UNIVERSITY OF GOTHENBURG
SCHOOL OF BUSINESS, ECONOMICS AND LAW

Paris and the voluntary reduction of emissions -

A study on Grandfathering and the Environmental Kuznets Curve

Isac Boukachabia and Stina Magnusson

Abstract:
After the global climate meeting in Paris 2015, which resulted in the Paris Agreement, a common goal was set to keep the global temperature from rising over 2 ºC and preferably under 1.5 ºC. Prior to the agreement, each country published a document called National Determined Contribution, NDC, which included the intended climate actions each country would implement during the agreement. This thesis uses the data presented in the NDCs to investigate if there is any connection between the ambition level of reducing greenhouse gases and the economic principles of grandfathering and the Environmental Kuznets Curve. Through several regression analyses, the result states that the principles of grandfathering seems to be an explanatory factor, regarding countries decisions on reduced emission. Furthermore, no assumption can be made concerning the Environmental Kuznets Curve as results are proven to be insignificant. The thesis aim to contribute to the understanding of countries decisions in the Paris Agreement and serve as a support for further debate regarding global warming.

Keywords: NDCs, Paris Agreement, Grandfathering, Environmental Kuznets Curve (EKC)
JEL: Q50, Q54, Q56

Bachelor thesis (15hp)
Department of Economics
School of Business, Economics and Law
University of Gothenburg
Supervisor: Thomas Sterner

Acknowledgement

We would like to express our greatest thanks to our supervisor Thomas Sterner for his guidance and support throughout our thesis.

Table of Contents

1. Introduction 4
1.1 Purpose 6
1.2 Layout 6
2. Literature review 7
2.1 Research regarding NDCs 7
2.2 Categorizing NDCs 8
2.3 The relevance of the NDCs and the Paris Agreement 8
3. Theoretical framework 9
3.1 Grandfathering 9
3.1.1 Proponents and opponents of grandfathering 11
3.2 Environmental Kuznets Curve 13
3.2.1 Proponents and opponents of EKC 14
4. Methodology 17
4.1 Data 17
4.2 Meinshausen's factsheet 17
4.2.1 Comparisons between NDCs and Meinshausen's standardization 18
4.3 Variables 19
4.3.1 Emissions per capita 2010 and Emissions per capita 2030 19
4.3.2 GDP per capita 20
4.3.3 GDP per capita squared 20
4.3.4 ND-GAIN index, vulnerability and readiness 21
4.4 Hypothesis 21
4.5 Regression analysis 21
4.6 Validity of the regressions 23
5. Results and analysis 25
5.1 Correlation between dependent and independent variables 25
5.2 Linear regression analysis 26
5.2.1 Results connected to hypotheses 1 and 2 26
5.2.2 Results connected to hypothesis 3 28
6. Discussion and Conclusion **29**
7. References **32**
8. Appendix **38**

1. Introduction

It is a well-known fact that the human population stands in front of its severest challenge yet, the climate threat. As the global temperature rises, the risks of natural and social disasters increase as well. The consequences are predicted to be much more alarming than previously expected. Counteracting measures needs to be initiated in order to manage this crisis (Stern 2006).

In October 2015 the Paris Agreement was established at the twenty-first session of the "Conference of the Parties", the executive unit of the "United Nations Framework Convention on Climate Change", UNFCCC. Participating countries adopted the first global accord with the objective to prevent and reduce the damages of climate change. Through this agreement, countries will strive to reduce their emissions of greenhouse gases in order to limit the global warming to well below 2 ºC and preferably under 1.5 ºC. Countries were free to formulate their own goals without any restriction. The only rule that figured concerned the ambition level. The rule stated that countries cannot lower their emission goals, only raise them. (UNFCCC, 2015).

The countries of the world have gathered many times to negotiate conditions concerning emission reductions. The debate has constantly circulated around which methods that should be used in mitigations. Economically developed countries have argued for methods based on grandfathering. Less developed countries on the other hand, have defended emission reductions based on an equal per capita approach (Damon, M. et al., 2019). This debate cumulated after nearly a decade of controversies, in 2009 at the United Nations Climate Change Conference 2009 in Copenhagen. The event came to be known as a major setback for environmental discussions as countries could not agree on the terms of an eventual agreement. However, the failure worked like a wake-up call. To avoid a tie in environmental negotiations, the approach concerning reduction methods needed to evolve (Sterner and Damon, 2011). These are the underlying causes leading up to the Paris Agreement.

In preparation of the Paris Agreement, the participating countries were encouraged to provide their own contribution of measures for the reduction of greenhouse gas emissions, at the Conference of the Parties in Warsaw 2013 (UNFCCC, 2013). These preparatory documents were called Intended Nationally Determined Contributions, INDCs. Based on these documents, the Paris Agreement was formed (UNFCCC, 2015). As countries confirmed the agreement,

INDCs became referred to as NDCs instead. The report will henceforth only refer to this work as NDCs. To clarify the serious consequences of the difference between the target levels of 2 ºC and 1.5 ºC, the "Intergovernmental Panel on Climate Change", IPCC, published a special report in 2018. At a level of 2 ºC, the following effects can be expected amongst others: 99 % of the coral reefs will perish, natural disasters will cause mass starvation and the sea level will rise significantly (IPCC 2018). Hence, dramatic effects can be expected, for humans as well as for animals and ecosystems.

As soon as all 184 NDCs had been published, they became a subject of great scrutiny by several examiners which observed large variations (Admiraal et al., 2015; Meinshausen et al., 2016; Climate Analytics et al., 2017 & World Resources Institute, 2015). The structure and measures of the documents differed, as countries had used different measurement methods to collect information about their emissions and current economic and environmental condition in the country. For example, the countries within EU have, in their common NDC, promised greenhouse gas emission reductions which extends over a long period of time (Meinshausen et al, 2016). Others, mainly oil-dependent countries, aim to increase the use of CCS-technique in order to contain and store the greenhouse gas emissions produced when combusting fossil fuels (Frieler et al., 2017). The reference points used when defining the emission reduction also varied between countries. Some countries used a certain base year, which also sometimes differed between countries. Other countries applied the business-as-usual (BAU[1]) approach and set their emissions reduction in relation to this level (Frieler et al., 2017). Even the target year, when promises should be fulfilled, varied among the NDCs. Summarized, it is clear that the NDCs show different levels of ambition and are hard to compare against each other. The differences create many interesting investigation opportunities. Can various trends be traced among the NDCs?

[1] BAU - if the country continues emitting without considering climate promoting actions.

1.1 Purpose

Through the material presented by the NDCs, this thesis will quantitatively investigate the relationship between the ambition level of countries NDCs and a selection of variables. The thesis will focus on two different kinds of economic principles, grandfathering and the Environmental Kuznets Curve. This leads to the research question: *How does these principles affect countries decisions regarding emission reduction in their NDCs?* By testing for any connection between the economic principles and the nations NDCs, the thesis will investigate whether any of the principles can be used in order to explain countries actions and ambitions concerning greenhouse gas emissions. This thesis aims to contribute to the current debate regarding the environment and global warming. The thesis intend to contribute to the understanding of countries actions in environmental negotiations and serve as a support for further studies and discussions of the subject. Earlier research on NDCs discuss interpretation of the documents. What this thesis wishes to add to current research is why countries form the ambition level of their NDCs the way they do and which factors that can possibly explain their behavior.

1.2 Layout

The thesis is structured as follows. After the introduction follows the literature review where earlier studies of the NDCs are presented. Afterwards, the theory section is presented, which describes the principles used in this thesis. Next, the methodology part presents the data used, followed by hypotheses and regression models. Thereafter, the results are presented, followed by further discussion and conclusion.

2. Literature review

Earlier research and reports have shown that there is a considerable research interest regarding the NDCs and their contribution to sustainable development. In the following section, research about the NDCs and relevant principles connected to the purpose of this thesis will be presented. First a more detailed account of the research done on NDCs and the prevailing attitude towards them, is given. Thereafter an account of the two principles grandfathering and Environmental Kuznets Curve follows.

2.1 Research regarding NDCs

During 2015 and 2016 the first edition of all NDCs was handed in and documented by the interim NDC registry (UNFCCC, 2015, 2016). Naturally, research teams and institutes immediately started to compile and analyze the documentation. Their work provides a solid foundation of data for further studies. The NDCs were compiled in UNFCCC's "Synthesis Report on the Aggregate Effect of the Intended Nationally Determined Contributions", which presented the combined reduction of greenhouse gas emissions. The synthesis report only contained 147 NDCs as it was constructed from the NDCs that were handed in by the time of 1 October 2015 (UNFCCC, 2015). Through this summary, multiple trends could be detected. These could be summed up by three points:

1. More countries than ever have accepted their global responsibility and engaged in environmental issues by undertaking climate promoting actions. The actions do not only concern certain projects or programs but the whole economy.
2. A majority of the countries have implemented more climate promoting policies on a national level. One common goal is the increased use of emission-lowering-tools and policies in order to achieve a more sustainable development.
3. The positive attitude towards cross-border collaboration permeates all participating countries.

The report also identified several obstacles that needed to be addressed. These include the differences of how emissions levels, time frames, reference years and other factors are expressed and how they create categorizing and estimating challenges (UNFCCC 2016).

2.2 Categorizing NDCs

The variation of information presented in the NDC's generated a need for categorizing. One of the most thorough reports on the NDC's was made by Kajta Frieler and her research team in 2017. They managed to organize the undertakings connected to each emission reduction. Through their work, they have established which comparison point each emission reduction should be compared to. Countries have either used an approach based on BAU or used a special base year. A presentation of total emission reductions, a timeframe and which sectors the NDCs concerns was also displayed (Frieler, et al., 2017).

The comparison difficulties also inspired researcher Meinshausen at University of Melbourne. Together with colleagues from Potsdam Institute, they created factsheets which made comparison possible. By predicting the change in greenhouse gas emissions between 2010 and 2030 under the assumption that each country's NDC is followed, they have been able to rank all countries NDCs. They gave each country a percentage expected change in greenhouse gas emission (Meinshausen et al, 2016).

2.3 The relevance of the NDCs and the Paris Agreement

With 184 participating countries, it is clear that the Paris Agreement and the NDCs make a large contribution to the work of lowering global emissions and in the long run the average temperature. However, reports show that further efforts must be made. Complied studies made by institutes and research teams such as Climate Action Tracker, Massachusetts Institute of Technology and United Nations Environmental Program, all present a temperature increase above outlined levels. Their predictions differ amongst each other, but they are all convinced that the average temperature will settle far above 2 ºC (Fransen and Levin, 2015). It can thus be discussed whether the Paris Agreement and the NDCs actually do contribute in an efficient way. However, some maintain a positive attitude and argue that the data presented by the NDCs can be used as new baseline and benchmark emissions when new reductions need to be done. This measure will move environmental negotiations away from prior deadlock discussions regarding different emission reduction methods (Damon, M. et al., 2019).

3. Theoretical framework

The Paris Agreement and the NDCs differs a lot from earlier climate negotiations as countries could formulate their own reduction goals. It is therefore interesting to look at different economic theories to find an explanation of countries actions and promises. This thesis will use two different principles, grandfathering and the Environmental Kuznets Curve (EKC). These two principles are interesting as they have been subject to great research and affected environmental regulations and discussions over a long time. The following section will first explain the concept of grandfathering and how it is connected to climate negotiations. Thereafter, a definition and further explanations of the EKC follows.

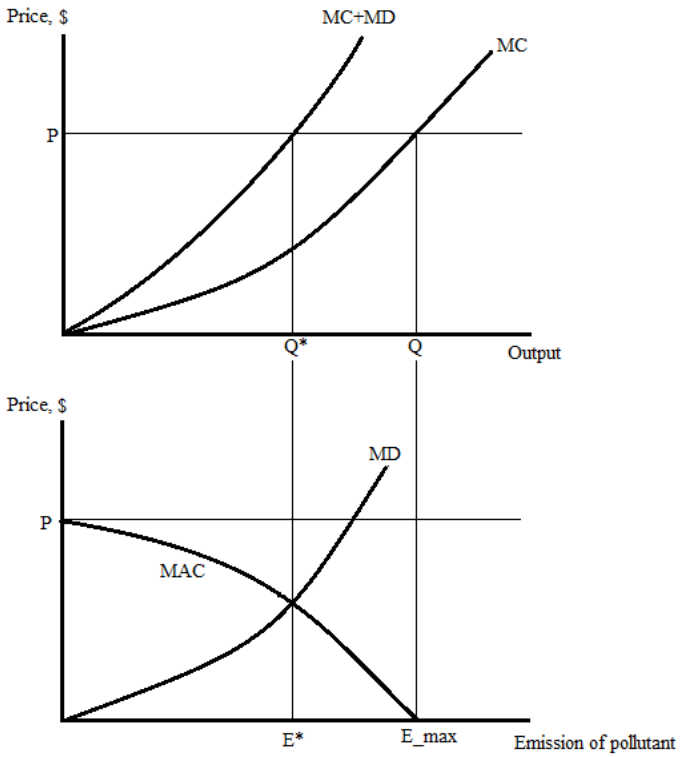
3.1 Grandfathering

Grandfathering is a concept commonly used in environmental negotiations. The term can be found in other disciplines as well, but this thesis will concentrate on its environmental economic meaning. Grandfathering can be described as an allocation approach where countries are entitled to emit based on their prior emissions through the "rule of first possession" (Nash 2009). Actors that already pollute meet less strict standards than new polluters. These less strict standards can include reliefs or exceptions to regulations, which may apply for a certain period or action. The emissions are mostly controlled through permits, distributed by a regulator. An actor can only emit as much as it is entitled to through its permits. Usually, markets for these emission permits are constructed where actors can trade or permits are distributed freely (Kolstad 2011). Grandfathering then becomes relevant as parties who have large prior emissions are allocated most of the emission rights (Damon, M. et al., 2019).

To explain grandfathering an explanation of the theory of profit maximization and marginal abatement cost are in order. Firms want to maximize profit through high revenues and low costs. In a market with prefect competition actors set their price equal to the marginal cost (P = MC), which will later decide the level of output (Q). However, the firm does not only produce output but also harmful emissions, which leads to environmental damages. Marginal damage (MD) is the environmental damage caused by one increased unit of emissions. Without restrictions concerning emission abatement actors can emit as much as they want (E_max) and maximize profit when price is equal to marginal cost (P = MC) and cause environmental damages. Marginal profit for an actor is price minus marginal cost. Through regulations like

abatement cost, the environmental damage that the actor causes can be internalized in their own production function. Actors would then lose marginal profit, as they would have to lower their output level due to abatement cost. As one unit of output leads to one unit of emissions, the marginal profit can represent the marginal abatement cost for an actor. The marginal abatement cost (MAC) is the increased cost when lowering emissions with one unit. As abatement costs is required the MD-curve becomes relevant and an actor will produce output levels that considers the cost of emissions that the production causes. Optimal output level of emissions for the environment (E*) will then be found where the marginal abatement cost equals marginal damage (MAC = MD). This is explained by figure 1 below (Field, Olewiler, 2011).

Figure 1.



The graph displays the different scenarios if abatement cost and environmental degradation is considered or not. P = price. MC = marginal cost. MD = marginal damage. Q= output of goods. Q=optimal output of goods. MAC = marginal abatement cost. E* = optimal emissions. E_max = maximal emissions.*

High marginal costs of abatement can be used to understand the principles of grandfathering. Arguing against high marginal costs of abatement has been a common strategy for actors to receive generous allocations of emissions (Sterner, Coria, 2012). Actors that emit considerable amounts often base their energy consumption on fossil fuels, causing environmental

degradation. They are dependent on emissions to maintain economic activity in the society. If they were to reduce their emissions, this would be followed by abatement costs. This abatement cost can be interpreted as a welfare cost for the society, according to a utilitarian perspective. The perspective assumes that the higher the cost of abatement is the higher the welfare cost is for the society. Emitters with great emissions confront extensive marginal abatement costs compared to low emitters (Knight 2012). Ergo, the welfare cost is greater if large emitters reduce their emissions instead of small emitters. Large emitters should then be authorized to emit more, which is an argument for grandfathering (Wesley and Peterson 1999).

3.1.1 Proponents and opponents of grandfathering

The approach of grandfathering has generated great discussion as it creates issues of injustice by the clear advantages to previous emitters (Knight 2012). If entitled emissions should be exclusively based on previous emissions, then less developed countries would not be able to enhance their economic growth, given that emissions are necessary to growth (Caney 2009). The issues of injustice and the inhibition of achieving environmental political goals are two consequences of grandfathering that have been observed. In the long run researchers are not sure of the effects but fear "resource races" and more generous emissions allowances. Since grandfathering has been an accepted method in emission and pollution regulations, scientists do not know what emission levels would look like without it. This creates a comparison problem in general and also problems when targets of welfare or emission levels are set (Damon, M. et al., 2019).

The opinions on grandfathering are, as mentioned above, many and varying. Supporters of the concept argue that grandfathering can be used in treaties and negotiations in order to involve participants. Through grandfathering, recalcitrant actors can be convinced to agree the terms of the regulations. In this way, the regulation gains approval and can enter into force (Damon, M. et al., 2019). Critics, on the other hand, mean that this behavior only demonstrates how crucial actors are bribed into consent (Nash 2009; Montero 1999). An example of this can be found in the Kyoto protocol, where Russia received more generous emission permits than originally planned in order to approve the protocol (Cole 2008).

Furthermore, parties in favor of grandfathering claim that the principle can be useful when defining or constructing property rights. A lack of property rights may cause overexploitation of a certain resource, a phenomenon defined as tragedy of the commons (Libecap 2008). By

applying grandfathering, which defines and reinforces the property rights to actors with earlier access to the resource, this unwanted tragedy can be avoided. As a result, the actor can preserve and exploit the resource in a more sustainable way (Damon, M. et al., 2019).

The arguments against grandfathering are many. Opponents states that the method creates injustices and also reduces the effectiveness of the economy and the social welfare in society. The method creates incentives which makes actors act in a more environmentally restrictive way. For example, when implementations of a new regulation is known to be based on grandfathering, parties can increase their emissions in advance and through this action obtain a more favorable benchmark point. This can lead to more generous emission allowances, when the regulation concerns emission reductions. The countries that have reduced their emissions before the regulation will be disadvantaged while polluters who have not taken earlier action or increased their emissions, will benefit. It results in an inhibiting effect on environmental promoting actions. This behavior shows that repeated grandfathering can cause great problems, as reference amounts or baselines, of for example greenhouse gas emissions, can be manipulated. Regulations can thus increase benchmark emissions and with it environmental damage (Damon, M. et al., 2019).

An alternative to grandfathering allocation is equal per capita emissions. Hence, a country's population would decide the amount of emission as countries would emit the same amount per inhabitant. The following equation displays the relationship:

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

Where emissions (E) are divided on population (P), resulting in a constant (C), which is the amount each country will emit per inhabitant. If an approach of equal per capita emissions is used, the conditions for developing as well as for developed countries would change significantly. A clarifying example of this can be obtained by looking at United States and India. These two countries differ a lot regarding per capita emissions and population (Agarwal and Narain 1991; Ahuja et al. 2015). India stands for a large part of the total world population but emits small amounts of greenhouse gas emissions per capita. United States emits more emissions per capita but stands for a smaller percentage of world population. If grandfather principles would control emission allowances exclusively, it would be harder for a country like India to have economic growth. They would always emit the same percentage amount as

before. This explains why countries like India oppose grandfathering as well as EPR and support methods based of per capita emissions (Bretschger 2013).

It can thus be stated that methods based on grandfathering benefit countries and economies that already have experienced an economic growth phase and now face a lower growth rate. Developing, middle-income or poor countries on the other hand experience disadvantages that inhibits or jeopardizes their economic and social prosperity. They are in need of increased emissions to overcome economic and social challenges in the countries (Damon, M. et al., 2019).

3.2 Environmental Kuznets Curve

Other explanations for countries' environmental degradation can be traced through the environmental Kuznets curve (EKC). The EKC displays a relationship between a country's economic growth (income) per capita and the environmental quality (Kolstad 2011). The model takes the shape of an inverted U, with income per capita on the horizontal axis and environmental degradation on the vertical axis. See figure 2, page 15. It resembles the original Kuznets curve, which displays the relationship between income biasness and development, hence the name (Kuznets 1955, 1963).

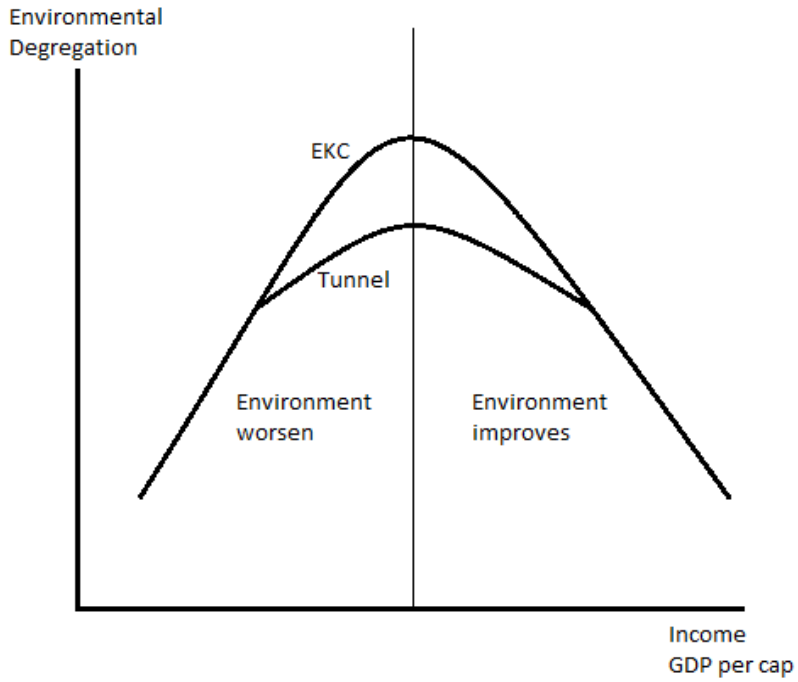
A country starts out in a growth phase, when the foundation of the economy and society is constructed. This growth phase relies on environmentally demanding measures, which leads to a decline in environmental quality. At this point, people are less interested in environmental aspects, e.g. air quality, and mainly focuses on increased income opportunities. Abatement of environmental damages is too expensive for the undeveloped society, which contributes to the poor level of environmental quality. In the course of time, the economy, industry, technical standard etc. is developed. When a certain income level is reached, and the structure of the society changes, people start paying attention to environmental aspects. This will lead to a successive recovery of the environmental quality. With the increased focus on environmental aspects, a shift from an industry based society to a service based society and increased institutional regulating power, the environmental quality is improved. Thus, it is possible to

observe changes of environmental quality as income changes, through the EKC model. Summarized, according to the EKC, each country must strive to increase its economic growth first as this will lead to a better environmental quality in the long run (Kaika and Zervas 2013).

3.2.1 Proponents and opponents of EKC

The Environmental Kuznets Curve has generated debate among scientists and politicians during many years. The results of research are not consistent, which generates split opinions (Kaika and Zervas 2013). Results from cross-section regressions show that pollution increases with income but ceases when income per capita arrives at certain levels. After these levels it is possible to distinguish a trend of increased environmental quality. As a result of these data, proponents justify the EKC-model and argues that primary focus should be economic growth and thereafter pollution abatement. Opponents however, argue that this assumption removes focus from the environmental debate as economic growth is justified regardless of the price of over-exploited natural resources (Dasgupta, et al, 2002). Such reasoning indicates that the environment is an inexhaustible resource, which will not be affected by long-term growth. Growth would thus not be a threat to the environment, which has long been established (Stern, et al, 1996). Furthermore, proponents argue that the EKC displays a relevant scenario as a country passes different structural stages. When a country evolves, going from an industry to a service based society, the environmental quality improves. The industry phase harms the environment as it requires considerable natural resources. The service based society on the other hand is more beneficent to environment (Panayotou, 2003). However, some suggest that the EKC is misguiding as a service sector still causes environmental damages. Many factors are needed when fulfilling a service. Offices, restaurants, transports and other material elements are required and causes environmental degradation (Stern and Cleveland, 2004). Other critique against the EKC is the fact that developed, service based countries outsource their emissions to developing countries by relocating their production (Baumert et al., 2019). However, research implies that developing countries today can" tunnel" through the curve, meaning that they do not have to meet the same challenges as previous developing countries, as shown in figure 2 on page 15. The countries can peak their environmental degradation earlier than before at a lower economic level, through environmentally promoting policies for example (Munasinghe, 1995).

Figure 2.



EKC and the "tunneling through" phenomenon.

Some opponents argues furthermore that it is hard to assume an EKC for a certain country as time series of data often are incomplete. The technical development also creates issues. It is hard to compare countries as they behave very different regarding the effects of technical innovation and development. Additionally, different population densities need to be acknowledged. Developing or poor countries have often more generous populations. Richer, developed countries on the other hand have smaller populations. The differences in population densities would lead to different curves as income in each country increases. Furthermore, a smaller population can be related to lower abatement costs. A small population makes it easier for the environment to recover by itself. Leading to the assumption that countries with a large population has higher abatement costs (Kolstad 2011).

It is clear that the EKC is much criticized, however it can still be useful in environmental negotiations. The curve shows some relationship between economic growth and environmental quality worth recognizing. Some argues that stabilization of growth and environmental quality in poor countries should be a global goal. Through investments of international institutions and

developed countries, the economy and environmental quality in less developed countries could rise. Through this funding, protection of natural resources could be established, and environmentally hazardous waste could be taken care of. Furthermore, new technology or production methods could be developed which would not be based on environmentally inhibitory materials or technologies. In this way, the economy could be directed towards environmental promotion activities (Kolstad 2011).

The EKC displays how growth from a low-income level generates environmental degradation while growth at a higher income level generates better environmental quality. An explanation for the improvement of environmental quality in rich countries, is the possibility to deal with local damage through increased institutional empowerment (Pihl 2014). This reasoning may thus apply on a local level. However, in order to manage environmental damage at a more global level, some believe that greater institutional development is required (Arrow, et al, 1995).

Strong pessimists claim that the EKC curve is an unrealistic model. Some emitters may be controlled or eliminated but the increased economic activity will boost new polluters and new toxic material. This will lead to deteriorated environmental quality, despite increased economic growth. Still, proponents of EKC states that, according to empirical research, the curve should move to the left on the horizontal axis. Modern economic growth does not cause as much pollution as previously in the initial phase of a country's industrial development, thanks' to environmentally friendly technology and energy sources. This also indicates that the environment faster recovers and that environmental quality starts to increase at a lower degree of economic growth (Dasgupta, et al, 2002).

4. Methodology

4.1 Data

The database created for this thesis contains data from three different sources, the World Bank, the University of Notre Dame and the University of Melbourne. A large sample set of at least 170 observations is used in the tests. Due to limited data regarding certain countries the observations varies between the models. The data was collected from credible sources and enables the possibility to conduct tests with a large sample set and testing the hypotheses on almost all of the published NDCs. Given that each country have only published a single NDC so far, all of the regressions are cross-sectional regressions measuring the ambition level in a single point in time. Following section wish to explain the data and variables before the hypotheses and the regression models are further explained. The section ends with an account of measures that has been taken to reinforce the validity of the regressions.

4.2 Meinshausen's factsheet

One of the challenges are the different base years that are used. For example, some countries discuss to lower their greenhouse gas emission in relation to their levels in 1990, others want to lower their greenhouse gas emissions in relation to their levels in 2005 (UNFCCC 2015).
This thesis will use the estimated values Meinshausen and his colleagues conducted in 2016, mentioned above in the literature review. They have through recalculation created a percentage expected change in greenhouse gas, between 2010 and 2030, for each country and ranked them based on this reduction. These recalculated values will be used to calculate the dependent variable, when conducting the regressions and answering the hypotheses of this thesis (Meinshausen et al, 2016).

It is important to acknowledge that this data of greenhouse gas emissions, measured in CO2 equivalents[2], is a rough measurement when it comes to ranking contributions from different

[2] The World Bank explains the CO2 equivalents and what they are composed of like this.
"Total greenhouse gas emissions in kt of CO2 equivalent are composed of CO2 totals excluding short-cycle biomass burning (such as agricultural waste burning and Savannah burning) but including other biomass burning (such as forest fires, post-burn decay, peat fires and decay of drained peatlands), all anthropogenic CH4 sources, N2O sources and F-gases (HFCs, PFCs and SF6)." (World Bank, 2012)

nations. For example, both the United States and Sweden had an approximate equal percentage reduction of greenhouse gas around 30%. Should the contribution from the United States, who in 2010 had a per-capita emission level of 22.2 tCO2eq, be considered as an equally large contribution as Sweden who had a per capita emission level of 7 tCO2eq? Or, should an increase of greenhouse gas emissions like Nigeria's, going from 1.4 to 2.3 tCO2eq, be seen as a worse contribution than the ones mentioned above?

Meinshausen's standardization of NDCs comes with assumptions. When reading the NDCs, it is possible to observe differences between them and Meinshausen's standardizations. The goal of this section is to mediate the assumptions about the NDCs and explain which approximations Meinshausen has reached regarding the NDCs ambition level. To illustrate how their NDCs ambition level differ from Meinshausen's, the thesis specifies four large polluters: United States, China, Australia and the European Union. See appendix figure A, for graph over ambition levels.

4.2.1 Comparisons between NDCs and Meinshausen's standardization

United States declares in their NDC (2016), that they aim to reduce their greenhouse gas emissions with 26 – 28 % until 2025, in relation to the level they had in 2005. The greenhouse gases included in this measurement are all that were included in the 2014 inventory of United States greenhouse gas emissions and sinks: carbon dioxide, methane, nitrous oxide, perfluorocarbons, hydrofluorocarbons, sulphur hexafluoride and nitrogen trifluoride. Covering all the sectors from the IPCC regarding greenhouse gas emissions (2006). When Meinshausen recalculate the ambition level from the United States it was given, as mentioned earlier in this thesis, in per capita emissions in 2030 relative to 2010. In 2010 the United States had the emission level of 22.2t (CO2eq/cap). Converting the NDCs ambition level trend to this, would mean that in 2030 the emission level would have declined to 15.3t (CO2eq/cap). This indicates a reduction of 31% (Meinshausen et al, 2016).

Looking at Chinas NDC (2016) we can see that the country is determined to reduce their carbon dioxide emissions per unit of GDP by 60 – 65% until 2030 from the level of 2005. The NDC also mentions that China plans to invest a lot in green investments and therefore planning to peak their total carbon dioxide emissions by 2030. This means that they would have an ambition level, according to Meinshausen, of increasing their greenhouse gas emissions per

capita until 2030. Meinshausen concludes that China is planning to increase their CO2eq/cap by 29% until 2030 from the level 2010 (Meinshausen et al, 2016). The numbers are controversial compared to the numbers found in China's NDC and it is important to acknowledge that the assumptions of Meinshausen, could be further questioned.

The European Union, which have a common NDC (2015), plans to reduce their total greenhouse gas emissions by at least 40% in domestic reduction until 2030, in relation to their 1990 level. The European Union include the same greenhouse gases as the United States. Converting this into a per capita emission level between 2010 and 2030, Meinshausen has made the assumption that the European Union will lower their greenhouse gas emissions by 26% (Meinshausen et al, 2016).

According to their NDC (2015), Australia is having an economy-wide target of reducing its greenhouse gas emissions by 26-28% from the level of 2005 until 2030. Meinshausen has approximated that Australia will go from 25.7 tCO2eq per capita in 2010 to 15.7 tCO2eq per capita in 2030. Reducing their per capita emissions by 38% (Meinshausen et al, 2016). Australia intend to include the same greenhouse gases as the United States, mentioned above. Australia's NDC is explicit and the approximation made by Meinshausen is not to be seen as controversial when looking at the nations NDC, as they are quite similar.

4.3 Variables

The dependent variable, Emission per capita 2030, will be measured as expected greenhouse gas emissions per capita that each country has in 2030. This will be tested against the variables Greenhouse gas emissions per capita 2010, GDP per capita, GDP per capita squared and Vulnerability. Further explanations for each variable follow in this section.

4.3.1 Emissions per capita 2010 and Emissions per capita 2030

The thesis will use the variables Emissions per capita 2010 and Emissions per capita 2030 to explain the per capita greenhouse gas emissions countries had in 2010 and the expected level they aim to have in 2030, according to their NDCs from the Meinshausen study (2016). Using the amount of emission in 2030, instead of the percentage change of emissions until 2030, deletes the existence of negative numbers. Otherwise, if the percentage change had been used

as a dependent variable, it would have been difficult to interpret the results, as the regression would have shown double negatives. Meaning that a negative value would indicate a positive impact on environment. Consequently, the thesis uses the emission per capita levels in 2030 as a dependent variable. This variable has been calculated by multiplying a countries emission level from 2010 with the related NDC percentage ambition level. For example, The United States had a greenhouse gas emission level per capita of 22.1 (tCO2eq) and an ambition level of -31%, according to Meinshausen. This would give us an estimated value of 15.3 (tCO2eq) in 2030.

$$\textit{Equation: } 22.1 * 0.69 = 15.3$$

4.3.2 GDP per capita

Other variables intended to be tested are GDP (PPP[3]) per capita, which is measured in 10 000 US dollar. Collected data from the World Bank (2019) will be used to test if there is any significant correlation between a country's development level, measured in GDP (PPP) per capita, and the level of ambition in the NDCs. The debate regarding PPP has been going on for many years. Opponents suggests that PPP can be misleading as it is a simple model which bases on the principle of law of one price. Certain assumptions need to be satisfied, such as perfect information and no transaction costs, which are hard to fulfill (Taylor, et al, 2002). Although PPP is not a perfect measurement, it does let us compare countries' purchasing power with the same currency. GDP per capita is a rough measurement and does not account for all factors which are important when comparing the level development of nations. However, it is an easy and effective way to compare nations and the necessary data is highly available worldwide.

4.3.3 GDP per capita squared

This variable is relevant as it captures the inverted U-shape of the EKC. The variable illustrates the non-linear relationship between emissions and GDP per capita. The sign of the coefficient, if positive, will expose an inverted U-shape of the curve.

[3] PPP = Purchasing power parity. A measurement that makes it possible to compare GDP between countries by adjusting for purchasing power and keeping a constant price level.

4.3.4 ND-GAIN index, vulnerability and readiness

One of the variables, which will be used to control the NDCs ambition levels, is the ND-GAIN index created by University of Notre Dame (Chen, et al, 2015). It measures both vulnerability and readiness against negative climate related impacts. The vulnerability score relies on six different sectors – food, water, health, ecosystem service, human habitat and infrastructure. The readiness score indicates of how well countries can manage to leverage investments and use them to adapt to the negative climate impacts. The three factors that the index consists of is governance readiness, economic readiness and social readiness (University of Notre Dame, 2019). Each country is given a total score between 0 and 1, composed both by the vulnerability score and the readiness score. The countries also receive a separate value for each of the variables. Thereafter, an overall score is given through the following equation:

$$\text{ND-GAIN index} = (Readiness - Vulnerability + 1) * 50.$$

This thesis investigates the two scores individually but will only use Vulnerability in the regression as a control variable. Vulnerability is more interesting as the thesis wants to investigate how countries act based on their exposure to negative climate impacts regardless of how prepared they are.

4.4 Hypothesis

Based on previous literature and the purpose of this thesis, the following hypotheses will be tested:

1. *Null hypothesis: Grandfathering is not significant for how a nation chooses ambition level.*
2. *Null hypothesis: The ambition level of the NDC depends only on equal per capita emissions.*
3. *Null hypothesis: The nation's ambition level of NDC cannot be described as an Environmental Kuznets curve.*

4.5 Regression analysis

The method in this report relies on the use of regression analysis. It is a quantitative study, which is reasonable, given the extensive data amount provided by the NDCs and the purpose of this thesis. An investigation of the relationship between greenhouse gas emissions and

several variables that could affect the willingness to contribute to the global temperature goals, will be conducted by Ordinary Least Squares regressions (OLS). The method of OLS estimates unknown parameters of a model. This is possible by minimizing all the squared differences between the observed values and the predicted ones. Each observation in an OLS-regression is given equal weight. By studying the different outputs from the regressions, assumptions will be made about the significance to the tests and the relationship between the variables. After defining the variables and running them through the model used for the regression analysis, the hypotheses will be answered. One important thing to emphasize when looking at regression analysis is how models only show correlation, not causality. This means that if it is desired to observe a positive correlation between a climate risk variable and an NDC-effort variable, it can be said that they move in the same direction but not with causality. However, this is not a severe issue in this study since the aim is to investigate if there is a relationship rather than a causality between the variables.

The OLS-regression model investigates the linear relationship between the dependent variable and the independent ones, with the following equation:

$$Y_i = \beta_0 + \sum_{k=1}^{K} \beta_k X_{ki} + \varepsilon_i$$

Where, *Y,* is the dependent variable, in this case Emissions per capita 2030. β_0 , the intercept, is a constant. X_k , symbolizes the independent variable and the coefficient, β_k shows the effect that the independent variable X_k has on Y. Furthermore the index k, represents the number of independent variables in the model. $\beta_k X_k$ represents further dependent variables and their effect. ε_i is the unobserved variable. Below, the different models used in the thesis are explained.

The thesis uses four different models to investigate the relationship between the dependent variable and the independent ones, to test the hypotheses regarding grandfathering, the equal per capita emissions and the Environmental Kuznets Curve. Results will show if the independent variables are significant and affect the ambition level of a country regarding mitigation. Following section presents the four models.

Model 1:

$$Emissions_{2030} = \beta_0 + \beta_1 Emissions_{2010} + \varepsilon$$

The test for grandfathering begins with an OLS-regression where the relationship between emissions per capita in 2030 is compared to the emissions per capita in 2010. The β_1 coefficient shows the how many units Emissions per capita 2030 increases if Emissions per capita 2010 increases by one unit.

Model 2:

$$Emissions_{2030} = \beta_0 + \beta_1 Emissions_{2010} + \beta_2 GDP + \varepsilon$$

In model 2, GDP per capita is added as an independent variable, to investigate the linear effect of GDP, on how countries plan to change their emissions between 2010 and 2030.

Model 3:

$$Emissions_{2030} = \beta_0 + \beta_1 Emissions_{2010} + \beta_2 GDP + \beta_3 Vulnerability + \varepsilon$$

In model 3, the control variable Vulnerability is added to see if the effect from this variable affects the ambition level a country gives in their NDC.

Model 4:

$$Emissions_{2030} = \beta_0 + \beta_1 Emissions_{2010} + \beta_2 GDP + \beta_3 GDP_{squared} + \varepsilon$$

In model 4, the independent variable GDP_squared is added to test for the Environmental Kuznets Curve. Here, the expectation is that GDP and GDP_squared will have different signs to control for the environmental Kuznets curve.

4.6 Validity of the regressions

In order to reinforce the validation of the regressions, measures and several tests has been conducted. To adjust for possible heteroscedasticity, robust standard errors have been used in all regressions. Robust standard errors are more accurate in case of heteroscedasticity. Moreover, according to the conducted VIF test, variance inflation factor test, data is not exposed for multicollinearity, see tables in appendix. Values under 10 in the VIF are desirable,

otherwise there exists multicollinearity (Williams, 2015). As shown in the appendix, none of the values in the VIF tests exceed 10. Since the data set consist of at least 170 observations, a normal distribution is assumed. A large enough sample size makes it hard to pass a normality distribution test, such as Jarque-Bera test. Results from the test show that the data is not normally distributed since it shows significance. However, the existence of violations of the normality assumption, does not cause any major damages, with a large enough sample size. Furthermore, the histogram in figure B, see appendix, show how the residuals are normally distributed in the data set.

5. Results and analysis

This section will firstly present a correlation matrix where the different relationships between variables are displayed and explained. Thereafter, the regression and associated table, which display the relationship between the dependent variable and the independent variables, are presented. The regressions will be used to answer if it is possible to reject the hypotheses.

5.1 Correlation between dependent and independent variables

Table 1. Matrix of correlations

Variables	(1)	(2)	(3)	(4)
(1) Emissions per cap, 2030	1.000			
(2) Emissions per cap, 2010	0.910	1.000		
(3) GDP per cap	0.645	0.805	1.000	
(4) Vulnerability	-0.446	-0.564	-0.680	1.000

Correlation matrix over the dependent variable and the independent variables.

The results from the correlation test are shown in table 1. The results show us how a country's expected emission level in 2030 correlates with the explanatory variables and how the variables correlates amongst each other. Primary it is possible to observe a strong positive correlation between a country's greenhouse gas emissions per capita in 2010 and its expected level of the same in 2030. This indicates that countries will behave in a similar way in 2030 as in 2010.

The rather high positive correlation between GDP per capita and Emissions per capita 2030, shows that a country with high level of GDP per capita in 2010 will have a quite high level of emissions per capita in 2030. A negative correlation between vulnerability and emissions 2030, means that the more vulnerable a country is to climate change the less it will emit per capita in 2030.

5.2 Linear regression analysis

A linear regression analysis is used to investigate the relationship between the dependent variable Emissions per capita 2030 and the independent variables, with a few control variables. By conducting different linear regressions, conclusions regarding the hypotheses of the thesis can later be made.

Table 2. Linear regression model 1 -4

Emissions per cap, 2030	Units	Model 1 N = 193	Model 2 N = 178	Model 3 N = 170	Model 4 N = 178
Emissions per cap, 2010	ton CO2eq	.8812 *** (.0608)	1.0516*** (.1001)	1.0779 *** (.1041)	1.0536*** (.0480)
GDP per cap	10 000 USD	-	-.7174 ** (.3177)	-.7727 ** (.4215)	-.7655** (.3054)
GDP per cap, squared	10 000 USD	-	-	-	.0058 (.0730)
Vulnerability	ND-GAIN index 0-1	-	-	1.4431 (3.8722)	-
Constant		**.4669**	**.6906****	**.0298**	**.7212****

*** p<0.01, ** p<0.05, * p<0.1

Number of observations = N

Standard errors in brackets.

5.2.1 Results connected to hypotheses 1 and 2

To test the first hypothesis, models 1, 2 and 3 are consulted. Model 1 exposes the relationship between the independent variable emissions per capita in 2010 and expected emissions per capita in 2030, according to each country's NDC. The model shows a significant result which indicates that an increase in emissions by one unit 2010 would result in an increase of 0.8807 units of emissions per capita in 2030. Based on the correlation conducted earlier in the thesis, a significant result is anticipated and exposes a similar linear trend of emissions. In order to see if other factors affect ambition level, further tests are conducted.

Adding a second independent variable in model 2, enlarges the coefficient of Emissions per cap 2010. If it increases by one unit of emissions, then Emission per capita 2030 will increase by 1.0516 units. The significant variable GDP per capita indicates that one positive unit increase of GDP per capita 2010, lowers a country's anticipated level of greenhouse gas emissions per capita by 0.7174 units in 2030. Meaning that countries with a higher GDP per capita, seem to lower their expected emissions. In order to further investigate and explain the relationship of how countries choose their ambition level, a control variable is added in model 3. The result shows that the first two explanatory variables display a similar relationship with the dependent variable, as shown in the first two models. Vulnerability seems to affect emissions per capita in 2030 positively but is not significant and cannot be used to make any assumptions in this analysis.

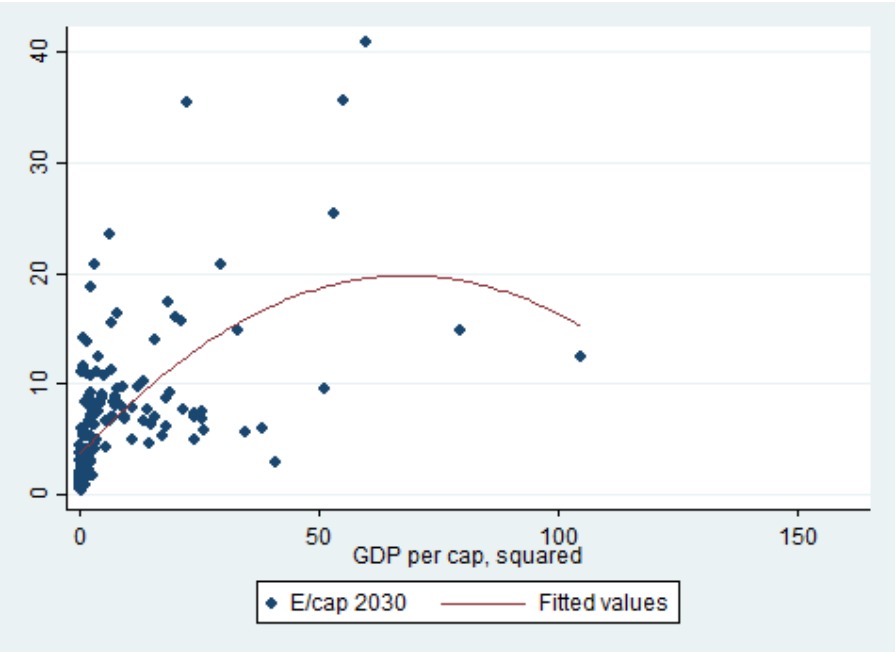
The result in model 1 indicates support for the principle of grandfathering. The value of the coefficient of Emissions per capita 2010, 0.8807 is close to 1, which would mean that emissions in 2030 are proportionate to emissions in 2010. This is in line with the assumptions of grandfathering. To enforce the support of grandfathering further variables are included. The results given from model 2 and 3, show that the coefficients of emissions per capita in 2010 are even closer to 1 compared to the first model. Thus, emissions per capita in 2030 seems to be proportionate to emissions per capita in 2010, which supports the principles of grandfathering. Therefore, the first hypothesis may be rejected.

The second hypothesis if countries based their ambition level on equal per capita emissions, can also be rejected. The regressions in models 1 – 4 expose different significant values of the constants as well as other significant variables. This indicates that countries do not act according to equal per capita emissions, otherwise the constants would show the same value and no other coefficient would be significant. As shown in model 2, the variable, GDP per capita is significant and has a negative linear effect on emission per capita in 2030. This result implies that there are other driving factors when countries set their ambition level, besides grandfathering. Consequently, traces of the EKC could be plausible even though we have a strong grandfathering relationship. As grandfathering seems to be the general trend in the NDCs and is well supported by the model, EKC should not have an effect on countries decision regarding ambition level. In order to confirm the suspicions, further investigation follows by conducting test for the EKC.

5.2.2 Results connected to hypothesis 3

In order to confront the third hypothesis, model 4 is constructed in table 2 above. The model exposes a regression with Emission per capita 2030 as dependent variable with Emission per capita 2010, GDP per capita and GDP per capita squared as independent variables. The first two variable show significant results, corresponding with the results from previous regressions. Squared GDP per capita is not significant, which means that no assumption about the effect on Emissions per capita 2030 can be made. However, the sign of the coefficient is still interesting. It shows an opposite sign compared to GDP per capita which indicates a U-inverted relationship like the EKC, which can be observed in figure 3. Nevertheless, GDP per capita squared is not significant and although tendencies of EKC are visible, the hypothesis cannot be rejected.

Figure 3.



Scatterplot of EKC-relationship, GDP per capita squared and Emissions per capita in 2030.

When looking at the scatter plot of GDP per capita squared and Emissions per capita 2030, it is clear that it resembles the shape of the EKC. As countries increases their GDP per capita the emissions increases, until a turning point. Here the curve switch direction. Thereafter, emissions seems to decrease as GDP per capita increases, supporting the principles of the EKC. However, as discussed above, the GDP per capita squared is not significant and no assumption about the EKC can be made.

6. Discussion and Conclusion

The purpose of this thesis was to analyze countries ambition level presented in their NDCs, which were constructed prior to the Paris Agreement. The analysis was connected to two different economic principles, the principles of grandfathering and the principles of the Environmental Kuznets Curve (EKC). The thesis aimed to explain countries choices in environmental negotiations. Specifically, why countries chose a particular ambition level concerning their reduction of greenhouse gases in order to meet the common goals of the Paris Agreement.

When looking at results connected to the principles of grandfathering, signs suggests that countries did act according to it during their construction of the NDCs. It should be noted however, that there is not a mechanical connection between grandfathering and the ambition levels of the NDCs. The ambition level chosen by the countries are probably a mix of principles, which is why the thesis later investigates the EKC. The results of the regressions 1 – 3 show coefficients of Emissions per capita in 2010 that are close to 1. This implies proportionate emissions in 2030. Thus, it can be assumed that the principles of grandfathering had an effect when countries formulated their own goals. Hence, the first hypothesis of the thesis is rejected.

Perhaps the generous self-chosen emission levels could be explained by the only rule that applied to the Paris Agreement, which determines that the ambition level cannot be lowered. The rule may have had an intimidating power and driven countries towards generous emissions. As discussed in the theory-section, actors are driven by profit maximization which could be a reason for their lack of consideration of the environment. When countries can choose mitigation freely, the effort is not enough. A regulating authority is required, as mentioned both in the literature and theory section. The generous emission levels, based on grandfathering, can be seen as a failure of the Paris Agreement, even though they may have generated participation and avoided deadlock of negotiations. The emissions align with the discussion in the literature review part, which implies that countries efforts during the agreement are insufficient. Perhaps the result would have looked different if countries resonated differently. There are issues of fairness that needs to be acknowledged. Should developed countries keep on emitting in proportion to historical numbers or should they leave room for less developed countries, struggling with poverty? However, despite grandfathering methods and insufficient efforts,

there are also positive aspects of Paris Agreement. As mentioned above in this thesis, more countries than ever have engaged in climate negotiations and feel responsible to fulfill the global temperature goals. Even though the one rule of the agreement might have had a deterrent effect it still ensures that ambitions cannot decline. Now, the levels set in countries' NDCs can be used as new baselines when new reductions needs to be done. Hopefully, as researcher speculates, emissions will slowly but surely shift away from historical amounts and principles of grandfathering. Summarized, the agreement engages a majority of all countries, forcing them to acknowledge environmental issues. Then, the Paris Agreement should not be looked upon as a failure, but a small step in the right direction.

The second hypothesis concerning equal per capita emissions could be rejected. The constants displayed in the regressions does not have the same value, at the same time as other variables show significance. As the signs regarding grandfathering were evident, this was not a surprising result. Countries did not set an ambition level of emissions that would reflect an equal per capita allocation. This might be explained by the fact that countries set their own ambition level and are driven by profit maximization, as discussed above. Even though reductions were made, no party would have given themselves disadvantageous reduction goals. The result might have looked differently if aspects of justice or responsibility were acknowledged by the countries. Then more developed countries with smaller populations would have left room for developing countries, which are in need of economic growth to support their sizable populations, as discussed in the theory-section.

Furthermore, regressions have been made to investigate the principles of the Environmental Kuznets Curve and if this was visible among the countries. The results did not show statistical support for the theory. As discussed in the theory-section, the EKC has experienced extensive criticism and has been found difficult to prove. Therefore, this result was anticipated. However, the signs of the variables and the scatterplot implied tendencies of the EKC, even though no confirmations could be made. Thus, the third hypothesis of the thesis could not be rejected. The insignificance of the EKC test could be explained by the cautiousness taken by countries when setting their goals. Not knowing how other countries would act, they might have taken a more modest option in order to avoid paying a higher price than others for the effects of global warming. What is visible now, a few years after the first NDCs were published, is that the 2 ºC goal from the Paris Agreement is not met by many countries. An example can be obtained by looking at the United States. They have informally withdrawn from the Paris Agreement under

the Trump administration, since an exit is not possible until November 4th 2020. The decision is defended by the argument that the agreement would hurt the economy of the United States and put the country in a permanent disadvantage position against other countries. Once again the profit maximization theory is visible.

Now when the second NDCs will be published it will be interesting to make comparisons. If the general approach of the NDCs has changed or if countries still act quite modest or unchanged in their goals. The NDCs are an interesting research subject which will surely result in further studies in the future. This thesis contributes to the understanding of why countries have acted in a certain way during the Paris Agreements and problematizes voluntary emission reductions. Hopefully, the thesis can be used as a discussion material in further debates concerning NDCs. However, it would be good if countries could unite around some measurements when constructing their NDCs, which would make them easier to compare and more concrete. Even though Meinshausen's standardization has been used in this thesis to make comparisons, it must be emphasized that it is based on assumptions. This could have an inaccurate effect if the assumptions differs too much from the reality.

Finally, it would have been interesting to examine other variables as well, which could together with grandfathering explain how countries ambition levels are chosen. Perhaps the level of democracy, level of fear of climate change and level of opinions of justice among the population, could have a large impact on environmental ambitions. These are just a few examples of interesting aspects, which could not be addressed in this thesis due to lack of aspects like time, measures and limited data. However, the potentiality of other variables creates continued intriguing research opportunities.

7. References

Admiraal, A., Elzen, M., Forsell, N., Turkovska, O., Roelfsema, M., Soest, H. (2015). *Assessing Intended Nationally Determined Contributions to the Paris Climate Agreement – What are the Projected Global and National Emission Levels for 2025–2030?* (Report No.1879). http://www.pbl.nl/en/publications/assessing-intended-nationally-determined-contributions-to-the-paris-climate-agreement [Accessed 23-04-2019]

Agarwal, A., Narain, S. (1991). *Global warming in an unequal world: a case of environmental colonialism*. New Delhi: Centre for Science and Environment.

Ahuja, R., Camuzeaux, J., Sterner, T., Wagner, G. (2015). *From Copenhagen to Paris – the current state of climate negotiations*. Foreign Affairs. https://www.foreignaffairs.com/articles/2015-11-25/copenhagen-paris [Accessed 08-05-2019]

Arrow, K., Bolin, B., Costanza, R., Dasgupta, P., Folke, C., Helling, C. S., Jansson, B.-O., Levin, S., Mailer, K.-G., Perrings, C., Pimental, D. (1995). *Economic growth, carrying capacity, and the environment*. Science, Vol. 268.

Baumert, Nicolai et al. (2019). Global outsourcing of carbon emissions 1995–2009: A reassessment. *Environmental Science And Policy*. 92, pp.228–236.

Bretschger, L. (2013). *Climate policy and equity principles: fair burden sharing in a dynamic world*. Environment and Development Economics. Cambridge University Press. https://www.cambridge.org/core/journals/environment-and-development-economics/article/climate-policy-and-equity-principles-fair-burden-sharing-in-a-dynamic-world/348085753028FE1EF4B9B05CA6116652 [Accessed 08-05-2019]

Caney, S. (2009). *Justice and the distribution of greenhouse gas emissions*. Journal of Global Ethics, 5 (2), pp.125–146.

Chen, C., Noble, I., Hellmann, J., Coffee, J., Muri
llo, M., Chawla, N. (2015). *ND-GAIN index University of Notre Dame Global Adaptation Index, Country Index Technical Report*. https://gain.nd.edu/assets/254377/nd_gain_technical_document_2015.pdf [Accessed 20-04-2019]

Cleveland, Cutler J., (2004). *Energy and Economic Growth*. , FS IV 01-01.

Cole D. (2008). *Climate change and collective action*. Current Legal Problems 61:229–64 https://academic-oup-com.ezproxy.ub.gu.se/clp/article/61/1/229/612723 [Accessed 08-05-2019]

Damon, M. et al. (2019). *Grandfathering: Environmental Uses and Impacts. Review Of Environmental Economics And Policy*, 13 (1), pp.23–42.

Dasgupta, S., Laplante, B.,Wang, H., Wheeler, D. (2002). *Confronting the Environmental Kuznets Curve.* Journal of Economic Perspectives. 16 (1), pp.147–168.

Field, B., Olewiler, C., Nancy, D. (2011) *Environmental Economics, Third Canadian Edition*. McGraw-Hill Ryerson. Toronto.

Fransen, T., Levin, K. (2015). WRI. *INSIDER: Why Are INDC Studies Reaching Different Temperature Estimates?* https://www.wri.org/blog/2015/11/insider-why-are-indc-studies-reaching-different-temperature-estimates?fbclid=IwAR1w56HWGwO3ZNsZu_ZS9Fmdz8lXOzn-PnegTeIypfVmOcCggGWGK4uEFoU [Accessed 23-04-2019]

Frieler, K., Geiger, T., Gieseke, R., Gütschow, J., Jeffery, L., Lange, S., Meinshausen, M., Narezo Guzman, D., Otto, C., Schewe, J., Volkholz, J. (2017). *PRIMAP*. https://www.pik-potsdam.de/research/climate-impacts-and-vulnerabilities/research/rd2-flagship-projects/gia/primap/primap. [Accessed 20-04-2019]

The Intergovernmental Panel on Climate Change, (2006). *IPCC Guidelines for National Greenhouse Gas Inventories*. https://www.ipcc-nggip.iges.or.jp/public/2006gl/ Accessed [13-05-2019]

The Intergovernmental Panel on Climate Change, (2018). *Special Report on Global Warming*. https://www.ipcc.ch/sr15/ [Accessed 29-03-2019]

Kaika. Zervas, (2013). *The Environmental Kuznets Curve (EKC) theory—Part A: Concept, causes and the CO2 emissions case*. Energy Policy, 62. pp. 1392–1402. https://www.sciencedirect.com/science/article/pii/S0301421513007970?fbclid=IwAR2Pq2nfSIqc2J4o1UkCeqlk1vwH-zvVvNtBazfwEDCDIa1bLG-mqTjJsZY [Accessed 07-05-2019]

Knight, C. (2012) *What is grandfathering?* Environmental Politics, 22:3, 410-427 https://doi.org/10.1080/09644016.2012.740937 [Accessed 2019-04-29]

Kolstad, D.C. (2011) *Intermediate environmental economics*. Oxford University Press.

Kuznets, S. (1955). *Economic growth and income inequality*. American Economic Review. 49. pp. l-28.

Kuznets, S. (1963). *Quantitative aspects of the economic growth of nations, VIII: The distribution of income by size*. Economic Development and Cultural Change. 11 pp. l-92.

Libecap, G.D. (2008). *The tragedy of the commons: property rights and markets as solutions to resource and environmental problems.* Australian Journal of Agricultural and Resource Economics, 53 (1), pp.129–144. https://onlinelibrary-wiley-com.ezproxy.ub.gu.se/doi/full/10.1111/j.1467-8489.2007.00425.x [Accessed 08-05-2019]

Meinshausen, M., et al. (2016). *INDC Factsheets.* Australian-German Climate and Energy College. http://climate-energy-college.net/indc-factsheets [Accessed 15-04-2019]

Montero, J.P. (1999). *Voluntary compliance with market-based environmental policy: evidence from the U.S. acid rain program*. Journal of Political Economy. 107. pp. 998–1033.

https://www-journals-uchicago-edu.ezproxy.ub.gu.se/doi/10.1086/250088 [Accessed 08-05-2019]

Munasinghe, M. (1995). *Making economic growth more sustainable.* Ecological Economics, 15(2), pp.121–124.

Nash, J.R. (2009). *Allocation and uncertainty: strategic responses to environmental grandfathering*. Ecology Law Quarterly. 36. pp. 809–50.

Panayotou, T., 2003. *Economic Growth and the Environment 2003, in Economic Survey of Europe: UNECE*.

Penman, J., Gytarsky, M., Hiraishi, T., Irving, W., Krug, T. (2006). IPCC. *2006 IPCC Guidelines for national greenhouse gas inventories*. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/0_Overview/V0_1_Overview.pdf [Accessed 17-05-2019]

Pihl, H. (2014). *Miljöekonomi för en hållbar utveckling*. Studentlitteratur AB. Lund.

Stern, N. (2006). *The economics of climate change: The Stern review.* Cambridge: Cambridge University Press.

Stern., Common., Barbier. (1996). *Economic growth and environmental degradation: The environmental Kuznets curve and sustainable development.* World Development, 24(7), pp.1151–1160.

Sterner, T. Damon. (2011). *Green growth in the post-Copenhagen climate*. Energy Policy. 39(11), pp.7165–7173.

Sterner, T., Coria, J. (2013). *Policy instruments for environmental and natural resource management* 2. ed., Hoboken: Taylor and Francis.

Taylor, Alan M,. Taylor, Mark P. (2002). *The Purchasing Power Parity Debate. Journal of Economic Perspectives*. 18(4), pp.135–158.

Wesley, E., Peterson, F. (1999). The ethics of sharing in the global greenhouse. Journal of Agricultural and Environmental Ethics. 11 (3), pp.167–196

Williams. (2015). *Multicollinearity*. University of Notre Dame. https://www3.nd.edu/~rwilliam/stats2/l11.pdf?fbclid=IwAR0f1Mu5pZ4yV-00LFHvQ7b1qLsLYtbElflfpRjKKwVv9-TElefnAhlLFrs [Accessed 17-05-2019]

The World Bank. (2012). *GDP PER CAPITA (PPP)*. https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.CD?end=2012&page=1&start=2012 [Accessed 17-04-2019]

UNFCCC. (2013). *About the Secretariat* https://unfccc.int/about-us/about-the-secretariat [Accessed: 10-04-2019]

UNFCCC. (2015). *Paris Agreement*. https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement [Accessed 08-04-2019]

UNFCCC. (2016). *Interim NDC Registry*. https://www4.unfccc.int/sites/NDCStaging/Pages/Home.aspx [Accessed 08-04-2019]

UNFCCC. (2016). *Synthesis Report on the Aggregate Effect of the Intended Nationally Determined Contributions*. https://unfccc.int/process/the-paris-agreement/nationally-determined-contributions/synthesis-report-on-the-aggregate-effect-of-intended-nationally-determined-contributions [Accessed 22-04-2019]

UNFCCC. (2019). *Nationally determined contributions*. https://unfccc.int/process/the-paris-agreement/nationally-determined-contributions/ndc-registry [Accessed: 17-04-2019]

UNFCCC. (2019). *What is the United Nations Framework Convention on Climate Change?* https://unfccc.int/process/convention/what-united-nations-framework-convention-climate-change [Accessed: 07-04-2019]

University of Notre Dame. (2017). *ND-GAIN INDEX*. https://gain.nd.edu/our-work/country-index/rankings/ [Accessed 17-04-2019]

8. Appendix

Figure A. NDC ambition level according to Meinshausen.

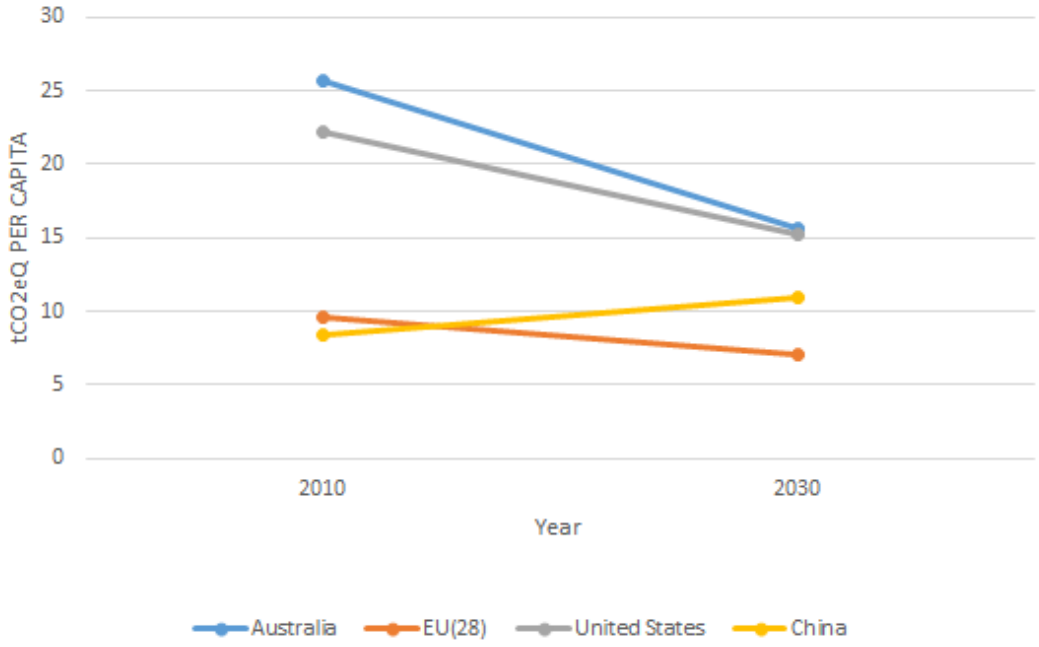
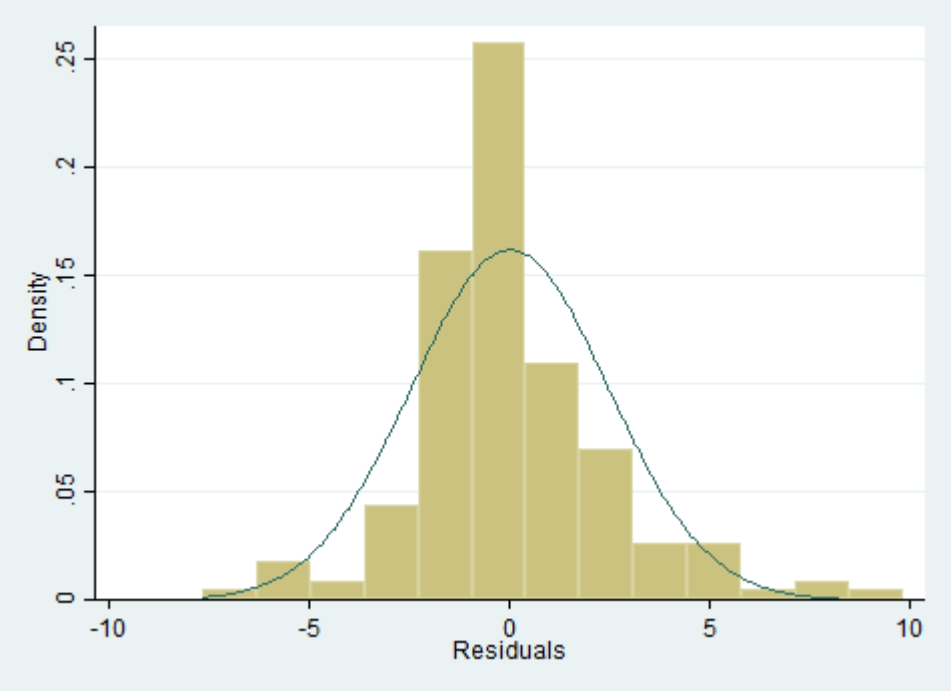


Figure B. Histogram over density spread of residuals.



VIF tests

A VIF test is used to determine if there could be any multicollinearity in the data. None of the variables displays values above the critical level.

Variance inflation factor Emissions 2010, GDP per capita

	VIF	1/VIF
Emissions 2010	**2.702**	**.37**
GDP per capita	**2.702**	**.37**
Mean VIF	**2.702**	**.**

Variance inflation factor GDP per capita, Emissions per capita 2010, Vulnerability

	VIF	1/VIF
GDP per capita	**3.6**	**.278**
Emissions per capita 2010	**2.839**	**.352**
Vulnerability	**1.861**	**.537**
Mean VIF	**2.767**	**.**

Variance inflation factor GDP per capita squared, GDP per capita

	VIF	1/VIF
GDP per capita squared	**7.236**	**.138**
GDP per capita	**7.236**	**.138**
Mean VIF	**7.236**	**.**