)
Renewable Electricity	−0.0403939 *** (0.0150572)	−0.0402543 *** (0.0151285)	−0.0533901 *** (0.0154951)		
Electricity Coal	0.0454717 *** (0.0142749)	0.0450693 *** (0.0143393)		0.0558482 *** (0.0143908)	
Livestock production index	0.0266518 (0.0210008)		0.0251657 (0.0224459)	0.0262404 (0.0219935)	
Mean dependent var	6.486654	6.486654	6.486654	6.486654	6.486654
R-squared	0.518664	0.506359	0.441139	0.463678	0.327403
Adjusted R-squared	0.480463	0.475506	0.406210	0.430158	0.307022
P-value(F)	5.46e-09	2.66e-09	1.24e-07	3.48e-08	2.07e-06

Table 2. The results of the regression for industrial countries. The number of observations is 69. Full results in appendix. * = Significance at 1% level, ** = Significance at 5% level, *** = Significance at 10% level.

Model 1a: Cross-sectional regression results using all independent variables.
Model 1b: Cross-sectional regression results using leaving out the independent variable Livestock production index, using all others.
Model 1c: Cross-sectional regression results using leaving out the independent variable Electricity Coal-Sources, using all others.
Model 1d: Cross-sectional regression leaving out the independent variable Renewable Electricity, using all others.
Model 1e: Cross-sectional regression results using only the independent variables GDP/Capita and $GDP/Capita^2$.

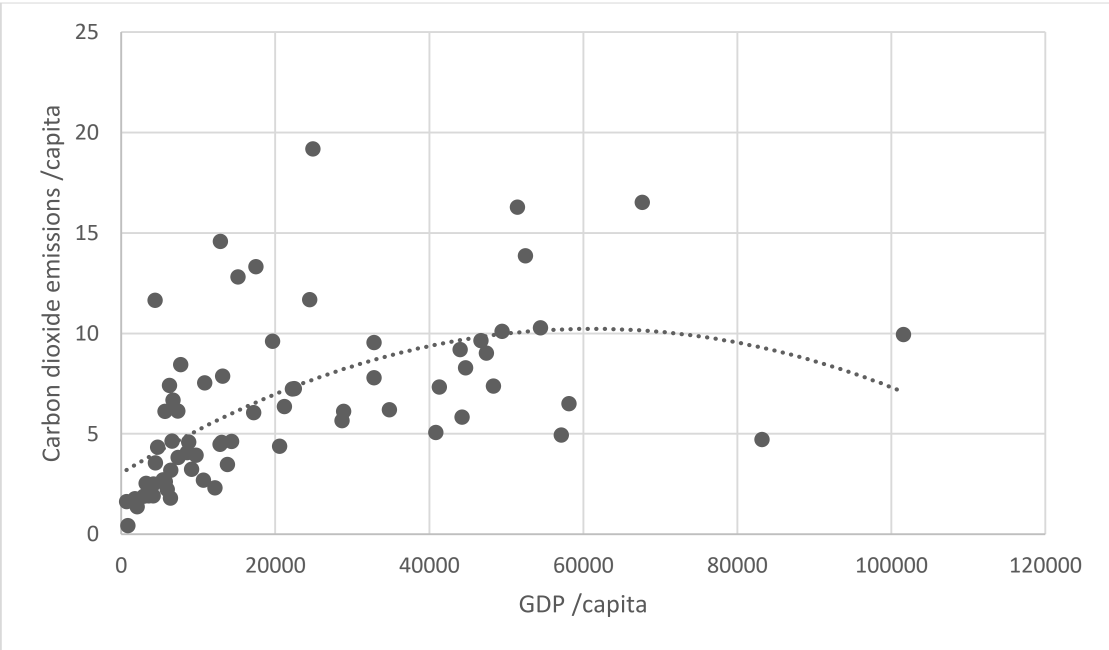

Figure 7. Graphical view of the results from the collected data for industrial countries. Per capita GDP is represented on the x-axis and environmental damage on the y-axis. Carbon dioxide emissions measured in tons per capita.

The results of the regression verify the expected outcome of all independent variables with significant effects on all variables but one, Livestock production index. However, when omitting the variable Livestock production index in model 1e, it does not seem to have caused any bias. When comparing the results of model 1a and model 1e, the signs of the coefficients are the same and the adjusted R-squared is actually higher when the livestock production index is included.

Interpreting the results

The results show a positive correlation between the dependent variable CO_2 emissions and the independent variable GDP per capita at the highest level of significance in all model variations. The positive relationship provided indicates CO_2 emissions increase as a result of economic growth.

The negative correlation between CO_2 emissions and GDP per capita squared suggests a possible polynomial form similar to the inverse U-shape of the EKC. The coefficient is significant in all models although the level of significance varies. The size of the coefficient however is very small, which suggest the impact of the negative correlation after the possible turning point is fractional. A 1-dollar increase in per capita GDP after the turning point would, according to the results, cause a decrease in CO_2 emissions by 1.44965e-09 tons (1.44965 mg) per capita when all other variables are being held constant. Comparing these numbers to the ones of the variable GDP per capita, they differ by a factor of about 100 000. The results provided for GDP per capita suggest CO_2 emissions increase by approximately 0.0002 tons (0.2 kg) per capita when GDP per capita increase by 1 dollar, holding all other variables constant.

The negative relationship between CO_2 emissions and the share of renewable electricity output is significant at the highest level for all models. As expected, the results indicate a higher percentage of renewable electricity output causes a decrease in CO_2 emissions.

The predicted positive relationship obtained between CO_2 emissions and the percentage electricity produced from coal-sources is significant at the highest level for all models. A higher percentage of electricity produced from coal-sources increases per capita emitted CO_2 according to the results. If one were to compare the coefficients regarding electricity production with the others, one should be aware of the different units of the variables (percent and US dollars).

The coefficient for livestock production does not show significance at any level for any model tested. The results do not support the expected positive relationship between livestock production and CO_2emissions. Even though the coefficient is positive, which indicates a positive relationship between the variables, the probability of it not being random is not high enough for it to be significant. What is clear is that both per capita GDP and electricity production is affecting the amount of CO_2 emitted to the atmosphere according to this study.

Table of means

Variable	**Mean**
Per capita CO_2emissions	6.310392
Per capita GDP	22012.04
Percent renewable electricity	26.77212
Percent electricity from coal-sources	20.74050532
Livestock production index	112.6541

Table 3. Table of means

Possible inaccuracy

When conducting an empirical analysis, the researcher must be aware of possible inaccuracy in the empirical results. The empirical analysis in this study is made using variables chosen with a theoretical background supporting the expected outcome, however, all relevant possible variables did not have data available. There is a possibility of an omitted variable in the regression model, since the variable deforestation does not have any reliable data. Deforestation is a large anthropogenic source of CO^2 emitted in the atmosphere (Van der Werf, et al., 2010). If deforestation were to be an omitted variable in the regression model, there could be biased estimations of the coefficients (Studenmund, 2014).

In order to exclude collinearity amongst the variables in the regression model, a VIF-test (Variance Inflation Factors) is performed. A VIF test shows the level of multicollinearity amongst the variables used, taking any value between 1 and ∞. The variable $GDP/Capita^2$ is a function of the variable $GDP/Capita$, still the results of the VIF-test is in the lines of what is considered non-multicollinearity. There was no indication of multicollinearity for any of the other variables either.

4.2 Regression analysis for poor countries

Due to lack of data, the variables renewable electricity output, electricity production from coal-sources and livestock production are not included in the regression model for poor countries. The regression model includes the dependent variable CO_2 emissions per capita and the independent variables GDP per capita as well as GDP per capita squared, as specified previously in this chapter. The reason for introducing another model is to be able to include poor countries in the empirical study without having to remove the variables only available for industrial countries. A regression analysis is performed for industrial countries as well as all countries with available data for comparing reasons. The results of the regression analysis are presented in table 3. Model 2a represents all countries with available data (190 observations), model 2b represents industrial countries included in model 1 (71 observations) and model 2c represents poor countries (45 observations).

Dependent variable CO_2 emission level			
Models	**2a**	**2b**	**2c**
Independent variable	Estimated Coefficient (Standard Error)	Estimated Coefficient (Standard Error)	Estimated Coefficient (Standard Error)
Constant	1.0113 ** (0.468392)	3.03509 *** (0.755046)	0.0619705 (0.0916098)
GDP/Capita	0.000355778 *** (3.46417e-05)	0.000235249 *** (5.28430e-05)	0.000296528 ** (0.000296528)
GDP/Capita^2	−2.26823e-09 *** (3.52351e-010)	−1.92398e-09 *** (6.63186e-010)	−1.02046e-08 (2.46062e-08)
Mean dependent var	4.844110	6.486654	0.367472
R-squared	0.441578	0.327403	0.479838
Adjusted R-squared	0.435638	0.307022	0.455069
P-value(F)	1.64e-24	2.07e-06	1.09e-06

Table 4. Cross-sectional regression analysis results. Model 2a represents all countries with available data (190 observations), model 2b represents industrial countries included in model 1 (71 observations) and model 2c represents poor countries (45 observations).
* = Significance at 1% level, ** = Significance at 5% level, *** = Significance at 10% level.

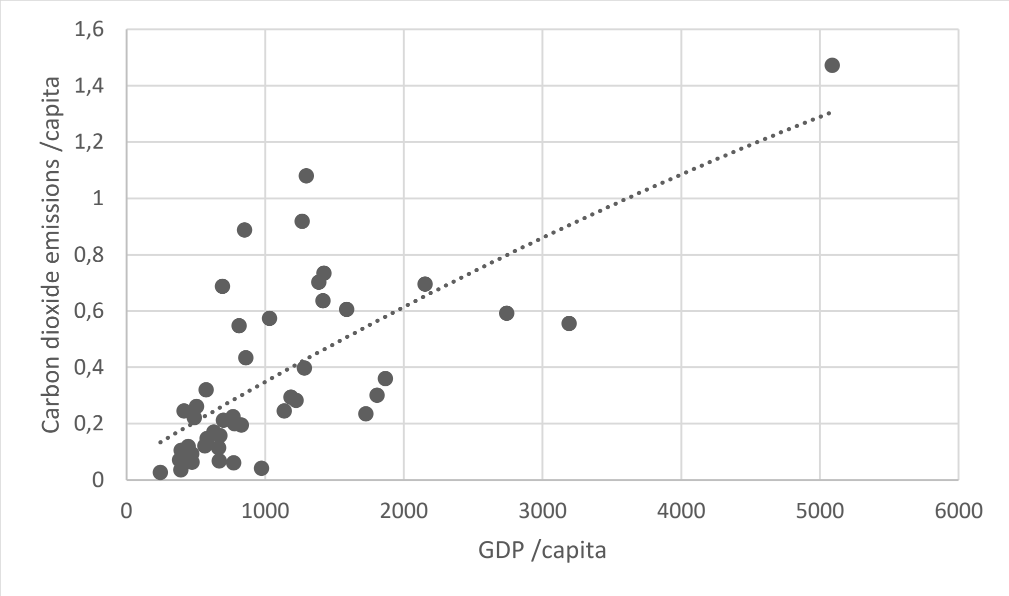

Figure 8. Graphical view of the regression results for poor countries. Per capita GDP is represented on the x-axis and environmental damage on the y-axis. Carbon dioxide emissions measured in tons per capita.

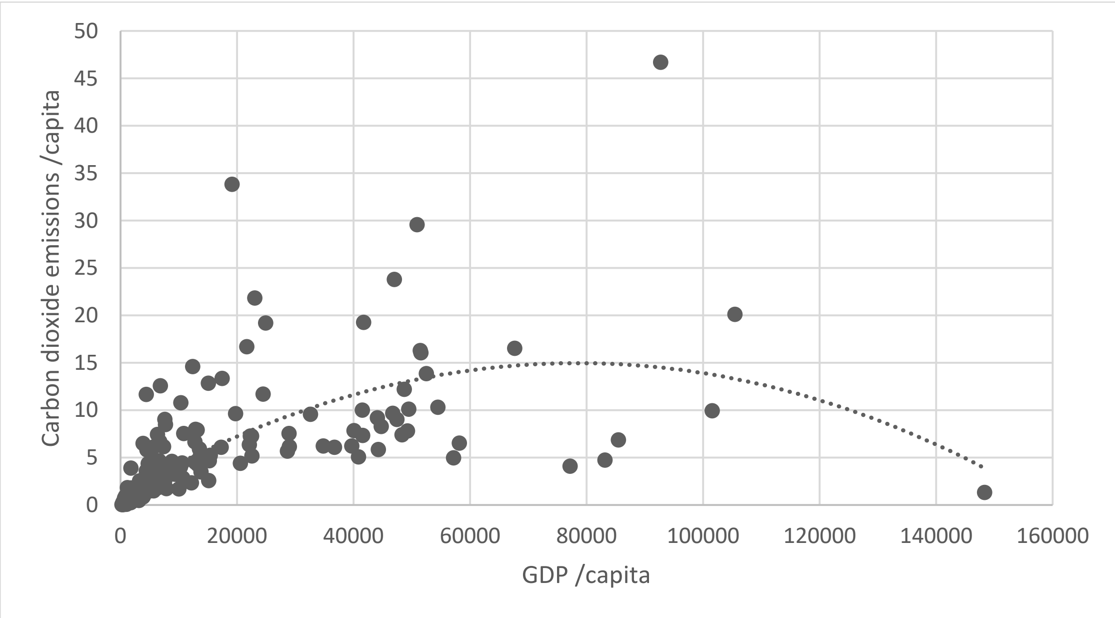

Figure 9. Graphical view of the regression results for all countries with available data. Per capita GDP is represented on the x-axis and environmental damage on the y-axis. Carbon dioxide emissions measured in tons per capita.

The results of the regression analysis for poor countries shows a significant positive relationship between CO_2emissions per capita and GDP per capita. As the economy grows, CO_2 emissions increase as well, according to the results. The positive relationship can also be found for both industrial countries (2b) and worldwide (2a) at the highest level of significance.

When it comes to the variable $(GDP/Capita)^2$, there is no significant effect on CO_2 emissions. This means that one cannot argue, according to these results, that the shape of the curve of CO_2 emissions for poor countries is polynomial. However, this does not contradict the EKC theory as the poor countries are below the hypothesised turning point. The results for industrial countries as well as the world show the opposite, a significant negative relationship between CO_2 emissions and $(GDP/Capita)^2$. Again, the coefficients of $(GDP/Capita)^2$ are of a very small nature, indicating a less substantial impact on the CO_2 emissions than argued by EKC supporters.

Notation about the sampling process

When making the samples for industrial countries and poor countries, one country actually fitted both criteria. The country Bangladesh is defined as a low development country by the UN, but has a HDI above 0.5. Bangladesh is the only country included in both poor countries and industrial countries.

5. Discussion and conclusion

The hypothesised correlation between per capita GDP and CO_2 emissions is statistically supported for both industrial countries and poor countries in the empirical part of this study. At the highest significance level, per capita GDP is positively correlated with per capita CO_2 emissions. As per capita GDP increases, CO_2 emissions increase as well in accordance with many of the previous studies examined. The theoretical concept most likely explaining the increase in CO_2 emissions is the scale effect. The mechanism is very simple indeed, increased per capita GDP implies higher production - since the concept of GDP itself is defined as the value of all final products and services produced in one period. When production increases in intensity, by-products and pollution increase as a result. The scale effect is included in all theories examined in this study, that is the EKC hypothesis, the Brundtland Curve hypothesis and the Daly Curve hypothesis. Although in different sections of the curves, the scale effect is recognized to play an important role in the three different theorized evolutions of emission levels studied. The finding of a positive relationship between per capita GDP and CO_2 emissions for poor countries contradicts the Brundtland Curve, but is consistent with the EKC as well as the Daly Curve.

The theory behind the scale effect is based on the assumption that increased production creates increased pollution and environmental damage. In what magnitude the environmental damage increases however, might not be consistent for all economies. When analysing the results graphically, various patterns of how CO_2 emissions increase with increasing per capita GDP can be recognized. This suggests an increase in per capita GDP could have different impacts on the CO_2 emissions in different countries. The differences in the responses to economic growth between economies could be seen as a given, since the structural form of governance and the access to natural resources such as oil differs greatly globally. One could argue that if increased emissions depend on increased production, the type of production that is increased is of importance. However, both the EKC and Brundtland Curve hypotheses underestimate the importance of the differences among the economies thought to fit into the theorized curves. Some economies stand out because they emit higher levels of CO_2 emissions than other economies at the same level of per capita GDP. One could suggest this group of economies are characterised with "dirty" production, or taking less actions counteracting the increased pollution levels. Two of the countries that stand out are Saudi Arabia and Russia, both of which are one of the countries extracting the greatest amount of oil in the world

(International Energy Agency, 2015). Extracting oil creates high levels of CO_2 emissions (Dibble & Bartha, 1979), which could explain why per capita CO_2 emissions are higher than in other countries with similar per capita GDP.

There is a general consensus about the existence of a scale-type effect, but mechanisms counteracting increased pollution are of differing opinions. Is there a turning point at which pollution starts to decrease? The regression analysis conducted in this study shows a significant polynomial shaped relationship between per capita GDP and CO_2 emissions for all regressions performed except the one for poor countries. The lack of significant results for poor countries when discussing the variable GDP per capita squared is not surprising since the potential turning point is situated on higher levels of per capita GDP than that of poor countries according to the EKC hypothesis. The signs of the coefficients of GDP per capita and GDP per capita squared tells us that the shape of the curve could in fact be an inverted U-shape, which is the case for the EKC but the opposite to the Brundtland curve. The coefficient of the variable GDP per capita squared however, is approximately 100,000 times smaller than the coefficient of the variable GDP per capita, which suggests the probability of a perfectly inverted U- shape, such as the EKC, is low. This indicates an extremely small decrease in CO_2 emissions, if any, after the hypothesized turning point. The magnitude of the mechanisms supposed to alleviate CO_2 emissions are probably not strong enough to counteract the increased CO_2 emissions due to an increase in GDP per capita. The theoretical concepts behind the downward sloping shape of the EKC after the turning point are based on basic economic theory and seems plausible. However, based on the results provided in this study, one could argue that the magnitude of these effects are overestimated in relation to the scale effect.

The results of the empirical part of this study does not fit perfectly with either of the theorized curves examined (the EKC, the Brundtland curve or the Daly curve). The positive correlation between per capita GDP and per capita CO_2 emissions followed by a potential turning point is indeed consistent with the EKC. The decreasing trend after the turning point however, is much smaller than the theory claims. The small value of the coefficient for GDP per capita squared relative the variable GDP per capita suggests a less increasing rise of CO_2 emissions rather than decreasing actual levels of CO_2 emissions. The mechanisms counteracting the scale effect proposed by the EKC theory could very well be responsible for the decrease in the acceleration of CO_2 emissions. However, as the Daly curve suggests, these mechanisms are not strong enough to turn things around completely. Both the EKC and the Brundtland Curve have important points to consider, and thus the way to interpret the empirical results given in this study is not to dismiss existing theories but to combine them.

The results provided in this study differ from the results in some of the previous empirical studies examined. One could argue that the decreasing trend in emissions with economic growth found in previous studies is merely a spurious correlation or significant due to poor statistical method. Selden & Song (1994) finds statistical support for an inverted U-shape, however the sample size of countries included in the study are no more than 30 due to lack of data. The results should therefore be treated with caution. Acaravci & Ozturk (2010) state that the EKC-hypothesis could be supported statistically for some of the countries included in the study, but not for others. Considering the sample size in this case is 19 countries, the results should not be used as an example of studies supporting the EKC hypothesis. Holtz-Eakin & Selden (1995) studies levels of CO_2 emissions but receives results very unlike the ones in this study, stating that economic growth could decrease the environmental degradation. Considering the lack of time-series data for CO_2 emissions, the study stands out with the sample size of 130 countries. The data is in this case provided from an organisation not wanting to making the dataset public or disclose how it is obtained (which could raise a red flag). When analysing the empirical evidence for the EKC, the statistical method is questionable. The EKC have been subject to criticism from an empirical standpoint before, especially due to the lack of reliable time-series data from a big enough sample of countries.

Since the statistical support for a decreasing trend in emissions as economies develop is scarce and criticised, should we really count on the market economy to solve environmental issues internally? One could argue that instead of relying on mechanisms that is thought to automatically decrease emissions at certain income-levels, policymakers must recognize the importance of environmental regulations. One might argue that economic growth stimulates the development of stable environmental regulations and therefore economic growth is important when discussing regulations. On the other hand, the per capita GDP level is not the only factor affecting decisions of regulations and thus policymakers cannot wait for a magical moment to come along when both producers and consumers are pro environmental regulations.

Conclusion

The relationship between per capita GDP and per capita CO_2 emissions is statistically supported at the highest level of significance. The outcome of an increase in per capita GDP should, according to the results given in the study, be an increase in the level of CO_2 emissions. The theory to which our conclusion is most similar is the Daly curve hypothesis, which states the willingness to decrease pollution of wealthier countries might not be enough. Even though the increase in emissions might be alleviated, the point is that the decrease in emissions is not strong enough for the EKC hypothesis to be applied on its own in reality. Further studies including panel data are desirable to get a consensus of the mechanisms affecting pollution levels in order to set environmental regulations.

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Appendix

Industrial countries used in regression model 1

Albania	Georgia	Moldova
Argentina	Germany	Mongolia
Armenia	Greece	Morocco
Australia	Hungary	Netherlands
Austria	Iceland	Norway
Azerbaijan	Iran, Islamic Rep.	Panama
Bangladesh	Iraq	Peru
Belarus	Ireland	Poland
Belgium	Israel	Portugal
Brazil	Italy	Romania
Bulgaria	Jamaica	Russian Federation
Canada	Japan	Saudi Arabia
China	Jordan	Serbia
Cuba	Kazakhstan	Singapore
Cyprus	Korea, Rep.	Slovak Republic
Czech Republic	Latvia	Slovenia
Denmark	Lebanon	Spain
Dominican Republic	Lithuania	Sweden
Ecuador	Macedonia, FYR	Switzerland
Egypt, Arab Rep.	Malaysia	Tunisia
Estonia	Malta	United Kingdom
Finland	Mauritius	United States
France	Mexico	Vietnam

Number of observations: 69

Full results for regression analysis 1

Dependent variable CO_2 emission level					
Models	**1a**	**1b**	**1c**	**1d**	**1e**
Independent variable	Estimated Coefficient (Standard Error)	Estimated Coefficient (Standard Error)	Estimated Coefficient (Standard Error)	Estimated Coefficient (Standard Error)	Estimated Coefficient (Standard Error)
Constant	−0.159771 (2.75976)	3.18246 *** (0.828846)	1.17512 (2.91617)	−1.27620 (2.85723)	3.03509 *** (0.755046)
GDP/Capita	0.000228978 *** (5.09626e-05)	0.000201951 *** (4.65197e-05)	0.000237729 *** (5.44037e-05)	0.000242500 *** (5.31112e-05)	0.000235249 *** (5.28430e-05)
GDP/Capita^2	−1.49158e-09 ** (6.26902e-010)	−1.24755e-09 ** (5.99522e-010)	−1.57005e-09 ** (6.69687e-010)	−1.87876e-09 *** (6.38915e-010)	−1.92398e-09 *** (6.63186e-010)
Renewable Electricity	−0.0403939 *** (0.0150572)	−0.0402543 *** (0.0151285)	−0.0533901 *** (0.0154951)		
Electricity Coal	0.0454717 *** (0.0142749)	0.0450693 *** (0.0143393)		0.0558482 *** (0.0143908)	
Livestock production index	0.0266518 (0.0210008)		0.0251657 (0.0224459)	0.0262404 (0.0219935)	
Mean dependent var	6.486654	6.486654	6.486654	6.486654	6.486654
Sum squared resid	550.1841	597.7531	622.8746	622.8746	749.6373
R-squared	0.506359	0.463678	0.441139	0.441139	0.327403
F(5, 65)	16.41220	13.83285	12.62964	12.62964	16.06359
Log-likelihood	−169.5338	−172.3947	−173.8150	−173.8150	−180.2059
Schwarz criterion	360.2382	365.9600	368.8005	368.8005	373.1142
S.D. dependent var	4.048497	4.048497	4.048497	4.048497	4.048497

S.E. of regression	2.932000	3.056124	3.119682	3.370184	3.370184
Adjusted R-squared	0.475506	0.430158	0.406210	0.307022	0.307022
P-value(F)	2.66e-09	3.48e-08	1.24e-07	2.07e-06	2.07e-06
Akaike criterion	349.0676	354.7894	357.6300	366.4118	366.4118
Hannan-Quinn	353.4993	359.2212	362.0617	369.0709	369.0709

Poor countries used:

Afghanistan	Malawi
Angola	Mali
Bangladesh	Mauritania
Benin	Mozambique
Burkina Faso	Myanmar
Burundi	Nepal
Cameroon	Niger
Central African Republic	Nigeria
Chad	Pakistan
Comoros	Papua New Guinea
Congo, Dem. Rep.	Rwanda
Congo, Rep.	Sao Tome and Principe
Cote d'Ivoire	Senegal
Djibouti	Sierra Leone
Ethiopia	Solomon Islands
Gambia, The	Sudan
Guinea	Tanzania
Guinea-Bissau	Togo
Haiti	Uganda
Kenya	Yemen, Rep.
Lesotho	Zambia
Liberia	Zimbabwe
Madagascar	

All countries with available data used (sample 2a):

Andorra	Finland	Maldives
Afghanistan	Fiji	Mexico
Angola	France	Marshall Islands
Albania	Faroe Islands	Macedonia, FYR
United Arab Emirates	Micronesia, Fed. Sts.	Mali
Argentina	Gabon	Malta
Armenia	United Kingdom	Myanmar
Antigua and Barbuda	Georgia	Montenegro
Australia	Ghana	Mongolia
Austria	Guinea	Mozambique
Azerbaijan	Gambia, The	Mauritania
Burundi	Guinea-Bissau	Mauritius
Belgium	Equatorial Guinea	Malawi
Benin	Greece	Malaysia
Burkina Faso	Grenada	North America
Bangladesh	Greenland	Namibia
Bulgaria	Guatemala	Niger
Bahrain	Guyana	Nigeria
Bahamas, The	Hong Kong SAR, China	Nicaragua
Bosnia and Herzegovina	Honduras	Netherlands
Belarus	Croatia	Norway
Belize	Haiti	Nepal
Bermuda	Hungary	Nauru
Bolivia	Indonesia	New Zealand
Brazil	India	Oman
Barbados	Ireland	Pakistan
Brunei Darussalam	Iran, Islamic Rep.	Panama
Bhutan	Iraq	Peru
Botswana	Iceland	Philippines
Central African Republic	Israel	Palau
Canada	Italy	Papua New Guinea
Switzerland	Jamaica	Poland

Chile	Jordan	Portugal
China	Japan	Paraguay
Cote d'Ivoire	Kazakhstan	Qatar
Cameroon	Kenya	Romania
Congo, Rep.	Kyrgyz Republic	Russian Federation
Colombia	Cambodia	Rwanda
Comoros	Kiribati	South Asia
Cabo Verde	St. Kitts and Nevis	Saudi Arabia
Costa Rica	Korea, Rep.	Sudan
Cuba	Kuwait	Senegal
Cyprus	Lao PDR	Singapore
Czech Republic	Lebanon	Solomon Islands
Germany	Liberia	Sierra Leone
Djibouti	St. Lucia	El Salvador
Dominica	Liechtenstein	Serbia
Denmark	Sri Lanka	South Sudan
Dominican Republic	Lesotho	Sao Tome and Principe
Algeria	Lithuania	Slovak Republic
Ecuador	Luxembourg	Slovenia
Egypt, Arab Rep.	Latvia	Sweden
Spain	Macao SAR, China	Swaziland
Estonia	Morocco	Seychelles
Ethiopia	Moldova	Chad
Trinidad and Tobago	Madagascar	Togo
Tunisia	Uzbekistan	Thailand
Turkey	St. Vincent and the Grenadines	Tajikistan
Tanzania	Venezuela, RB	Turkmenistan
Uganda	Vietnam	Timor-Leste
Ukraine	Vanuatu	Tonga
Uruguay	Samoa	Congo, Dem. Rep.
United States	Yemen, Rep.	Zambia
Zimbabwe	South Africa	

Explanation of keywords.

GDP - Gross domestic product, a measurement of all goods and services provided in a country during one period.
Economic growth - An increase in the capacity of an economy to produce goods and services in one period compared to another.
Environmental degradation - Reducing quality of the environment due to pollutants affecting the planet through both air, water and land