STOCKHOLM SCHOOL OF ECONOMICS
Department of Economics
659 Degree project in economics
Spring 2020

The Presence of Cheap Riders in International Environmental Regimes

Elin Yang Liu (24114) and Denise Shen (24183)

Abstract. Tragedy of the commons is reflected in the international climate policy arena as countries are unable to coordinate and cooperate to reach the goals set within the conventional framework of the Paris Agreement. Although carbon mitigation plans have been submitted by member states, the pledges lack ambition and are not sufficient to prevent anthropogenic warming. The difference between countries' commitments and the level of emissions the world needs to reduce to is defined as the emission gap. It is therefore more interesting to consider the concept of cheap riding instead of free riding, as institutional settings, national interests and opportunistic behaviours cause suboptimal, rather than zero contribution outcomes in the climate regime. With *Collective action in an asymmetric world* by Chen and Zeckhauser as the foundation of this thesis, we investigate the phenomenon where either large or small countries cheap ride on each other, whilst relating this occurrence to nations' respective emission gaps. Our correlation test results indicate that countries with higher GNI have relatively less ambitious climate mitigation policies compared to countries with lower GNI, suggesting that bigger states cheap ride on smaller nations. In other words, our findings oppose that of Chen and Zeckhauser.

Keywords: Climate change, Emission gap, Cheap riding, Collective action, International environmental agreements

JEL: D79, F53, F64, H41, Q54

Supervisor: Karl Wärneryd
Date Submitted: 12th May 2020
Date Examined: 19th May 2020
Discussant: Aeneas Ljungkvist
Examiner: Johanna Wallenius

ACKNOWLEDGEMENT

We would like to express our gratitude to our supervisor Karl Wärneryd for giving us feedback and support throughout this journey, as well as the preconditions to face the world of academic writing in a growingly independent way. His propositions of inspirational papers sparked our own ideas, resulting in our final research question, hence influencing the core essence of our study. We would also like to give gratitude to Robert Östling for providing us valuable statistical advice and insights.

Table of Content

I. INTRODUCTION **4**

II. COLLECTIVE ACTION IN AN ASYMMETRIC WORLD **5**

III. THEORETICAL FRAMEWORK **6**

3.1 THE PUBLIC GOOD AND THE FREE RIDER PROBLEM 6
3.2 PRISONER'S DILEMMA 7
3.3 THEORY OF COLLECTIVE ACTION 8
3.4 PREVIOUS RESEARCH 9
3.4.1 Climate change *9*
3.4.2 Emission gap *9*
3.4.3 International treaties and environmental agreements *10*

IV. DATA AND METHOD **13**

4.1 DATA 13
4.1.1 Variables *13*
4.1.2 Control for confounders *14*
4.2 STATISTICAL METHODS 16
4.2.1 Spearman rank correlation *16*
4.2.2 Kendall partial rank correlation *16*
4.2.3 Limitations and considerations *17*

V. RESULTS **17**

5.1 RESULTS – SPEARMAN RANK CORRELATION 18
5.2 RESULTS – KENDALL'S TAU 20

VI. DISCUSSION **21**

6.1 DISCUSSION OF RESULTS 21
6.1.1 Extreme events and historical annual average temperature *22*
6.1.2 Cheap riding on the basis of emission gap *23*
6.1.3 Global inequity and the burden of climate change *29*
6.1.4 The Paris Agreement *32*
6.2 DIRECTIONS FOR FUTURE RESEARCH 33

VII. CONCLUSION **34**

VII. REFERENCES **35**

VIII. APPENDIX **39**

I. INTRODUCTION

The industrial revolution did not only commence a new era of economic and technological development, but also an age where humankind has gained immense influence over the natural sphere of our planet. The global threat that is climate change has become difficult to neglect any further and its presence is steadily increasing in prominence.

One of the most important and well-known international collaborations regarding global warming is the Paris Agreement. Its foundation is built upon the notion of shared responsibility among nations towards the climate. Through this agreement, member states have collectively committed to keep the global average temperature below 2°C, whilst striving to limit the temperature to 1.5°C as well as enhancing countries' ability to adapt to the adverse effects of climate change. The goal with the treaty is to balance man-made emissions and the absorption of greenhouse gases by the second half of this century. Each nation will contribute to this development by devising a climate mitigation plan. Its ambition level will be determined by the nation itself. However, wealthier states, that have historically emitted more pollutions, are expected to take the responsibility of leading and making their sustainability transition faster than the global average. The climate policies are then jointly reviewed and updated every five years (UNFCCC Nov 2015).

As of 2019, a total of 196 states and the European Union have signed this settlement. Each country has likewise come up with specific national goals to combat climate change, so called Nationally Determined Contributions (NDCs). However, a recent report from the United Nations states that these contributions are lacking in ambition if the global mean temperature is to be kept well below the 2°C limit (United Nations Environment Programme 2019). In other words, an emission gap has originated from insufficient national climate mitigation efforts. This suggests that in a projected future, where each country continues to implement their current NDCs, the effects of climate change may be more severe than what is currently anticipated.

The aim of our thesis is consequently to investigate this problem further and denote the increasingly critical emission gap's role for cooperation in international climate regimes and the combat against environmental challenges. Another matter central in our study is the notion of collective action problems. Because, it is established that international climate regimes, similar to any other transnational alliance whose work revolves around collective goods, are susceptible to free riding complications. Even though some eminent previous works argue that small countries tend to abuse the system which forces larger countries to bear unevenly large costs, our test results arrive at the opposite conclusion. With two statistical rank correlation tests we provide evidence that, in the light of emission gap, carbon emissions and the size of countries' GNI, there is a propensity for large nations to take advantage of smaller states by adopting relatively less ambitious climate pledges, resulting in excess emission gap.

Even though the steps to successfully and collectively reach the goals of the accord are very evident, with prevailing collective action obstacles it has proven to be an immense challenge to raise national ambitions to required levels. This is alarming as, based on current pledges, projections indicate that the global mean temperature will rise above 3°C by 2100 (Climate Action Tracker). Although the heaviest responsibility and potential for change lies with the large and industrialized economies, the surest way to avoid this future scenario is still to seek more striving NDCs from all participating countries.

II. COLLECTIVE ACTION IN AN ASYMMETRIC WORLD

The essence of our study is based upon the work of Chen and Zeckhauser (2018), regarding *Collective action in an asymmetric world*. One of the main issues that hinders efficient transnational cooperation can be explained by the similarities between the international policy arena and that of an anarchic world. With no central authority or supranational organization that can enforce coveted actions and contributions from states, opportunistic behaviours and incentives to free ride will always be present in the public goods paradigm. Chen and Zeckhauser conclude that asymmetries inherent in countries is a fundamental cause which has led smaller nations to cheap ride on larger states, i.e. provide a positive but suboptimal contribution. Hence, due to the voluntary nature of provisions to public goods, general welfare, such as the climate, will be severely under-provided.

In their paper, the authors test the hypothesis of whether smaller nations cheap ride on larger ones in the context of climate change mitigation policies. They use countries' intended nationally determined contributions (INDCs) as a measurement of national contribution to the common good, in relation to country size, assessed as GNI. After controlling for confounders, the test results yield a positive correlation that is statistically significant. Thus, there seems to be a tendency for larger countries to contribute disproportionately more to the mitigation efforts of greenhouse gas emissions compared to smaller states.

In the light of Chen and Zeckhauser's findings, we are intrigued as to whether this principle still holds if the level of contribution is defined as the magnitude of nations' emission gaps, rather than individual pledges. This modification is both interesting and pertinent as state-of-the-art studies, as well as reports, all denote the lack of ambition in current mitigation policies under the UNFCCC. If countries continue to deliver pareto insufficient contributions, then the world's mean temperature is expected to exceed that of the objectives of the Paris Agreement. Therefore, our research question is expressed as follows:

⇒ *If a country's contribution to the Paris Agreement is specified by its emission gap, rather than pledge, relative its gross national income (as defined by Chen and Zeckhauser (2018)), can the conclusion that small countries cheap ride on bigger nations in the instance of voluntary contribution to a public good, in this case climate, still be drawn?*

The rest of this paper will proceed as follows. In section III we will dive deeper into the theoretical frameworks that serves as the foundation of this study, mainly being the theory of public good, the theory of collective action and an overview of existing research touching this subject. Section IV and V present the statistical models and data used to determine the correlation between our variables, as well as the results. In section VI we discuss our findings and answer the research question. Section VII concludes.

III. THEORETICAL FRAMEWORK

In this section we will introduce the theory of public good and the theory of collective action. Both are considered to be conventional theories and explanations to the free rider problem. Furthermore, we will present previous research about coordination problems, climate change and environmental treaties.

3.1 The public good and the free rider problem

A public good exists when one's consumption of a commodity does not exclude or diminish the opportunity of others to enjoy the same benefits provided by the same good (Samuelsson 1954). That is, when a commodity exhibits the properties of being nonrival and nonexclusive. The free rider problem occurs when a person can consume the nonexclusive service without having to incur any costs of contribution. The weak incentive to pay for a public good is often caused by the awareness that even if oneself is not subsidizing, other parties will still contribute. Similarly, the belief that one is not able to make a difference between a successful and unsuccessful outcome can cause decreasing incentives. If plenty of others contribute, then one will gain more benefit from free riding. However, if an ample amount people do not supply, then one will have to account for a cost. Either way, one's contributions will, in the end, not be determining the ultimate benefit or cost. This is because the outcome is not only dependent on the actions from oneself but likewise that of other individuals. This gives rise to the temptation to free ride. In situations where opportunistic behaviours are widely conducted, the risk for market failure increases as contributions to the public good will equivalently decrease.

Earth's climate constitutes a social good that is constantly being openly consumed by humans. Unsurprisingly, once carbon dioxide and other greenhouse gasses are emitted into the atmosphere there is no way of limiting its environmental impacts to national borders (Seo 2017). That is, the action carried out by one country will have an effect on a global level. It is therefore improbable to charge an individual state for the amount of emissions they release, hence, a free riding problem in the climate context has appeared. In the study by Chen and Zeckhauser, they have chosen to rephrase the term free riding to cheap riding (Chen and Zeckhauser 2018). They deem free riding to be a very extreme behaviour that rarely occurs in practice, as parties seldom contribute with absolutely nothing in the context of public goods. Often, nations do subsidize, however the contribution may be less than what is considered efficient or sufficient. Thus, the term cheap riding is being used instead of free riding.

Carbon dioxide, being countries' main greenhouse gas emission, is a by-product of the way societies have produced and consumed goods historically and presently. The amount that is being released into the air accumulates steadily in the atmosphere, leading to global warming. Countries have a general tendency and desire to act according to their own self-interests, rather than in harmony with the purpose of a greater collective. Policies facilitating economic development are often prioritized and considered more important than programmes aimed to reduce carbon emissions. Global warming is a phenomenon with world-wide impact, leaving no nation untouched. Yet, countries seem to, more often than not, wait for and rely on other states to actively step up their own mitigation game. In the meantime, opportunity is given to cheap riding countries to focus on their own agendas, creating additional costs and hindrance to achieve the common objectives set by the collective. In order for a state to be willing to contribute, there must be a common belief that other nations will likewise subsidize a sufficient amount. This way, the determination to pursue the common goal will be greater than the enticement to deviate. However, without reciprocal confidence and credence in other parties' actions, countries will be triggered to focus on their own profits, which prompts cheap riding. Hence, cooperation and mutual trust between states must come about as a precursor if a successful collective action to reduce global emissions is to be realized.

3.2 Prisoner's dilemma

The Prisoner's Dilemma can be depicted as a nonzero-sum game, which is a game where the outcome always ends in net benefit or net loss (that is, never summing up to zero). Its structure allows for players to either cooperate, or defect. The participants can have common and opposing interest at the same time. As players' choice of actions remain unknown until each party's decisions have turned into action, uncertainty and cynicism permeates prevailing relationships between players.

Many scholars illustrate the efforts of combating climate change as a Prisoner's Dilemma. The game can be presented as follows. Consider two countries, country A and country B. The game has three possible outcomes. The first being is the ideal, where both countries choose to cooperate and reduce emissions. A second outcome is if one country attempts to reduce emissions while the other defects and instead chooses to pursue their own interests. The country that is maximizing its selfish profits will be the beneficial player as that country will have avoided costs stemming from unsuccessful cooperation whilst achieving their own agenda. The cost will subsequently be borne by the other compliant player. The third and worst result is if neither chooses to cooperate and are instead maximizing their own interests. As it is already hard to achieve the desirable outcome with only two countries in a Prisoner's Dilemma, the larger the number of actors that are involved in the game, the more challenging it will be to manage and reach pareto efficient results.

3.3 Theory of collective action

Collective action problems occur when individual actions of people create worse outcomes than what would have been if they had coordinated their movements beforehand. The problem arises when each actor of a group shares the same goal but achieving it does not require contribution from all members.

The theory of collective action claims that individuals will not act cooperatively unless the group is small, the individual is coerced or share a common interest. If the conditions are not met, it is in best interest of the individual to become a free rider. In small groups, connections between involved members are usually stronger than that in larger groups, preventing a few states from exploiting the collective. Therefore, free rider problems are more likely to occur in larger groups (Olson 1971).

In Olson's book, he describes how tax incentives and social norms are some of many methods that have been used to address collective action problems. In the case of climate change, carbon taxes have been used to encourage consumers to purchase products with less environmental impact and create incentives for manufacturers to choose less carbon intensive production alternatives. In smaller groups, social norms address collective problems rather well. They can, for instance, include family or friends. In contrast, social customs are less effective in larger groups as it is more difficult to distinguish between those who comply and those who do not. It is also more difficult to persuade people to change their behaviours and make sacrifices in order to contribute to the collective good (Olson 1971). Even if laws and norms can be used to solve some collective action problems, there are also cases where they are not as useful. In some instances, the problems may not even be worth solving, as the benefits are smaller than the costs from solving the problem.

The objectives of the Paris Agreement require collective action across national borders. The fragility of this act becomes noticeable if a group of countries (or a single significant nation) fails to contribute, as other countries will then most likely also give in. It is therefore vital, as every country decides their own level of national contribution and commitment under the accord, that cooperative action is successful, in order to solve the climate crisis.

3.4 Previous research

Climate change mitigation is a common depiction of transnational collective action and the challenge of voluntary provision to a public good in the presence of free riders. Apart from classical theories regarding this matter, extensive research has been conducted in pursuit of solving the urgent social dilemma of international cooperation to combat anthropogenic warming.

3.4.1 Climate change

The most recent Emission Gap Report (Environment 2019) disclosed that "We are on the brink of missing the opportunity to limit global warming to 1.5°C". It states that global aggregated emissions must decrease to 25Gt by 2030 in order for the world to get back on track. If things are remained unchanged, with current mitigation policies, total emissions will amount to 56Gt by 2030. Vital ecosystems will be lost, cities will be flooded and there will be harmful disruptions to global economy and human societies. To add on, limitations exist as to how much global temperatures can rise before the earth reaches a tipping point (Steffen, Rockström et al. 2018), after which if reached, emission reductions will be useless to prevent further warming. It is suggested that this threshold, being scientifically evident albeit uncertain as to its exact whereabouts, may very well lie within the temperature range set by the Paris Convention.

Countries will suffer from global warming in a disproportionate matter. It is reported that the least developed nations as well as landlocked and small island developing states are the most vulnerable and susceptible to the impacts of climate change. Ironically, they are also the ones who have contributed the least to global warming and have the worst basis to cope with disasters (Stern 2007, Traore Chazalnoël and Puscas 2019). Researchers have for a long time urged policy makers to increase climate mitigation efforts. Yet, obstacles such as power asymmetries and national interests present in the international policy arena aggravate efficient transnational collaboration. Treaties to protect global public goods are inclined to many challenges, some of which stem from the anarchic nature of the international landscape of sovereign states (Enuka 2018).

3.4.2 Emission gap

The difference between the aggregate effect of countries' 2030 NDC pledges and the goals formulated in the Paris Agreement is referred to as the emission gap, ambition gap and sometimes even the implementation gap. It is a short coming that perfectly reflects the social dilemma of international treaties and the need for countries to further their climate ambitions. According to UN's yearly emission gap report, the goal of limiting the mean global temperature to 1.5°C is on the brink of becoming unattainable. If countries act according to their current policies until 2030, emissions will be more than twice what they should be (Commit & CD-links 2018, United

Nations Environment Programme 2019). Studies show that in order to drastically change the direction of this undesirable evolvement, fundamental transitions must happen, mainly in the energy sector. The later the change, the more stringent must countries act in the future to decarbonise the atmosphere and the more costly and risky will this shift be (Riahi, Kriegler et al. 2015, Commit & CD-links 2018). Even though the objective in the form temperature limits, of 2°C respectively 1.5°C, are based on scientific reports, they also contain a certain degree of flexibility necessary to help parties reach political consensus and a firm direction all countries can work towards together. Nonetheless, as Earth's climate system is highly complex and integrated, indecisions remain as to how responsibilities should be shared amongst nations (Gao, Gao et al. 2017)

3.4.3 International treaties and environmental agreements

Multinational agreements are seen by some researchers to be a conceivable, if not necessary, way of overcoming the cooperation obstacle being the absence of a leading central authority in the global arena. They mean that international institutions are vital if we are to expect any reciprocal collaborations between states at all. Even if these foundations have limited impact on a particular state's behaviour and are not a panacea for all dangers and threats that pose societies, scholars still deem them indispensable as a constituent of good-will between nations (Keohane and Martin 1995).

Treaties formed within the framework of transnational institutions have been studied widely across many subjects and areas where several prominent works evolve around war funding and military alliances. Leeds (Leeds 2003) for instance, investigates violation of treaties and commitments in times of war. She establishes that it is improbable of states to commit to treaties that leaders themselves do not intend to fulfil, and that states will honour past agreements around 75 percent of the time. With regard to signatories' asymmetrical powers, it is believed that major nations have a higher tendency to breach contracts than smaller states, whereas the opposite is understood about minor powers. She presents evidence that insinuate asymmetric treaties to have unequal reneging costs depending on relative state power, which explains why more dominant countries are more inclined to relinquish past commitments. However, opposite findings are obtained in a study by Olson and Zeckhauser concerning the asymmetric alliance NATO and the level of contribution member states provide to the shared funding (Olson and Zeckhauser 1966). They conclude that larger nations, such as the United States, contribute disproportionately more to the alliance's common defence than smaller signatories. It is even stated that the latter tend to cheap ride on larger ones by providing less than appropriate, as defined by their own common interest. Olson explains this phenomenon as the result of nations acting according to their own national self-interest when committed to a multinational treaty. Without hierarchical governance in the international system, provision to public goods is only possible if countries' private benefits and group interests align, or else various forms of free riding will occur (Olson 1965). This is because nations have no intention of providing the optimal amount of subsidy to a commodity if its benefits are divided with others, limiting their own potential share, hence the contribution will remain suboptimal.

Climate change mitigation is not only a dispute between separate and common interest, it is also a trade-off between short-term and long-term costs and benefits. Global warming will affect all countries in various ways, hence there are numerous different national interests underlying the bargaining of environmental treaties. With countries formulating its own compromises it is difficult to reach political consensus as arguments will always yield winners and losers (O'Neill 2009, Enuka 2018). As proposed by the conventional rational choice theory, a rational human being will try and maximize his or her own short-term well-being, resulting in future benefits becoming inadequate incentive for a person (or nation) to participate in collective actions serving common interests. Precisely stated by Ostrom: "Social dilemmas occur whenever individuals in interdependent situations face choices in which the maximization of short-term self-interest yields outcomes leaving all participants worse off than feasible alternatives" (Ostrom 1998). It is in other words an outcome of a situation where independent sovereign states make decisions in interdependent settings.

That is not to say that international cooperation to protect global public goods is unfeasible. A prominent example of a successful transnational treaty is the Montreal Protocol 1987. Its aim was to reduce global chlorofluorocarbon (CFC) emissions that were depleting the atmosphere's ozone layer, exposing earth to extensive and harmful UV radiation. After the ratification, nations were able to take actions in a collective matter and successfully reduced the CFC substances by over 95%. Furthermore, it is prognosed that the concentration will return back to its natural levels by 2050. Similar to earth's environment, the atmosphere is classified as a global common where the cumulative CFC pollution is the result of countries' emissions added together over time. Likewise, the Montreal Protocol, aimed to protect the ozone layer, resembles in many ways the Paris Agreement fighting climate change[1] (Sunstein 2007). However, clear distinctions that separates the two can rationalise why the former has been fruitful and the latter not. A review of the Montreal and Kyoto protocol suggests that nations had clear self-motivating incentives to effectuate the former. Scientific certainty and tangible cost-benefit analyses proved that the monetized benefits of action far outweigh the costs of inaction. The Montreal Protocol does not take after a prisoner's dilemma as signatories gain from independent action, even in absence of other countries' compliance. Similar conclusions were drawn by Murdoch and Sandler (Murdoch and Sandler 1997). Climate mitigation agreements, on the other hand, involve a larger number of participants which inhibits effective coordination and is coloured by scientific and political

---

[1] For similarity examples, see SUNSTEIN, C.R., 2007. Of Montreal and Kyoto: A tale of two protocols. *Harvard Environmental Law Review,* page 2-3.

uncertainties. The costs and benefits of action compared to inaction differs country-wise and for many big emitters, the expected gain from curbing carbon emissions is unappealingly small (Nordhaus 1991, Sandler and Sargent 1995). To add on, unlike the Montreal Protocol, climate change treaties *can* be depicted as a prisoner's dilemma, where each country would benefit from cooperation and together reduce emissions, but each have no incentive to do so as short-term self-interests prevent cooperative behaviour. Barret and Dannenberg (Barrett and Dannenberg 2012) reason that if a clear and certain threshold for sudden disastrous climate change events can be identified, then the free-rider problem would be controlled for and a coordination game would replace the prisoner's dilemma. Nonetheless, due to ambiguity as to where this threshold exactly is, the coordination game returns to a prisoner's dilemma. As stated by the authors: "Our research suggests that, under these circumstances, countries are very likely to propose to do less collectively than is needed to avert catastrophe, pledge to contribute less than their fair share of the amount proposed, and end up contributing even less than their pledge.".

In the paper *Self-enforcing International Environmental Agreements*, Barret investigates whether it is possible for these treaties to be in fact sustainably self-enforcing. Under strict assumptions the results suggest that it is highly unlikely, with two frameworks supporting this outcome (Barrett 1994). However, more promising findings are asserted by Gerber and Wichardt (Gerber and Wichardt 2009). In the absence of strong institutions to regulate international provision for public goods, they find that by introducing a commitment stage where countries who wish to join the alliance make a deposit prior to uniting with the coalition, will act as a self-sanctioning formula and promote cooperation, as it is now in every individual's rational interest to comply. This method of facilitating compliance is especially applicable when there is no third party that can sanction free riders.

Many scholars argue that collective action and coordination is more difficult to achieve the larger the group is (Gerber and Wichardt 2009). This is due to the greater trade-offs that are required when there is an increase in the number of personal interests within the group. A larger set of signatories creates uncertainty as individual monitoring steadily becomes more cumbersome and nonparticipants start to enjoy free-riding benefits from the public good, which may induce internal deviations where eventualities make partakers prioritise short-run gains. It can therefore sometimes be more beneficial to form a minimal-sized coalition instead of engaging as many parties as possible (Sandler and Sargent 1995). However, the number of actors is not the only factor that defines a large-scale collective action problem. In the scenario where signatories are nations rather than individuals, Jager, Harring et. al (Jagers, Harring et al. 2019) name a few other central characteristics that describes large-scale problems, namely spatial distance, temporal distance and complexity. The latter is a prominent feature of global warming as the world's ecosystems, biodiversity and climate are all interconnected. This interrelation makes the width of consequences climate change can cause incredibly hard to predict. As collective actions of this scale also require individuals to represent their own country and interests, there is an evident risk for agency problems. Overall, in the case of climate change, global cooperation is crucial to successfully mitigate carbon emissions and preserve the earth's natural habitat (Sandler 1998).

IV. DATA AND METHOD

4.1 Data

Our empirical analysis is based on two correlation tests, Spearman rank correlation and Kendall's tau. We use the latest available data for all variables and confounders. Our data source for computing country-level emission gap is provided by Climate Action Tracker, hence the number of observations in our dataset is limited to the number of countries which data is available for on their website. It is consequently important to bear in mind that due to the limited number of observations, the following statistical tests conducted in this thesis may be short of the statistical power required to make a perfect confident conclusion that the results will also hold for a larger sample, including all member states of the Paris Agreement.

4.1.1 Variables

Unlike testing the rank correlation between the reduction per dollar of GNI and GNI as Zeckhauser and Chen (Chen and Zeckhauser 2018) we replaced reduction per dollar with the predicted emission gap in year 2030. With country specific data provided by Climate Action Tracker, such as countries' NDCs, pledges and current policies, we projected national levels of emissions in 2030. The projected emission gap is then calculated as the difference between the estimated emission size 2030 and the magnitude of emission needed to keep the global warming below 2°C increase above pre-industrial levels[2].

Climate Action Tracker has been providing analysis for policymakers and is essentially a collaboration between the two organizations, Climate Analytics and New Climate Institute, since 2009. Up to date, they have measured governments' climate actions in 35 countries against the goals of the Paris Agreement and thus cover data which corresponds to about 80% of total global emissions. Furthermore, the analysis covers three main areas when tracking national actions. First, they trace the effect of how current mitigation policies will most likely develop over a time period up until 2030[3]. Second, they track the impact of national pledges and targets for the same duration. Lastly, Climate Action Tracker tracks whether, relative to other nations, a country is doing its "fair share" of mitigation work of the total global effort to limit warming consistent with the Paris Agreement.

---

[2] The reference is the fair share range limit between 2°C compatible and 1.5°C Paris Agreement compatible emission levels. For more information please visit: https://climateactiontracker.org/about/

[3] As the data Climate Action Tracker provides only stretches until the year 2030, our thesis exclusively covers projections up until this point in time.

According to Chen and Zeckhauser, GNI is the most appropriate measure for country size as nations differ in vulnerability and technology. And unlike using a country's geographical scope or population as such, GNI further includes economical aspects of societal changes that may vary from the impact of climate change over the years, not to mention a country's ability to provide economic subsidy to the Paris Accord and their own capacity to reduce national environmental impact. The reason why GNI is preferred over GDP is the fact that GNI recognizes all income that contributes to the national economy, regardless of whether it is earned within the country or overseas.

Data is extracted from the World Bank (The World Bank c) to estimate projections for our confounders. By using a growth trend derived from countries' GNI in 2017 and the average growth rate between year 2000-2017, we predicted corresponding GNI in 2030. However, as no data was available for the average annual percentage growth for Ethiopia and Indonesia, GNI was substituted with GDP 2030 accordingly.

4.1.2 Control for confounders

6 different confounders were included in our tests. In order to answer our research question as accurately as possible, we have included the same variables as the ones used in Chen and Zeckhauser's paper to the best of our abilities. The first 5 are direct replications. We added the 6th variable (population) out of inquisitiveness.

Population was not a variable Chen and Zeckhauser controlled for in their study. However, we consider this variable to be of interest as human activities are the main source of increasing global warming. In a report from the International Panel of Climate Change (IPCC) population growth is identified as one of the main elements why there are difficulties of achieving the 1.5°C degree target as stated by the Paris Agreement. Consequently, as population size is the result of population growth, *Population 2030* is added to our data set (Masson-Delmotte, Zhai et al. 2018).

1) **GNI per capita in 2030** (The World Bank b). Population was projected using the available data of population size in 2018 and the estimated population growth rate. By using following formula: Estimated GNI 2030/Projected population in year 2030, we were able to obtain the GNI per capita in 2030. This enabled us to compare relative GNI per person between countries.

2) **Percentage of urban** and 3) **Percentage of rural population estimated living in coastal areas where elevation is below 10 meters** (SEDAC). These variables are estimated by taking the population living in the low elevation coastal zone of the country's population in year 2000. Even if the latest available data is rather dated, we consider it safe to assume that the variable stays relatively constant over the years.

4) **Percentage of population exposed to disaster** (The World Bank a). This variable targets disasters such as drought, flood and extreme temperature events in 2009. Unfortunately, we could not find any up to date data for this confounder, even though it is in our understanding that climate change intensifies natural disasters and extreme weather events.

5) **Historical annual temperature** (Climate Change Knowledge Portal). The data is collected from the Climate Change Knowledge Portal using the average temperatures over the time period 1901 – 2016.

6) **Population 2030** (The World Bank). Data of population in 2018 and the estimated population growth rate is used to estimate the population in 2030.

TABLE A: Descriptive Statistics

Tested variables	Mean	Standard Deviation	Min	Max	No. observations
Emission gap	652.2415	1212.974	-114.7037	5287.329	35
GNI2030	3531.06	8244.688	2.2591	40828.2	35
GNI per capita	25610.07	26504.98	688.8946	88909.66	35
% Population rural	0.0833	0.1228	0	0.5452	35
% Population urban	0.1193	0.1503	0	0.7390	35
% Population extreme events	0.0111	0.0192	0	0.08	33
Historical average annual temperature	14.7000	0.3777	-6.8861	27.4275	35
Population 2030	0,1954	0,3995	0,0009	1,5982	35

Table A shows the distribution for every variable and confounder used. Ideally every dataset should consist of 35 observations. However, observations for the percentage of population exposed to disasters are missing for Singapore and UAE.

4.2 Statistical methods

As the aim of this paper is to replicate a modification of Chen and Zeckhauser's study, we used the same statistical methods in our thesis as the authors did in their paper, namely the Spearman rank correlation test and the Kendall partial rank correlation test. Our null hypothesis is consequently that a correlation exists between our main variables[4]:

› H_0: $\rho_s = 0$

› H_1: $\rho_s \neq 0$

Both of the statistical tests are nonparametric, because we cannot ensure normal distribution in our data. All statistical tests are performed in the software Stata.

4.2.1 Spearman rank correlation

The Spearman rank correlation is a statistical test used for assessing the monotonic relationship between two variables. The values can vary between -1 and +1, where ± 1 signifies perfect positive or negative correlation, whilst 0 indicates no correlation. Unlike the more common Pearson's correlation coefficient, there is no precondition that the relationship must be linear. The ambition of this paper is not to distinguish a linear relationship, but rather the strength and direction of the connection between country size and emission gap. This is to say that the variables need not change together at a constant pace. As GNI varies greatly between nations, extreme values may result in biased outcomes if we were to use Pearson's test as it is sensitive to these imperfections. However, this problem is resolved by Spearman's test as it is based on ranking rather than solely on the trend of correlations.

4.2.2 Kendall partial rank correlation

Kendall's tau coefficient or Kendall rank correlation coefficient is an alternative nonparametric test to Spearman rank correlation. It has been proven to provide better answers than Spearman's test when the number of observations is smaller. A dissimilarity between the two tests is that Kendall is based on the relationship between the pattern of concordant and discordant pairs, rather than just observations per se. It also produces two,

[4] More precisely, we test the correlation between the variable of interest, *GNI2030*, and the relative ratio *emissiongap/GNI2030*.

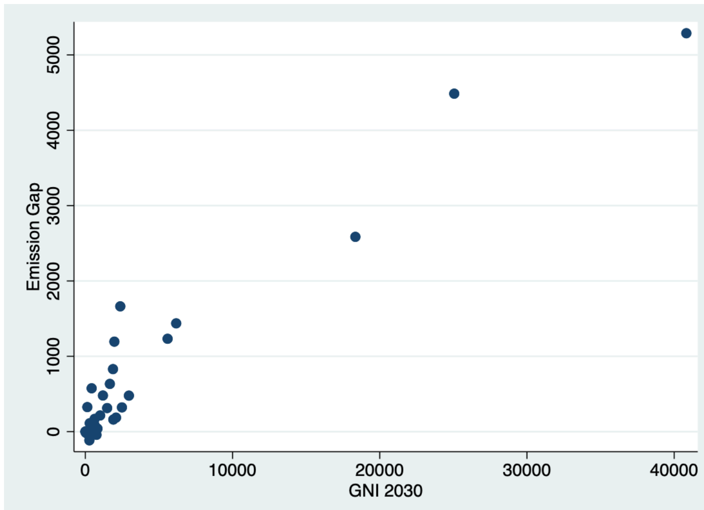
sometimes three, coefficient results, namely tau a, tau b, and tau c. The latter two are adjusted for pairs with tied ranks. This makes Kendall's tau less sensitive to errors and yield more accurate p-values with smaller sample sizes, which is fitting in our case, considering the data limitations of our study.

4.2.3 Limitations and considerations

There are several limitations to our statistical tests that readers must bear in mind. First, in contrast to Chen and Zeckhauser, our sample does not include all countries that have submitted climate pledges under the Paris Agreement. This is because we want to investigate the relationship between emission gap and country size. In order to define emission gap, one must decide what is the 'fair' amount of emission a specific country is allowed to emit. The only known and reliable organisation that has made an effort to translate this carbon emission limit into actionable numbers is Climate Action Tracker. Hence, the number of countries in our study is equivalent to those covered by their data and calculations. This limitation, of having a small sample of countries, may entail that our test results might not be fully representative of how large and small states act relative their ambition level of climate mitigation efforts, and the results from our tests can turn out to be insignificant, therefore. Second, the data which this study is based on has its own limitations. With the direction of Chen and Zeckhauser, we used the latest data derived from the same databases as them. However, some have not been updated for several years, hence the numbers may be slightly outdated. This can result in skewed results. Third, in order to project countries' emission gaps by 2030, we used forecasted trends of each nation's NDC carbon emission. As there are no regulations as to how a national pledge should be designed in the Paris Agreement, the emission gaps calculated by Climate Action Tracker is already exposed to uncertainty to a certain degree. Furthermore, for several states we had little choice but to substitute NDC projections to either policy projections or national target due to missing data.

V. RESULTS

In this section we present the data and results from our two correlation tests. Different from Chen and Zeckhauser, we added a test between the variables *GNI2030* and *EmissionGap,* without dividing the latter with the variable of interest, that is *GNI2030*. The first row of table C and table D display this test result. The rows beneath follow the same correlation assessment pattern, namely *Variable* examined against *EmissionGap/Variable*. The reason for this addition of the first row is because we want to confirm the existing relationship between country size and emission gap and therefore the relevance as well as interest of our research question. As depicted in the scatter plot diagram, there seems to be a somewhat positive linear relationship between GNI and emission gap across countries. A regular regression output table shows that the linear coefficient is statistically significant (Table B). As one may have presumed, there is a pronounced link where larger economies are connected with greater emission gaps. This is anticipated as production is heavily dependent on energy consumption, which is the sector that emits most carbon emissions to date, and is also more extensively consumed the larger the economy is (Commit & CD-links 2018).



Scatter plot diagram: Emission gap and GNI 2030

Table B: Linear Regression Output Table

Emission gap	**Coefficient**	**Std. Error.**	**p-value**
GNI 2030	0.1650	0.0074	0.0000
Residual	144.0577	65.7014	0.035

5.1 Results – Spearman rank correlation

The results from the Spearman rank correlation test are shown in Table C. Similar to the linear regression coefficient, the Spearman rank correlation coefficient for *EmissionGap* and *GNI2030* is strong and statistically significant with a p-value of zero.

Our main variable of interest, *GNI2030,* also proves to have a positive association with emission gap when analysing it in relation to *emissiongap*/*GNI*, year 2030 (second row). This result indicates that larger nations tend to have relatively greater emission gaps. This finding opens up the question of whether larger economies cheap rides on smaller economies in terms of ambition level in carbon emission mitigation efforts, as defined by Climate Action Tracker.

The percentage of population that is exposed to extreme events, to be specific, drought, floods and severe temperatures, also has a noteworthy test result, that is valid already on a 5% significance level. To interpret the negative value of the coefficient, the larger fraction of the population that is under threat of natural disasters, the smaller that country's emission gap tends to be. However, as not all countries have experienced mentioned climate extremes and due to missing information, the number of observations has been reduced to 25, which is equivalent to 29% loss of data which can cause uncertainties in the test results.

Even though our results for population size in 2030 is insignificant, it is still an interest outcome to comment on, since a positive correlation is a very natural presumed hypothesis. However, as we are looking at a time period that stretches merely over 10 years, even though the relationship is insignificant in the short-term, it is uncertain whether it will remain this way in the long-term.

An interesting study examined the effects of various factors that may influence carbon dioxide concentrations in the atmosphere in the short run (A. Tapia Granados, L. Iondies et al. 2012). Even though most variables gave no meaningful or significant results, it was found that changes in world GDP, that is economic activity, was the major reason of rising carbon dioxide levels in the short-term. This may justify why our population size variable is insignificant. Another reason could be countries' differing carbon footprint per capita. Depending on a nation's level of economic development and the adoption of clean energy sources, emission gap will depend on more than solely the number of people contributing to emissions, but also the amount of emissions that each person adds with. This means that two nations, with an identical population size and climate pledge, yet radically different carbon footprint will have very distinct emission gaps. Hence, this could be, yet another explanation of the insignificant result related to population size.

The remaining outcomes do not yield results of importance as their p-values are all too high. Still, as this is a Spearman correlation test, we can only draw the conclusion that no *monotonic* relationship exists. This does not exclude other possible connections between the variables.

TABLE C: Spearman Rank Correlation Test Results

Tested variables Variable and EG/Variable	**Coefficient** $-1 \leq x \leq 1$	**p-value**	**No. observations**
Emission gap (EG), GNI2030	0.8067	0.0000	35

GNI2030	0.3109	0.0691	35
GNI per capita	0.0986	0.5731	35
% Population rural	-0.3023	0.1044	30
% Population urban	-0.2111	0.2627	30
% Population extreme events	-0.4661	0.0189	25
Historical average annual temperature	-0.2551	0.1392	35
Population 2030	0,0109	0,9503	35

5.2 Results – Kendall's tau

Unlike Chen and Zeckhauser, we do not include the World Value Survey in our Kendall test. The reason is because 14 countries from our sample are missing in their survey, making it quite unfit to generate any reliable or valuable results. Instead, we perform the Kendall partial rank correlation test on all variables that were analysed previously in the Spearman correlation test, in order to discover either similarities or deviations.

Again, the coefficient between emission gap and GNI of 2030 has proven to be strongly statistically significant, however, the results yield a smaller coefficient, compared to Spearman's coefficient.

GNI2030 has a tau of 0.2370 and is statistically significant on a 5% significance level, confirming the previous positive results and the possibility of larger states cheap riding on smaller countries.

Furthermore, the extreme events variable is significance on a 5% significance level, however the monotonic relationship is somewhat weaker.

The Kendall correlation test yields another statistically significant coefficient, namely average historical average annual temperatures. With a significant level of 10%, tau takes on the value of -0.2017. After adjusting for tied ranks, the coefficient becomes -0.2019. This indicates that countries with historically colder temperatures have larger emission gaps.

The remaining variables do not produce any interesting results as p-values are too high.

TABLE D: Kendall Partial Rank Correlation Test Results

Tested variables Variable and EG/Variable	**Kendall's tau a** $-1 \leq x \leq 1$	**Kendall's tau b** $-1 \leq x \leq 1$	**p-value**	**No. observations**
Emission gap (EG), GNI2030	0.6437	0.6437	0.0000	35
GNI2030	0.2370	0.2370	0.0468	35
GNI per capita	0.0218	0.0218	0.8647	35
% Population rural	-0.2092	-0.2092	0.1083	30
% Population urban	-0.1402	-0.1402	0.2844	30
% Population extreme events	-0.3267	-0.3393	0.0222	25
Historical average annual temperature	-0.2017	-0.2019	0.0910	35
Population 2030	0,0286	0,0286	0,8203	35

VI. DISCUSSION

6.1 Discussion of results

The Spearman rank correlation shows that there is a positive correlation between *emission gap/GNI 2030* and *GNI 2030*, which is an indication of that the relative emission gap increases with the size of a nation, measured by the size of the economy. This outcome proves that the null hypothesis can be rejected at 10% significance level. However, as our sample size is small and the number of countries is limited to the amount of observations provided by Climate Action Tracker, there is an inevitable uncertainty regarding the applicability of our findings in real life. With a larger sample size there is a higher probability of detecting the true effect as standard error decreases, which causes the sample mean to be closer to the actual population mean. However, this is not to cast doubt on the general findings and implications our thesis may entail, as it has also been proven through statistics, reports, studies and articles that larger countries who are emitting relatively more are also doing relatively less, considering their potential to change. We therefore speculate that in a scenario where tests are run with a full set of observation, the pattern that large countries possibly cheap rides, as found in our results, will most likely still hold.

Even if we are not able to modify the sample size, we have taken this ambiguity into consideration. The Climate Action Tracker projects the emission gap data of 2030 based on a range of NDCs, pledges and current policies with a lower and upper limit. We have chosen to use the lower limit since, if our results hold for the optimistic scenario, it will surely also do so for the pessimistic one. By running our tests based on lower limits, we can also ensure that the effect is true even for the smallest predicted emission gap.

In the remaining sections we will discuss the implications of our findings, use game theoretical approaches to explanations why collective action has been proven difficult in climate regimes, the economic and social factors behind larger countries' opportunistic behaviours and why smaller nations are performing relatively better at reducing the emission gap.

6.1.1 Extreme events and historical annual average temperature

Both *Extreme events* and *Historical annual average temperature* are negatively correlated with emission gap. To interpret, the emission gap tends to be smaller when a larger fraction of the population is exposed to extreme events or if the countries historically have had higher temperatures.

A result of rising temperatures is that economies across the globe are to be adversely affected by its consequences. Kahn, Mohaddes et al. study how economic activity across countries are affected by long-term climate change, by using a cross-country analysis. The results show evidence of how real production and economic sectors are being long-lastingly negatively affected. Their analysis indicates that by 2100, an average global annual increase of 0.04°C will decrease the world GDP per capita by 7.22 percent (Kahn, Mohaddes et al. 2019). That economic activity is affected by temperature fluctuations is also argued by authors in another research study. Burke et al. conclude that crops and humans are the most productive when the temperature is neither to hot nor cold (Burke, Diffenbaugh et al. 2018). In cold countries, growth increased as the temperature increased. On the other hand, a rise in temperature decreased growth in warmer nations. Diffenbaugh et al. use the agriculture sector as an example, stating that growing periods are limited in countries with winter seasons. At the same time, crop yields decline in countries where the temperature is extremely high. These studies together with the significant correlation our test results yield speak for the thesis that colder countries have larger emission gaps than warmer nation. This is a very interesting finding since larger nations, and especially richer nations are usually located in colder climate, either below or above the equator. Deeper discussions related to this topic will be held later in section 6.1.3.

By conducting the Spearman rank correlation test between the historical annual average temperature and extreme events we can also observe a positive correlation between the two, as shown in Table E. This result has a p-value of 0,0056 and it is thus significant on a 1% significance level. This is an implication that higher historical average temperature may contribute to more extreme events[5].

TABLE E: Spearman Rank Correlation

Tested variables	Coefficient $-1 \leq x \leq 1$	p-value	No. observations
% Population extreme events and Historical average annual temperature	0,4715	0.0056	33

When a country suffers from abnormal temperatures, they have little choice but to bear its consequences. Effects such as rising sea levels, drought and flooding. Our results suggest that when a country suffers from extreme weather events it will also have incentives to set more ambitious NDCs, pledges or policies resulting in smaller emission gaps. Unlike vulnerable countries, nations that are less exposed to extreme events will have a more difficult time to set ambitious goals since they have fewer national incentives for such actions. It may be harder to realize the dangers climate change poses to societies and the need for drastic emission gap reductions, as they are currently not the primary ones who are bearing its direct costs and damages.

6.1.2 Cheap riding on the basis of emission gap

In many ways, the Paris Agreement is an unprecedented treaty, as it prompts commitment and contribution from all 196 states that have ratified it, equally, compared to the previous Kyoto Protocol where Annex-I and

[5] The causality described here has not been tested, however it is more realistic to assume that hotter temperature causes extreme weather events, than the other way around.

Annex-II countries[6] were treated differently. The voluntary nature of self-determined national pledges causes national mitigation efforts to reflect each country's self-set ambition level combatting climate change. NDCs that contain satisfactory policies and ambition levels therefore indicate that the particular country is contributing their fair share to the public good. The paper that makes up the foundation for our thesis, that is *Collective action in an asymmetric world* by Chen and Zeckhauser*,* states that equal contribution to common goods from countries is not possible when there are asymmetries between the cooperating states. This leads to larger countries, in terms of GNI, bearing disproportionately more of the costs compared to smaller nations. The latter is instead more inclined to cheap ride. In contrast to these findings, our results suggest the opposite. To be specific, larger countries tend to contribute less to the social good than smaller states, as they have relatively less ambitious pledges, measured as the size of their comparable emission gap. With these two opposing findings in mind, this speaks for the proposition that depending on the variable used to define a nation's contribution, in this case either *reduction pledge* or *emission gap*, the conclusion of who cheap rides on whom, in the context where the global climate constitutes the collective good, cannot be readily made.

Either way, it is safe to establish that the free rider problem is present now as ever in international climate regimes. And with the presence of cheap riders, the incentives to do more for the climate declines, unless it lies in the nation's own interest to actively decrease greenhouse gas emissions. Our results illustrate the difficulties of attaining collective action in international settings and the great uncertainties that prevails the current climate agenda, causing individual states to rely on other's initiatives, resulting in inadequate joint actions being taken, as shown be the existing emission gaps.

6.1.2.1 Relating our findings to theory and research

Disregarding country level asymmetries, how can one facilitate coordination in social goods dilemmas? The classical theory of collective action proposed by Olson argue that successful cooperation is facilitated by three things: limited group sizes, introducing external coercive forces and proposing individualized incentives (Olson 1971). Sandler also suggests that an alternative mean for promoting cooperation can be made, as a final course of action, by introducing supranational constitutions designed with personalized incentives in mind (Sandler 1998). However, as none of these elements that encourage cooperative behaviour are currently prevalent in the international climate regime, introducing them now to an institution like the United Nations will most likely be challenging (Harris 2007). The grand number of signatories that today adds up to 196 participants already dismisses the first recommendation posed by Olson. The anarchic nature of the international policy arena rejects the second. Individualized incentives on the side of the benefits provided by the public good is outright impossible to offer all member states, as every country has their own national interest, not to mention that

[6] In simpler terms developed and developing countries.

climate change affects each country very differently. Without personal incentives, rational actors tend to refrain from acting in a collective matter, even if they as a group have interest in providing for the good and are in accordance with how to attain the desired outcome (Harris 2007).

Other challenges that hinders collective action in the climate regime can be illustrated by public goods games. One-round-games, or the first round in a repeated game, tend to have a rather high level of initial contribution. However, as the game is reiterated there is a propensity for inputs to decline, as well as cooperation levels. The problem of suboptimality is argued to lie in meagre institutional structures (Ostrom 1998). The inability to effortlessly monitor countries' actions as well as the struggle for nations to sustain reporting commitments without delays has also proven hard to abide by, preventing effectful cooperation and causing incentivization for cheap riding (Baettig, Brander et al. 2008). It is therefore accepted that collective efforts to combat climate change comes with free rider problems. In joint action situations, where there are many parties involved, instead of a certain individual, sub-groups tend to stand for the main cost (Olson 1971). This conclusion is supported by Chen and Zeckhauser's findings as well as our own.

The theory of collective action also suggests that actors with more resources will bear a greater burden when providing for a public good than poor individuals who tend to free ride. This is in line with Chen and Zeckhauser's conclusions yet speaks against our own results. A possible explanation for this is the use of different main variables to define and measure a country's contribution to the collective good. If the *emission reduction pledge* is employed, then the correlation tests are based on countries' self-motivated commitments and intended implementation of policies that are designed with their own capital and contributing ability in mind. Adding on, having country size determined by an economic meter such as GNI does not come without biasedness as it is known that wealthier nations dispense more subsidies. Since the majority of the states with higher GNIs are industrialized countries, or countries with abundant resources, they are also inclined to possess an ample supply to fund their Paris pledges. To compare, developing states are in need of financial aids to phase out coal power plants as their main energy source and to assist the implementation of their obligations under the convention (UNFCCC Nov 2015).

Our *emission gap* variable on the other hand, includes a parameter that defines the 'fair' share of contribution by each state. It puts pledges and the necessary actions to prevent severe climate change into perspective, without relying too heavily on nation's self-determined goals that are easily manipulated. It measures the gap between what countries are planning to do and what they should be doing. With this configuration, its relation to GNI will consequently echo more so what is at stake if countries choose to contribute as opposed to not. Nations with more resources have also more to lose if other, less wealthy treaty members, were to take advantage of their sizes. It is for example already known that the United States, the second largest country in terms of GNI after China, is in the ongoing process of withdrawing from the Paris Agreement and its climate pledges (UN News 2017, BBC News 2019). Many countries fear the economic trade-off from complying with the protocol and the future, although uncertain, costs of climate change. Due to significant time-lags in the environment's response to policies and politics, climate inaction is becoming the new action. Instead, short-term financial interests are favoured as their associated conceivable economic costs, on the contrary to the costs of global warming, are manageable and tangible.

6.1.2.2 Additional material that support our findings

A policy research working paper by the World Bank Group estimates the economic impact of implementing the Paris Agreement for major countries and regions around the world (Mani, Hussein et al. 2018). One of their two modelling scenarios depicts the implementation of INDCs[7] by all member states that ratified the Paris Convention. They found that for major net emission importers, more ambitious pledges led to higher costs on society. Across the G20 nations, that are responsible for 78% of global emissions (United Nations Environment Programme 2019), carrying out the accord would mean a deterioration in welfare. In a scenario where European countries are only able to achieve 40% of their planned emission reductions, the costs will already range between \$54 per ton CO_2 in Spain and \$372 per ton CO_2 in France. Even the OPEC countries, where the majority have yet to sign the accord, will experience higher costs and welfare losses from the execution of the treaty. It is an implication that the implementation of the agreement may also affect non-member states negatively, because of the interconnectedness of global trade and investments.

To illustrate this result and weigh it against our own, we have compiled the countries in our data in Table F and assorted them according to the size of their GNI in the year 2030. Table G shows how the implementation of the convention will affect country GDP in the year of 2030, obtained from their working paper[8]. One can clearly see that the great majority of the countries that are considered large in terms of GNI, will also experience negative changes in GDP 2030. This is especially the case for EU, that also corresponds to a geographical region which consists of many developed nations. One may therefore argue that because of greater estimated losses in national welfare for larger countries, it will prompt them to contribute less than appropriate, in order to alleviate damages and economic costs resulting from them carrying out the Paris Convention.

[7] INDC stands for Intendend Nationally Determined Contribution and converts to NDC once everything is finalized and countries have formally ratified the accord.
[8] The countries in the two tables do not match because not all states were listed individually in the study by the World Bank Group.

TABLE F: Countries assorted according to GNI 2030 $ Billion

Country	GNI 2030 $ Billion	Country	GNI 2030 $ Billion
1. China	40828.1987	19. UAE	633.7440
2. USA	25059.1920	20. Singapore	623.8793
3. EU	18345.2593	21. Norway	524.7094
4. India	6171.2560	22. South Africa	491.2961
5. Japan	5587.5216	23. Chile	454.7938
6. Brazil	2959.8297	24. Vietnam	427.2298
7. South Korea	2485.9023	25. Peru	403.1606
8. Russian Federation	2373.1644	26. Kazakhstan	297.4701
9. Canada	2084.5444	27. Ethiopia	273.7704
10. Indonesia	1970.4723	28. New Zeeland	271.8201
11. Australia	1901.1637	29. Morocco	187.8046
12. United Kingdom	1879.5189	30. Kenya	147.2692
13. Turkey	1665.1972	31. Ukraine	134.2273
14. Mexico	1481.5641	32. Costa Rica	94.2366
15. Saudi Arabia	1193.8338	33. Nepal	43.5609
16. Argentina	1004.3989	34. Bhutan	5.5426
17. Switzerland	822.9412	35. The Gambia	2.2591
18. Philippines	756.3773		

Source: Author's computations with data retrieved from the World Bank.

TABLE G: % Change in GDP 2030 resulting from Paris Accord implementation

Country	% Change GDP 2030	Country/Region	% Change GDP 2030
1. South Korea	0.04	13. USA	-0.62
2. South Africa	0.02	14. Russian Federation	-0.83
3. Brazil	0	15. Australia	-0.84
4. India	-0.01	16. New Zealand	-1.06
5. Argentina	-0.01	17. Germany	-1.06
6. Indonesia	-0.02	18. United Kingdom	-1.06
7. China	-0.06	19. Italy	-1.13
8. UAE	-0.15	20. Mexico	-1.18
9. Spain	-0.23	21. Other EU 27	-1.61

10. Japan	-0.26	22. France	-1.63
11. Canada	-0.27	23. Norway	-4.6
12. Turkey	-0.35		

Source: (Mani, Hussein et al. 2018)

Another study estimates and describes countries' cooperative behaviour within the international climate organization (Baettig, Brander et al. 2008). Their cooperation index consists of measurements regarding nations' swiftness to commit to common goals, as well as whether and how effectively they have been fulfilling these commitments. An index of 0 indicates least cooperative behaviour and 6 most cooperative behaviour. The results are portrayed in Table H. The most conspicuous about a comparison between Table F and H is how China and USA, being the largest countries, drop to twelfth and thirty-third place after being ranked according to their cooperation level. In contrast, the two smallest nations, Bhutan and The Gambia, jump up to fifth and sixth place respectively. General findings from their research paper denote that whilst developed countries are faster to ratify climate agreements, submit reports and pay financial donations, developing states are more optimistically evaluated concerning their carbon emissions.

TABLE H: Countries arranged according to Cooperation Index

Country	Cooperation Index	Country	Cooperation Index
1. Switzerland	4.77	19. South Korea	3.65
2. Mexico	4.53	20. Nepal	3.58
3. United Kingdom	4.42	21. Brazil	3.54
4. Argentina	4.39	22. Indonesia	3.53
5. The Gambia	4.36	23. Canada	3.52
6. Bhutan	4.34	24. Russian federation	3.49
7. New Zealand	4.12	25. Philippines	3.46
8. Vietnam	4.09	26. Kazakhstan	3.25
9. South Africa	4.07	27. Kenya	3.05
10. Ethiopia	4.05	28. Japan	2.84
11. EU[9]	3.87	29. Singapore	2.81
12. China	3.82	30. UAE	2.79
13. Costa Rica	3.82	31. Ukraine	2.63
14. Peru	3.82	32. Australia	2.54

[9] The Cooperation Index for EU is calculated as the mean index value of all member states

15. Chile	3.81	33. USA	2.53
16. India	3.81	34. Saudi Arabia	2.42
17. Norway	3.66	35. Turkey	2.22
18. Morocco	3.65		

Source: Baettig, Brander et al. (2008)

These two studies in combination with our own test results show that, compared Chen and Zeckhauser's findings, larger countries may very well be cheap riding on smaller nations in environmental regimes. This also argues for that the statement which small countries take advantage of bigger states, who bear disproportionately more of the costs in the context of climate change, cannot be conclusively drawn. Rather, it depends on the variable used to determine the level of contribution treaty members make to the collective good and the ambiguous notion of fairness.

6.1.3 Global inequity and the burden of climate change

In contrast to other pre-existing literature on cooperation in international alliances, our results suggest an opposing view to the conclusion that small states are more prone to cheap ride. Plausible speculations for what might encourage this exploiting behaviour of bigger countries may be found in the innate differences that exist between rich and poor nations[10].

The Industrial Revolution has, in many ways, changed people's lives for the better as societies keep on evolving through astonishing transformations and progressions. For the first time in human history did we achieve sustained economic growth and continuous innovation of new technologies. The Great Divergence showed how a few countries ran ahead of others and enjoyed economic prosperity faster, whilst other less fortunate nations lagged behind in poverty traps. A part of the extraordinary advancement that took place in certain countries is due to the extensive use of abundant and relatively cheap energy sources like oil and coal (Allen 2011). Thus, it is not surprising that the industrialized countries of today are responsible for nearly 80 percent of historical global carbon emissions (Center for Global Development 2015). Alas, the burden of climate change is not distributed proportionately to what each country has previously emitted. Scientific reports have yielded results showing how greenhouse gas emissions were distributed incredible unevenly across the globe, with a

[10] Before diving into this analysis, we wish to clarify that we are aware of the fact that the parameter GNI, which has been used extensively in this study as a means of describing country size, does not fully reflect the welfare of a nation, nor does it give any indications of domestic income distribution. However, for the sake of the following discussion, it is worthwhile to note that a state's total wealth is in most cases positively correlated with non-economic factors such as quality of life. Not to mention that more often than not, industrialized countries are likewise nations with high GNI. For more information on this subject please visit the World Bank's Website: https://datahelpdesk.worldbank.org/knowledgebase/articles/378831-why-use-gni-per-capita-to-classify-economies-into

Gini coefficient of 80.9[11] and a Robin Hood index of 64[12]. In point of fact, an excessively large part of the cost that is anthropogenic warming, is being carried by nations who have contributed the least to its genesis (Tol, Downing et al. 2004, Althor, Watson et al. 2016, Eckstein, Hutfils et al. 2018).

Another discovery reveals that the largest emitters also constituted of nations who are least vulnerable to climate change. These countries are also systematically located in areas with cooler climate. Vice versa, countries that are least responsible for historical emissions are, conversely, the most vulnerable. Factually, climate vulnerability tends to decline with increasing GDP (Tol, Downing et al. 2004). There are several reasons as to why poorer countries are suffering greater costs. The most prominent explanation is a relatively higher geographical vulnerability as well as lower capacity for climate adaptations. These include both unfavourable exposure by environmental elements but also insecure socio-economic and political circumstances, which eventually accumulates to risk factors far exceeding any conceivable threats richer or more developed states may face now or in the near future(Füssel 2010). This is further enlightened by the fact that IPCC-, World Bank reports and several scientific studies all label large nations such as the United States of America, Russia and Australia as free riders of climate change. China and the United States are also accused for reaping economic benefits from exploiting fossil fuels whilst having to suffer comparably little from consuming it, in contrast to Island states or countries in Sub-Saharan Africa, South and South East Asia (Althor, Watson et al. 2016). To add on, projections show that by 2030 global inequalities will increase even more. Global warming has therefore not only caused countries to be disproportionately exposed to climate risks, but also to immense economic inequities. In fact, a recent study reveals that global GDP differences are 25% larger than what they would have been, if temperatures had stayed at a natural level (Tol, Downing et al. 2004).

To better understand these findings' relation to country size and climate cheap riding, it is worthwhile to revise the general conclusion made by Olson (Olson 1965, Olson and Zeckhauser 1966). He established that countries who do contribute to public goods had their actions mainly motived by private interests. Countries who did not have other benefits than the one provided by the collective good would instead exploit the ones that do by cheap riding. This is because of the sharing nature of common goods, where costs may be greater than the benefits that are distributed amongst members, resulting in decreasing incentives to provide an optimal amount of donation. Seeing how nations will be diversely affected by climate change, in addition to our earlier discussion on negative impacts on country GDP from implementing the Paris Accord (section 6.1.2), may explain why large states cheap ride with lacking emission mitigation efforts. That is, relative to a country's resilience, adaption

[11] The Gini coefficient is a parameter measuring inequality of the income or wealth distribution within a country. An index of 0 equals perfect equality and a coefficient of 100 represent maximum inequality.
[12] Robin Hood index, also known as the Hoover index or Schutz index, defines the proportion that needs to be redistributed in order to achieve an equal and uniform outcome. In this scenario, 64 indicates that 64% of greenhouse gas emissions must be reallocated to attain an even emission distribution among countries.

capacities, vulnerability and short-term benefits from global warming, it may lie in a nation's interests to view climate change as an opportunity rather than threat. This means if climate inequity will bring about sufficient gains relative costs for a country, there will be little incentive to knowingly decrease carbon emissions and truly make effort to close the emission gap. Suboptimality in these scenarios may in other words be caused by wealthy nations' contributions only being mere for display, a false virtue and duplicity. On the other hand, the reason why smaller countries are providing relatively more is most likely because ambitious mitigation efforts are in line with other private interests, beyond economic welfare, to protect their nations from further damage and harm caused by global warming. We have for example previously mentioned in the discussion that countries affected by extreme weather events will set more ambitions pledges, and smaller countries have subsequently proven to be more optimistically evaluated than larger countries regarding the amount of emission released.

However, this is not to say that certain countries will always benefit from global warming. That is far from the truth. The scientific community have long stated that no country will walk into a warmer world without being affected by its negative consequences. There are even studies that show how economic costs will be felt universally by all countries by the year 2100, regardless of country asymmetries or disproportionate risks and exposure (Kahn, Mohaddes et al. 2019). Specifically, the world real GDP per capita is estimated to shrink by 7.22 percent up until 2100. Individual countries who will suffer greater losses than the global mean are India, Japan and New Zealand with a 10 percent decrease in national income, Russia 9 percent, Switzerland 12 percent, the United States 10.5 percent and Canada 13 percent, to name a few. These countries are all large nations according to the size of their GNI. Why these nations currently behave opportunistically despite the inevitable economic distress from global warming that is expectedly awaiting them might be because these numbers embody a future that is considered distant by contemporary citizens and politicians and thus, it is not immediately threatening (Jones and W. Hine 2016). In contrast, the affliction that will be brought upon smaller nations by 2030 is more alarming and met with greater weight today as 10 years is considered a near future. Besides, these countries are already experiencing climate change, but in a smaller scale, today.

The previously portrayed phenomenon is referred to as psychological distance. Factors such as social relevance, hypothetical, spatial and temporal distance all influence the personal engagement level of different situations, mentally and physically. The greater the distance, the more abstract will the impression and thought be, whilst decreasing proximity enhances concreteness and tangibility. At times, when analysing national level economic dilemmas such as climate change, it happens that one overlooks the power held by individuals when coming together as a collective group and the fact that nations consist of people. By adopting a top-down approach as this analysis of countries' cheap riding behaviour continues, it befalls that psychological distance alongside culture and the availability of information are evident to have great influence over policy making and climate adaptation. It is for example known that public knowledge is one key factor which impacts a country's choice of climate mitigation strategies, more so than having democratic institutions (Steves and Teytelboym 2013). And it is true, on one hand, that the public knowledge of climate change is greater and more widespread in industrialized countries, owing to education and public discourse. However, being aware of a problem does not necessarily imply possessing the will or intention to do something about it. Especially if there are minimal to no disruptions in people's daily lives. In smaller and developing states with less climate awareness, citizens are on the other hand experiencing the cost of climate change first-hand, as their country may be facing temperatures rising faster than the global average. Still, even though fewer are aware of the phenomenon that is global warming, those that are in fact conscious of it have expressed more concern than the corresponding citizens of industrialized countries (Leiserowitz and Howe 2015, McSweeney 2015). Indeed, a lower psychological distance is related to higher levels of worry whilst a greater distance is associated with less support for climate adaptation policies (Spence, Poortinga et al. 2011, Singh, Zwickle et al. 2017). In other words, psychological distance may function as a mediating factor between climate concern and intentions to proactively take action (Jones and W. Hine 2016). The immediate disturbance of daily lives climate change has caused in smaller countries might therefore make residents of these nations to become more inclined and accepting of policies that are in favour of the environment.

Nonetheless, the general public's concern for the climate has seemingly been decreasing over the last few decades. Whilst the scientific consensus regarding global warming's consequences and severity is becoming more accurate by the day, distress over global warming and its political prioritization in countries are falling. This is especially the case in wealthier countries (Stoknes 2014). The ongoing trend makes transferring knowledge from the scientific community to the political showground more tiresome as lacking concern shifts public spotlights to other agendas that are deemed more acute and important at the moment. This may explain why the global emission gap even exists in the first place. According to our study, it is true that larger countries cheap ride on smaller ones. However, as good as no country in the world is taking sufficient action to close the gap in a meaningful way. Smaller nations are merely performing relatively better. Still, given the size of the gap and how much emission that is still being released into the atmosphere globally, little will change if not major emitters decide to step up their game and realize more ambitious pledges that are better in line with the agenda of the Paris Agreement.

6.1.4 The Paris Agreement

The foundation of the Paris Agreement is a shared responsibility among nations. It is the responsibility of all countries to combat global warming and climate change by limiting manmade emissions. However, according to Article 4, developed countries are the ones who ought to take the lead and a heavier responsibility than the global average (UNFCCC Nov 2015). It is stated that the mitigation responsibility distribution is partly based on historical emissions and GDP. Naturally, as industrialized countries have relatively stronger economic positions, it gives them greater power to influence the international policy arena and can therefore set good examples by leading the global climate mitigation work. Hence, the ambitions and actions set by larger countries play a vital role in reaching global emission targets.

Unfortunately, as larger and developed countries are cheap riding, the foundation on which the Paris Agreement is partly built upon turns out to be rather fragile. This can prove as an explanation to why the climate goals have not yet been reached and is far from being achieved. That is, our findings can be one reason clarifying why it is such a challenge to raise national ambitions to the required levels and why the contributions of keeping the global mean temperature well below the 2°C limit are still lacking.

6.2 Directions for future research

To confirm our hypothesis with greater confidence, future work needs to include most, and if possible, all member states that have signed as well as ratified the Paris Convention in their study. Due to limited data, we were only able to analyse our proposition with a sub-group of countries and the generated results are only significant on a 10% significance level. This insinuates uncertainties in our data, as deviations may occur once the sample group increases in size.

It may also be of interest to investigate how institutional changes may affect countries' opportunistic behaviours in the international climate change regime, when country asymmetry has been taken account for. To illustrate an example, as one issue triggering collective action problems in the UNFCCC is the great number of participants, would it be possible, and perhaps more effective, to only include the G20 countries in a binding climate agreement, as a version of a minimal sized coalition? Owing to the fact that they stand for 78% of global emissions, without clear mitigation efforts from these countries, even a successful cooperation between the rest of the world would most likely not produce a sufficient impact for positive environmental changes to be significant.

VII. CONCLUSION

In this thesis we have reassessed the paper *Collective action in an asymmetric world* by Chen and Zeckhauser as well as rerun a modification of their correlation analysis, where the variable for reduction pledges was substituted with emission gaps. Instead of the generic phenomenon of free riding, we used the definition of cheap riding. It stands for a less extensive form of free riding, where actors contribute a positive yet suboptimal amount.

We began our study by first observing the collective action social dilemma as a whole, introducing existing frameworks, theories and research papers. It is found that the voluntary nature of NDCs, committed within the settings of the Paris Accord, have insufficient ambition levels for countries to reach the global climate goals in time as a collective unit. Cheap riders are some of many inhibiting factors for efficient collaboration.

We then progressed to examine whether the same conclusions made by Chen and Zeckhauser, that large countries bear a disproportionate amount of climate mitigation costs, can be drawn if we specify countries' contributions to the social good on the basis of the size of their emission gaps, rather than their policy promises. Two correlation tests were run, namely Spearman Rank Correlation test and Kendall's Tau test. The output shows no significance for most of our confounders, apart from the percentage of population exposed to extreme events as well as historical average annual temperature. The correlation between or main variables, emission gap and GNI2030, are statistically significant on a 10% significance level according to both tests.

Our main discovery consequently contradicts the theory that founded this thesis. Our results point towards a tendency that large countries cheap ride on small nations in the international climate regime. After a careful discussion of underlying reasons to why this is, it is understood that short-term economic benefits, unequal distribution of global warming aftermaths and psychological distance are some of many factors that intensify the incentives for opportunistic behaviour. Cheap riding diminishes the initiatives of larger states to come forward in the combat against climate change. Inevitably, the global emission gap will remain a constant defect of the alliance and the once perceived promising Paris Agreement.

VII. REFERENCES

A. Tapia Granados, J., L. Iondies, E. and Carpintero, Ó, 2012. Climate change and the world economy: short-run determinants of atmospheric CO2. *Environmental Science & Policy,* **21**, pp. 50-62.

Allen, R.C., 2011. *Global economic history: A very short introduction.* Oxford, New York: Oxford University Press.

Althor, G., Watson, J.E.M. and Fuller, R.A., 2016. Global mismatch between greenhouse gas emissions and the burden of climate change. *Scientific Reports,* **6**(1), pp. 1-6.

Baettig, M.B., Brander, S. and Imboden, D.M., 2008. Measuring countries' cooperation within the international climate change regime. *Environmental Science & Policy,* **11**(6), pp. 478-489.

Barrett, S., 1994. Self-enforcing international environmental agreements. *Oxford Economic Papers,* **46**, pp. 878-894.

Barrett, S. and Dannenberg, A., 2012. Climate negotiations under scientific uncertainty. *Proceedings of the National Academy of Sciences,* **109**(43), pp. 17372-17376.

BBC News, 2019, -11-05. Paris climate accords: US notifies UN of intention to withdraw. *BBC News.*

Burke, M., Diffenbaugh, N.S. and Davis, W.M., 2018. Large potential reduction in economic damages under UN mitigation targets. *Nature,* **557**(7706), pp. 549-553.

Center for global development, 18 August, 2015-last update, developed countries are responsible for 79 percent of historical carbon emissions. Available: https://www.cgdev.org/media/who-caused-climate-change-historically [Apr 28, 2020].

Chen, C. and Zeckhauser, R.J., 2018. Collective action in an asymmetric world. *Journal of Public Economics,* **158**, pp. 103-112.

Climate Action Tracker, Addressing global warming. Available: https://climateactiontracker.org/global/temperatures/ [March 24, 2020].

Climate change knowledge portal, Historical data. Available: https://climateknowledgeportal.worldbank.org/download-data [23 March, 2020].

Commit & CD-links, 2018. *Opportunities for enhanced action to keep Paris goals in reach - Contribution to the talanoa dialogue by the Commit and CD-links projects.*

Eckstein, D., Hutfils, M. and Winges, M., 2018. *Global climate risk index 2019.* Berlin: Germanwatch.

Enuka, C., 2018. Challenges of international environmental cooperation. *Global Journal of Human-Social Science: B,* **18**(3),.

Environment, U.N., Tue, 11/26/ - 11:00, 2019-last update, Visual feature: The emissions gap report 2019. Available: https://www.unenvironment.org/interactive/emissions-gap-report/2019/ [Mar 13, 2020].

Füssel, H., 2010. How inequitable is the global distribution of responsibility, capability, and vulnerability to climate change: A comprehensive indicator-based assessment. *Global Environmental Change,* **20**, pp. 597-611.

Gao, Y., Gao, X. and Zhang, X., 2017. The 2 °C global temperature target and the evolution of the long-term goal of addressing climate change—From the United Nations framework convention on climate change to the Paris agreement. *Engineering,* **3**(2), pp. 272-278.

Gerber, A. and Wichardt, P.C., 2009. Providing public goods in the absence of strong institutions. *Journal of Public Economics,* **93**(3), pp. 429-439.

Harris, P., 2007. Collective action on climate change: The logic of regime failure. *Natural Resources Journal,* **47**, pp. 195-224.

Jagers, S.C., Harring, N., Lofgren, A., Sjostedt, M., Alpizar, F., Brülde, B., Lanlet, D., Nilsson, A., Carnet Almroth, B., Dupont, S. and Steffen, W., 2019. On the preconditions for large-scale collective action. *CeCAR Working Paper Series,* .

Jones, C. and W. Hine, D., 2016. The future is now: Reducing psychological distance to increase public engagement with climate change. *Risk Analysis An International Journal,* **37**(2), pp. 331-341.

Kahn, M., Mohaddes, K., NG, R., Pesaran, H., Raissi, M. and Yang, J., 2019. Long-term macroeconomic effects of climate change: A cross-country analysis. *Federal Reserve Bank of Dallas, Globalization Institute Working Papers,* .

Keohane, R. and Martin, L., 1995. The promise of institutional theory. *International Security,* **20**, pp. 39-51.

Leeds, B.A., 2003. Alliance reliability in times of war: Explaining state decisions to violate treaties. *International Organization,* **57**(4), pp. 801-827.

Leiserowitz, A. and Howe, P., 2015. *Climate change awareness and concern in 119 countries.* Yale program in climate change communication.

Mani, M.S., Hussein, Z., Gopalakrishnan, B.N. and Wadhwa, D., 2018. Paris climate agreement and the global economy: winners and losers. *Policy Research Working Paper,* **1**.

Masson-Delmotte, V., Zhai, P., Portner, H., Roberts, D.C., Skea, J., Shukla, P.R., Pirani, A., Moufouma-Okia, W., Péan, C., Pidcock, R., Connors, S., Matthews, J.B.R., Chen, Y., Zhou, X., Gomis, M., Lonnoy, E., Tignor, M. and Waterfield, T., 2018. *Global warming of 1.5°C.* Geneva, Switzerland: Intergovernmental Panel on Climate Change.

Mcsweeney, R., -07-27, 2015-last update, Global survey: Where in the world is most and least aware of climate change?. Available: https://www.carbonbrief.org/global-survey-where-in-the-world-is-most-and-least-aware-of-climate-change [Apr 28, 2020].

Murdoch, J.C. and Sandler, T., 1997. The voluntary provision of a pure public good: The case of reduced CFC emissions and the Montreal protocol. *Journal of Public Economics,* **63**(3), pp. 331-349.

Nordhaus, W.D., 1991. A sketch of the economics of the greenhouse effect. *Papers and proceedings of the hundred and third annual meeting of the American economic association,* **81**(2), pp. 146-150.

Olson, M., 1971. The logic of collective action: Public goods and the theory of groups. *Harvard University Press,* , pp. 1-141.

Olson, M., 1965. *The logic of collective action.* Harvard University Press. Cambridge.

Olson, M. and Zeckhauser, R., 1966. An economic theory of alliances. *The Review of Economics and Statistics,* **48**(3), pp. 266–279.

O'Neill, K., 2009. *The environment and international relations.* Cambridge: Cambridge University Press.

Ostrom, E., 1998. A behavioral approach to the rational choice theory of collective action: Presidential address, American Political Science Association, 1997. *American Political Science Review,* **92**(1), pp. 1-22.

Riahi, K., Kriegler, E., Johnson, N., Bertram, C., den Elzen, M., Eom, J., Schaeffer, M., Edmonds, J., Isaac, M., Krey, V., Longden, T., Luderer, G., Méjean, A., McCollum, D.L., Mima, S., Turton, H., van Vuuren, D.P., Wada, K., Bosetti, V., Capros, P., Criqui, P., Hamdi-Cherif, M., Kainuma, M. and Edenhofer, O., 2015. Locked into Copenhagen pledges — Implications of short-term emission targets for the cost and feasibility of long-term climate goals. *Technological Forecasting and Social Change,* **90**, pp. 8-23.

Samuelsson, P.A., 1954. The pure theory of public expenditure. *The Review of Economics and Statistics,* **36**(4), pp. 387-389.

Sandler, T., 1998. Global and regional public goods: A prognosis for collective action. *Fiscal Studies,* **19**(3), pp. 221-247.

Sandler, T. and Sargent, K., 1995. Management of transnational commons: Coordination, publicness, and treaty formation. *Land Economics,* **71**(2), pp. 145-162.

SEDAC, Urban-Rural Population Estimates. Available: https://sedac.ciesin.columbia.edu/data/set/lecz-urban-rural-population-estimates-v1/data-download [23 March, 2020].

Seo, S.N., 2017. *The behavioral economics of climate change.* Academic Press. London.

Singh, A.S., Zwickle, A., Bruskotter, J.T. and Wilson, R., 2017. The perceived psychological distance of climate change impacts and its influence on support for adaptation policy. *Environmental Science & Policy,* **73**, pp. 93-99.

Spence, A., Poortinga, W. and Pidgeon, N., 2011. The psychological distance of climate change. *Risk Analysis an International Journal,* **32**(6), pp. 957-972.

Steffen, W., Rockström, J., Richardson, K., Lenton, T.M., Folke, C., Liverman, D., Summerhayes, C.P., Barnosky, A.D., Cornell, S.E., Crucifix, M., Donges, J.F., Fetzer, I., Lade, S.J., Scheffer, M., Winkelmann, R. and Schellnhuber, H.J., 2018. Trajectories of the Earth system in the anthropocene. *Proceedings of the National Academy of Sciences,* **115**(33), pp. 8252-8259.

Stern, N., 2007. *The economics of climate change -The Stern Review.* Cambridge University Press. Cambridge.

Steves, F. and Teytelboym, A., 2013. Political economy of climate change policy. *SSEE Working Paper.*

Stoknes, P.E., 2014. Rethinking climate communications and the "psychological climate paradox". *Energy Research & Social Science,* **1**, pp. 161-170.

Sunstein, C.R., 2007. Of Montreal and Kyoto: A tale of two protocols. *Harvard Environmental Law Review,* **31**.

The World Bank, a-last update, World development indicators: Climate variability. Available: http://wdi.worldbank.org/table/3.11 [23 March, 2020].

The World Bank, b-last update, World development indicators: Population dynamics. Available: http://wdi.worldbank.org/table/2.1 [March 23, 2020].

The World Bank, c-last update, World development indicators: Towards a broader measure of national income. Available: http://wdi.worldbank.org/table/4.10 [March 22, 2020].

Tol, R.S.J., Downing, T.E., Kuik, O.J. and Smith, J.B., 2004. Distributional aspects of climate change impacts. *Global environmental change,* **14**(3), pp. 259-272.

Traore Chazalnoël, M. and Puscas, S., 2019. *Climate change and migration in vulnerable countries.* International Organization for Migration (IOM).

UN News, 2017, August 4. UN officially notified of US intention to withdraw from Paris climate pact.

UNFCCC, Nov 2015. The Paris agreement, *2015 United Nations climate change conference *, 30 November 2015 - 12 December 2015 Nov 2015, UNFCCC.

United Nations environment programme, 2019. *Emission gap report 2019.* Nairobi: UNEP.

VIII. APPENDIX

A. Stata DO-file

```
clear all

set more off

import excel "/Users/deniseshen/Handelshögskolan/Thesis/Thesis Data Lower Limit.xlsx", firstrow //first row as variable name

scatter EmissionGap GNI2030 //Graphical illustration of the relationship between EmissionGap and GNI in year 2030


//Test: Emission gap of GNI 2030 and GNI 2030//
gen emission_d_GNI = EmissionGap/GNI2030 //Generating a new variable; Emission gap of GNI 2030
spearman GNI2030 emission_d_GNI //Spearman Rank Correlation test
ktau GNI2030 emission_d_GNI //Kendall's Tau


//Test: Emission gap of GNI per capita 2030 and GNI per capita 2030//
gen emission_d_GNICapita2030 = EmissionGap/GNICapita2030 //Generating a new variable; Emission gap of GNI per capita 2030
spearman GNICapita2030 emission_d_GNICapita2030 //Spearman Rank Correlation test
ktau GNICapita2030 emission_d_GNICapita2030 //Kendall's Tau


//Test: Emission gap of population living in rural area and population living in rural area
gen emission_d_poprural = EmissionGap/PoplivinglowareaRural //Generating a new variable; Emission gap of population living in rural area
spearman PoplivinglowareaRural emission_d_poprural //Spearman Rank Correlation test
ktau PoplivinglowareaRural emission_d_poprural //Kendall's Tau


//Test: Emission gap of population living in urban area and population living in urban area
gen emission_d_popurban = EmissionGap/PoplivinglowareaUrban//Generating a new variable; Emission gap of population living in urban area
spearman PoplivinglowareaUrban emission_d_popurban //Spearman Rank Correlation test
ktau PoplivinglowareaUrban emission_d_popurban //Kendall's Tau


//Test: Emission gap of population exposed to disaster and population exposed to disaster
gen emission_d_disaster = EmissionGap/Popex_ev //Generating a new variable; Emission gap of population exposed to disaster
spearman Popex_ev emission_d_disaster //Spearman Rank Correlation test
ktau Popex_ev emission_d_disaster //Kendall's Tau


//Test: Emission gap of average historical temperature and average historical temperature
gen emission_d_temp= EmissionGap/AverageHistoricalTemperature //Generating a new variable; Emission gap of average historical temperature
spearman AverageHistoricalTemperature emission_d_temp //Spearman Rank Correlation test
ktau AverageHistoricalTemperature emission_d_temp //Kendall's Tau

//Test: Emission gap of Population 2030 and Population 2030
gen emission_pop2030= EmissionGap/Population2030 //Generating a new variable; Emission gap of population 2030
spearman Population2030 emission_pop2030 //Spearman Rank Correlation test
ktau Population2030 emission_pop2030 //Kendall's Tau

//Descriptive Statistics
sum EmissionGap
sum GNI2030
sum GNICapita2030
sum PoplivinglowareaUrban
sum PoplivinglowareaRural
sum Popex_ev
sum AverageHistoricalTemperature
sum Population2030
```

B. Countries Included in our Data

Argentina
Australia
Bhutan
Brazil
Canada
Chile
China
Costa Rica
EU
Ethiopia
India
Indonesia
Japan
Kazakhstan
Kenya
Mexico
Morocco
Nepal
New Zeeland
Norway
Peru
Philippines
Russian Federation
Saudi Arabia
Singapore
South Africa
South Korea
Switzerland
The Gambia
Turkey
UAE
USA
Ukraine
UK
Vietnam

C. Excel: Data used in our rank correlation tests

Countries	1.5°C-2°C Limit	Lower Projections	Emission Gap	GNI 2030	GNI/Capita 2030	% Pop ex_ev	% Pop air pollution	Fossil consumption % tot	NO emission TMt	% Pop living low area Urban	% Pop living low area Rural	Average Historical Temperature	Population 2030
Argentina	207,1212	422,0968	214,9756	1004,3989	20030,4058	0,002	0,939	0,877	53101	0,1211	0,0526	14,307	0,05014
Australia	275,0616	436,0768	161,0152	1901,1637	63604,3777	0,03	0,249	0,896	54247	0,1251	0,0938	21,476	0,02989
Bhutan	3,4054	6,3945	2,9891	5,5426	5863,6967	0	1	0	555	0,0000	0,0000	11,901	0,00095
Brazil	411,3383	889,7059	478,3676	2959,8297	12537,9407	0,005	0,681	0,591	214529	0,0815	0,0274	24,955	0,23607
Canada	331,7173	518,2000	186,4827	2084,5444	49863,2707	0	0	0,741	33414	0,0417	0,0478	-6,886	0,04181
Chile	71,4532	121,7089	50,2557	454,7938	21328,4401	0,003	0,977	0,746	8949	0,0225	0,0209	8,283	0,02132
China	8456,2669	13743,5960	5287,3291	40828,1987	27612,7654	0,08	1	0,877	587166	0,1847	0,0782	6,391	1,47860
Costa Rica	10,6315	13,7022	3,0707	94,2366	16141,2095	0,007	0,997	0,499	1566	0,0166	0,0332	24,516	0,00584
EU	804,4164	3389,7176	2585,3012	18345,2593	14562,8954	0,011	20,0416	18,745	240543	0,1002	0,0558	9,481	1,25973
Ethiopa	299,7037	185,0000	-114,7037	273,7704	1799,8920	0,033	1	0,066	39854	0,0000	0,0000	22,606	0,15210
India	4596,7622	6034,0811	1437,3189	6171,2560	3861,4349	0,044	1	0,736	239755	0,1046	0,0448	25,835	1,59818
Indonesia	622,3666	1817,0000	1194,6334	1970,4723	6303,8898	0,002	0,956	0,661	93139	0,2792	0,1445	10,456	0,31258
Japan	-154,0000	1078,8624	1232,8624	5587,5216	44170,1316	0	0,768	0,93	24911	0,2567	0,1078	5,782	0,12650
Kazakhstan	206,8504	318,8776	112,0272	297,4701	14255,3672	0,002	0,874	0,992	17822	0,0000	0,0000	24,290	0,02087
Kenya	115,2689	89,0028	-26,2661	147,2692	2105,6223	0,065	1	0,174	11590	0,0093	0,0091	20,572	0,06994
Mexico	442,0248	755,3456	313,3209	1481,5641	9935,8639	0,001	0,997	0,904	43436	0,0536	0,0620	17,488	0,14911
Morocco	159,0766	145,3338	-13,7428	187,8046	4521,0317	0,001	1	0,885	6007	0,1241	0,0259	12,090	0,04154
Nepal	82,6706	67,2671	-15,4035	43,5609	1392,1827	0,007	1	0,155	4598	0,0000	0,0000	12,090	0,03129
New Zeeland	45,5968	62,3319	16,7351	271,8201	47508,5983	0	0	0,597	11880	0,1541	0,1189	9,701	0,00572
Norway	8,5815	30,7262	22,1447	524,7094	88909,6633	0	0,02	0,57	3305	0,0737	0,1152	1,024	0,00590
Peru	54,1879	130,5601	76,3722	403,1606	11048,7765	0,02	1	0,796	8478	0,0184	0,0174	19,546	0,03649
Philippines	132,2065	90,0275	-42,1790	756,3773	5790,5878	0,008	0,964	0,624	12762	0,2737	0,1293	25,475	0,13062
Russian Federation	828,1607	2491,3758	1663,2151	2373,1644	16621,6498	0,001	0,916	0,921	65194	0,0248	0,0237	-6,235	0,14278
Saudi Arabia	381,4078	861,4666	480,0588	1193,8338	25731,7101	0	1	0,999	6517	0,1616	0,0284	24,698	0,04640
Singapore	-21,5493	68,0483	89,5976	623,8793	88883,7495		1	0,906	1909	0,1402	0,5452	27,187	0,00702
South Africa	363,6247	414,4485	50,8238	491,2961	7193,8268	0,018	1	0,868	21149	0,0158	0,0030	17,538	0,06829
South Korea	217,1683	539,3649	322,1966	2485,9023	45377,6088	0,001	1	0,81	14979	0,0530	0,1008	10,655	0,05478
Switzerland	-13,6627	26,6000	40,2627	822,9412	86947,2527	0	0,493	0,502	2385	0,0000	0,0000	5,874	0,00946
The Gambia	5,6584	3,7795	-1,8789	2,2591	688,8946	0,002	1	0	500	0,4714	0,2663	27,427	0,00328
Turkey	364,7115	998,6476	633,9360	1665,1972	16922,8427	0,001	1	0,868	35612	0,0431	0,0247	11,168	0,09840
UAE	109,0040	278,7413	169,7373	633,7440	32073,6507		1	0,861	2413	0,2506	0,0560	26,824	0,01976
USA	1836,1391	6321,5838	4485,4447	25059,1920	69602,9077	0,002	0,033	0,824	288878	0,0889	0,0469	6,998	0,36003
Ukraine	216,6652	542,9862	326,3210	134,2273	3196,1637	0,003	1	0,753	22549	0,0297	0,0221	8,274	0,04200
UK	-441,0000	389,2545	830,2545	1879,5189	25993,8971	0	0,665	0,804	25335	0,1175	0,1170	8,496	0,07231
Vietnam	296,2772	871,8565	575,5792	427,2298	3970,1025	0,016	1	0,698	34494	0,7390	0,4971	24,218	0,10761