DISS. ETH NO. 22516

Fairness and Components of Architectures in International Climate Negotiations

A thesis submitted to attain the degree of
Doctor of Sciences of ETH ZURICH
(Dr. sc. ETH Zurich)

presented by

Max Meulemann
Diplom Volkswirt, University of Münster
19.12.1983
citizen of Germany

accepted on the recommendation of
Prof. Dr. Lucas Bretschger
Prof. Dr. Andreas Ziegler

2015

Preface

The last four years have been a great continuation of a journey that started with studying economics back in 2004. Looking back at my level and understanding of economics when I graduated, I feel privileged to be given the opportunity to explore the field of economics on a completely different level. I enjoyed taking an in depth look into academia to witness high level research thanks to seminars at CER-ETH, conferences and other workshops. The discourse with people from different fields and backgrounds helped me grow personally and in my work. To name a few outstanding events: The trip to Berlin with Filippo, Janick, Lisa, and Nick, the EEA, EAERE, and SURED conferences.

For all these opportunities, I am deeply grateful to my supervisor Prof. Bretschger, my co supervisor Andreas Ziegler, the BMBF, ETH Zurich, and the other project partners. While probably forgetting some people, I would like to thank the following people who helped a lot with valuable comments and or proofreading: My roommate Przemek, Janick, Justin, Therese, Adriana, Julie, Julien, Roger, Andreas and Filippo. I always remember our group spirit and the times we had at ZUE at different social events.

Finally, I owe a huge dept to my father who always supported and improved my work by giving valuable comments and insights from a similar but different perspective. Last but not least, I owe all I have achieved to my family, especially my mother, who supported me all the way.

Zurich, December 2014 Max Meulemann

Contents

List of Figures

List of Tables

List of Abbreviations

AP	Ability to Pay rule
BASI	Brazil, South Africa, and India
BASIC	Brazil, South Africa, India, and China
BSR	Burden Sharing Rule
CBDR	Common But Differentiated Responsibility
CDM	Clean Development Mechanism
CONS-C	Current Consumer Pays rule
CONS-H	Historic Consumer Pays rule
COP	The Conferences of Parties
CO_2	Carbon dioxide
EGA	Egalitarian rule
EU	European Union
FOC	First Order Condition
G77	Group of 77
GDP	Gross Domestic Product
GF	Grandfathering rule
GHG	Greenhouse Gas
ICA	International Climate Agreement
IEA	International Environmental Agreement
IPCC	Intergovernmental Panel on Climate Change
LRTAP	Long-Range Trans-boundary Air-Pollution
MARPOL	International Convention for the Prevention of Pollution From Ships
NGO	Non Governmental Organization

OECD	Organization for Economic Co-operation and Development
POLL-C	Current Polluter Pays rule
POLL-H	Historic Polluter Pays rule
R&D	Research and development and technology transfers
REDD	Reducing Emissions from Deforestation and Forest Degradation
SUR	Seemingly Unrelated Regression
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USA	United States of America
WTO	World Trade Organization
ZEW	Center of European Economic Research

Thesis Summary

This thesis addresses international climate agreements: For one part, it does so empirically while the other part uses a theoretical microeconomic model. The empirical part of this thesis conducts a microeconometric analysis of survey data. As part of a larger project, we conduct a survey among participants of the Conferences of Parties in Cancun and Durban. The data used here focuses on two different aspects of international climate negotiations: Burden sharing rules and different components of architectures for agreements. The theoretical paper analyzes how social preferences would affect the outcome of a non cooperative permit market. For this, it chooses inequality aversion as a special case of social preferences.

In the context of international climate negotiations, fairness has gained more attention in the last years. There are many examples for the use of fairness arguments in the negotiation process and public statements about fairness by important stakeholders of different countries. In this regard, we analyze burden sharing rules and use an item based questionnaire to elicit the views of participants of international climate conferences about these rules. We see burden sharing rules based on certain fairness principles as a way to address fairness considerations of negotiators at international climate conferences. The econometric analysis tests if the attitude towards fairness as a part of an international climate agreement, vulnerability, or economic factors influence the perception of burden sharing rules. There is some indication that respondents expect higher emission reductions for rules that allocate emission rights according to historic responsibility. It appears that the rules

that allocate emission rights according to historic responsibility and ability to pay are the most accepted rules.

The Kyoto Protocol has so far been the only significant step to prevent global climate change. It mostly focused on setting global quantitative emission reduction targets for its participants. However, other components could be the core of an architecture for an international climate agreement. We select the six most prominent components: Global targets, sector targets, research and development, geoengineering, land-use, and adaptation. A section of the aforementioned survey explores the importance of these components and which countries respondents expect to take a leading role. Global targets and adaptation are the preferred components, while geoengineering seems to be quite unpopular. Macroeconomic indicators play an important role and surprisingly vulnerability does not help a lot to explain the preference of components or expected leadership roles. It seems that respondents in favor of fairness as an important part of an international climate agreement tend to expect a leading role of China, the EU, and the USA. This is not really in line with the current events and a sign for a normative bias.

The microeconomic study extends a model of a non cooperative permit market by social preferences. A non cooperative permit market is somehow similar to the first stages of the European Trading System. Countries can freely choose the amount of permits they deem necessary, but are aware that other countries do so as well. This results in an endogenous amount of permits and a corresponding price as a reference case. Adding a social preference influences the endogenous amount of permits and the price. We analyze how adding inequality aversion as a special case of social preferences changes the outcome. The chapter obtains analytic results of the price and compares this to the price of the reference case. If the price increases, the amount of total emissions would go down, if it decreases, emissions would increase. We show analytically that the price decreases, when countries are inequality averse with respect to permits. With inequality aversion about payoffs, we can specify a solution for the price, but cannot say if it increases or decreases.

A numerical example shows both cases in order to demonstrate the impact of inequality aversion.

Kurzfassung

Diese Doktorarbeit beschäftigt sich mit internationalen Klimaabkommen: Dafür werden sowohl empirische Methoden als auch ein mikroökonomischer Modellansatz verwendet. Der empirische Teil untersucht Daten einer Umfrage der Teilnehmer der internationalen Klimakonferenzen in Cancun und Durban. Im Rahmen eines größeren Projekts werden zwei verschiedene Aspekte internationaler Klimaverhandlungen betrachtet: Verteilungsregeln und verschiedene Komponenten der Architektur eines Abkommens. Der mikroökonomische Abschnitt analysiert, wie soziale Präferenzen das Ergebnis eines nicht kooperativen Emissionsmarktes beeinflussen. Hierbei wird Ungleichheitsaversion als Spezialfall sozialer Präferenzen ausgewählt.

Im Rahmen der internationalen Klimaverhandlungen hat Fairness in den letzten Jahren mehr und mehr Aufmerksamkeit gewonnen. Es gibt viele Beispiele der Verwendung von Fairnessargumenten im Verhandlungsprozess und weitere öffentliche Aussagen über Fairness von wichtigen Vertretern verschiedener Länder. Daher untersuchen wir Verteilungsregeln basierend auf verschiedenen Fairnessprinzipien mit Hilfe eines Item-gestützten Fragebogens. Dies erlaubt uns mehr über die Ansichten der Teilnehmer internationaler Klimakonferenzen zum Thema Fairness zu erfahren. Die ökonometrische Analyse testet, ob die Einstellung zu Fairness als Teil eines Klimaabkommens, Verwundbarkeit oder ökonomische Faktoren die Wahrnehmung von Verteilungsregeln beeinflussen. Es gibt Hinweise, dass die Befragten höhere Emissionsreduktionen von Regeln erwarten, die Emissionsrechte anhand von historischer Verantwortung verteilen. Im Allgemeinen werden die Regeln, die Emissions-

rechte an Hand von historischer Verantwortung und Leistungsfähigkeit vergeben, bevorzugt.

Das Kyoto Protokoll ist bisher der signifikanteste Schritt, um den Klimawandel zu verhindern. Es legt hauptsächlich globale quantitative Emissionsziele für seine Teilnehmer fest. Andere Komponenten könnten jedoch den Kern eines neuen internationalen Klimaabkommens bilden. Wir wählen die sechs meistdiskutierten Komponenten aus: Globale Emissionsziele, sektorale Emissionsziele, Forschung und Entwicklung, Geoengineering, Landnutzung und Anpassung. Ein Teil der zuvor erwähnten Umfrage befasst sich mit der Frage wie wichtig die Komponenten für ein Klimaabkommen sind und welche Länder eine Führungsrolle spielen würden. Globale Emissionsziele und Forschung und Entwicklung sind die bevorzugten Komponenten, im Gegensatz zu Geoengineering, das wenig Unterstützung findet. Die makroökonomischen Faktoren spielen eine wichtige Rolle und überraschenderweise trägt Verwundbarkeit nicht viel dazu bei, die Präferenz verschiedener Komponenten oder erwarteter Führungsrollen zu erklären. Es scheint, dass die Befragten, die sich mehr um Fairness als Bestandteil eines Klimaabkommens sorgen, eher eine Führungsrolle der Europäischen Union, Chinas oder der USA erwarten. Dies zeigt sich nicht wirklich auf den Klimaverhandlungen und ist ein Zeichen einer normativen Verzerrung.

Die mikroökonomische Untersuchung erweitert das Model eines nichtkooperativen Emissionsmarkts um soziale Präferenzen. Ein nichtkooperativer Emissionsmarkt modelliert die ersten Phasen des Europäischen Emissionshandels. Die Länder wählen unabhängig voneinander die Menge an Emissionsrechten, die sie benötigen. Dabei sind sie sich bewusst, dass die anderen Ländern dies ebenso tun. Daraus resultiert eine endogene Menge an Gesamtemissionen mit einem entsprechendem Preis als Referenzfall. Wenn man nun soziale Präferenzen berücksichtigt, beeinflusst dies den Preis und damit die Menge an Zertifikaten. Die Studie verwendet Ungleichheitsaversion als einen Spezialfall von sozialen Präferenzen, um die Änderung des Preises gegenüber dem Referenzfall zu berechnen. Wenn der Preis steigt, verringert sich die

Menge an Emissionen. Umgekehrt steigt die Menge an Emissionen, wenn der Preis sinkt. Der Preis sinkt, wenn Länder Abneigung gegenüber Ungleichheit im Bezug auf Emissionsrechte aufweisen. Wenn sich die Aversion auf die Wohlfahrt des Referenzfalls bezieht, erhalten wir eine Lösung für den Preis, die jedoch nicht klar zeigt, ob der Preis steigt oder sinkt. Ein numerisches Beispiel zeigt in beiden Fällen, wie sich die Ungleichheitsaversion auswirken könnte.

Chapter 1

Introduction

The drastic consequences of climate change are a major challenge for mankind. According to the Intergovernmental Panel on Climate Change (IPCC) and scientific consensus, the average global temperature in 2050 is expected to rise by more than 2°C due to the increasing amount of greenhouse gas (GHG) emissions. This result has been stressed again by the recent IPCC synthesis report (Stocker et al., 2013). Given that GHG emissions are a global externality, encouraging coordinated actions against climate change is just as difficult as for a public good. Therefore, it is not surprising that countries are not about to voluntarily curb their emissions. On the one hand, they are afraid to dampen their economic growth and on the other hand they do not expect other countries to take action. This is the main reason why global emissions have increased by 40% since 1990 and only few countries have committed to significant efforts against climate change. Unilateral actions alone are unlikely to prevent climate change since they might be counterbalanced by leakage, which means increasing emissions in the rest of the world. The lack of any meaningful supranational authority requires that countries reach an international climate agreement to prevent drastic climatic changes.

However, some examples of international agreements on environmental problems show that this is indeed possible and the number of international environmental agreements has been increasing. Barrett (2005) presents an overview of the development of international environmental agreements and the number of transnational environmental problems is countless, e.g.: Transnational river use like the Nile, acid rains caused by sulfur emissions, or fishing grounds in international seas. Fortunately, the formation of some international environmental agreements shows the possibility of international cooperation. Notable examples are the Montreal Protocol on Ozone depletion, the International Convention for the Prevention of Pollution From Ships (MARPOL), or on a smaller scale the Rhine Chlorides agreement on river pollution.

Unfortunately, the nature of these examples is very different compared to an international climate agreement. First, the size of the problem and the associated costs of an international climate agreement are much larger than for previous environmental agreements. The United Nations Environment Programme (UNEP) reports costs of 235 billion US (1997) dollars for the Montreal protocol (United Nations Environmental Programme, 2012). Getting a similar figure for climate change costs is much harder due to uncertainties and the much larger scale. The macroeconomic costs or benefits of preventing climate change range from a gain of 1% to a decrease of 5.5% in global Gross Domestic Product (GDP) (current global GDP equals 71,830 billion current US dollars) (Wråke et al., 2012).

Second, the time lag between abatement costs now and future damages makes it harder for both policy makers and the general population to grasp the problem they are facing and to accept the necessary steps against climate change now. For instance, the peak of the global damages will not be reached before 2100 and the uncertainty about future damages and abatement costs is very high. Due to the technical progress in abatement, adaptation, and mitigation it is very hard to predict damages and costs almost a century in advance. In contrast to that, technically feasible solutions to replace ozone depleting gasses were already available when the Montreal Protocol was passed.

Third, the difficulty to pin down the present value costs of climate change can also been seen in the debate about the appropriate intertemporal discount rate. The original cost and benefit predictions of climate change by Stern et al. (2006) are criticized by Nordhaus (2007) to hinge on a low intertemporal discount rate. Sterner and Persson (2008) vindicate the original report and reproduce the same conclusion considering relative price effects.

Fourth, global climate change virtually affects every country of the world, but not to the same extent so that distributional issues are a major problem. An international climate agreement has to include almost all countries. Otherwise, leakage reduces the efficiency and effectiveness of the agreement. The existing international environmental agreements only concern a small number of countries or groups of countries which made it easier to reach agreement.[1] All the above given points explain why international climate negotiations have not yet achieved more than the Kyoto Protocol.

The process of finding an international climate agreement began in 1992 with the creation of the United Nations Framework Convention on Climate Change (UNFCCC). This date often serves as the point of time when the world community recognized the problem of anthropogenic climate change.[2] Instead of already fixing limits on GHG emissions, the UNFCCC rather set goals and a framework to negotiate a future climate agreement. The Conferences of Parties (COP) are an essential part of this process. Every year, representatives from almost every country come together to negotiate an international climate agreement. In 1997, the first and so far only climate agreement came to existence. It was meant to reduce emissions by 5% in comparison to 1990. Seen as a success at the time, in hindsight Posner and Weisbach (2010) as well as Böhringer and Vogt (2004) describe it as more or less symbolic. A more detailed discussion about the flaws of the Kyoto Protocol is given by Aldy et al. (2003).

Empirically, some studies suggest that the impact of Kyoto has been rather

[1] Barrett (2005) lists only 22 signatories for the Helsinki protocol or 35 countries the Atlantic Tunas Convention.

[2] A further discussion on when anthropogenic climate change was recognized and when responsibility for it started is given by Caney (2005) or Leist (2011).

small when self selection and other problems are controlled for. While Iwata and Okada (2010) find at least some positive effects, Slechten and Verardi (2014) conclude that most carbon dioxide (CO_2) reductions are rather supplied by the Long-Range Trans-boundary Air-Pollution (LRTAP) convention. This convention mostly aims at reducing acid rain and sulfur dioxide emissions, but provides significant CO_2 reductions as well. New hope for a follow up of Kyoto came up when the Bali Road map was passed in 2007. When no agreement could be reached at the 2009 COP in Copenhagen, the process split up to find either a follow up for Kyoto or a completely new comprehensive agreement. The Durban accord emphasized the willingness of all countries to participate in an international climate agreement and new hopes are set on the 2015 COP in Paris to formulate a new international climate agreement.

The urgency of finding a meaningful international climate agreement to prevent dramatic consequences of climate change originally inspired the project by which this thesis is partly funded. The motivation of our project, just as of our thesis, is twofold:
(1) We follow the idea that fairness influences the formation and the outcome of an international climate agreement. (2) We address different components of architectures for an international climate agreement and how they are perceived by participants of international climate conferences.

The role of fairness has gained more and more public and academic attention. The initial differentiation between Annex I and Annex II countries and the Principle of Common but Differentiated Responsibilities are prove for that. In the academic world, climate ethics emerged as a new field of academic interest to address these topics (Pachauri et al., 2010). While taking account of moral considerations and non-monetary issues might not be new to environmental economics, this development is more recent for the economic mainstream. The narrow view of self serving utility maximizing agents has been upgraded to account for agents that care about distributions of goods or inequality. The introduction of these social preferences improves social welfare analysis and provides more realistic predictions that align better with reality.

Although the Kyoto Protocol has so far been the only successful step towards preventing global warning, many experts and scholars advocate for a different focus of an international climate agreement. By focus we mean a set of policies or measures against climate change that we define as components of architectures for an international climate agreement. We follow Aldy and Stavins (2007) who discuss the six most prevalent components of architectures and henceforth use the term component to describe different parts of the design and form of an international climate agreement. It is not necessarily clear which components are best suited or if a mix of components would work better to prevent climate change.

1.1 Fairness

An increasing number of studies referred to in this thesis highlights the general importance and role of fairness in international climate negotiations. In the public and academic debate the terms "fairness" and "equity" are often used synonymously (Klinsky and Dowlatabadi, 2009). We continue to use the term fairness in the meaning of equal treatment, which is perceived as right and reasonable by society.

One rather anecdotic example of how fairness has at least publicly been used in climate change negotiations is the development of the Kyoto protocol. The Kyoto protocol would have induced huge costs for the United States of America, but officially the lack of binding limits for all countries was given as justification to not ratify it. On the opposite side, developing countries did not want to dampen their economic growth before reaching a certain threshold by accepting any binding limits or targets for their GHG emissions. They blamed the industrialized countries as responsible for climate change and its costs. Additionally, the industrialized countries would be more able to react to the problem and could afford it. The following citation of G.W. Bush shows that at least publically both economic and fairness considerations influenced his political agenda.

> "I oppose the Kyoto Protocol because it ... would cause serious harm to the U.S. economy. The Senate's vote, 95-0, shows that there is a clear consensus that the Kyoto Protocol is an unfair and ineffective means of addressing global climate change concerns."
>
> — George W. Bush, Whitehouse Press Release

Obviously, countries did not agree on how the burden of Kyoto should be shared by the participating countries.

Contrary to the detrimental impact of fairness on reaching an agreement, there is hope that an agreement that is perceived as fair by all participants is more likely to succeed and to be complied with after its formation. In this regard, fairness would serve as a focal point of agreement. Schelling (1960) introduces this concept as a game theoretical coordination device. Common beliefs about what is fair could break up the grid lock of international climate negotiations, and learning more about how fairness influences negotiators is essential to find common grounds for an agreement. Yet, negotiators might intentionally use fairness arguments to achieve their goals (Lange et al., 2010; Johansson-Stenman and Konow, 2010) as shown in the two above given examples.

An extensive list of literature postulates the importance of fairness in international climate negotiations: Ringius et al. (2002), Cazorla and Toman (2001), Paavola and Adger (2006). The first paper to introduce the concept of burden sharing rules based on fairness rules was Ringius et al. (2002). The authors give three reasons why fairness arguments are important for international climate negotiations: 1.) Normative considerations influence to which point negotiators perceive certain distributions as right or wrong. 2.) Fairness arguments could enforce bargaining positions. 3.) Fairness perceptions could serve as focal points in negotiations. Furthermore, Posner and Weisbach (2010) and Miller (2008) believe that any successful climate agreement has to be considered as fair or countries do not abide by it on the long run. We continue to discuss more thoroughly the two aspects of fairness that are analyzed in this thesis.

1.1.1 Burden Sharing

The UNFCCC acknowledges burden sharing by stating that the parties should address climate change according to "...their differentiated responsibilities and respective capabilities." (UNFCCC, 1992, Article 2) which is also known as the Common But Differentiated Responsibility (CBDR) principle. Unfortunately at present, the parties are not able to agree how the burden should be shared among them. Yet, the CBDR shows that the idea of burden sharing has been prevalent since the start of the UNFCCC process.

The official goal of the UNFCCC is to prevent a long-term global temperature rise of more than 2°C. One could assume that a global carbon budget is defined by scientific calculations as in Meinshausen et al. (2009). Given such a carbon budget, recent publications by Mattoo and Subramanian (2012) and Bretschger (2013) calculate hypothetical distributions of permits of an international climate agreement based on burden sharing rules using linear and nonlinear burden sharing functions. Depending on the rules or the weighting of different rules, results vary drastically and in some cases the developed world would have already used up its carbon budget up to 2050. This approach would narrow down the process of finding an agreement to finding the right weighting of different burden sharing rules accepted by most participants. Focusing on a small set of burden sharing rules would reduce transaction costs and help to solve the gridlock of present negotiations.

Chapter 2 introduces a set of burden sharing rules which are the most prevalent in the current discussion in international climate negotiations.
Ringius et al. (2002) are among the first to formulate burden sharing rules based on fairness principles for the context of international climate negotiations. The following list leans on their work but also introduces new dimensions of burden sharing.

- Egalitarian rule (EGA): Principle of equal per capita GHG emissions
  - If the population of a country amounts to x% of global population, this country should receive x% of the global entitlements for GHG emissions.
- Grandfathering rule (GF): Principle of equal percentage reduction of GHG emissions
  - If the GHG emissions of a country amount to x% of global GHG emissions, this country should receive x% of the global entitlements for GHG emissions.
- Ability to Pay rule (AP): Principle of equal ratio between GDP and abatement costs
  - If the GDP of a country amount to x% of gross world product, this country should receive entitlements for GHG emissions such that it bears x% of the global abatement costs for reductions of GHG emissions.
- Polluter Pays rule (POLL): Principle of equal ratio between production-based GHG emissions and abatement costs
  - If the production-based GHG emissions of a country amount to x% of global GHG emissions, this country should receive entitlements for GHG emissions such that it bears x% of the global abatement costs for reductions of GHG emissions.
- Consumer Pays rule (CONS): Principle of equal ratio between consumption-based GHG emissions and abatement costs
  - If the consumption-based GHG emissions of a country amount to x% of global GHG emissions, this country should receive entitlements for GHG emissions such that it bears x% of the global abatement costs for reductions of GHG emissions.

This set is different from the previous studies of Ringius et al. (2002) or Lange et al. (2007), because we include two new dimensions of burden sharing in this thesis. Based on Peters and Hertwich (2008a,b), we introduce a Consumer Pays rule, that uses consumption based GHG emission accounting instead of production based accounting as in the Polluter Pays rule. Looking at the ongoing discussion on historic responsibility (among others Caney (2005) or Leist (2011)), we consider two different time frames for the calculation of the Polluter and Consumer Pays rules. We take the average GHG emissions since 1990 or current GHG emissions as the base line and discuss this in detail in Chapter 2. Furthermore, we also differentiate between personal preference and usefulness of the burden sharing rules to find out if personal preferences are more prone to normative biases.

We analyze the perception of these burden sharing rules based on fairness principles to address fairness concerns of the negotiators. We investigate how burden sharing is perceived by the official participants of international climate negotiations using an item based questionnaire on the importance and usefulness of burden sharing rules.

1.1.2 Social Preferences and Inequality Aversion

For the second aspect of fairness we consider social preferences. It would also be applicable to use the term non standard preferences opposed to the standard preferences of self maximizing utility agents. We opt for social preferences as it better describes the idea of incorporating considerations about distributions and inequality.

This topic has gained more attention since Rabin (1993) introduced the concept in a seminal paper. He designed a two player game in which players experience guilt if they behave non cooperatively depending on their beliefs about the others players' actions. The most prominent examples of social preferences are the two papers by Fehr and Schmidt (1999) on inequality aversion and Bolton and Ockenfels (2000) on distributional preferences. Both models were seen as a step towards explaining experimental results that were not in line with the standard preferences of self interested utility maximizing agents. A large body of the literature is devoted to empirically test these two concepts in laboratory or field experiments and has found convincing evidence that social preferences can help to rationalize the behavior of people.

Both above mentioned concepts are used to analyze international climate negotiations. Lange (2006) applies distributional preferences in a coalition formation game, and as a result the number of coalition members increases for some cases. Unfortunately, these results do not hold in general and are taken from simulations. Cai et al. (2010) show that the willingness to pay for climate change mitigation is greatly influenced by distributional considerations. Therefore, it is necessary to specify the distributional consequences of policies to obtain the true willingness to pay. This thesis focuses on inequality aversion to show its impact on a special setting of an international climate agreement, a non cooperative permit market.

We opt for inequality aversion since a sizable amount of evidence indicates that it plays an important role for a wide range of economic issues (Fischbacher and Gächter, 2010; Cooper and Kagel, 2009). The integration of the CBDR principle by the UNFCCC shows that inequality concerns successfully entered the first meaningful step against climate change. Dannenberg et al. (2010) find rather strong support of inequality aversion among negotiators of climate agreements. Lange and Vogt (2003) show how inequality aversion in an emission game of homogeneous players can increase coalition size and efforts depending on the strength of the aversion. Fischbacher and Gächter (2010) demonstrate the explanatory power of inequality aversion in public good games. Furthermore, there are countless examples in the experimental literature using inequality aversion and other regarding preferences. For a broader overview, we refer to Cooper and Kagel (2009).

Chapter 4 extends Eyckmans and Kverndokk (2010) who investigate how moral concerns about permit trading affect a non cooperative permit market. Their two main results are: 1. Reluctance to trade can have positive but also negative impacts on the total amount of emissions. 2. Moral concerns to prefer abatement at home decrease the total amount of permits.

We complement their reasoning by focusing on inequality aversion as in Fehr and Schmidt (1999) which is straightforward to understand and founded on a large body of empirical and experimental evidence. Just like Johansson-Stenman and Konow (2010), we think that the behavior of private and public decision makers reflects concerns about fairness which matters for social welfare analysis. We analyze the effect of inequality aversion on the price formation and hence the effect on total emissions.

1.2 Components of Architectures

With the Kyoto Protocol as the only more or less successful step against climate change, the focus on comprehensive binding targets for all participating countries seems natural. Looking at different possibilities of efforts against climate change could open new opportunities for an international climate agreement. The book "Architectures for Agreement: Addressing Global Climate Change in the Post-Kyoto World" by Aldy and Stavins (2007) introduces the term architecture and discusses six possible components of architectures for a future international climate agreement.

1. Comprehensive quantitative targets for a reduction in global GHG emissions
2. Quantitative GHG emission reduction targets for individual economic sectors
3. Research and development and technology transfers (R&D)
4. Geoengineering
5. Land use change and reforestation
6. Adaptation

(1) Comprehensive quantitative targets dominate the agenda of negotiations seen in the formation of the Kyoto Protocol. The formation of Kyoto shows, for some surprisingly, that the signatories were able to agree on differentiated national quantitative targets. The lack of stringent reduction targets or any real punishment mechanism made reaching an agreement much easier. (2) As an addition to a comprehensive agreement, sector targets focus on fewer participants and key sectors but still cover large amounts of emissions. (3) The idea of knowledge diffusion via the Clean Development Mechanism (CDM) is already a part of Kyoto, and R&D is essential to prevent climate change.
(4) Recently, the idea of geoengineering has emerged but has not yet made it onto the conference table. Land use (5) and adaptation (6) seem a natural part of international climate negotiations and have recently gained more attention due to natural catastrophes.

A more comprehensive overview of the six components is presented in chapter 3. Although there is a huge body of literature dealing with each component separately, the debate on what should be the focus of an international agreement is not very extensive. Empirically, there seems to be no comprehensive study on the acceptance of these components. Shedding light on the determinants of the preference for these components can help negotiators to focus on the most accepted components and address concerns by other negotiators.

For this purpose, chapter 3 uses unique data from our worldwide survey to analyze the perception of those components. We focus on the importance of the different components as well as the leadership role of different players of international climate negotiations for these components. We explore which components are the most preferred and which countries are expected to take a leading role for each component.

1.3 Contribution

This thesis intends to contribute to the literature in two ways. A thorough microeconometric analysis of unique survey data provides new and current insights on how participants of climate change negotiations perceive important issues, i.e., burden sharing (Chapter 2) and components of architectures for agreements (Chapter 3). We include further dimensions of burden sharing and extend the previous work by Lange et al. (2007) and others. The descriptive results alone are interesting for the participants of the climate conferences. The topic of components of architectures for agreement is new in its comprehensive coverage of the six most important possible components for an international climate agreement. Although many studies analyze and discuss the pros and cons of the components separately, empirically this topic has so far been neglected.

Secondly, the microeconomic study in chapter 4 extends the existing literature on non cooperative permit markets. Including social preferences like inequality aversion provides insights how the outcome of the model changes.

1.3.1 Burden Sharing Rules

Chapter 2 discusses the role of burden sharing rules for an international climate agreement and reviews the existing literature. The descriptive results show a high acceptance of the Polluter and Consumer Pays rules in contrast to a low acceptance of the Grandfathering rule. We discuss three different determinants of the perception of burden sharing rules: 1.) A normative bias could lead people who care more about fairness in general to prefer certain burden sharing rules. 2.) The vulnerability of a respondent's home country influences the perception of the burden sharing rules due to the expected reduction target of the burden sharing rules. 3.) Self interested motives explain the preference of burden sharing rules.

The normative bias shows for the Ability to Pay rule and vulnerability is a strong factor for the Polluter and Consumer Pays rules and strongest for the Historic Polluter Pays rule. This implies that participants might expect larger emission reductions from these rules, since the effect remains when we control for self interest and further control variables. The macroeconomic variables used as proxies of self interest show by and large negative effects on the acceptance of the burden sharing rules. We do however find positive effects on the Grandfathering rule, which could be seen as altruistic behavior. This effect is rather surprising given the prevalence of grandfathering in climate change negotiations as a default burden sharing rule, which favors rich and polluting countries.

1.3.2 Components of Architectures

Chapter 3 focuses on different components of architectures for international climate agreements. A literature survey analyzes the six presented components according to their efficiency and effectiveness, participation and compliance, and risk and uncertainty. Four different factors are considered which might influence the perceived importance of the components and the expected leadership role for them. These are fairness, vulnerability, abatement cost and economic capacity, and democracy and governance.

We provide further evidence for the importance of fairness in international climate conferences, as fairness prone participants prefer the more efficient components global targets and R&D. The fact that participants who care a lot about fairness expect leadership roles of USA, China, and Brazil, South Africa and India (BASI) for global targets and R&D is not in line with what we see at the actual negotiations. This could be worrisome if respondents expect more from these players out of normative considerations, in contrast to what those countries are actually prepared to do.

The impact of vulnerability is rather low, especially on adaptation and the effects of the macroeconomic indicators approximating abatement costs and economic capacity are in line with self interested motives. There is some evidence for a non linear relationship that very rich countries do indeed endorse adaptation while countries with very high abatement costs endorse global and sector targets and R&D. The empirical analysis finds no significant effect of the level of democratic development or governance structures of the participants' home countries on the importance of the components.

1.3.3 Inequality Aversion

Chapter 4 presents a microeconomic study of inequality aversion in a non cooperative permit market. We extend a theoretical model of a permit market with inequality aversion in two different ways: 1.) Countries care about the distribution of the permits as the good of the market and 2.) countries care about the distribution of the payoffs. In the first case we can show that the total amount of permits increases due to the fact that people dislike it more when they have less permits than others than when they have more. For the second case we can show three different effects, but cannot exactly specify whether or not this increases or decreases the total amount of permits. Using specific functional forms, we show cases when the price increases and decreases. We can confirm that the price would increase when countries feel stronger about being poorer and the price would decrease when countries feel more guilty about being richer.

1.4 Conclusion

This thesis set out to analyze the role of fairness and different components of architectures for international climate negotiations from an empirical and microeconomic point of view. The results show that there are different preferences on burden sharing rules, but that there is also common ground among participants of international climate conferences. The egalitarian rule might serve as a focal point since it is widely accepted and fewer factors influence its perception. The relationship between vulnerability towards damages of climate change and the implied reduction targets of burden sharing rules should be further analyzed in the future. Learning more about the commonly accepted weighting of burden sharing rules could help to allocate a global budget of emissions. Furthermore, we should set out to compare the views of the official participants with the views of the general population. It is important to see if their views coincide and if the official participants really represent the opinion of their constituents.

The role of the components should be explored further to see which components are most likely to foster a meaningful international climate agreement. Global targets are indeed most accepted, but there is a high acceptance of all other components but geoengineering. It would be interesting to learn more about why geoengineering is disliked to this degree as we might eventually end up needing it. Normative expectations could be a reason why some respondents expect leading roles from the big players not in line with the actual intentions of these big players. This could complicate finding an agreement if the big players are not ready to meet these expectations.

Usually, fairness is most often expected to alleviate problems of distribution and to yield better outcomes in total. The case of inequality aversion in a non cooperative permit market shows that this is not necessarily the case. If poorer countries were to issue more permits to catch up with the richer countries, the total amount of permits and emissions might very well increase although richer countries would relinquish some permits, too.

Chapter 2

The Role of Burden Sharing Rules in International Climate Negotiations*†

Abstract

We analyze the role of burden sharing rules in international climate negotiations. Based on unique data from a world wide survey among participants of international climate conferences, we conduct an econometric analysis of the determinants of burden sharing rules. We find a considerable self serving bias. However, participants from rich and polluting countries show altruistic behavior by rejecting burden sharing based on grandfathering of greenhouse gas emissions. We detect a normative preference for certain rules and evidence that the Historic Polluter and Consumer Pays rules imply larger greenhouse

---

*This chapter represents joint work together with Andreas Ziegler (University of Kassel)

†Financial support from BMBF is gratefully acknowledged. We greatly benefited from the joint cooperation with our project partners at the Centre for European Economic Research and the University of Hamburg. We are thankful to useful comments made at the conference of the European Association of Environmental and Resource Economics and at the European Meeting of the Econometric Society in 2013 and feedback provided by our colleagues Lucas Bretschger, Astrid Dannenberg, Martin Kesternich, Andreas Lange, Andreas Löschel, Adriana Marcucci, Janick Mollet, and Bodo Sturm.

gas emission reductions. The consideration of consumption or production based greenhouse gas emissions as well as different time frames do not play a huge role for participants of international climate negotiations. Our results indicate that the Polluter Pays and the Ability to Pay rules are the most accepted rules.

2.1 Introduction

The importance of fairness in international climate negotiations has been established using empirical studies (Lange et al., 2007) or theoretical arguments (Ringius et al., 2002). We analyze the perception of burden sharing rules (BSR) based on equity principles as a proxy of fairness. Different BSRs have been proposed as a focal point to facilitate agreement and to approximate fairness concerns. More empirical research is required to determine the role of burden sharing in climate negotiations, extending work by Lange et al. (2010). To this end, we perform an econometric analysis of data from a survey among participants of international climate conferences conducted in 2012. In international climate negotiations, advocating for certain BSRs could conceal self interest or substantiate bargaining positions.

One example of how fairness might influence negotiators is the development of the Kyoto protocol. The Kyoto protocol would have induced huge costs for the United States of America, but officially the lack of binding limits for all countries was given as justification to not ratify it. On the contrary, developing countries did not want to dampen their economic growth by accepting any binding limits or targets for their greenhouse gas emissions. They blamed the industrialized countries as responsible for climate change and its costs. Obviously, countries did not agree on how the burden of Kyoto should be shared by the participating countries.

Learning how fairness influences negotiators is essential to find common grounds in negotiations as stipulated by Schelling (1960). New ideas of burden sharing focus on simple linear rules (Mattoo and Subramanian, 2012) or combine rules (Bretschger, 2013) to allocate costs or permits among countries. This is in line with a theoretical design of an international climate agreement that simplifies an effective agreement on climate change to the negotiation of a sharing rule (Gersbach and Winkler, 2011). The cited study neglects how such a sharing rule would be agreed on and that is why it is insightful to question negotiators about burden sharing and its role for an international climate agreement. Years of negotiations have not yet yielded an international environmental agreement on climate change that would prevent the global average temperature to raise more than two degree Celsius. Some even judge that the efforts so far were actually marginal (Posner and Weisbach, 2010) or believe that most attempts were bound to fail because of over-ambition (Keohane and Raustiala, 2008). BSRs could help to solve the gridlock of international negotiations since focusing on a few prominent BSRs reduces transaction costs. Therefore, we investigate how equity and burden sharing is perceived by the official participants of international climate negotiations and analyze three determinants of the perception of BSRs.

First, we consider the idea that participants have a normative preference or bias for BSRs. This is inspired by Johansson-Stenman and Konow (2010) who state that the distribution of an outcome might matter for policy makers due to fairness concerns. For the case of an international climate agreement, the respondents might therefore prefer different distributions of greenhouse gas (GHG) emissions among countries, more specifically BSRs. Secondly, we analyze if participants expect certain BSRs to imply different total greenhouse gas emission outputs, indicated by their vulnerability. Thirdly, like many other studies on fairness we analyze if the perception of BSRs is distorted by an unconscious self serving bias (Babcock and Loewenstein, 1997) or a self serving bias where people intentionally use equity arguments to achieve their goals (Lange et al., 2010).

In order to assess the motives of the negotiators, we conducted an item based survey among the official participants of the Conferences of Parties (COP), which is the group of people that actually negotiates an international climate agreement[1]. Compared to the previous cited studies we include three new aspects: 1.) A differentiation between the personal importance and the usefulness of the BSRs. 2.) Two different references points in time for the calculation of some of the BSRs. 3.) Consumption based GHG emission accounting as the basis of an additional BSR. Given that aforementioned survey was conducted in 2004, a new assessment about an extended set of BSRs and other angles of burden sharing can provide new insights.

The Polluter and Consumer Pays rules (i.e., the rule of equal ratio between abatement costs and production/consumption based GHG emissions) are the most accepted BSRs among participants. Changes of the temporal baseline of the Polluter and Consumer Pays rules and the differentiation of consumption and production based GHG emissions do not have a huge impact, although this has been a hotly discussed topic. Surprisingly, the Grandfathering rule is rejected to a strong degree and even more by rich or highly emitting countries. Nevertheless, it remains quite salient in negotiations as a default option. Additionally, we find a personal normative preference for the Ability to Pay rule. There is evidence that participants expect the Historic Polluter and Consumer Pays rules to imply higher total GHG emission reductions. The possibility that different targets are associated with different BSRs challenges the idea of a redistribution of a fixed budget according to some sharing rule as in Bretschger (2013) or Mattoo and Subramanian (2012). Looking at the low impact of the time frame variation and the GHG emission accounting variation, it seems that the general principles behind the rules are more important than how exactly they are phrased out.

Section 2.2 shows the influence of BSRs in international climate negotiations. Section 2.3 discusses which factors could determine attitudes towards BSRs. In Section 2.4, we present the data and the variables used for the empirical analysis, that is discussed in Section 2.5. Section 2.6 presents and discusses our results and Section 2.7 concludes.

[1]Using revealed preferences types of surveys could have been considered, but the complexity of the BSRs prompted us to use an item based survey.

2.2 Burden Sharing Rules in International Climate Negotiations

In the following, we summarize the literature on fairness and BSRs. The importance of equity in international climate negotiations has been postulated by Ringius et al. (2002), Cazorla and Toman (2001), Paavola and Adger (2006), and many others. Ringius et al. (2002) stated that equity arguments in international climate negotiations are important for three reasons: 1.) Normative considerations influence to which point negotiators perceive certain distributions as right or wrong. 2.) Equity arguments could enforce bargaining positions. 3.) Equity perceptions could serve as focal points in negotiations. The last point goes back to Schelling (1960) who argued that common perceptions could serve as a coordination device in negotiations to reduce costs and facilitate agreement. One example of a focal point would be the egalitarian rule (see below) due to its simplicity and pragmatism of distributing GHG emissions according to population shares (Brown, 2014). Ringius et al. (2002) transform the most discussed equity principles into BSRs, a more tangible object of economic interest. In this line of thought, Lange et al. (2007, 2010) analyze data from a survey among participants of international climate negotiations that explores their preferences on a subset of our BSRs. They conclude that equity issues are regarded as more important by the Group of 77 (G77) and China and that GDP has an important effect on participants' attitudes. Furthermore, they detect a self serving bias, that country representatives prefer BSRs that are less costly for their home country. Hjerpe et al. (2011) surveyed 500 participants at COP-15 in Copenhagen in 2009 on their support for different BSRs. Similarly to Lange et al. (2007), the authors find strong support for the Ability to Pay and the Polluter Pays rules including historic emissions since 1990. Looking instead at the preference of common citizens in the USA and China in 2009 Carlsson et al. (2012) find that in line with self interest, citizens in the USA favor a polluter-pays scheme while Chinese respondents prefer a scheme based on historical emissions. Cai et al. (2010) show that the willingness to pay for climate change mitigation is greatly influenced by distributional considerations. Therefore, it is necessary to specify the distributional consequences of policies to obtain the true willingness to pay.

Theoretical work by Gersbach and Winkler (2011) designs an international climate agreement for marketable permits where the proceeds of the auctioned permits are shared among participants. Retaining qualitatively similar results, this could easily be modified to a redistribution of permits, for instance according to BSRs. This provides a theoretical foundation to why the acceptance of BSRs is important for an international climate agreement.

Since the official goal of the United Nations Framework Convention on Climate Change (UNFCCC) is to prevent a long-term global temperature rise of more than 2°C, one could assume that a global carbon budget is defined by scientific calculation as in Meinshausen et al. (2009). Based on this idea, recent publications by Mattoo and Subramanian (2012) and Bretschger (2013) calculate hypothetical distributions of permits of an international climate agreement based on BSRs using linear and non linear burden sharing functions. Depending on the rules or the weighting of different rules, results vary drastically and in some cases the developed world would have already used up its carbon budget up to 2050.

The UNFCCC acknowledges burden sharing by stating that the parties should address climate change according to "...their differentiated responsibilities and respective capabilities." (UNFCCC,1992, Article 2) also known as the Common But Differentiated Responsibility (CBDR) principle. Unfortunately at present, the parties could not agree how this burden is to be shared among them, but it shows that the idea of burden sharing has been prevalent since the start of the UNFCCC process. More recently a proposal by the BASIC[2] expert group (2011) supports equal per capita GHG emissions (i.e. the

[2]Brazil, South Africa, India, and China (BASIC)

Egalitarian rule) and advocates for historic responsibility up to 1850. Lastly, the UNFCCC hosted a workshop in cooperation with Belgium and Sweden to gather scholars and negotiators from over 30 countries to discuss equity in the context of the UNFCCC negotiations.[3] This shows that the question of fair burden sharing is still important to the parties negotiating an international climate agreement.

Similar to Lange et al. (2007) and Ringius et al. (2002), we focus on the most salient BSRs in the current political and academic debate on international climate negotiations. Building on their work, we include further dimensions of fairness that have not been considered before:[4]

- Egalitarian rule (EGA): Principle of equal per capita GHG emissions
  - If the population of a country amounts to x% of global population, this country should receive x% of the global entitlements for GHG emissions.
- Grandfathering rule (GF): Principle of equal percentage reduction of GHG emissions
  - If the GHG emissions of a country amount to x% of global GHG emissions, this country should receive x% of the global entitlements for GHG emissions.
- Ability to Pay rule (AP): Principle of equal ratio between GDP and abatement costs
  - If the GDP of a country amount to x% of gross world product, this country should receive entitlements for GHG emissions such that it bears x% of the global abatement costs for reductions of GHG emissions.

[3]Equity Workshop Brussels 6/11/2012.

[4]A more detailed overview can be found in: Cazorla and Toman (2001) or Najam et al. (2003).

- Polluter Pays rule (POLL): Principle of equal ratio between production-based GHG emissions and abatement costs
  - If the production-based GHG emissions of a country amount to x% of global GHG emissions, this country should receive entitlements for GHG emissions such that it bears x% of the global abatement costs for reductions of GHG emissions.
- Consumer Pays rule (CONS): Principle of equal ratio between consumption-based GHG emissions and abatement costs
  - If the consumption-based GHG emissions of a country amount to x% of global GHG emissions, this country should receive entitlements for GHG emissions such that it bears x% of the global abatement costs for reductions of GHG emissions.

In contrast to the survey by Lange et al. (2007), we include a new BSR, the Consumer Pays rule, and consider different time horizons for the Consumer and Polluter Pays rules. We opt to differentiate between personal preference and usefulness of BSRs to obtain a better understanding of the respondents' views. The personal preferences might be more prone to normative distortions than the usefulness statements.

The reason we include the Consumer Pays rule is inspired by work of Peters and Hertwich (2008a,b) and Davis and Caldeira (2010) who argue that most of the developed world's GHG emission reductions are due to outsourcing of carbon intensive production to the developing world, which they deem as unfair. Therefore, the Consumer Pays rule uses consumption based GHG emission accounting to calculate the share of global abatement costs. The problem is that the production-based accounting systems do not consider the different flows of trade and investments that contain GHG emissions and influence mitigation policies and GHG emission trends (Peters et al., 2011). This rule can be seen as a substitute to the original Polluter Pays rule based on the production based GHG emission accounting.

We address the ongoing discussion about historic responsibility and what reference point should be used for the GHG emission reductions of an international climate agreement. Several proposals of parties advocate for different points in time or schedules. For instance, Brazil suggests a BSR based on accumulated emissions since the industrial revolution during the Kyoto negotiations (UNFCCC , 1995). The BASIC (2011) proposal favors the beginning of the industrialization, roughly 1850, as the reference point of GHG emission reductions, but also discusses 1970 as the point of time when, according to the authors, the developed world started to recognize the problem of global warming. Looking at the UNFCCC process, 1990 is still the most salient reference point used in the UNFCCC.

The literature on climate ethics and several proposals support or reject certain points of time and discuss the concept of excusable ignorance. This concept states that past generations were not aware that their actions would be harmful to future generations and cannot be held accountable. Caney (2005) or Leist (2011) think that the first Intergovernmental Panel on Climate Change (IPCC) assessment report in 1990 established the connection between GHG emissions and climate change and therefore, should be taken as the reference point. This also coincides with the Rio COP in 1992. On the other hand, some claim that people in industrialized countries are accountable for the emissions of their ancestors (Neumayer, 2000).

Since it is not clear when exactly historic responsibility started, both the Polluter and Consumer Pays rules are based on current GHG emissions (C) or average historic GHG emissions since 1990 (H). We subsequently abbreviate the Polluter Pays rule with POLL-C and POLL-H and the Consumer Pays rule with CONS-C and CONS-H. It could very well be that the focus on historic GHG emissions is holding up the negotiations and participants already prefer current valued rules. To take account of this, we differentiate for both the Polluter Pays and the Consumer Pays rules between average historic GHG emissions since 1990 and current GHG emissions.

2.3 Determinants of Burden Sharing Rules

We discuss three factors that could determine the perception of BSRs, which are fairness, vulnerability, and self interest.

To start off, the believe that fairness is very important for an international climate agreement could influence the perception of the BSR. This refers to Johansson-Stenman and Konow (2010) who incorporate the notion of distributive justice in a conventional social welfare function to take account of normative preferences on certain distributions. Since the preference on fairness and different distributions has implications for the behavior of individuals, policy makers, and people, fairness should be considered for social welfare analysis. Therefore, people with a higher weight on fairness might prefer different distributions, in this case BSRs. The previous paper by Lange et al. (2007) had already established the importance of fairness for international climate negotiations, but did not connect it with the preference for BSRs. The impact of fairness might be off a more normative nature. Some respondents could rather express their opinion an how important the BSRs ought to be. In this regard, we use the term normative in reference to the differentiation of positive and normative economics as discussed by Friedman (1953) or presented in Samuelson's textbook (Samuelson and Nordhaus, 2010). A normative bias leads people to see things how they ought to be, not the way they are. Therefore the impact of fairness considerations might be stronger for the personal preferences than the usefulness of the BSRs. We explore if the attitude towards fairness as a part of an international climate agreement influences the perception of the BSRs. Judging from anecdotal evidence and the climate ethics literature, we expect that this will be the case for the Egalitarian and Ability to Pay rules and some form of responsibility rule (Konow, 2003).

Secondly, the vulnerability of one's country could be important for the participants' perception of BSRs. Many models of international climate agreements include a term for the global externality of climate change that depends on the total amount of permits.[5] Therefore, the total amount of GHG emissions or permits an international climate agreement yields, is of grave importance for a representative of a highly vulnerable country. Variation in vulnerability can be used to implicitly explore if respondents attach different total GHG emission targets to different BSRs. If participants of international climate conferences believe that different BSRs imply different total GHG emission reductions, vulnerability could explain a preference for certain BSRs. This explanation becomes more robust if we detect the effect while controlling for motives of self interest at the same time. We think that the implicit nature of this exploration is more worthwhile than asking directly about different targets of BSRs.

Finally, economists and especially psychologists acknowledge that preferences and the perception of non monetary concepts can depend on material self interest. According to Babcock and Loewenstein (1997), the self serving bias describes behavior where "people conflate their personal preferences with self interested motivations" or use certain principles to advance one's goals (Lange et al., 2010). Since the BSRs are based on socio-economic indicators like population, GHG emissions, or GDP, participants might consciously or unconsciously be influenced by their country's performance in those indicators.

In the following, we explain how the perception of BSRs might be impacted by macroeconomic indicators. Participants from highly populated countries could prefer the Egalitarian rule as countries would receive the same percentage of global entitlements for GHG emissions as their global population share. Nevertheless, economically only per capita GHG emissions should matter, since a country only profits if it pollutes less than the agreed per capita limit. Hence, countries with high per capita GHG emissions levels should dislike the

[5] See for example the coalitional game theory models on international climate agreements in Barrett (1994), Carraro and Siniscalco (1993) or others as Helm (2003) and Gersbach and Winkler (2011).

Egalitarian rule. The Grandfathering rule appeals to countries that already have high GHG emission output as the amount of global entitlements would match their previous share of GHG emissions. As for the Egalitarian rule, per capita GHG emissions would economically matter more as they better represent the relative benefit for a country. Rich countries should dislike the Ability to Pay rule as they would be expected to take up the same percentage of abatement costs. Per capita GDP should be the better indicator of the relative costs than total GDP. The Polluter and Consumer Pays rules would impose the abatement costs proportionally to the amount of GHG emissions. Hence, we expect all per capita indicators of current or historic, production or consumption based GHG emissions to negatively effect the perception of both rules.

2.4 Data and Variables

The population of interest comprises the official participants of the Conferences of Parties (COP) whose names are published online by the UNFCCC.[6] For this analysis, a participant is everybody who was officially associated with a negotiation party of a country, which includes advisers and experts to the parties. We focus on representatives of countries in international climate negotiations, specifically participants of COPs, since they conduct the negotiations and represent their countries' interest. In their role as pundits, negotiators, or observers, they are familiar with burden sharing discussed in the context of climate negotiations. Thanks to the official lists of participants, we were able to contact every official participant of the COPs of 2010 and 2011 supplying a potentially large sample. Although work by Lange and Vogt (2003) suggests that voters' preferences could influence negotiators,[7] many participating countries do not have democratically elected governments.

[6] UNFCCC Participation List COP 17.

[7] For a more detailed discussion see, Böhringer and Vogt (2004), Vogt (2002), or Congleton (1992a).

Therefore, we focus on the most important subject group of international climate negotiations: The official participants published by the UNFCCC.

The data was collected in a worldwide on-line survey conducted in spring 2012 in joint collaboration with our project partner from the Center of European Economic Research (ZEW), and parts of the survey are also used in Kesternich et al. (2014). We gathered all possible email contacts from the official UNFCCC list of participants and other sources. Trying to include all the participants from COP 16 in Durban and COP 17 in Cancun, we harvested around 6500 addresses. The ZEW designed the questionnaire and sent out emails with personalized links to a standardized on-line platform where respondents could fill out the questionnaire. On request, a printable PDF version was also provided to be sent back by email or post. After up to three follow-ups, about 500 persons participated in the survey, of which approximately 350 completely filled out the questionnaire. The participation rate of $6-7\%$ is rather low but still fairly typical for on-line surveys. Results from regressions on the likelihood to respond to the survey show that negotiators from poor and less polluting countries are more prone to answer, as well as Europeans. Yet, sensitivity analyses using different weightings obtained from those regressions did not significantly change the results.[8] Looking at the share of some of the key regions of international climate negotiations the actual sample matches the contact group quite well. For instance, the share of Europeans is 22% in the sample while it is 19% in the mailing list, the G77 representatives amount to 59% in the sample against 62% on the list and BASIC member comprise 10% of the sample and 14% on the list. Compared to the survey by Lange et al. (2007), our effective sample size is almost doubled and explores new aspects of burden sharing.

[8]We cannot rule out problems of self-selection, but since most biases depend on differences between developing and developed countries we think that it is not problematic that we have less participants from developed countries, as long as their views don't differ from their non responding compatriots.

2.4.1 Dependent Variables

The econometric analysis focuses on two sets of seven ordinal variables. These variables are based on two questions explaining the personal preference and usefulness of BSRs in international climate negotiations.[9] The differentiation intends to elicit a more robust statement by abstracting between the personal preference and the usefulness of the BSRs. Participants are instructed to consider an international climate agreement up to 2050 with long term, binding targets of tradable entitlements for GHG emissions between countries.

The first question asks to what degree the set of BSRs should guide the distribution of GHG emissions in an international climate agreement on a scale of: 1 “No degree”, 2 “Low degree”, 3 “Moderate degree” and 4 “High degree”. This yields seven ordinal variables named “Degree of Personal Preference” for each BSR reflecting the personal preference of the participants.

The second question asks how useful participants think the specific BSRs are for achieving significant reductions in global GHG emissions. The scale for the seven ordinal variables created from this question is 1 “Useless”, 2 “Neither useful nor useless”, 3 “Useful”, and 4 “Very useful”. We name these ordinal variables “Degree of Usefulness” for each BSR.

Table 2.1 shows the relative frequencies of all fourteen ordinal variables used in the econometric analysis; the seven on the personal preference on the top, the seven on the usefulness at the bottom. The seven BSRs are: Egalitarian (EGA), Grandfathering (GF), Ability to Pay (AP), Current Polluter Pays (POLL-C), Historic Polluter Pays (POLL-H), Current Consumer Pays (CONS-C), and Historic Consumer Pays (CONS-H)

According to the participants, the Polluter Pays rule is the most preferred and useful principles looking at the relative frequencies. The differentiation of the historic and current valued rules does not show a huge impact and indeed those items are highly correlated. Furthermore, the Consumer Pays rule is less accepted than the production based rule.

[9]The exact wording of the questions is supplied in the Appendix.

Table 2.1: Relative frequencies to which degree BSRs should guide an international climate agreement and how useful they are for achieving a significant GHG emission reductions.

	Relative frequency [%]				N
	High Degree	**Moderate**	**Low Degree**	**No Degree**	
EGA	18.5	27.0	33.3	21.1	351
GF	15.1	26.7	37.8	20.2	336
AP	24.5	42.2	23.9	9.2	346
POLL-C	47.1	35.5	12.4	4.8	354
POLL-H	47.0	32.7	14.8	5.3	357
CONS-C	28.9	35.2	24.9	10.8	349
CONS-H	28.4	34.0	25.2	12.2	344
	Very Useful	**Useful**	**Neither Useful Nor Useless**	**Useless**	**N**
EGA	17.1	34.8	25.8	22.1	344
GF	12.9	36.0	28.8	22.2	333
AP	24.8	46.4	19.0	9.6	342
POLL-C	45.9	40.4	8.3	5.2	346
POLL-H	42.9	36.3	12.6	8.0	349
CONS-C	28.2	44.9	17.9	9.3	343
CONS-H	26.5	39.8	21.2	12.3	339

2.4.2 Explanatory Variables

To analyze the role of fairness and vulnerability as explanatory variables, we create two binary indicators based on two questions of the survey. The first question[10] asks how important fairness would be for distributing GHG emission reduction targets between countries in an international climate agreement. We obtain the binary indicator “Fairness” with the value 1 for the highest category “Very important” and 0 for the lower categories. In a second question, participants assess the consequences of climate change for their home country on a scale from “positive” to “very negative”. We establish the binary indicator “Vulnerable” with 1 for “Very negative consequences” and

[10]The exact wording of the questions is supplied in the Appendix.

0 for less negative consequences.

A set of five binary indicators takes account of the socio economic background of the participants. The binary variable "COP" signals if a participant is a party member of his country's COP delegation, the binary variable "NGO" signals if he is a member of a Non Governmental Organization (NGO). Almost 80% of the sample indicate that they participated as a member of a party at either COP 2010 or 2011. Being a member of a party and a member of NGO is not mutually exclusive as they are cases of advisers to the parties that are also members of a NGO. From the answers about the field of highest educational degree, we create a binary indicator "Social Science" when participants obtained a degree in either political science, economics, business administration, or law. We gather "Age" as years of age and the binary indicator "Gender" with the value 1 for female participants. The nationality and the represented country match in all but some cases the information from the official UNFCCC participation lists.

Using the information about the participants' origin, we are able to obtain various aggregate (country level) economic variables provided by The Penn World Table (Heston et al., 2012). "GDP Capita" supplies the per capita GDP in ten thousand $ and "GDP Total" gives the total GDP in trillion $. The Energy Information Agency (EIA) provides data about carbon dioxide (CO_2) emissions from the consumption of energy as a proxy for GHG emissions in CO_2 equivalents. We add two variables: "GHG Capita" for per capita GHG emissions in Gigatons CO_2 and total GHG emissions as "GHG Total" in trillion metric tons (U.S Energy Information Administration, 2010). Due to collinearity problems between consumption and production based GHG emissions, we refrain from including consumption based GHG emissions.

An overview of the explanatory variables including the mean, minimum and maximum values, and the standard deviation is given in Table 2.2.

Table 2.2: Means and standard deviations of explanatory variables

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**N**
Fairness	0.50	0.50	0	1	405
Vulnerable	0.30	0.46	0	1	360
COP	0.77	0.42	0	1	371
Social Science	0.37	0.48	0	1	371
Age	45.07	11.06	23	78	365
Gender	0.26	0.44	0	1	371
NGO	0.12	0.32	0	1	371
GDP Capita	1.68	1.63	0.03	9.35	405
GDP Total	1.08	2.50	0.00	16.03	405
GHG Capita	5.24	5.89	0.03	41.58	405
GHG Total	0.37	1.05	0.00	8.32	405

2.5 Econometric Method

Owing to the structure of our survey data we opt to use multivariate ordered probit models. As seen in the data section, we analyze two sets of seven ordinal variables. The seven ordinal variables, "Degree of Personal Preference", range from $y_{ik} = 1 =$"No degree" to $y_{ik} = 4 =$"High degree". In this notation i defines the respondent and k one of the seven BSRs on which the statement was given. We use the same order in which the BSRs are presented throughout the paper, so that $k = 1 =$"Egalitarian rule" and $k = 7 =$"Historic Consumer Pays rule". The seven ordinal variables, "Degree of Usefulness", range from $y_{ik} = 1 =$"Useless" to $y_{ik} = 4 =$"Very useful". The same order applies to k as above. In order to conduct a regression analysis, the ordinal nature of the data suggests an ordered probit link function. Given that respondents gave assessments about seven BSRs in the same item battery, we use the multivariate approach that allows for a more flexible error structure. Following Cappellari and Jenkins (2003) and Roodman (2009), we estimate a K-equation multivariate ordered probit model for both sets. Following a latent variable derivation, the $K = 7$ latent variable equations are:

$$y^*_{ik} = \beta_k X_{ik} + \epsilon_{ik}, \qquad k = 1, ..., K \tag{2.1}$$

The relation between the latent and the observed variables is:

$$y_{ik} = c \quad if\ \lambda_{c-1} < y^*_{ik} < \lambda_c,\ with\ c = 1,\ ..., 4;\ \ \lambda_0 = \infty\ and\ \lambda_4 = \infty \tag{2.2}$$

c represents one of the four categories of both sets of variables. β_k describes how the explanatory variables X_{ik} influence the latent variables. The error terms ϵ_{ik} are supposed to follow a multivariate normal distribution with mean of zero and a variance covariance matrix Σ that gives the correlations among the errors as $\rho_{jk} = \rho_{kj}$ on the off diagonal cells. The diagonal cells equal 1. y_{ik} either represents a choice or an assessment at different points of time or K different choices or assessments by one individual at the same point of time, which is the case for this study. We then allow for free correlation among the K different assessments. This is otherwise also known as a Seemingly Unrelated Regression (SUR) since the dependent variables are generated by independent processes, but allow for a multidimensional error distribution. Although this can become computationally demanding, recent implementations of simulation techniques as the GHK simulator into popular statistical programs like STATA make it feasible to estimate such models. We rely on the cmp STATA tool written by Roodman (2009) that allows fitting fully observed recursive mixed process models.[11] Using the multivariate structure and the SUR approach makes estimation of this kind of models more efficient although an equation by equation estimation would also be consistent. The extent of correlation among the different items is an indication of unobserved heterogeneity and supplies more robust standard errors and estimates, which

[11]Fully observed allows only for the use of observed variables of the latent variables, recursive implies that the stages are clearly defined and that not all dependent variables appear on the right hand. Mixed process allows combining different categorical, ordinal, binary, or continuous dependent variables.

substantiates our findings. The log likelihood function of this model is given by

$$lnL(\beta, \Sigma; y|x) = \sum_{i=1}^{N} ln\ \Omega_K((q_{i1}x_{i1}\beta_1, ..., q_{i7}, x_{i7}\beta_7);\ \Omega) \tag{2.3}$$

For this case Ω_K denotes the joint normal distribution of order K, i.e., 7. $q_{ik} = 2y_{ik} - 1$ and the matrix Ω has values of 1 on the diagonal and $\omega_{jk} = \omega_{kj} = q_{ij}q_{ik}\rho_{jk}$ for $j \neq k$ and $j, k = 1, ..., 7$ as off-diagonal elements.

This high dimensional integral cannot be solved analytically so we have to use simulation methods. The aforementioned user written program cmp allows us to do that. The estimation is consistent if the number of draws for the simulation rises with the number of observations and to reduce the simulation bias we always use a number of draws twice as large as the square root of the number of observations. We use draws based on the Halton sequences method as suggested by Train (2009).

2.6 Results

We investigate the three postulated determinants from Section 2.3 by using multivariate ordered probit models using robust standard errors of the estimated parameters. All models control for the five socio economic variables to capture the heterogeneity of the participants. In order to analyze the effects of fairness and vulnerability, all models consider both corresponding indicators. Due to reasons of multicollinearity, we choose different sets of macroeconomic variables to account for self interested motives while controlling for the above mentioned variables. We estimate one model including per capita and total GDP, a second one with per capita and total GHG emissions, and a third model with all four macroeconomic variables.

Given the two different sets of ordinal variables on the personal preference and usefulness, we estimate six different models, three for the "Degree of Personal Preference" and three for the "Degree of Usefulness". Of those

Table 2.3: Parameter estimates of multivariate ordered probit model with **GDP** and **GHG emissions** as explanatory variables, determinants of personal preference on BSRs, dependent variables: "Degree of Personal Preference".

	EGA	GF	AP	POLL-C	POLL-H	CONS-C	CONS-H
Fairness	0.212	0.236*	0.310**	-0.139	0.058	-0.154	0.007
	(1.64)	(1.79)	(2.33)	(-1.03)	(0.42)	(-1.21)	(0.05)
Vulnerable	-0.051	-0.090	-0.392**	0.221	0.440**	0.071	0.362**
	(-0.33)	(-0.54)	(-2.37)	(1.30)	(2.45)	(0.47)	(2.38)
GDP Capita	0.056	-0.202***	-0.079	0.026	-0.225***	-0.020	-0.176***
	(0.91)	(-2.88)	(-1.23)	(0.53)	(-4.22)	(-0.35)	(-3.17)
GDP Total	-0.024	0.060	0.005	-0.162***	-0.094	-0.012	-0.016
	(-0.39)	(1.13)	(0.07)	(-2.98)	(-1.37)	(-0.19)	(-0.23)
GHG Capita	0.004	0.014	0.007	0.008	0.009	0.018	0.013
	(0.29)	(0.97)	(0.43)	(0.61)	(0.64)	(1.60)	(1.09)
GHG Total	0.163	-0.254**	-0.066	0.136	0.134	0.014	0.096
	(1.53)	(-2.54)	(-0.56)	(1.55)	(1.00)	(0.12)	(0.88)
COP	-0.140	0.087	0.093	0.004	0.264	-0.040	0.182
	(-0.77)	(0.49)	(0.54)	(0.02)	(1.46)	(-0.24)	(1.12)
Social Science	-0.062	0.143	0.290**	0.113	0.166	-0.034	0.082
	(-0.46)	(1.02)	(2.12)	(0.81)	(1.20)	(-0.25)	(0.60)
Age	0.000	-0.004	-0.001	0.008	0.001	0.008	0.001
	(0.00)	(-0.68)	(-0.22)	(1.19)	(0.11)	(1.21)	(0.23)
Gender	-0.097	0.022	-0.112	-0.222	-0.121	0.099	0.058
	(-0.67)	(0.15)	(-0.75)	(-1.42)	(-0.78)	(0.63)	(0.36)
NGO	-0.181	-0.433*	-0.399*	-0.304	0.238	-0.259	-0.099
	(-0.79)	(-1.80)	(-1.88)	(-1.39)	(1.01)	(-1.18)	(-0.43)
Observations	304						
chi2	387.749						

Notes: * p < 0.1, ** p < 0.05, *** p < 0.01. Robust z-statistics in parentheses.

six models we present the two comprehensive models with all four economic variables, Tables 2.3 and 2.4. The other four models can be found in the Appendix: Tables 2.5 to 2.8.

Looking at the impact of fairness, we analyze if judging fairness to be very important for an international climate agreement influences the personal preference and usefulness of the BSRs. To do so, we include the indicator of how important fairness is for an international climate agreement into the econometric models. The fairness indicator has a positive effect ($p < 0.05$) on the Ability to Pay rule for all three models (Tables 2.3, 2.5, and 2.7). This shows a tendency that negotiators, who are more concerned about fairness, believe that richer countries should compensate the poor ones. For the model only including GHG emissions, we find a positive effect ($p < 0.05$) on the

Grandfathering rule which is at odds with a normative judgment. We find no effect of fairness on the perception of the usefulness of the BSRs which shows that the usefulness statements are less prone to this bias as expected although we can not specifically test this. In summary, we establish a robust effect of fairness on the Ability to Pay rule but a less robust effect on the Grandfathering rule with a rather surprising direction.

Next, we explore if the vulnerability of a participant's home country impacts the perception of BSRs due to different expected reduction targets of the BSRs. We use the participants' statements about their own country's vulnerability as an indicator in the econometric models. We find positive effects on the personal preference as well as the usefulness of both the Historic Polluter and Consumer Pays rules. The effect on the Historic Polluter Pays rule is more robust since the estimates are more significant than the estimates for the Consumer Pays rule. The p-level of the effect on the Historic Polluter Pays rule is always $p < 0.05$ and Tables 2.4, 2.6, 2.7, and 2.8 show p-values of less than 0.01. Similarly, the effect on the Consumer Pays rule is strongest in Tables 2.7 and 2.8 when we control for GHG emissions. On the other hand, Tables 2.6 or 2.4 only show p values of less than 0.1 for the set of the usefulness of the BSRs when we include GDP or all macroeconomic variables. This might be due to the correlation between the vulnerability statement and the macroeconomic variables, although it is less strong than if we had used some other vulnerability indicators. A negative effect of vulnerability ($p < 0.05$) on the personal preference of the Ability to Pay rule can be seen in Tables 2.3, 2.5, and 2.7. This suggests that participants of vulnerable countries expect this rule to convey small GHG emission reductions. In contrast, especially the Historic Polluter Pays and Consumer Pays rules are expected to imply large GHG emission reductions. Given that we control for different factors like GDP and GHG emissions, we can show that the perception of the BSRs is indeed influenced by concerns about vulnerability. This result opposes the ideas of Bretschger (2013) and Mattoo and Subramanian (2012) that both use a fixed amount of total GHG emissions to be distributed according to

Table 2.4: Parameter estimates of multivariate ordered probit model with **GDP** and **GHG emissions** as explanatory variables, determinants of usefulness of BSRs, dependent variables: "Degree of Usefulness".

	EGA	GF	AP	POLL-C	POLL-H	CONS-C	CONS-H
Fairness	0.197	0.145	-0.029	-0.148	-0.119	-0.133	-0.012
	(1.56)	(1.12)	(-0.22)	(-1.11)	(-0.89)	(-1.03)	(-0.09)
Vulnerable	-0.022	0.032	-0.242	0.209	0.536***	0.193	0.263*
	(-0.15)	(0.20)	(-1.47)	(1.23)	(3.13)	(1.22)	(1.78)
GDP Capita	0.014	-0.124**	-0.120**	-0.118**	-0.238***	-0.068	-0.187***
	(0.23)	(-2.11)	(-2.05)	(-1.99)	(-4.52)	(-1.14)	(-3.64)
GDP Total	0.005	0.035	0.003	-0.118***	-0.104	-0.117**	-0.079
	(0.08)	(0.67)	(0.04)	(-2.62)	(-1.54)	(-2.21)	(-1.27)
GHG Capita	0.002	0.005	0.030***	0.031**	0.018	0.030**	0.018
	(0.14)	(0.37)	(2.66)	(2.54)	(1.60)	(2.40)	(1.61)
GHG Total	-0.001	-0.157*	-0.085	0.074	0.210	0.159	0.242**
	(-0.00)	(-1.82)	(-0.77)	(1.01)	(1.35)	(1.58)	(2.10)
COP	-0.126	-0.186	-0.245	0.027	0.148	-0.092	0.163
	(-0.72)	(-1.01)	(-1.38)	(0.17)	(0.89)	(-0.53)	(0.95)
Social Science	-0.217	0.169	0.237*	0.063	0.062	0.026	0.095
	(-1.57)	(1.23)	(1.67)	(0.43)	(0.43)	(0.18)	(0.69)
Age	-0.003	-0.004	-0.002	0.003	-0.014**	0.001	-0.007
	(-0.50)	(-0.71)	(-0.41)	(0.46)	(-2.42)	(0.18)	(-1.12)
Gender	0.213	0.088	-0.041	-0.176	-0.148	0.023	-0.106
	(1.37)	(0.55)	(-0.27)	(-1.12)	(-0.98)	(0.15)	(-0.72)
NGO	-0.375*	-0.599**	-0.377	-0.133	0.111	-0.273	-0.109
	(-1.75)	(-2.24)	(-1.59)	(-0.55)	(0.47)	(-1.17)	(-0.44)
Observations	301						
chi2	346.767						

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust z-statistics in parentheses.

BSRs. The above presented results indicate that different BSRs imply different amounts of total GHG emissions implied by an international climate agreement.

As a robustness check, we also use two different vulnerability indicators (Gain Index and Climate Drivers index[12]). The results remain qualitatively similar compared to the vulnerability self assessment but are weaker and less robust. The main reason for this is the much higher correlation of those indicators with GDP and GHG emissions. Although there is clear negative correlation with the items, a significant effect only shows when we only include GDP or GHG emissions. The most robust effect remains the negative impact on the personal preference of the Historic Polluter Pays rule. We can provide further tables on request.

[12]Homepage NG-GAIN and Homepage Climate Drivers.

As a last step we check if the macroeconomic variables influence the perception of the BSRs due to self serving motives. In accordance with economic thinking, this effect should be stronger for the per capita macro indicators but we also simultaneously use the total macro indicators as control variables.

Looking at the Egalitarian rule, we only find a positive effect ($p < 0.05$) of total GHG emissions for the model including GHG emissions on the personal preference in Table 2.7. This would be rather altruistic than self serving. Similarly, the negative effects found for the Grandfathering rule in all six models contradicts self serving motives. Further evidence of altruism is a joint negative effect of per capita GDP and total GHG emissions on the Grandfathering rule in the comprehensives models of Table 2.3 and 2.4, though the effect is weaker for the usefulness. We find almost no significant effect on the Ability to Pay rule but for Table 2.4, in which er capita GDP negatively influences ($p < 0.05$) the usefulness of the Ability to Pay rule while per capita GHG emissions positively influence ($p < 0.01$) it. This joint effect makes sense as high polluting countries would like the Ability to Pay rule since rich countries would have to bear the mitigation costs. The strongest indications of self interest can be seen by the robustly negative effect of per capita GDP on the Historic Polluter and Consumer Pays rules, which are always $p < 0.01$. By and large, we see negative effects of the macroeconomic variables on the personal preference and usefulness of the BSRs with some minor exceptions.

The strong negative impacts of the macroeconomic indicators suggest that self interest does play an important role, but the rather negative effects on the Grandfathering rule might show some altruistic motives. Considering the general low acceptance of the Grandfathering rule, especially among rich and high polluting countries, it is puzzling that the Grandfathering rule is still on the agenda of climate negotiations. Maybe, it is still salient in negotiations because participants believe that it is endorsed by industrialized countries, which is not the case according to our data.

To complete our analysis, it should be mentioned that the socio-economic control variables do not have a strong impact. Participants with a background from social sciences prefer the Ability to Pay rule, while representatives of NGOs reject it. Older people reject the usefulness of the Historic Polluter Pays rule. The last section summarizes the results and concludes the paper.

2.7 Conclusion

Our paper analyzes the role of BSRs for international climate negotiations. Compared to previous studies, we include further dimensions of equity in the set of BSRs and analyze three different ways in which the perception of the participants can be influenced. We find that the Polluter Pays rule is the most accepted rule, followed by the Ability to Pay and Consumer Pays rules. Contrary to widespread discussions among negotiators, scholars, and representatives of NGOs, the differentiation between consumer and polluter based GHG emissions does not play a big role. Neither do the different temporal baselines of GHG emission calculation, which implies that more detailed differentiation of BSR might not be necessary. Given the amount of literature on those issues, this is rather surprising and shows that the general fairness principles on which the BSRs are based on are more important than the exact specification.

On the basis of our econometric analysis using multivariate ordered probit models, we can show strong effects of economic or GHG emission performance as well as vulnerability on the BSRs. The Grandfathering rule is rejected by rich and polluting countries although it is still very salient in negotiations. Participants from rich and highly polluting countries strongly reject the Historic Polluter and Consumer Pays rules. Participants that expect very negative consequences for their home country especially endorse the Historic Polluter Pays rule because it might yield large GHG emission reductions.

The majority of our results align with pure economic self interest as predicted by a self serving bias and also demonstrate strategic behavior. Yet, the rejection of the Grandfathering rule by rich and highly emitting countries shows altruistic behavior. Additionally, we detect a normative preference for the Egalitarian and Ability to Pay rules indicated by the general fairness preference of participants.

The importance of vulnerability for the perception of equity and BSRs should be analyzed more closely as we find an impact on both the personal preference and the usefulness. It seems especially interesting to find out why participants expect the Historic Polluter Pays rule to imply larger GHG emission reductions. Looking at some proposals that allocate a given budget according to BSRs (Bretschger, 2013; Mattoo and Subramanian, 2012), varying targets for different BSRs would oppose this idea.

Recently equity arguments have been brought up more frequently in proposals and negotiations as well as in recent papers about international climate agreements. That is why, the idea of BSRs as a focal point seems more important than ever. The general acceptance of the Ability to Pay rule implies that rich countries are ready to make sacrifices, but the rejection of the Polluter and Consumer Pays rules indicates that this readiness might not be that high. This highlights that the way burden sharing is framed is very important as some rules, i.e., the Ability to Pay and Polluter Pays rules, impose similar burdens for different reasons.

2.8 Appendix

To provide the exact wording of the questions that were used to obtain the dependent and explanatory variables, we present question A.4 on the vulnerability and parts of the section that focused on BSRs.

Question A.4

How would you assess the consequences of climate change on future living conditions up to 2100 in the following countries or groups of countries?

Countries or groups of countries	Very negative	Negative	Neither negative nor positive	Positive	Don't know
AOSIS	O	O	O	O	O
BASIC without China	O	O	O	O	O
China	O	O	O	O	O
EU	O	O	O	O	O
USA	O	O	O	O	O

Your home country (if your home country is China or USA, please indicate same assessment as above)	O	O	O	O	O

Part E
Distribution of GHG emission reduction targets in an international climate agreement

This part also considers current international climate negotiations under the UNFCCC framework for a time horizon up to 2050. We consider a comprehensive international climate agreement which aims to create long-term, binding quantitative targets for a reduction in global GHG emissions compared to economic development with no new international climate agreement. We assume tradability of emission entitlements between countries.

Question E.1

How important do you think equity issues for distributing GHG emissions reduction targets between countries are in an international climate agreement?

Very important	Important	Moderately important	Not important	Don't know
O	O	O	O	O

In the following, please consider your personal assessment of different burden-sharing rules for distributing GHG emission reduction targets between countries. Before starting to answer the questions, please carefully read the following description of five rules which have been discussed in the past:

Egalitarian rule: Principle of equal per capita emissions

If the population of a country amounts to x% of global population, this country should receive x% of the global entitlements for GHG emissions.

Grandfathering rule: Principle of equal percentage reduction of emissions

If the GHG emissions of a country amount to x% of global emissions, this country should receive x% of the global entitlements for GHG emissions.

Ability-to-pay rule: Principle of equal ratio between GDP and abatement costs

If the GDP of a country amounts to x% of gross world product, this country should receive entitlements for GHG emissions such that it bears x% of the global abatement costs for reductions of emissions.

Polluter-pays rule: Principle of equal ratio between production-based emissions and abatement costs

If the production-based GHG emissions of a country amount to x% of global emissions, this country should receive entitlements for GHG emissions such that it bears x% of the global abatement costs for reductions of emissions.

Consumer-pays rule: Principle of equal ratio between consumption-based emissions (i.e., production-based emissions adjusted by the net trade balance in emissions of a country) and abatement costs

If the consumption-based GHG emissions of a country amount to x% of the global emissions, this country should receive entitlements for GHG emissions such that it bears x% of the global abatement costs for reductions of emissions.

The polluter-pays and consumer-pays rules may be based on either current or average historical GHG emissions since 1990.

Question E.2

To what degree do you think the following burden-sharing rules should guide the distribution of GHG emission reduction targets between countries in an international climate agreement?

Burden-sharing rule	High degree	Moderate degree	Low degree	No degree	Don't know
Egalitarian rule	O	O	O	O	O
Grandfathering rule	O	O	O	O	O
Ability-to-pay rule	O	O	O	O	O
Polluter-pays rule (based on current GHG emissions)	O	O	O	O	O
Polluter-pays rule (based on historical GHG emissions since 1990)	O	O	O	O	O
Consumer-pays rule (based on current GHG emissions)	O	O	O	O	O
Consumer-pays rule (based on historical GHG emissions since 1990)	O	O	O	O	O

Question E.3

How useful do you think the following burden-sharing rules are for achieving a significant reduction in global GHG emissions in an international climate agreement?

Burden-sharing rule	Very useful	Useful	Neither useful nor useless	Useless	Don't know
Egalitarian rule	O	O	O	O	O
Grandfathering rule	O	O	O	O	O
Ability-to-pay rule	O	O	O	O	O
Polluter-pays rule (based on current GHG emissions)	O	O	O	O	O
Polluter-pays rule (based on historical GHG emissions since 1990)	O	O	O	O	O
Consumer-pays rule (based on current GHG emissions)	O	O	O	O	O
Consumer-pays rule (based on historical GHG emissions since 1990)	O	O	O	O	O

Table 2.5: Parameter estimates of multivariate ordered probit model with **GDP** as explanatory variables, determinants of personal preference on BSRs, dependent variables: "Degree of Personal Preference".

	EGA	GF	AP	POLL-C	POLL-H	CONS-C	CONS-H
Fairness	0.238*	0.212	0.306**	-0.111	0.085	-0.132	0.033
	(1.86)	(1.62)	(2.32)	(-0.83)	(0.62)	(-1.04)	(0.26)
Vulnerable	-0.061	-0.058	-0.383**	0.206	0.429**	0.071	0.355**
	(-0.41)	(-0.35)	(-2.30)	(1.24)	(2.42)	(0.48)	(2.35)
GDP Capita	0.051	-0.142***	-0.056	0.032	-0.215***	0.020	-0.153***
	(1.10)	(-2.87)	(-1.17)	(0.79)	(-4.79)	(0.45)	(-3.44)
GDP Total	0.044	-0.044	-0.022	-0.102***	-0.037	-0.006	0.026
	(1.44)	(-1.60)	(-0.65)	(-4.42)	(-1.20)	(-0.20)	(0.88)
COP	-0.149	0.074	0.088	-0.008	0.247	-0.057	0.168
	(-0.82)	(0.42)	(0.52)	(-0.05)	(1.40)	(-0.35)	(1.04)
Social Science	-0.065	0.160	0.295**	0.108	0.161	-0.027	0.081
	(-0.48)	(1.13)	(2.16)	(0.78)	(1.17)	(-0.20)	(0.59)
Age	0.000	-0.004	-0.001	0.008	0.001	0.008	0.002
	(0.07)	(-0.65)	(-0.19)	(1.29)	(0.23)	(1.36)	(0.35)
Gender	-0.081	0.004	-0.115	-0.210	-0.112	0.099	0.062
	(-0.56)	(0.03)	(-0.77)	(-1.34)	(-0.72)	(0.64)	(0.39)
NGO	-0.200	-0.435*	-0.405*	-0.325	0.212	-0.287	-0.126
	(-0.87)	(-1.83)	(-1.94)	(-1.51)	(0.91)	(-1.30)	(-0.55)
Observations	304						
chi2	245.878						

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust z-statistics in parentheses.

Table 2.6: Parameter estimates of multivariate ordered probit model with **GDP** as explanatory variables, determinants of usefulness of BSRs, dependent variables: "Degree of Usefulness".

	EGA	GF	AP	POLL-C	POLL-H	CONS-C	CONS-H
Fairness	0.199	0.126	-0.013	-0.107	-0.074	-0.080	0.036
	(1.59)	(0.99)	(-0.10)	(-0.82)	(-0.56)	(-0.64)	(0.28)
Vulnerable	-0.022	0.050	-0.227	0.199	0.516***	0.174	0.243*
	(-0.14)	(0.31)	(-1.38)	(1.18)	(3.06)	(1.11)	(1.69)
GDP Capita	0.019	-0.096**	-0.043	-0.054	-0.211***	-0.014	-0.162***
	(0.40)	(-2.23)	(-0.93)	(-1.15)	(-4.50)	(-0.31)	(-3.68)
GDP Total	0.005	-0.030	-0.030	-0.083***	-0.017	-0.046*	0.020
	(0.18)	(-1.23)	(-0.99)	(-4.09)	(-0.56)	(-1.89)	(0.70)
COP	-0.127	-0.182	-0.257	0.005	0.119	-0.117	0.134
	(-0.72)	(-0.99)	(-1.44)	(0.03)	(0.74)	(-0.68)	(0.79)
Social Science	-0.216	0.178	0.241*	0.067	0.056	0.024	0.088
	(-1.55)	(1.30)	(1.69)	(0.46)	(0.39)	(0.17)	(0.64)
Age	-0.003	-0.004	-0.002	0.004	-0.013**	0.002	-0.006
	(-0.48)	(-0.71)	(-0.28)	(0.63)	(-2.24)	(0.36)	(-0.97)
Gender	0.213	0.077	-0.042	-0.175	-0.141	0.030	-0.093
	(1.38)	(0.48)	(-0.28)	(-1.12)	(-0.93)	(0.20)	(-0.63)
NGO	-0.378*	-0.592**	-0.411*	-0.179	0.068	-0.322	-0.151
	(-1.78)	(-2.24)	(-1.76)	(-0.75)	(0.29)	(-1.40)	(-0.61)
Observations	301						
chi2	191.988						

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust z-statistics in parentheses.

Table 2.7: Parameter estimates of multivariate ordered probit model with **GHG emissions** as explanatory variables, determinants of personal preference on BSRs, dependent variables: "Degree of Personal Preference".

	EGA	GF	AP	POLL-C	POLL-H	CONS-C	CONS-H
Fairness	0.206	0.260**	0.325**	-0.095	0.131	-0.145	0.049
	(1.62)	(1.98)	(2.46)	(-0.72)	(0.96)	(-1.13)	(0.37)
Vulnerable	-0.097	0.079	-0.319**	0.225	0.646***	0.093	0.517***
	(-0.66)	(0.51)	(-2.03)	(1.41)	(3.90)	(0.65)	(3.51)
GHG Capita	0.012	-0.013	-0.005	0.009	-0.025**	0.015	-0.013
	(1.05)	(-1.13)	(-0.36)	(0.78)	(-2.09)	(1.54)	(-1.26)
GHG Total	0.118**	-0.142***	-0.056	-0.154***	-0.034	-0.011	0.067
	(2.55)	(-3.07)	(-1.24)	(-3.67)	(-0.56)	(-0.23)	(1.42)
COP	-0.120	-0.004	0.058	-0.013	0.122	-0.051	0.102
	(-0.67)	(-0.02)	(0.35)	(-0.08)	(0.72)	(-0.32)	(0.66)
Social Science	-0.062	0.117	0.274**	0.090	0.110	-0.040	0.055
	(-0.46)	(0.83)	(2.03)	(0.65)	(0.81)	(-0.29)	(0.40)
Age	0.000	-0.004	-0.001	0.008	0.000	0.008	0.001
	(0.03)	(-0.72)	(-0.25)	(1.24)	(0.03)	(1.22)	(0.14)
Gender	-0.086	-0.014	-0.129	-0.207	-0.167	0.098	0.008
	(-0.59)	(-0.09)	(-0.86)	(-1.31)	(-1.08)	(0.63)	(0.05)
NGO	-0.156	-0.510**	-0.431**	-0.320	0.100	-0.272	-0.173
	(-0.69)	(-2.20)	(-2.08)	(-1.52)	(0.45)	(-1.25)	(-0.79)
Observations	304						
chi2	219.886						

Notes: * p < 0.1, ** p < 0.05, *** p < 0.01. Robust z-statistics in parentheses.

Table 2.8: Parameter estimates of multivariate ordered probit model with **GHG emissions** as explanatory variables, determinants of usefulness of BSRs, dependent variables: "Degree of Usefulness".

	EGA	GF	AP	POLL-C	POLL-H	CONS-C	CONS-H
Fairness	0.193	0.160	-0.004	-0.078	-0.030	-0.086	0.052
	(1.54)	(1.25)	(-0.03)	(-0.59)	(-0.22)	(-0.68)	(0.40)
Vulnerable	-0.034	0.133	-0.135	0.326**	0.736***	0.275*	0.432***
	(-0.23)	(0.85)	(-0.90)	(2.02)	(4.50)	(1.83)	(3.07)
GHG Capita	0.004	-0.012	0.011	0.009	-0.019*	0.018*	-0.011
	(0.33)	(-1.02)	(1.10)	(0.89)	(-1.67)	(1.70)	(-1.02)
GHG Total	0.009	-0.091***	-0.079*	-0.137***	0.012	-0.053	0.090*
	(0.15)	(-2.75)	(-1.81)	(-3.59)	(0.19)	(-1.10)	(1.65)
COP	-0.114	-0.236	-0.294*	-0.050	0.005	-0.147	0.054
	(-0.66)	(-1.29)	(-1.67)	(-0.31)	(0.03)	(-0.87)	(0.33)
Social Science	-0.218	0.154	0.214	0.031	0.018	0.004	0.056
	(-1.56)	(1.13)	(1.52)	(0.22)	(0.13)	(0.03)	(0.41)
Age	-0.003	-0.004	-0.003	0.003	-0.014**	0.001	-0.007
	(-0.48)	(-0.78)	(-0.47)	(0.46)	(-2.38)	(0.21)	(-1.19)
Gender	0.215	0.068	-0.066	-0.204	-0.205	0.008	-0.149
	(1.38)	(0.42)	(-0.44)	(-1.29)	(-1.38)	(0.05)	(-1.02)
NGO	-0.361*	-0.639**	-0.424*	-0.193	-0.011	-0.318	-0.201
	(-1.72)	(-2.43)	(-1.85)	(-0.84)	(-0.05)	(-1.41)	(-0.85)
Observations	301						
chi2	209.190						

Notes: * p < 0.1, ** p < 0.05, *** p < 0.01. Robust z-statistics in parentheses.

Chapter 3

An Empirical Assessment of Components of Climate Architectures [*]

Based on unique data from a world wide survey among participants of international climate conferences, we investigate the acceptance of the most discussed components of architectures for an international climate agreement, namely: Global quantitative targets, sector targets, research and development, geoengineering, land use, and adaptation. Regional and economic differences as well as personal attitudes play an important role for the perception of the different components. Global quantitative targets and adaptation are deemed to be most important in contrast to a low acceptance of geoengineering. People that are more affected by climate change and value fairness a lot care more about global and sector targets and research and development. Surpris-

[*]Financial support from BMBF is gratefully acknowledged. We greatly benefited from the joint cooperation with our project partners at the Centre for European Economic Research and the University of Hamburg. We are thankful to useful comments made at the conference of the European Association of Environmental and Resource Economics and at the European Meeting of the Econometric Society in 2014 and feedback provided by our colleagues Lucas Bretschger, Martin Kesternich, Andreas Lange, Andreas Löschel, Janick Mollet, and Bodo Sturm.

ingly, being vulnerable to climate change does not increase the preference of adaptation by much. Furthermore, we analyze which countries or groups of countries are expected to play a leading role for each component. The EU is seen as a key player and not much is expected from the USA and China. We detect a normative bias that increases expectations on China, the EU, and the USA for some of the components.

3.1 Introduction

The book "Architectures for Agreement: Addressing Global Climate Change in the Post-Kyoto World" by Aldy and Stavins (2007) discusses six possible components of architectures for a future international climate agreement (ICA). Our empirical analysis of theses components provides insights which role they could play for an ICA. While scientific consensus demands actions against climate change, academics and policy makers argue which component should be the main focus of an ICA.

The homepage of the Harvard Project on Climate Agreements,[1] a large body of literature (see Section 3.2), and two books by Aldy and Stavins (2007) and Aldy et al. (2010) furnish more evidence for this. Considering the large complexity of the problem, it is instructive to explore the acceptance of different ways of addressing global climate change. Additionally, it has been argued by Keohane and Victor (2011) that a mixture of different components would be better than focusing on just one component that yields only little efforts due to a lack of acceptance. Therefore, we investigate which components are the most accepted among stakeholders of international climate negotiations and which country or group of countries will play a leading role.

Previous work by Bosetti et al. (2008) compares different architectures of cap and trade systems, a carbon tax, and research and development (R&D) cooperation. There are trade offs between effectiveness, efficiency, and political enforceability and all architectures fail to achieve the 2°C goal if they are not stringent enough. Similar to their aforementioned books, Aldy et al. (2003) discuss thirteen different architectures and classify them according to their: environmental outcome, dynamic efficiency, dynamic cost-effectiveness, distributional equity, flexibility, and participation and compliance. Their analysis reveals tensions among the criteria and it is not clear which architecture should prevail for an ICA. Bodansky et al. (2004) provide a summary

[1] Homepage of the Harvard Project on Climate Agreements.

of eight different architectures to guide the policy makers at the Climate Dialogue at Pocanticos.[2] This shows that different architectures for agreements and their components are not only of academic interest.

We can subsume the components of most of these proposals under one of the following six different components in current international climate negotiations that we analyze in this paper:

- Comprehensive quantitative targets for a reduction in global greenhouse gas (GHG) emissions
- Quantitative GHG emission reduction targets for individual economic sectors
- Research and development and technology transfers (R&D)
- Geoengineering
- Land use change and reforestation
- Adaptation

Up to now, comprehensive quantitative targets dominate the agenda of negotiations seen in the formation of the Kyoto Protocol. The signatories of the Kyoto Protocol surprisingly demonstrated that they could agree on differentiated national quantitative targets, possibly because the targets were mostly easy to comply with. Apparently, it was more feasible to agree on international quotas than taxes and let countries choose their instruments domestically (Frankel, 2007). On a similar scale, sector targets would focus on fewer participants and key sectors but still cover large amounts of emissions. The idea of knowledge diffusion via the Clean Development Mechanism (CDM) is already a part of the Kyoto Protocol and R&D is essential to prevent climate change. Recently, the idea of geoengineering has emerged but has not yet made it onto the conference table. Land use and adaptation seem

[2] Homepage of the Climate Dialogue at Pocanticos.

a natural part of international climate negotiations and have recently gained more attention due to natural catastrophes.

Knowing more about the acceptance of these components is important for negotiators to focus on the most accepted components and to be able to address concerns or biases of other negotiators. Furthermore, we investigate which countries or groups of countries are expected to take a leading role in the presented components. The set of possible leading countries or groups of countries comprises the Alliance of Small Island States (AOSIS), a group we define as the BASI group (Brazil, South Africa, and India)[3], China, the European Union (EU), the United States of America (USA), and none of the above.

Thanks to our unique data set from a survey among the official participants of the Conference of Parties (COP), we investigate how the participants of international climate negotiations asses the selected components of architectures. To our knowledge, there are no other empirical studies of this kind in the literature and no comprehensive studies of the selected components.

We consider four factors as determinants of the acceptance of the components or the expected leadership role: Fairness, vulnerability, abatement costs & economic capacity, and democracy & governance. The data shows that global targets and adaptation are the most accepted components whereas geoengineering is least accepted. Respondents most often think that the EU will take a leading role and least often expect USA and China to do so. While we show the relevance of fairness and vulnerability, democracy and governance do not influence the acceptance of components. The negative influence of abatement costs and economic capacity highlights the conflict and divergence between the developed and developing countries. We find evidence for a normative bias that leads people to expect a leading role of BASI, China, EU, and the USA for some components. This is in contrast to anecdotal evidence that does not suggest corresponding leading roles.

[3]This is a subset of the BASIC group which would also include China. Due to its important role, we look at China and BASI as a separate players.

The paper continues to discuss the six components chosen for the survey in Section 3.2. We outline the empirical agenda in Section 3.3 and present the data and some descriptive tables in Section 3.4. Section 3.5 presents the applied econometric methods and we present the results in Section 3.6. Section 3.7 concludes.

3.2 Components of Climate Architectures

In this section, we present the six components analyzed in this paper and discuss the existing literature. In line with work by Aldy and Stavins (2007) and Olmstead and Stavins (2012), we classify the components according to three broad criteria: First, an effective component prevents climate change from happening and it is efficient if the costs are close to a first best solution or the social optimum. Second, we discuss how the components would affect participation & compliance of a possible ICA. Third, we look at the riskiness of the components, since future costs of the components are not certain or there might be possible side effects.

3.2.1 Global Quantitative Targets

Global targets would be effective and efficient to prevent climate change, but including all countries and securing compliance proves a challenge. They would be effective, if the limit was set low enough, and efficient, if trading of emission reductions was allowed to equalize marginal costs across countries. So far, the agreed targets of the Kyoto Protocol lacked stringency to attract broad participation at reduced effectiveness and efficiency. That is why the total amount of reductions was rather symbolic than substantial (Posner and Weisbach, 2010; Keohane and Victor, 2011), which risks to prevent climate change in time.

Frankel (2007) discusses the constraints and the criteria of an ICA based on global quantitative targets. He tries to formulate realistic targets taking account of participation and compliance, efficiency, dynamic consistency, equity, and uncertainty. The proposal is criticized by Bodansky (2007b) for two reasons. Firstly, the focus to include all countries is unnecessary when only 25 countries account for 80% of the emissions and ignoring the other countries would facilitate the process. Secondly, Frankel's proposal represents an ideal architecture but not ideal politics and will not be feasible. Olmstead and Stavins (2012) agree that precise, numerical, and inflexible emission targets with long time horizons are impractical due to uncertainty over future growth, technological change, and the science of climate change and its effects. Thus, long-term targets must retain some flexibility, but still be considerably stringent. In contrast, short-term targets shouldn't be too stringent. McKibbin and Wilcoxen (2008) note that a rigid system of targets and timetables for emission reductions pushes participants into a zero sum game.

Furthermore, the redistribution of wealth implied by a Kyoto like architecture is not going to be accepted by the developed countries and might enrich the powerful and already rich in the poorer countries due to corruption and favoritism (Cooper, 2007). Lutter (2000) stresses the importance of uncertainties for countries when they grow faster (slower) and create excessive emissions (hot air) and targets are too strict (lose). This would reduce participation and compliance and therefore, emission targets should be indexed on certain variables like lagged GDP or emissions in order to reduce that risk. In conclusion, global quantitative targets serve as a first best solution but in reality it is hard to agree on sufficiently stringent targets.

3.2.2 Sector Targets

Given the stalemate in international negotiations, some argue that it would be better to regulate certain carbon intensive sectors, since this would only concern a smaller group of countries and firms, which would greatly reduce transaction costs. Or, some think that a sector approach was always meant to be part of a more comprehensive agreement like the Kyoto Protocol and has been successfully employed in other contexts, for instance the World Trade Organization (WTO). A sector approach could defuse competitiveness concerns, focus on critical and technology dependent sectors, and take advantage of the fact that some sectors consist of a few key parties (Bodansky et al., 2004; Bodansky, 2007a; Pew Center for Global Climate Change, 2005). Since this would be less effective and efficient than global targets, concerns about leakage and lobbying have to be addressed.

Philibert and Pershing (2001) state that it might be easier for developing countries to accept sector targets which would increase environmental effectiveness. Additionally, sector targets offer a scope to satisfy concerns about flexibility or equity from yet not participating countries. Sawa (2008) explores the possibilities of a sector approach to engage developing countries despite the disadvantage in environmental and cost effectiveness. He argues that a sector approach is complex due to data collection problems and should rather complement a Kyoto like agreement. In contrast, Barrett (2008b) argues that sector level agreements are more effective and flexible by avoiding the enforcement and negotiation problems of an aggregate approach. Bradley et al. (2007) believe that a sector agreement can help since it would increase participation, alleviate competitiveness issues and target key areas. Nevertheless, it is only a second best solution for the problem and the risk of lobbying and creating counter effective exemptions for energy intensive sectors have to be taken care of.

In this regard, Schmidt et al. (2008) design an architecture proposal based on a sector agreement in which the top 10 developing country emitters would pledge to non binding emission targets based on energy intensity benchmarks and their capabilities. There would be no penalties for non compliance but emission reductions beyond the target would earn emission credits to be sold to the developed countries. One could see this as a bigger, more comprehensive sector Clean Development Mechanism (CDM) with the advantage of stronger incentives for technological transfers. Keeping in mind their drawbacks, sector targets play an important part for an ICA. Both, global and sector targets, should dynamically adapt to changes of economic or scientific factors to boost participation and compliance.

3.2.3 Research and Development

Research and development (R&D) offers an alternative way to prevent climate change by using technical progress to reduce emissions. To quote Cao (2008): "R&D and technology development are the key solution for humanity to reverse the climate trend." While this could be very effective and efficient, free riding on the efforts of others has to be avoided and the diffusion of new developments should be facilitated. Without further reduction targets, technical progress alone might not be able to prevent climate change in the short run and the diffusion of technology to developing countries is especially problematic.

A recurring idea is to combine R&D investments with CDMs or other knowledge diffusing mechanisms. Among others, Hall et al. (2008), Cao (2008), and Teng et al. (2008) advice to improve the CDM to boost efforts in R&D. Furthermore, subsidies help to induce investments into R&D regardless of the stringency of the cap or the lack of enforcement (Datta and Somanathan, 2011).

Clarke et al. (2008) show that R&D and the diffusion of climate technology are most important, so that other ICA architecture considerations lose importance when more focus is put on R&D. This is especially true considering a lack of participation or compliance. Somanathan (2008) argues that an ICA should promote R&D and support the diffusion of new technologies as a necessary part, since R&D provides huge emission reductions. Newell (2008) proposes that the United Nations Framework Convention on Climate Change (UNFCCC), supported by the International Energy Agency, should develop a framework for coordinating and augmenting climate technology R&D. This should include the creation of public funds to foster joint collaboration and attract non-OECD countries. This architecture would induce innovation and the diffusion of technologies which is essential to prevent global climate change due to the enormous economic and environmental benefits.

Contrasting the idea of global emission targets, an ICA could instead set technological standards which are easier to monitor and it would be in the interest of all participants to take care of the adoption and diffusion of these standards due to positive feedback. Unfortunately, this creates incentives to lock in existing technologies in contrast to price mechanisms that would create dynamic innovation. This trade-off between dynamic cost-effectiveness vs. compliance and participation ("high payoff with low probability" vs. "low payoff with high probability") is described by Barrett (2002, 2003) and Barrett and Stavins (2003). By its nature, R&D must be an essential part of preventing climate change, but an ICA can promote it indirectly or directly.

3.2.4 Geoengineering

In reference to Gardiner (2010) and Schelling (1996), we define geoengineering as "the intentional manipulation of the environment on a global scale". It promises an effective and efficient solution for climate change without the need to reduce emissions. At the same time, tampering further with the ongoing natural experiment of climate change has side effects or unforeseen consequences. To prevent countries from conducting geoengineering unilaterally, an ICA should regulate its use.

By hosting a conference about geoengineering, the National Academy of Sciences (1992) put geoengineering on the map for the first time. Recently, it regained attention when Nobel laureate Paul Crutzen (Crutzen, 2006) published an editorial essay in favor of geoengineering as a last resort in the face of drastic climate change in the future. He and Cicerone (2006) are rather optimistic about the prospects of geoengineering and emphasize that research is needed to properly evaluate it. To this point, Victor et al. (2009) add the need of regulation due to moral hazards and unilateral action. They stress that geoengineering should only be a last resort and that it is vital to explore its cost and benefits.

MacCracken (2006) warrants caution since once geoengineering is chosen, it has to be continued virtually indefinitely due to the different decay rates of GHG gases and albedo particles. After all, reducing emissions would be the safer way to prevent climate change in the first place and geoengineering should not be used as an excuse to stop abatement efforts. In this sense, Wigley (2006) regards geoengineering as a means to buy time so that humanity can solve the initial problem by mitigation efforts.

A very skeptical view is presented by Gardiner (2010), who contests the notion that geoengineering is the "lesser evil" with which we should arm the future by doing research in geoengineering. In short, he casts doubt that geoengineering is less risky or politically more feasible than other options and that there are severe moral problems evoking emergency arguments to free the current generation from obligations. The moral thing would be to avoid climate change in the first place.

Schelling (1996) discusses the implications and possible forms of geoengineering and points out that it might reduce the complexity of international climate negotiation but that it could lead to more international tensions. Barrett (2008a) believes that we will not be able to stop climate change so that we will eventually need geoengineering. Geoengineering only serves as a band aid or a stop gap measure, but does not solve the cause of the problem and even substitutes for emission reductions. Due to the dangers of unilateral action, it should be part of an ICA.

From an economic point of view geoengineering can be seen and modeled as a public good that prevents the temperature rise with possible negative side effects, that might qualify it as economically viable or not (Goeschl et al., 2013; Urpelainen, 2012). Estimates about the cost and benefits of geoengineering are not clear. Goes et al. (2011) conclude with rather pessimistic results due to uncertainties and possible side effects. In contrast Bickel and Agrawal (2011) explore different scenarios of the former paper to conclude with a positive cost benefit analysis. Bahn et al. (2014) further extend the integrated assessment analysis to show that the results are quite sensitive to parameter changes.

Obviously, geoengineering offers great potential similar to R&D, but the downside risk is much bigger. Nevertheless, it should be accounted for in future climate negotiations if only to regulate or restrict its use.

3.2.5 Land Use and Reforestation

Land use and reforestation on their own are unable to efficiently and effectively prevent climate change but significantly contribute to climate change as further emission reductions or increases. Only a few countries, like Brazil or Russia, are relevant for land use and reforestation which reduces transaction costs. Additionally, some of the benefits are more direct to the countries which might increase acceptance. The emission changes attributed to land use change and reforestation have to be calculated carefully to avoid creating virtual emission reductions ("hot air").

According to Kalnay and Cai (2003), urbanization and land use increases the mean surface temperature by 0.27°C per century. Therefore, an agreement including land use and reforestation would have a sizable impact because of the huge potentials from emission sinks or sources. This was partly already considered in the Kyoto Protocol as Russia was granted a lot of emission credits because of its large forests.

Additionally, it seems that negotiations on reforestation were less stalled in the past and making full use of the forest carbon sinks is appealing to both the developed, as low cost mitigation possibilities, and the developing world, as an additional income (Baldwin and Richards, 2010). Apparently, the negotiations in the latest COP in Warsaw progressed in this negotiation track by creating the "Warsaw Framework for REDD Plus".[4]

Plantinga and Richards (2008) stress the importance of forest carbon sequestration and the advantages of the national inventory approach. Sasaki

[4] UNFCCC press release.

and Putz (2009) state that it is imperative to define the term “forest” to avoid further forest degradation which is equally responsible for CO_2 emissions than actual deforestation. Noss (2001) discusses different aspects of forest management and how to best prepare forests to dramatic climate change. Land use and reforestation is an essential part of an ICA and it is foremost important to set a regulatory framework.

3.2.6 Adaptation

Adaptation is defined as the “adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities” (McCarthy et al., 2001). In principle, countries could try to adjust (not prevent) to climate change unilaterally, but it would be the least efficient way. Any country could adapt on its own but the most affected countries neither have the money nor the capability or their mere existence is threatened by climate change. That is why adaptation should be part of a more comprehensive ICA to transfer money from the least to the most affected countries. Unfortunately, some countries are not able to adjust to climate change because the consequences are too drastic. Given that some degree of climate change will most likely occur, adaptation will be necessary for some countries. Considering constraint resources, it makes sense to invest into adaptation to the point where its marginal benefit equals the benefit of emission reductions.

Adger and Barnett (2012) discuss four concerns about adaptation to climate change: 1. Climate change might be too drastic to adapt in time, 2. Some adaptation measures are not adequate to respond to climate change, 3. Some adaptation measures are unsustainable as they are polluting even more, and 4. Sometimes adaptation is not possible due to high (psychological) costs, i.e., relocation of inhabitants of sinking islands. On the other hand, Adger et al. (2009) conclude that the limits to adaptation are contingent on ethics, knowledge, attitudes to risk and culture and not only technical considerations. Therefore, these limits are mutable and can be overcome.

Although some effort is already put into adaptation, Adger et al. (2005) argue that in the future it will be necessary and more urgent to focus on it. Therefore, it is instructive to judge the efforts of adaptation according to effectiveness, efficiency, equity, and legitimacy which challenges the institutional processes on all levels. Barrett (2008b) agrees that adaptation as well as geoengineering are necessary no matter what we do so that it should be included in an ICA. Bouwer and Aerts (2006) propose to include adaptation into a future ICA either as a separate protocol or as an integrated part. The authors analyze different ways of funding adaptation and show that benefits of adaptation for both Annex I and II countries should be made more explicit. A clear funding commitment by the developed countries could be part of a new ICA to improve the situation. Despite the fact that preventing climate change in the first place would be a better solution, adaptation is an important topic, especially for the most affected countries.

From the extensive literature on the different components of climate architectures, it is likely that not one component alone will dominate a future ICA. The content of this section and further literature show the diverging opinions among researchers which might carry over to policymakers. The sections also reveals the diverging interest between developed (rich) and developing (poor) countries. Looking at the views of the actual stakeholders of the climate conferences helps to see which components are most prominent and why they are preferred.

3.3 Determinants of the Acceptance of Components of Climate Architectures

We consider the following four factors as determinants of the acceptance of different components and leadership roles in international climate negotiations:

- Fairness
- Vulnerability
- Abatement cost and economic capacity
- Democracy and governance

Since fairness has become a recognized topic for international climate conferences and has been considered in other surveys (Lange et al., 2007, 2010), we test if the attitude towards fairness as a part of an ICA matters for the acceptance of the components. The influence of fairness on social welfare analysis has also been proposed by Johansson-Stenman and Konow (2010). We expect that people who are more sensitive about fairness generally are prone to find the components more important due to normative considerations. In this regard, we use the term normative in reference to the differentiation of positive and normative economics as discussed by Friedman (1953) or presented in Samuelson's textbook (Samuelson and Nordhaus, 2010). A normative bias leads people to see things how they ought to be, not the way they are. Therefore, considerations about the efficiency or effectiveness of components might increase their perceived importance, which would indicate a higher importance for global targets or R&D.

The impact on the assessment of the leadership roles can be seen accordingly. The fairness prone respondents could rather express their expectation for some countries to act since they see them as morally obliged. This would indicate a higher expectation on the big players like USA and China.

A case study on the Montreal and Helsinki protocol by Sprinz and Vaahtoranta (1994) proposes two factors to explain countries' preferences: Vulnerability and abatement costs or economic capacity. Adapting this to the preferences about different components in ICAs, we check if concerns about one's own vulnerability increases the acceptance of the components. Vice versa, respondents expecting positive impacts for their country could be less positive about the components. Given that the respondents attach different potential emission reductions to different components, we implicitly explore which components are expected to reduce damages from climate change the most. It is not clear which of the components this should be, but assuming that global targets and R&D are the most efficient, they should offer the highest potential in damage reduction and therefore, those components might be preferred. Furthermore, adaptation could be more attractive to this subset of respondents.

Concerning the leadership role, respondents from countries for which climate change is negative or positive might have higher or lower expectations about countries pushing components. Due to self interest or hopeful expectations, participants might expect the big players, USA and China, to take up leading roles, although reality begs to differ.

Checking the postulated connection between abatement costs and acceptance of components poses some problems. Getting data on country specific abatement costs for such a widespread sample as ours (around 128 countries) is near impossible and estimates on abatement costs differ substantially (Kuik et al., 2009; Fischer and Morgenstern, 2006). Therefore, we resort to per capita emissions as a proxy of abatement cost which is readily available and more reliable. Countries with high per capita emissions have higher total abatement costs than low per capita emission countries, since it is easier to avoid emissions when a country is still building up its industry. It could also be an indicator that countries with high emissions are more reluctant to endorse the components because they depend on high emission levels.

Looking at the economic capacity, respondents from rich countries might perceive the components differently and be more reluctant about them. In that regard both emissions and GDP are expected to negatively influence the preference on the components.

Inspired by the Environmental Kuznets Curve (EKC) literature[5] we test for quadratic effects to see if there is an U-shaped relation of higher acceptance

[5]We refer to Panayotou (2003) for an overview.

among very rich or polluting countries.

The economic capacity and emission output might impact expectations on the leading roles, but we restrict the analysis to per capita GDP. Most probably, richer respondents have lower expectations on countries taking a leading role. In this regard we use per capita GDP rather as a control variable to account for economic differences.

Furthermore, we test if the institutional circumstance of a respondents home country influences the acceptance of the components, a connection which has been proposed in previous work. Though technically outdated, an early work by Congleton (1992b) establishes that democratic and free countries are more likely to sign two international environmental agreements on Chlorofluorocarbon and methane emissions. Among others, Barrett and Graddy (2000) find that institutionally advanced countries have lower pollution levels. In a theoretical model Lange and Vogt (2003) argue that voter preferences can increase cooperation in international environmental negotiations. More to our interest is a paper by Neumayer (2002) that assumes a connection between political freedom or democracy and environmental commitment. Regarding our respondents statements as a proxy for their commitment to the components, indicators of political freedom or governance should have a positive impact on the acceptance of the components.

3.4 Data

This section introduces the data originating from a worldwide on-line survey conducted in spring 2012 and already shows some descriptive results.

3.4.1 Sample

The population of interest comprises the official participants of the Conferences of Parties (COP). We focus on representatives of countries in international climate negotiations, specifically participants of COPs, since they conduct the negotiations. For this analysis a participant is everybody who was officially associated with a negotiation party of a country, which includes advisers and experts to the parties. We focus on representatives of countries in international climate negotiations, specifically participants of COPs, since they conduct the negotiations and represent their countries‘ interest. Thanks to the official lists of participants published by the UNFCCC, we were able to contact almost every official participant of the COPs of 2010 and 2011 supplying a potentially large sample. Although work by Lange and Vogt (2003) suggests that voters preferences can influence negotiators,[6] most of the participating countries do not have democratically elected governments. Therefore, we focus on the most important subject group of international climate negotiations: The official participants as released by the UNFCCC.

The data was collected in a worldwide on-line survey conducted in spring 2012 in joint collaboration with our project partner from the Center of European Economic Research (ZEW), and parts of the survey are also used in Kesternich et al. (2014). We gathered all possible email contacts from the official UNFCCC list of participants and other sources. Trying to include all the participants from COP 16 in Durban and COP 17 in Cancun, we harvested around 6500 addresses. The ZEW designed the questionnaire and sent out emails with personalized links to a standardized on-line platform where respondents could fill out the questionnaire. On request, a printable PDF version was also provided to be sent back by email or post. After up to three follow-ups, about 500 persons participated in the survey, of which approximately 350 completely filled out the questionnaire. The participation rate of $6-7\%$ is rather low but still fairly typical for on-line surveys. There is some evidence that negotiators from poor and less polluting countries are more prone to answer, as well as Europeans. Yet, sensitivity analyses using different weightings did not significantly change the results.[7] Looking at the

[6]For a more detailed discussion see, Böhringer and Vogt (2004), Vogt (2002), or Congleton (1992a).

[7]We cannot rule out problems of self-selection, but since most biases depend on differ-

share of some of the key regions of international climate negotiations the actual sample matches the contact group quite well. For instance, the share of Europeans is 22% in the sample while it is 19% in the mailing list, the G77 representatives amount to 59% in the sample against 62% on the list and BASIC member comprise 10% of the sample but 14% on the list. Compared to the similar survey by Lange et al. (2007) conducted in 2004, our effective sample size is almost doubled.

3.4.2 Dependent Variables

The econometric analysis focuses on two sets of categorical variables about the importance of the components and the leadership roles of certain countries for those components.[8] The first set is based on a question about the importance of the six different components for international climate change negotiations. We derive six ordinal variables "component importance" with values 1 for "Not important", 2 "Moderately important", 3 "Important", 4 "Very important". Table 3.1 shows the relative frequencies of the four categories, a measure of dispersion, ρ, and the number of observations (N) of all six ordinal variables used in the econometric analysis of the acceptance of the components. We abbreviate the six components with "Global" for global quantitative targets, "Sector" for sector targets, "R&D" for research and development, "Geoeng." for geoengineering, "Land" for land use and reforestation, and "Adaptation" as the term itself.

ences between developing and developed countries we think that it is not problematic that we have less participants from developed countries, as long as their views don't differ from their non responding compatriots.

[8]The exact wording of the questions is supplied in the Appendix.

Table 3.1: Relative frequencies of importance of different components in climate change negotiations.

	Relative frequency [%]					
	Very imp.	**Imp.**	**Mod. imp.**	**Not imp.**	$\rho = \sum_{i=1}^{4} p_i^2$	**N**
Global	74.6	21.2	3.5	0.7	0.603	429
Sector	46.1	34.1	14.1	5.6	0.352	425
R&D	56.5	31.3	10.7	1.4	0.429	428
Geoeng.	17.5	33.3	28.2	20.9	0.265	411
Land	54.0	35.6	10.0	0.5	0.428	430
Adaptation	68.6	22.3	8.6	0.5	0.528	430

According to the respondents, global targets and adaptation are the most important components of architectures for international climate change negotiations. Sector targets, R&D, and land use follow somewhat behind but still achieve rates of around 50% for the highest category "very important". The perceived importance of geoengineering is much weaker, although roughly 50% still see it as "very important" or "important". Comparing measures of dispersion underlines that geoengineering is the most controversial topic. To show the dispersion of ordinal variables, Good (1982) proposes the squared sum of category probabilities $\rho = \sum_{i=1}^{4} p_i^2$ as a measure of homogeneity, This measure yields 0.60 for global targets, the highest or most homogeneous, and 0.27 for geoengineering, the lowest and least homogeneous.[9]

The second set of dependent variables is established from a question that asked whom the respondents expect to take a leading role for one or more of the analyzed components. Since respondents were allowed to choose more than one country or group of countries to take a leading role for a component we obtain six (components) times six (regions) equals 36 binary indicators,

[9] The Hirschman-Herfindahl index of concentration would also be applicable and provide the same ranking.

"leadership role", that take one the value 1 if a leadership role is expected for a country for a component or 0 if not. In this regard, we obtain a six by six matrix of binary indicators that describes the expected leading roles of AOSIS, BASI, China, EU, USA or None for each component. Table 3.2 summarizes theses 36 items. We choose to keep the components on the vertical axis and depict the regions on the horizontal axis. Each cell gives the percentage of respondents that think that a country will take a leading role for this component.

Table 3.2: Relative frequencies of a leading role for different components in climate change negotiations.

Relative frequency [%]

	AOSIS	**BASI**	**China**	**EU**	**USA**	**Mean**	**None**
Global	54.0	28.7	32.7	81.9	28.0	45.1	1.7
Sector	29.7	25.8	33.1	72.3	33.9	39.5	7.0
R&D	29.7	45.6	53.6	58.0	43.9	46.2	3.9
Geoeng.	12.0	18.3	27.7	51.1	58.4	33.5	14.6
Land-Use	33.1	59.1	24.4	58.0	26.0	40.1	6.6
Adaptation	73.2	55.0	33.3	44.0	24.7	46.0	6.3
Mean	40.2	39.8	34.5	61.4	34.7	/	6.2

More than half and over 70% of the respondents think that AOSIS plays a leading role for global targets and adaptation respectively. The number drops to around 30% for the other components and only very few respondents see a leading role of AOSIS for geoengineering. The BASI group is rather expected to play a leading role for R&D, land-use or adaptation. The pattern is similar for China with a much lower rate for land use. Respondents expect the EU to play a very important role. Across components the ratio of a EU leading role is 61% and a staggering 82% expect the EU to take a leading role for global targets.

Looking at the averages one has to keep in mind that the averages across components for each region are a weighted average since the numbers of observations differ. For the average across regions we exclude "None". The mean leading percentage of 35% for both the USA and China shows that respondents do not expect much from them, although they are pivotal players in climate change negotiations. Usually, respondents rarely think that none of the countries takes a leading role but it is most often the case for geoengineering. In comparison to the average leading role of a country there is less variability about the components. The picture is somewhat similar to the general importance of the components in Table 3.1, so that respondents mostly expect a leading role of countries for global targets, R&D, and adaptation and least often for geoengineering.

Since respondents could select multiple countries or groups of countries for a leading role in an component, we check if some permutations come up more frequently. Indeed, 27% of respondents simultaneously see leading roles for AOSIS and EU for global targets, 13% for EU and USA for R&D, and 10% for all countries for adaptation. Roughly 50 respondents see a EU leading role for all components, which emphasizes the importance of the EU.

3.4.3 Explanatory Variables

To analyze the determinants discussed in Section 3.3, we create explanatory variables based on parts of the survey and other sources to be used in the econometric analysis.

To analyze the role of fairness and vulnerability, we use two questions from other parts of the survey to create binary indicators.[10] One question asks how important fairness is for distributing GHG emission reduction targets among countries in an ICA. We obtain a binary indicator, "Fairness", with the value 1 for the highest category "Very important" and 0 for the less important categories. In another question, participants assess the consequences of climate change for their home country on a scale from "positive" to "very negative".

[10] The exact wording of the questions is supplied in the Appendix.

Table 3.3: Means and standard deviations of explanatory variables

Variable	**Mean**	**Standard Deviation**	**N**
Fairness	0.50	-	403
Very neg. conseq.	0.30	-	383
Positive conseq.	0.05	-	383
AOSIS	0.08	-	429
BASIC	0.10	-	429
EU	0.23	-	429
GDP capita	1.66	1.63	429
GDP total	1.07	2.49	429
CO_2 capita	5.20	5.85	429
Partly Free	0.30	-	424
Free	0.58	-	424
Democracy Index	6.45	2.00	390
Governance Index	0.27	0.92	426

We establish one binary indicator, "Very neg. conseq.", with 1 for "Very negative consequences" and 0 for less negative consequences. Another binary indicator, "Positive conseq.", takes on the value 1 for "Positive consequences" and 0 for less positive consequences.

Based on the nationality and the represented country, which in all but some cases matches the information from the official UNFCCC participation lists, we are able to create indicators for the most important players from which we have enough respondents: AOSIS, BASIC[11], and EU.

Furthermore, we include three aggregate socio-economic variables: Per capita and total GDP (in ten thousand $ and in one trillion $) from the Penn World Table (Heston et al., 2012) and per capita CO_2 emissions in GT CO_2 (EIA 2010).

As proxies for democracy and governance, we use three different sources: Freedom House (2013), Economist Intelligence Unit (2013), and Kaufmann et al. (2012). All three indexes are aggregations of expert surveys or classi-

[11]It should be noted that we do not have any observations from India in our sample, so that our results do not include the Indian position within the group.

fications, which we do not explore in this paper. The Freedom House index provides two binary indicators that differentiate between partly free and free countries compared to not free countries as the base outcome. The democracy index ranges from 0 (authoritarian regimes) to 10 (full democracies) and the governance index of the World Bank ranges from −2.5 for weak to 2.5 strong governance performance. Further information are given by the sources or the corresponding homepages.

To avoid an omitted variables bias for the leadership roles, we derive binary indicators from the dependent variables of the respective component importance. They take on the value 1 when the respective component is viewed as "very important" or 0 for the lesser categories. This variables are referred to as "component very imp" in the models explaining the leadership roles.

An overview including the mean and the standard deviation of all explanatory variables but the component importance is given in Table 3.3. We do not include further socio economic variables on gender, education, or others since they neither change the results nor do they provide further insights at a considerable loss of observations.

3.5 Econometric Method

We opt to use multivariate ordered and binary probit models with respect to the structure of our survey data. The six ordinal variables, "component importance", range from $y_{ik} = 1 =$"not important" to $y_{ik} = 4 =$"very important". Therefore i defines the respondent and k one of the six components on which the statement was given. We keep the same order in which the components are presented throughout the paper, so that $k = 1 =$"Global" and $k = 6 =$"Adaptation". For the first part of the econometric analysis the ordinal dependent variables suggests an ordered probit regression model. Given that respondents gave assessments about six policies in the same item battery, the multivariate approach allows for a more flexible error structure.

Following Cappellari and Jenkins (2003) and Roodman (2009), we estimate a K-equation multivariate ordered probit model. Following a latent variable derivation, the $K = 6$ latent variable equations are:

$$y^*_{ik} = \beta_k X_{ik} + \epsilon_{ik}, \qquad k = 1, ..., K \tag{3.1}$$

The relation between the latent and the observed variables is described by:

$$y_{ik} = c \quad if\ \lambda_{c-1} < y^*_{ik} < \lambda_c,\ with\ c = 1,\ ...,\ 4;\ \ \lambda_0 = -\infty\ and\ \lambda_4 = \infty \tag{3.2}$$

c represents one of the four categories of importance. β_k describes how the explanatory variables X_{ik} influence the latent variables. The error terms ϵ_{ik} are supposed to follow a multivariate normal distribution with mean of zero and a variance covariance matrix Σ that gives the correlations among the errors as $\rho_{jk} = \rho_{kj}$ on the off diagonal cells. The diagonal cells equal 1. Either y_{ik} represents a choice or an assessment at different points of time or K different choices or assessments by one individual at the same point of time, which is the case for this study. We then allow for free correlation among the K different assessments. This is otherwise also known as a Seemingly Unrelated Regression (SUR) since the dependent variables are generated by independent processes, but allow for a multidimensional error distribution. Although this can become computationally demanding, recent implementations of simulation techniques as the GHK simulator into popular statistical programs like STATA make it feasible to estimate such models. We rely on the cmp STATA tool written by Roodman (2009) that allows fitting fully observed recursive mixed process models.[12] Using the multivariate structure and the SUR approach makes estimation of this kind of models more efficient although an equation by equation estimation would also be consistent. The

[12]Fully observed allows only for the use of observed variables of the latent variables, recursive implies that the stages are clearly defined and that not all dependent variables appear on the right hand. Mixed process allows combining different categorical, ordinal, binary, or continuous dependent variables.

extent of correlation among the different items is an indication of unobserved heterogeneity and supplies more robust standard errors and estimates, which substantiates our findings. We write down the log likelihood function of the model:

$$lnL(\beta, \Sigma; y|x) = \sum_{i=1}^{N} ln\ \Omega_K((q_{i1}x_{i1}\beta_1, ..., q_{i6}, x_{i6}\beta_6);\ \Omega) \tag{3.3}$$

For this case Ω_K denotes the joint normal distribution of order K, i.e., 6. $q_{ik} = 2y_{ik} - 1$ and the matrix Ω has values of 1 on the diagonal and $\omega_{jk} = \omega_{kj} = q_{ij}q_{ik}\rho_{jk}$ for $j \neq k$ and $j, k = 1, ..., 6$ as off-diagonal elements.

This high dimensional integral cannot be solved analytically so we rely on simulation methods. The aforementioned user written program cmp allows us to do that. The estimation is consistent if the number of draws for the simulation rises with the number of observations and to reduce the simulation bias we always use a number of draws twice as large as the square root of the number of observations. We use draws based on the Halton sequences method as suggested by Train (2009).

The second set of dependent variables includes the binary decision on the leadership roles of countries or groups of countries for the six components. We therefore adopt a multivariate binary probit estimation method. Since the statements indicate a leadership role across components and across regions, we can employ the multivariate estimation either across regions or components.[13] We use the variable y^*_{ikr}, "leadership role", with the additional subscript r, for the six different regions: $r \in (AOSIS,\ BASI,\ China,\ EU,\ USA,\ None)$. $y_{ikr} = 1$ means that a respondent expected country r to take on a leadership role for component k, otherwise $y_{ikr} = 0$. Therefore, we have 36 latent variable equations across regions, r, and components, k:

$$y^*_{ikr} = \beta_k X_{ik} + \epsilon_{ikr} \qquad k = 1, ..., K \tag{3.4}$$

The relation between the latent and the observed variables is described by:

$$y_{ikr} = 1 if y^*_{ikr} > 0 \quad and\ 0\ otherwise. \tag{3.5}$$

[13] Estimating 36 equations at the same time is computationally not feasible.

Using the same user written command cmp, we can estimate these equations with a multivariate binary probit model. Due to computational issues we have to fix either k or r to estimate for a fixed component k for all regions or a fixed region r for all components to account for unobserved heterogeneity. Otherwise the same logic that was given for the component importance applies and the estimation is done accordingly.

3.6 Results

3.6.1 Component Importance

Based on the ordinal scale of the first set of variables, this section relies on multivariate ordered probit models. To stress the different determinants, we present four regression tables that focus on fairness (Table 3.4), vulnerability (Table 3.5), the macro indicators for abatement costs and economic capacity (Table 3.6), and all explanatory variables together (Table 3.7). We are aware of problems of omitted variable bias due to the different sample sizes but

Table 3.4: Parameter estimates of multivariate ordered probit model focusing on **fairness** as an explanatory variable, determinants of importance of components, dependent variables: "Degree of Importance".

	Global	Sector	R&D	Geoeng	Land-Use	Adaptation
Fairness	0.583***	0.290**	0.273**	0.041	0.152	0.223*
	(4.28)	(2.54)	(2.30)	(0.37)	(1.29)	(1.73)
GDP Capita	-0.034	-0.038	-0.118**	-0.238***	-0.003	-0.168***
	(-0.53)	(-0.69)	(-2.09)	(-4.21)	(-0.06)	(-2.89)
GDP Total	-0.050**	-0.016	-0.010	-0.082***	-0.067***	0.017
	(-1.98)	(-0.67)	(-0.40)	(-3.04)	(-2.83)	(0.63)
GHG Capita	-0.013	-0.026**	-0.015	0.016	-0.036***	-0.021
	(-0.88)	(-2.06)	(-1.12)	(1.24)	(-2.82)	(-1.50)
AOSIS	0.208	0.444*	-0.056	0.045	0.230	0.882**
	(0.73)	(1.77)	(-0.23)	(0.20)	(0.93)	(2.41)
BASIC	-0.010	-0.034	0.537**	0.001	0.258	0.212
	(-0.04)	(-0.17)	(2.28)	(0.00)	(1.22)	(0.88)
EU	0.279	-0.105	-0.397**	-0.546***	0.187	-0.001
	(1.47)	(-0.64)	(-2.41)	(-3.21)	(1.10)	(-0.01)
Observations	404					
chi2	211.690					

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust z-statistics in parentheses.

Table 3.5: Parameter estimates of multivariate ordered probit model focusing on **vulnerability** as explanatory variables, determinants of importance of components, dependent variables: "Degree of Importance".

	Global	Sector	R&D	Geoeng	Land-Use	Adaptation
Very neg. conseq.	0.577*** (3.20)	0.266* (1.85)	0.396** (2.56)	0.244* (1.77)	0.203 (1.36)	0.320* (1.86)
Positive conseq.	-0.719** (-2.54)	0.133 (0.49)	0.446 (1.47)	0.756*** (2.78)	-0.071 (-0.25)	-0.451 (-1.57)
GDP Capita	-0.024 (-0.35)	-0.026 (-0.46)	-0.102* (-1.76)	-0.212*** (-3.71)	0.000 (0.00)	-0.148** (-2.45)
GDP Total	-0.043 (-1.61)	-0.011 (-0.47)	0.007 (0.28)	-0.064** (-2.41)	-0.074*** (-3.03)	0.012 (0.45)
GHG Capita	-0.007 (-0.43)	-0.025** (-2.03)	-0.014 (-1.07)	0.016 (1.30)	-0.038*** (-2.95)	-0.027* (-1.96)
AOSIS	-0.186 (-0.65)	0.502* (1.89)	-0.256 (-1.02)	-0.066 (-0.29)	0.111 (0.44)	0.770** (2.03)
BASIC	-0.146 (-0.62)	-0.087 (-0.43)	0.430* (1.79)	0.151 (0.74)	0.387* (1.74)	0.106 (0.43)
EU	0.207 (1.09)	-0.128 (-0.78)	-0.446*** (-2.68)	-0.595*** (-3.51)	0.170 (1.00)	-0.042 (-0.25)
Observations	384					
chi2	226.944					

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust z-statistics in parentheses.

think that the larger sample sizes justify the different models in addition to the comprehensive model with all variables. The omission of a table focusing on democracy and governance already forecloses that we cannot find any significant effect of democracy and governance on the importance of the components. For completeness, we include three models in the Appendix (Tables 3.14-3.16) that do not show any meaningful effect. In view of the existing literature (Neumayer, 2002), this contradicts previous results that have found a correlation between democracy, freedom, and governance and environmental commitments. Consequently, these variables are dropped and not included in the estimation of the other models of this section, including the comprehensive model that includes all other explanatory models.[14] All models include regional dummies to account for heterogeneity among the participants and regional effects.

[14]Including any of the democracy variables does not change our results and the sample size would be slightly reduced. Therefore, the inclusion would enlarge the tables at no added insight.

Both Tables 3.4 and 3.7 demonstrate that more fairness prone respondents are much more likely to consider global targets to be important ($p < 0.01$) but also sector targets and R&D ($p < 0.05$). One reason for this positive impact might be the stronger spillover nature of these components implying larger global benefits, which would represent efficiency concerns among those respondents. The effect is very robust for the different sample sizes of 404 and 359. In line with Lange et al. (2007, 2010), we supply further evidence for the importance of fairness in international climate negotiations.

Looking at the estimates for both indicators of vulnerability, we see that the impact of vulnerability is at times twofold. The expectation of very negative consequences for ones' home country has a strong, significantly positive effect on global targets across models and specifications ($p < 0.01$). There are weaker effects on the other components except on R&D, which is more robust than on the others. Surprisingly, the effect on adaptation is rather weak and only $p < 0.10$ significant. In contrast, positive expectations about the consequences of climate change decrease the acceptance of global targets and strongly increase the acceptance of geoengineering. The effects on global targets can be explained with self interest but the positive effect on geoengi-

Table 3.6: Parameter estimates of multivariate ordered probit model focusing on **macro indicators** as explanatory variables, determinants of importance of components, dependent variables: "Degree of Importance".

	Global	Sector	R&D	Geoeng	Land-Use	Adaptation
GDP Capita	-0.044	-0.044	-0.139**	-0.236***	-0.006	-0.166***
	(-0.71)	(-0.82)	(-2.52)	(-4.32)	(-0.11)	(-2.92)
GDP Total	-0.048*	-0.022	-0.004	-0.074***	-0.061***	0.018
	(-1.94)	(-0.98)	(-0.19)	(-2.86)	(-2.64)	(0.71)
GHG Capita	-0.011	-0.025**	-0.015	0.015	-0.036***	-0.023
	(-0.70)	(-2.06)	(-1.16)	(1.23)	(-2.85)	(-1.64)
AOSIS	0.157	0.444*	-0.019	0.161	0.304	0.981***
	(0.60)	(1.93)	(-0.08)	(0.79)	(1.32)	(2.75)
BASIC	-0.079	-0.030	0.386*	0.021	0.317	0.150
	(-0.36)	(-0.16)	(1.72)	(0.11)	(1.53)	(0.65)
EU	0.151	-0.116	-0.404**	-0.590***	0.122	-0.044
	(0.83)	(-0.73)	(-2.51)	(-3.56)	(0.74)	(-0.27)
Observations	431					
chi2	197.452					

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust z-statistics in parentheses.

Table 3.7: Parameter estimates of multivariate ordered probit model with **all explanatory variables**, determinants of importance of components, dependent variables: "Degree of Importance".

	Global	Sector	R&D	Geoeng	Land-Use	Adaptation
Fairness	0.550***	0.301**	0.266**	0.035	0.163	0.184
	(3.73)	(2.47)	(2.09)	(0.29)	(1.29)	(1.35)
Very neg. conseq.	0.519***	0.194	0.357**	0.260*	0.265*	0.262
	(2.76)	(1.29)	(2.25)	(1.82)	(1.71)	(1.49)
Positive conseq.	-0.624**	0.161	0.503*	0.756***	-0.043	-0.434
	(-2.15)	(0.58)	(1.66)	(2.76)	(-0.15)	(-1.49)
GDP Capita	-0.021	-0.031	-0.079	-0.203***	0.010	-0.153**
	(-0.31)	(-0.53)	(-1.33)	(-3.47)	(0.17)	(-2.48)
GDP Total	-0.049*	-0.004	0.001	-0.072***	-0.082***	0.007
	(-1.78)	(-0.17)	(0.05)	(-2.61)	(-3.28)	(0.27)
GHG Capita	-0.008	-0.026**	-0.013	0.017	-0.038***	-0.025*
	(-0.51)	(-2.07)	(-0.99)	(1.35)	(-2.91)	(-1.77)
AOSIS	-0.139	0.494*	-0.222	-0.107	0.068	0.714*
	(-0.44)	(1.74)	(-0.85)	(-0.45)	(0.26)	(1.85)
BASIC	-0.069	-0.107	0.597**	0.141	0.337	0.167
	(-0.28)	(-0.51)	(2.36)	(0.67)	(1.48)	(0.66)
EU	0.332*	-0.116	-0.452***	-0.568***	0.237	-0.011
	(1.69)	(-0.69)	(-2.65)	(-3.27)	(1.36)	(-0.06)
Observations	359					
chi2	233.164					

Notes: * p < 0.1, ** p < 0.05, *** p < 0.01. Robust z-statistics in parentheses.

neering is rather puzzling since geoengineering would prevent the "positive consequences" of climate change. The opposing effects on global targets are worrying as they show the conflict between countries loosing and gaining from climate change.

The three variables as proxies for abatement costs and economic capacity are by and large negatively correlated with the importance of the components, which is shown by the dominance of negative estimates in all tables and no significant positive effect at all. For instance, one sees a very strong negative effect of per capita emissions on sector targets (always $p < 0.05$). Since sector targets would probably focus on high emitters, a negative attitude towards sector targets would be in those countries' self interest. The negative effect of GDP on adaptation is always $p < 0.05$ in all 4 models. This can again be explained by self interest, since funds for adaptation would have to be supported mainly by rich countries. The joint negative effect of emissions and total GDP on land use reflects the unwillingness to finance land use and reforestation projects in developing countries. The negative effect on geoengineering is harder to explain and possibly shows a risk aversion of rich countries towards the risky prospects of geoengineering. Generally, the negative correlation of the macro indicators seems to resonate the reluctance of the developed (rich) countries to pay for the components in question, showing a huge divide between the developed and developing countries.

To test for a quadratic relationship between GDP or per capita emissions and the importance of the components, we include quadratic effects for each macro indicator in the base line models. Guided by these estimations, we estimate new models with the quadratic effects that turned out to be most significant. The base line models are the one using the macro-indicators as in Table 3.6 and the comprehensive one as in Table 3.7. We then test the Null-hypothesis of no quadratic effect in the base line model against the augmented models. We find positive quadratic effects for both models for per capita GDP on adaptation and for per capita emissions on global and sector target as well as R&D.

The joint inclusion of these quadratic effects is statistically significant at $p < 0.01$ compared to the macro-indicator model and at $p < 0.05$ compared to the comprehensive model. Due to the large number of permutations of quadratic effects, the results are ambiguous as there are many different specifications. The positive signs of the quadratic estimates of per capita GDP on adaptation and per capita emissions for global and sector targets and R&D does indicate a possible quadratic relationship. This means that very rich and polluting states do in fact consider some of the components more important than the middle income countries which are striving for more economic growth. In line with the EKC idea more polluting countries consider some of the components more important, which we would not have recognized if we only looked at the linear specifications.

We complete our analysis by discussing the effects of the regional control indicators. We observe a strong rejection of R&D and geoengineering by the European Union. The strong rejection of R&D by the EU highlights the problematic nature of knowledge diffusion in the context of climate change and the reluctance or inability of the EU to force European companies to give up their patents. Respondents from AOSIS are more likely to think that sector targets ($p < 0.05$ and $p < 0.10$) and adaptation (mostly $p < 0.01$) are very important. Notably, there are neither positive nor negative impacts on global targets and land use, which can be seen as an indication for the prevalence of global target and the recent advances in land use in climate negotiations.

To sum up, our econometric analysis identifies several factors that influence the acceptance of the components of an architecture of an international climate agreement. From an optimistic perspective, global targets are generally the most accepted component and endorsed by fairness prone and vulnerable participants but disliked by unaffected participants. Some evidence suggests a quadratic influence of some of the macro indicators, most likely per capita emissions. Pessimistically, the divergence between the developed and developing countries and the further rejection of R&D by the EU stick out. Further climate negotiations have to overcome those problems.

Table 3.8: Parameter estimates of multivariate binary probit model across components for **AOSIS**, determinants of leadership roles, dependent variables: "Leadership role".

	Global	Sector	R&D	Geoeng	Land-Use	Adaptation
Fairness	0.080	-0.005	0.178	-0.091	0.117	-0.011
	(0.58)	(-0.03)	(1.27)	(-0.43)	(0.83)	(-0.07)
Component very imp.	0.352**	0.443***	0.230	0.619***	0.396***	0.096
	(2.50)	(3.27)	(1.62)	(2.96)	(2.95)	(0.63)
GDP Capita	0.143***	0.015	-0.069	-0.236*	-0.108*	0.009
	(2.78)	(0.27)	(-1.20)	(-1.72)	(-1.92)	(0.16)
AOSIS	2.247***	1.394***	0.994***	0.920***	1.014***	0.000
	(4.70)	(4.63)	(3.60)	(2.64)	(3.69)	(.)
BASIC	0.190	-0.044	0.001	-0.165	-0.466*	0.068
	(0.83)	(-0.16)	(0.00)	(-0.44)	(-1.75)	(0.29)
EU	0.571***	0.345	0.177	-0.158	0.103	0.734***
	(2.90)	(1.59)	(0.82)	(-0.28)	(0.47)	(3.31)
Observations	397					
chi2	165.455					

Notes: * p < 0.1, ** p < 0.05, *** p < 0.01. Robust z-statistics in parentheses.

Table 3.9: Parameter estimates of multivariate binary probit model across components for **BASI**, determinants of leadership roles, dependent variables: "Leadership role".

	Global	Sector	R&D	Geoeng	Land-Use	Adaptation
Fairness	0.448*** (3.13)	0.297* (1.95)	0.237* (1.77)	0.252 (1.30)	0.135 (1.00)	0.070 (0.52)
Component very imp.	0.013 (0.09)	0.409*** (2.84)	-0.031 (-0.22)	0.841*** (3.79)	-0.093 (-0.72)	-0.056 (-0.39)
GDP Capita	-0.225*** (-3.31)	-0.116* (-1.75)	-0.045 (-0.89)	-0.101 (-1.07)	-0.110** (-2.16)	-0.128** (-2.34)
AOSIS	-0.264 (-0.97)	-0.064 (-0.23)	-0.225 (-0.83)	-0.262 (-0.65)	-0.045 (-0.17)	-0.167 (-0.66)
BASIC	0.546** (2.49)	0.534** (2.27)	0.280 (1.23)	0.226 (0.76)	0.614** (2.39)	0.276 (1.19)
EU	-0.031 (-0.12)	0.001 (0.01)	0.686*** (3.48)	-0.120 (-0.33)	0.443** (2.26)	0.371* (1.86)
Observations	397					
chi2	113.333					

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust z-statistics in parentheses.

3.6.2 Leadership Role

In the following, we analyze the determinants of the expected leading roles of countries for different components. Since the 36 dependent variables are binary, we use multivariate binary probit models to analyze these factors. We estimate across regions and components to take account of correlations among the items in both directions, but already note that results remain very similar in both specifications.

We present six tables of models where we estimate across components for each region in this section and refer to 6 similar tables of models across regions for each component in the Appendix (Tables 3.17-3.22). The models include the fairness indicator, the component importance, per capita GDP, and the three regional indicators as regressors. We exclude the vulnerability indicators as they show almost no significant effect at all. The lack of noteworthy results and the loss of 45 observations do not justify the inclusion, so we drop this variable[15].

[15] Although we did not find any effect for vulnerability when it is included in the sample, we cannot rule out an possible effect of vulnerability or an omitted variable bias when we include the 45 observations of which we lack the self assessed statements.

Table 3.10: Parameter estimates of multivariate binary probit model across components for **China**, determinants of leadership roles, dependent variables: "Leadership role".

	Global	Sector	R&D	Geoeng	Land-Use	Adaptation
Fairness	0.341**	0.212	0.207	0.196	-0.077	0.134
	(2.44)	(1.51)	(1.55)	(1.21)	(-0.54)	(0.98)
Component very imp.	-0.050	0.136	0.004	0.545***	0.163	0.280**
	(-0.38)	(1.17)	(0.03)	(2.84)	(1.27)	(1.99)
GDP Capita	-0.156***	-0.067	-0.024	0.058	-0.077	-0.037
	(-2.77)	(-1.26)	(-0.48)	(0.96)	(-1.37)	(-0.68)
AOSIS	-0.768***	-0.290	-0.378	-0.367	-0.289	-0.673**
	(-2.74)	(-1.05)	(-1.37)	(-1.00)	(-1.01)	(-2.28)
BASIC	-0.282	-0.021	-0.029	-0.347	-0.292	-0.184
	(-1.26)	(-0.09)	(-0.13)	(-1.19)	(-1.17)	(-0.77)
EU	-0.642***	-0.258	0.651***	-0.419	-0.254	0.013
	(-2.83)	(-1.19)	(3.31)	(-1.62)	(-1.15)	(0.06)
Observations	397					
chi2	104.080					

Notes: * p < 0.1, ** p < 0.05, *** p < 0.01. Robust z-statistics in parentheses.

It is rather intuitive that respondents that find a component very important also expect countries to take a leading role in this component. Therefore, we included this an binary indicator to avoid an omitted variables bias. The effect is strongest for the role of AOSIS, but is also visible for BASI, China, and EU, where this effect come ups for sector targets and geoengineering and for the EU in land use. It seems that these respondents do not particularly expect anything from the USA and otherwise rarely expect that no country takes a leading role.

The importance of fairness for an ICA increases expectations on a leading role for global targets and R&D for some countries or group of countries. The increased likelihood to expect a leading role especially from BASI and USA ($p < 0.01$) and China ($p < 0.05$) for global targets shows the normative bias discussed in Section 3.3 (see Tables 3.9, 3.10, and 3.12). The fact that there is no effect on a leading role of the EU for global targets seems justified as the EU has been pushing this component staying in line with normative expectations. On the other side, Table 3.11 shows that fairness prone respondents expect to see more responsibility by the EU for R&D ($p < 0.05$). Our results are a sign of unreasonable expectations about certain countries. It would

Table 3.11: Parameter estimates of multivariate binary probit model across components for **EU**, determinants of leadership roles, dependent variables: ”Leadership role”.

	Global	Sector	R&D	Geoeng	Land-Use	Adaptation
Fairness	0.099 (0.63)	-0.070 (-0.48)	0.304** (2.27)	0.036 (0.22)	0.019 (0.14)	0.031 (0.24)
Component very imp.	0.230 (1.45)	0.379*** (2.82)	-0.008 (-0.06)	0.360* (1.80)	0.293** (2.29)	0.051 (0.36)
GDP Capita	0.110* (1.78)	0.001 (0.02)	-0.067 (-1.33)	-0.158** (-2.50)	-0.024 (-0.48)	0.036 (0.67)
AOSIS	-0.288 (-1.06)	-0.776*** (-2.82)	-0.341 (-1.25)	-0.354 (-1.02)	-0.780*** (-2.91)	0.211 (0.82)
BASIC	0.096 (0.38)	-0.056 (-0.23)	-0.132 (-0.57)	-0.344 (-1.30)	-0.199 (-0.87)	0.150 (0.66)
EU	0.320 (1.30)	-0.094 (-0.44)	-0.311 (-1.60)	-0.408 (-1.60)	0.296 (1.48)	0.015 (0.08)
Observations	397					
chi2	101.004					

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust z-statistics in parentheses.

become problematic if those expectations held up an agreement when “fair” negotiators feel that the big players do not live up to their moral obligation and it is indeed the case that the normative expectations are stronger on the big players.

In line with the negative effects of economic capacity on the importance of the components, respondents from rich countries are more likely to expect that no country will take a leading role for sector targets, R&D, and geoengineering. They do expect AOSIS to take a leading role in global targets, but do not expect BASI or China to do so. The mostly negative relation is also shown by the negative impact on the leading role of BASI in adaptation, of USA in land use, and of EU in geoengineering.

Looking at the effects of the regional indicators, it is unfortunate that the sample does not contain enough observations of the respective groups to better analyze contradicting expectations of the five selected countries or groups of countries. Respondents from AOSIS tend to see themselves taking a leading role in all components but geoengineering (Table 3.8). It even goes to the point that all respondents from AOSIS think that AOSIS will take a leading role in adaptation, so that we had to omit this regressor. This seems

Table 3.12: Parameter estimates of multivariate binary probit model across components for **USA**, determinants of leadership roles, dependent variables: "Leadership role".

	Global	Sector	R&D	Geoeng	Land-Use	Adaptation
Fairness	0.416***	0.266*	0.078	0.146	0.142	0.144
	(2.89)	(1.86)	(0.59)	(0.93)	(0.99)	(1.01)
Component very imp.	-0.057	0.161	0.095	-0.123	-0.202	0.102
	(-0.47)	(1.45)	(0.77)	(-0.61)	(-1.50)	(0.68)
GDP Capita	-0.047	-0.079	0.027	-0.039	-0.125**	-0.002
	(-0.85)	(-1.42)	(0.54)	(-0.65)	(-2.02)	(-0.03)
AOSIS	-0.809**	-0.434	-0.386	-0.283	-0.092	-0.336
	(-2.51)	(-1.51)	(-1.42)	(-0.80)	(-0.33)	(-1.17)
BASIC	-0.231	-0.076	-0.360	-0.008	-0.189	0.138
	(-1.00)	(-0.33)	(-1.58)	(-0.03)	(-0.72)	(0.57)
EU	-0.756***	-0.652***	-0.495**	0.328	0.225	-0.338
	(-3.33)	(-2.85)	(-2.54)	(1.37)	(1.00)	(-1.51)
Observations	397					
chi2	68.349					

Notes: * p < 0.1, ** p < 0.05, *** p < 0.01. Robust z-statistics in parentheses.

a bit over-optimistic and driven by the necessity of progress in all components especially adaptation. On the other hand, they do not particularly expect BASI to take any leading role and they are even less likely to think that China takes a leading role in global targets ($p < 0.01$). They do not expect the EU to take a leading role in sector targets or land use and do not think that the USA will take a leading role in global targets ($p < 0.05$). None of the AOSIS representatives thinks that no country will take a leading role, as this perfectly predicts failure in the models. For this reason and due to computational problems we have to drop the regional variables for region "None".

The BASIC representatives also expect their own group to take a leading role in global and sector targets (both $p < 0.05$). Besides this, there is no real bias for BASIC representatives and they do not show any special focus on components or countries.

EU respondents think that AOSIS will play a leading role for global targets and land use and also expect BASI and China to take a leading role in R&D but do not see a leading role for China in global sector targets. Considering their own position, we only see a negative effect on geoengineering in the models across regions (Table 3.20). They expect very little of the USA as the strong negative effects on global and sector targets and R&D shows.

Table 3.13: Parameter estimates of multivariate binary probit model across components for **None**, determinants of leadership roles, dependent variables: "Leadership role".

	Global	Sector	R&D	Geoeng	Land-Use	Adaptation
Fairness	-0.046	0.154	-0.329	0.167	-0.056	0.012
	(-0.14)	(0.69)	(-1.18)	(0.82)	(-0.27)	(0.06)
Component very imp.	-0.161	-0.679***	0.147	-0.759**	-0.349*	-0.150
	(-0.48)	(-2.70)	(0.53)	(-2.16)	(-1.70)	(-0.68)
GDP Capita	0.046	0.216***	0.229***	0.149***	0.052	0.066
	(0.51)	(3.51)	(3.25)	(2.60)	(0.86)	(1.07)
Observations	385					
chi2	46.979					

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust z-statistics in parentheses.

Note: We omit AOSIS as it is a perfect predictor of failure and for computational reasons BASIC and EU as well.

In summary, the normative bias shows how fairness matters for international climate conferences. Unreasonable expectation could hold up agreements, when negotiators feel that some countries or group of countries do not live up to what they should do. GDP does matter but mostly in a negative way. Respondents from rich countries are usually less likely to expect a leading role and more likely to expect none of the five players to play a leading role. Due to a lack of data we can not satisfactorily explore the regional structure of expectations. If we had regional indicators for all five players we could maybe find some contradictions in expectations.

3.7 Conclusion

The intention of this paper is to identify the determinants of the acceptance of different components of climate architectures for an international climate agreement. Based on data of an international on-line survey we are able to analyze the following determinants: Fairness, vulnerability, abatement costs & economic capacity, and freedom & governance.

The focus of current negotiations on global targets appears justified since it is the most accepted and undisputed component according to our sample. This is shown by the highest acceptance rate and second highest average expected leading role. There is no direct negative impact of economic indicators and rather a U-shaped relation of emissions. Adaptation seems to be the second most popular component but with less support from developed countries. The disagreement of participants on the importance of geoengineering should motivate further inquiries as its use might be inevitable.

Our results underline that fairness plays an important role for international climate negotiations. Not only do fairness concerns increase the acceptance of global and sector targets and R&D, they also raise expectations that important players take a leading role. This normative bias is shown by the increased likelihood to expect BASI, China, and USA to play a leading role for global targets and less strongly for sector targets. Additionally, the EU should take a leading role for R&D, although EU representatives dislike this component.

Looking at the opposing effect of vulnerability on global targets, contrasting expectations about future damages of climate change could complicate finding an agreement based on this component. It is rather surprising that vulnerability does not strongly influence the perception of components. The issue of vulnerability and compensating vulnerable countries came up during COP 19 in Warsaw and the tragic events caused by the typhoon in the Philippines. Since our data was collected before this, the results could be different now. Nevertheless the effect is positive for the two components that promise to be most efficient in reducing emissions: Global targets and R&D.

The stark economic divide between rich and poor countries is troublesome, although some evidence of a U-shaped relation indicates that very polluting countries do in fact find some components more important than less polluting countries. Taking account of those differences is essential to reach an agreement.

The descriptive results of the leadership roles show that the EU is seen as a leader for most components while only little is expected from China and the USA. While we find some distinctive regional effects, per capita GDP does not play a big role and vulnerability matters even less. Unfortunately, the exploration of regional effects lacked enough participants from China and USA to get a more elaborate picture. More assessments about negotiators' motives and attitudes could be helpful to further explain their preferences.

The proposition that more democratic or free countries are more keen about environmental issues and hence the components could not be substantiated, as we almost find no evidence for this. This means that increasing democratization would no necessarily go hand in hand with an increased awareness or appreciation of environmental issues.

This empirical analysis of the six most discussed components of climate architectures helps to clarify the different viewpoints of stakeholders in international climate negotiations. One could explore further how cultural factors might influence the preference on the components. Future research could also explore the trade-offs of the different components and how stakeholders rank them.

3.8 Appendix

As mentioned in Section 3.4, we created a PDF version of the questionnaire. To provide the exact wording of the questions that were used to obtain the dependent and explanatory variables, we present question A.4 on the vulnerability and question E.1 about the importance of fairness for an international climate agreement

Question A.4

How would you assess the consequences of climate change on future living conditions up to 2100 in the following countries or groups of countries?

Countries or groups of countries	Very negative	Negative	Neither negative nor positive	Positive	Don’t know
AOSIS	O	O	O	O	O
BASIC without China	O	O	O	O	O
China	O	O	O	O	O
EU	O	O	O	O	O
USA	O	O	O	O	O

Your home country (if your home country is China or USA, please indicate same assessment as above)	O	O	O	O	O

Question E.1

How important do you think equity issues for distributing GHG emissions reduction targets between countries are in an international climate agreement?

Very important	Important	Moderately im-portant	Not important	Don’t know
O	O	O	O	O

We also include part C of the questionnaire that includes questions C.1 and C.2 about the different components of climate architectures.

Part C
Issues in current international climate negotiations

This part considers your personal assessment of the following issues in current international climate negotiations: Comprehensive quantitative targets for a reduction in global GHG emissions, quantitative GHG emission reduction targets for individual economic sectors, R&D and technology transfer, geo-engineering, land-use change and reforestation, and adaptation measures.

Question C.1

How important do you think it is to include the following issues in current international climate change negotiations?

Issues	Very important	Important	Moderately important	Not important	Don't know
Comprehensive quantitative targets for a reduction in global GHG emissions	O	O	O	O	O
Quantitative GHG emission reduction targets for individual economic sectors	O	O	O	O	O
R&D and technology transfer	O	O	O	O	O
Geo-engineering	O	O	O	O	O
Land-use change and reforestation	O	O	O	O	O
Adaptation measures	O	O	O	O	O

Question C.2

Which of the following countries or groups of countries do you think play a leading role in having the following issues included in current international climate negotiations? Multiple answers are possible.

Issues	AOSIS	BASIC without China	China	EU	USA	None of these five countries or groups of countries	Don't know
Comprehensive quantitative targets for a reduction in global GHG emissions	O	O	O	O	O	O	O
Quantitative GHG emission reduction targets for individual economic sectors or single GHG	O	O	O	O	O	O	O
R&D and technology transfer	O	O	O	O	O	O	O
Geo-engineering	O	O	O	O	O	O	O
Land-use change and reforestation	O	O	O	O	O	O	O
Adaptation measures	O	O	O	O	O	O	O

3.8.1 Democracy and Governance

Table 3.14: Parameter estimates of multivariate ordered probit model focusing on **democracy score** as an explanatory variable, determinants of importance of policies, dependent variables: "Degree of Importance".

	Global	Sector	R&D	Geoeng	Land-Use	Adaptation
Democracy Index	-0.098 (-1.61)	0.010 (0.20)	-0.018 (-0.33)	0.043 (0.89)	-0.054 (-1.03)	-0.051 (-0.88)
GDP capita	0.069 (0.71)	-0.042 (-0.51)	-0.133 (-1.59)	-0.321*** (-3.94)	0.051 (0.61)	-0.118 (-1.36)
GDP total	-0.098*** (-2.82)	-0.071** (-2.21)	-0.020 (-0.60)	-0.096*** (-2.69)	-0.103*** (-3.11)	-0.015 (-0.45)
CO_2 capita	-0.008 (-0.40)	-0.014 (-0.99)	-0.010 (-0.66)	0.034** (2.30)	-0.035** (-2.34)	-0.026* (-1.67)
AOSIS	4.972 (0.01)	0.451 (0.68)	0.178 (0.25)	0.282 (0.49)	5.592 (0.01)	-0.234 (-0.35)
BASIC	0.151 (0.61)	0.024 (0.11)	0.426* (1.71)	-0.043 (-0.20)	0.469** (2.01)	0.249 (0.97)
EU	0.140 (0.74)	-0.223 (-1.34)	-0.390** (-2.34)	-0.615*** (-3.59)	0.116 (0.68)	-0.057 (-0.34)
Observations	392					
chi2	187.662					

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust z-statistics in parentheses.

Table 3.15: Parameter estimates of multivariate ordered probit model focusing on **governance index** as an explanatory variable, determinants of importance of policies, dependent variables: "Degree of Importance".

	Global	Sector	R&D	Geoeng	Land-Use	Adaptation
Governance Index	-0.062 (-0.47)	0.187* (1.67)	-0.009 (-0.07)	0.038 (0.35)	0.018 (0.15)	0.087 (0.66)
GDP Capita	-0.010 (-0.11)	-0.136* (-1.77)	-0.133* (-1.66)	-0.250*** (-3.26)	-0.015 (-0.19)	-0.210** (-2.45)
GDP Total	-0.051** (-2.01)	-0.015 (-0.63)	-0.004 (-0.18)	-0.073*** (-2.77)	-0.060** (-2.57)	0.021 (0.78)
GHG Capita	-0.012 (-0.77)	-0.019 (-1.49)	-0.016 (-1.17)	0.016 (1.21)	-0.036*** (-2.70)	-0.020 (-1.41)
AOSIS	0.203 (0.73)	0.306 (1.25)	-0.016 (-0.06)	0.130 (0.59)	0.285 (1.15)	0.900** (2.44)
EU	0.179 (0.93)	-0.213 (-1.25)	-0.402** (-2.35)	-0.611*** (-3.51)	0.110 (0.63)	-0.091 (-0.51)
BASIC	-0.037 (-0.16)	-0.156 (-0.75)	0.391 (1.64)	0.001 (0.01)	0.300 (1.36)	0.078 (0.32)
Observations	428					
chi2	200.149					

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust z-statistics in parentheses.

Table 3.16: Parameter estimates of multivariate ordered probit model focusing on **freedom house indicators** as explanatory variables, determinants of importance of policies, dependent variables: "Degree of Importance".

	Global	Sector	R&D	Geoeng	Land-Use	Adaptation
Democracy Index						
GDP Capita	-0.005	-0.120*	-0.157**	-0.294***	-0.043	-0.162**
	(-0.07)	(-1.84)	(-2.35)	(-4.46)	(-0.64)	(-2.35)
GDP Total	-0.050**	-0.019	-0.003	-0.074***	-0.063***	0.022
	(-2.00)	(-0.84)	(-0.14)	(-2.81)	(-2.68)	(0.86)
GHG Capita	-0.008	-0.017	-0.014	0.023	-0.036**	-0.019
	(-0.48)	(-1.24)	(-0.96)	(1.64)	(-2.55)	(-1.30)
AOSIS	0.536*	0.500*	-0.106	0.139	0.268	0.867**
	(1.65)	(1.81)	(-0.40)	(0.59)	(0.99)	(2.33)
BASIC	0.071	-0.243	0.337	-0.139	0.156	0.237
	(0.28)	(-1.09)	(1.34)	(-0.63)	(0.66)	(0.90)
EU	0.229	-0.208	-0.431**	-0.652***	0.047	-0.014
	(1.20)	(-1.24)	(-2.54)	(-3.76)	(0.27)	(-0.08)
Free	-0.188	0.293	0.170	0.140	0.024	0.286
	(-0.76)	(1.36)	(0.73)	(0.66)	(0.10)	(1.19)
Partly Free	0.109	-0.033	0.111	-0.113	-0.281	0.585***
	(0.49)	(-0.17)	(0.55)	(-0.61)	(-1.41)	(2.71)
Observations	426					
chi2	220.781					

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust z-statistics in parentheses.

3.8.2 Leadership Role

The following tables are models estimated across regions for each policy. We omit the equation for region "none" as its error term would be too highly correlated with the others which would lead to computational problems during the estimation.

Table 3.17: Parameter estimates of multivariate binary probit model across regions for **global targets**, determinants of leadership roles, dependent variables: "Leadership role".

	Aosis	BASI	China	EU	USA
Fairness	0.126	0.417***	0.342**	0.197	0.385***
	(0.91)	(2.89)	(2.40)	(1.25)	(2.66)
Component very imp.	0.349**	0.083	-0.093	0.120	-0.163
	(2.21)	(0.49)	(-0.57)	(0.67)	(-0.99)
GDP Capita	0.130**	-0.236***	-0.172***	0.109*	-0.072
	(2.54)	(-3.35)	(-2.99)	(1.70)	(-1.32)
AOSIS	2.171***	-0.235	-0.792***	-0.318	-0.764**
	(4.56)	(-0.87)	(-2.80)	(-1.19)	(-2.45)
BASIC	0.189	0.581**	-0.279	0.094	-0.249
	(0.84)	(2.57)	(-1.26)	(0.37)	(-1.09)
EU	0.618***	-0.028	-0.745***	0.390	-0.896***
	(3.12)	(-0.11)	(-3.12)	(1.50)	(-3.69)
Observations	383				
chi2	174.571				

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust z-statistics in parentheses.

Table 3.18: Parameter estimates of multivariate binary probit model across regions for **sector targets**, determinants of leadership roles, dependent variables: "Leadership role".

	Aosis	BASI	China	EU	USA
Fairness	-0.041	0.275*	0.231	-0.015	0.304**
	(-0.27)	(1.78)	(1.59)	(-0.10)	(2.09)
Component very imp.	0.512***	0.621***	0.312**	0.284*	0.151
	(3.33)	(3.95)	(2.12)	(1.87)	(1.02)
GDP Capita	0.016	-0.118*	-0.076	0.004	-0.093*
	(0.29)	(-1.78)	(-1.32)	(0.06)	(-1.65)
AOSIS	1.394***	-0.086	-0.400	-0.694**	-0.458
	(4.63)	(-0.29)	(-1.37)	(-2.54)	(-1.58)
BASIC	0.041	0.587**	0.042	-0.103	-0.019
	(0.16)	(2.45)	(0.18)	(-0.42)	(-0.09)
EU	0.296	-0.035	-0.293	-0.122	-0.703***
	(1.34)	(-0.13)	(-1.28)	(-0.55)	(-2.94)
Observations	340				
chi2	112.653				

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust z-statistics in parentheses.

Table 3.19: Parameter estimates of multivariate binary probit model across regions for **R&D**, determinants of leadership roles, dependent variables: "Leadership role".

	Aosis	BASI	China	EU	USA
Fairness	0.195	0.230*	0.225*	0.315**	0.022
	(1.38)	(1.72)	(1.67)	(2.34)	(0.16)
Component very imp.	0.243	0.028	0.065	0.086	0.206
	(1.59)	(0.19)	(0.46)	(0.60)	(1.46)
GDP Capita	-0.085	-0.045	-0.017	-0.061	0.028
	(-1.45)	(-0.86)	(-0.34)	(-1.21)	(0.56)
AOSIS	0.923***	-0.092	-0.321	-0.343	-0.313
	(3.49)	(-0.36)	(-1.20)	(-1.32)	(-1.18)
BASIC	-0.026	0.200	-0.026	-0.140	-0.352
	(-0.11)	(0.85)	(-0.12)	(-0.62)	(-1.57)
EU	0.227	0.718***	0.701***	-0.290	-0.462**
	(1.04)	(3.56)	(3.46)	(-1.50)	(-2.38)
Observations	374				
chi2	89.124				

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust z-statistics in parentheses.

Table 3.20: Parameter estimates of multivariate binary probit model across regions for **geoengineering**, determinants of leadership roles, dependent variables: "Leadership role".

	Aosis	BASI	China	EU	USA
Fairness	-0.109	0.256	0.225	0.048	0.184
	(-0.48)	(1.33)	(1.31)	(0.29)	(1.15)
Component very imp.	0.899***	0.830***	0.509**	0.353*	-0.233
	(3.82)	(3.79)	(2.42)	(1.65)	(-1.12)
GDP Capita	-0.246	-0.091	0.078	-0.172***	-0.021
	(-1.56)	(-1.00)	(1.16)	(-2.65)	(-0.32)
AOSIS	0.916***	0.037	-0.237	-0.314	-0.255
	(2.70)	(0.11)	(-0.63)	(-0.90)	(-0.71)
BASIC	-0.112	0.262	-0.336	-0.291	-0.009
	(-0.30)	(0.84)	(-1.10)	(-1.07)	(-0.03)
EU	-0.270	-0.273	-0.610**	-0.525**	0.211
	(-0.44)	(-0.74)	(-2.19)	(-1.99)	(0.84)
Observations	256				
chi2	102.870				

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust z-statistics in parentheses.

Table 3.21: Parameter estimates of multivariate binary probit model across regions for **land use**, determinants of leadership roles, dependent variables: "Leadership role".

	Aosis	BASI	China	EU	USA
Fairness	0.091	0.114	-0.062	0.035	0.090
	(0.64)	(0.84)	(-0.42)	(0.26)	(0.62)
Component very imp.	0.442***	-0.062	0.158	0.318**	-0.167
	(3.05)	(-0.45)	(1.07)	(2.33)	(-1.16)
GDP Capita	-0.113**	-0.117**	-0.102*	-0.019	-0.118**
	(-1.98)	(-2.25)	(-1.69)	(-0.38)	(-2.01)
AOSIS	0.961***	-0.054	-0.219	-0.779***	-0.123
	(3.58)	(-0.21)	(-0.80)	(-2.91)	(-0.43)
BASIC	-0.397	0.667**	-0.272	-0.189	-0.169
	(-1.53)	(2.58)	(-1.06)	(-0.81)	(-0.67)
EU	0.105	0.460**	-0.226	0.292	0.153
	(0.48)	(2.31)	(-0.98)	(1.48)	(0.71)
Observations	363				
chi2	95.369				

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust z-statistics in parentheses.

Table 3.22: Parameter estimates of multivariate binary probit model across regions for **adaptation**, determinants of leadership roles, dependent variables: "Leadership role".

	Aosis	BASI	China	EU	USA
Fairness	0.069	0.073	0.118	0.027	0.112
	(0.47)	(0.55)	(0.86)	(0.20)	(0.78)
Component very imp.	0.179	0.015	0.189	0.111	0.064
	(1.06)	(0.10)	(1.21)	(0.73)	(0.39)
GDP Capita	0.009	-0.129**	-0.059	0.043	-0.002
	(0.16)	(-2.25)	(-1.07)	(0.82)	(-0.03)
AOSIS	0.000	-0.198	-0.813***	0.197	-0.445
	(.)	(-0.77)	(-2.60)	(0.76)	(-1.46)
BASIC	0.057	0.336	-0.190	0.160	0.194
	(0.24)	(1.44)	(-0.82)	(0.70)	(0.84)
EU	0.774***	0.413**	-0.043	0.006	-0.377*
	(3.46)	(2.00)	(-0.20)	(0.03)	(-1.76)
Observations	366				
chi2	54.610				

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust z-statistics in parentheses.

Chapter 4

Inequality Aversion in an International Permit Market*

We analyze how inequality aversion influences the outcome of a non cooperative permit market (Helm (2003)). In such a permit market, countries strategically issue permits which endogenously determines the total amount of permits. Empirical evidence suggests that inequality aversion as in Fehr and Schmidt (1999) matters for social welfare analysis and international climate negotiations. Therefore, we incorporate inequality aversion into the social welfare function of countries to analyze how this affects the total amount of permits in equilibrium. The incentives to issue more permits for poor countries can outweigh the incentives for rich countries to revoke permits. We consider two cases: Inequality aversion with respect to permits or social welfare. In the first case, the total amount of permits increases in equilibrium. In the second case, we are able to define three effects that determine how the total amount of permits changes.

*I am very grateful for help with the numerical examples and the paper provided by my colleagues Julie Ing and Andreas Schäfer.

4.1 Introduction

The integration of the principle of Common But Differentiated Responsibilities (CBDR) into the United Nations Framework Convention on Climate Change (UNFCCC) shows that inequality concerns successfully entered the first meaningful step against climate change. The developed countries conceded that they should undertake more actions since they are more responsible, due to high past emissions, and more capable, due to economic inequalities. Given the huge economic differences worldwide, inequality aversion might influence the outcome of an international environmental agreement (IEA). Concerns to reduce inequality could improve or worsen the environmental outcome.

Inequality aversion implies that countries care if they fare better or worse compared to other countries with respect to social welfare or the production or consumption of a single good. Fehr and Schmidt (1999) model inequality aversion in a simple functional form and we analyze how it affects the environmental outcome of a non cooperative permit market (Helm, 2003). A sizable amount of evidence indicates that inequality aversion plays an important role for a wide range of economic issues (Fischbacher and Gächter, 2010; Cooper and Kagel, 2009). Johansson-Stenman and Konow (2010) conclude that the behavior of private and public decision makers reflects concerns about fairness which matters for social welfare analysis. Furthermore, Posner and Weisbach (2010) and Miller (2008) believe that any successful climate agreement has to be considered as fair. Empirically, Lange et al. (2007) and Lange et al. (2010) analyze the importance of equity principles in international climate negotiations but conclude that their use can sometimes be explained with self interested motives.

We look at the first two stages of the European emission trading system as a possible example of a non cooperative permit market. According to the literature, its environmental outcome is ambiguous. Holtsmark and Sommervoll (2012) and Godal and Holtsmark (2011a) show that, under certain assumptions, the linking of national permit markets always leads to increased total emissions and welfare losses. MacKenzie (2011) analyzes the effect of sequential bargaining when permit markets are linked to find that aggregate emissions may very well go up for steep marginal damages. A more positive view is presented by a CGE simulation by Carbone et al. (2009), who find that emission reductions can sum up to about half of the first-best level and that permit trading would attract low abatement cost countries without binding targets. Gersbach and Winkler (2011) include auctioning of non grandfathered permits. The fewer permits are grandfather the closer they get to a socially optimal amount of total emissions, but they do not discuss the distribution of the permits. More pessimistically, Godal and Holtsmark (2011b) argue that if an international permit market game included domestic tax setting, one would obtain a mere redistribution of income away from the countries most affected. We add to this discussion by considering inequality aversion as a part of the welfare function of countries.

In this regard, we follow Eyckmans and Kverndokk (2010) that investigate how moral concerns about permit trading affect a non cooperative permit market. Their two main results are: 1. Reluctance to trade can have positive but also negative impacts on the total amount of emissions. 2. Moral concerns to prefer abatement at home decrease the total amount of permits. We complement their reasoning by focusing on inequality aversion as in Fehr and Schmidt (1999) which is straightforward to understand and founded on a large body of empirical and experimental evidence. For instance, Dannenberg et al. (2010) find rather strong support of inequality aversion among negotiators of climate agreements. Fischbacher and Gächter (2010) demonstrate the explanatory power of inequality aversion in public good games. Furthermore, there are countless examples in the experimental literature using inequality aversion and other regarding preferences. To mention a selective survey, we refer to Cooper and Kagel (2009). In another theoretical paper, Lange and Vogt (2003) show how inequality aversion in an emission game of homogeneous players can increase coalition size and efforts depending on the strength of the aversion.

Other examples of social preferences considering fairness or equity follow. Rabin (1993) includes beliefs about players actions towards one another in a 2-player game and players experience guilt if they behave non cooperatively. Konow (2000) discusses the concept of cognitive dissonance and models it as deviations from a given norm and what is regarded as fair by the player. Bolton and Ockenfels (2000) model distributional preferences as deviations from socially accepted distributions to explain behavior in experimental studies. Lange (2006) applies said distributional preferences in a coalition formation game and as a result the number of coalition members increases in some cases. Unfortunately, these results do not hold in general and are taken from simulations. Grüning and Peters (2010) have similar results using variance like social preferences.

The above cited work focuses on individuals and it is not necessarily true that such non standard preferences would carry over to country preferences. They could indeed represent preferences of voters or other stakeholders at home or the behavior of government officials and negotiators. We do not claim that countries have such preferences in reality but simply explore how such an example of social preferences would influences a non cooperative permit market similar to work by Nyborg (2014).

In our model, countries care how permits or social welfare are allocated among countries. Whenever a country has more or less permits or social welfare than another countries, it experiences dis-utility, but more from the latter. Due to this fact, the total amount of permits increases when permits are the reference point of the inequality aversion. Poor countries increase emissions to catch up with rich countries more than the latter relinquish emissions to reduce inequality. When the reference point is social welfare, the result is ambiguous and we identify three effects for country strategies and total emissions. A numerical examples indicates that both cases are possible depending on functional forms and parameters.

The paper continues as follows. Section 4.2 introduces the model by Helm (2003) and Section 4.3 extends the model with a general term of distributional preferences. Section 4.4 analyzes the impact of this term under the assumption of inequality aversion. Section 4.5 gives a short numerical example before Section 4.6 concludes.

4.2 Non Cooperative Permit market

This section introduces the three stage model of an IEA according to the original paper by Helm (2003). Countries play a non cooperative Nash game choosing the amount of permits instead of emissions. We assume that there are n countries ($i = 1, ..., n$) specified by a specific, concave benefit function from emitting emissions $B_i(e_i)$, with $B_i'(e_i) > 0$ and $B_i''(e_i) < 0$ and a convex damage function $D_i(E)$ with $E = \sum e_i$, which is increasing and convex in E, formally $D_i'(E)$, $D_i''(E) > 0$. In this set up, countries deal with a global public bad and have incentives to free ride hoping that other countries emit less to reduce the damages. To alleviate this problem, an international permit market following a three stage game could be created. The game setting follows:

- 1st stage: Countries decide to take part in the permit market or not. For simplicity, we assume that either all of the countries or none participate.[1]

- 2nd stage: Knowing their effect on the price and hence the demand

[1]Hence, we rule out any subset of countries forming a permit market, coexisting permit markets or not participating at all. Given that there are several real world examples like the European emission trading system it is worth analyzing this case ignoring how the initial agreement would come to exist. Including coalition formation greatly complicates the analysis to a point where it is not tractable. For the interested reader we refer to the standard literature by Barrett (1994) and Carraro and Siniscalco (1993). Furthermore, the developments in Cancun and the Durban platform show that a sizable coalition of countries willing to act exists.

of emissions at home, countries strategically issue permits to maximize their welfare.

- 3rd stage: The country representative firms maximize profits taking the amount of permits as given.

We solve the model as the reference case. We later focus on the first order conditions and the equilibrium results for the price and in consequence the amount of permits. This allows for very general results without any specifications of functional forms.

3rd stage

Solving the model recursively, we start in the 3rd stage where the representative firms of countries take the amount of permits ω_i as given and maximize their benefits from emitting and revenues of permit trade ignoring damages from total emissions.

$$\max_{e_i} \; B_i(e_i) + p(\omega_i - e_i) \tag{4.1}$$

This yields the following first order conditions (FOC) of profit maximization:

$$B_i'(e_i) - p = 0 \tag{4.2}$$

Therefore, we express the permit demand $e_i(p)$ as a function of the price and using the market clearing condition

$$\omega = \sum \omega_i = \sum e_i(p) = E \tag{4.3}$$

this system defines the equilibrium. The price, $p^*(\omega)$, and emissions, $e_i^*(\omega)$, are functions of the total amount of permits, $\omega = \sum \omega_i$. Furthermore, we obtain the responses to a change of the permit demand on the previous stage by differentiating (4.2) with respect to p and (4.3) with respect to ω.

$$B_i''(e_i)e_i'(p) - 1 = 0 \qquad \text{and} \qquad \sum e_i'(p)p'(\omega) - 1 = 0 \tag{4.4}$$

rearranging the second part, substituting for $e_i'(p^*)$, and keeping in mind $B_i''(e_i) < 0$ we get

$$p'^*(\omega) = \frac{1}{\sum \frac{1}{B_i''(e_i)}} < 0 \tag{4.5}$$

Therefore, the price of permits is decreasing in the total amount of permits as economic intuition indicates.

2nd stage

Each country chooses its allocation of permits which defines the total amount of permits. Countries know their own effect on the price and their influence on the profit of their respective firm. Additionally, they also take into account the effect of the global externality that their country has to face. Therefore, we formulate the welfare maximization as a typical Cournot-Nash game which leads to over-allocation of permits, nevertheless a potentially better result compared to a world without trade. In the non cooperative solution we solve:

$$\max_{\omega_i} \; B_i(e_i(\omega)) - D_i(\omega) + p(\omega)(\omega_i - e_i(\omega)) \tag{4.6}$$

The FOC gives us:[2]

$$B_i'(e_i(\omega))e_i'(\omega) - D_i'(\omega) + p'(\omega)(\omega_i - e_i(\omega)) + p(\omega)(1 - e_i'(\omega)) = 0 \tag{4.7}$$

This equation shows the different effects of issuing another permit for each country:

- First term: An additional permit increases benefits and the firm's demand of permits, so that benefits are increased by the product of the two effects.
- Second term: Increase of local damages.

[2]Following Helm (2003), we assume that the second order conditions for the solution of (4.6) hold.

- Third term: Trade gain/loss: Depending whether a countries is a net seller or buyer, an additional permit increases or decreases the total costs for a country.

- Fourth term: An additional permit decreases the costs of a country by the remainder of $1 - e_i'(\omega)$, where $e_i'(\omega) \in [0, 1]$.

Keeping in mind that $p(\omega) = B_i'(e_i)$, we rearrange the FOC to obtain a form where the marginal private benefit of issuing another permit plus trade equals the local marginal damages:

$$B_i'(e_i(\omega))) + p'(\omega)(\omega_i - e_i(\omega)) = D_i'(\omega) \qquad i = 1, ..., n \tag{4.8}$$

Following Helm (2003), we define countries as low damage countries when $B_i'(e_i(\omega)) > D_i'(\omega)$ or high damage countries when $B_i'(e_i(\omega)) < D_i'(\omega)$. This relation defines whether a country is a net seller or buyer of permits. Since $p'(\omega) < 0$ a low damage country has to be a net seller ($\omega_i > e_i(\omega)$) to equalize (4.8). Vice versa high damage countries are net buyers. Having discussed the individual effects of this equations, we sum (4.8) over n to get a solution for the price and hence the amount of permits.

$$p = 1/n \sum D_i'(\omega) \tag{4.9}$$

The price equals the average of the marginal damages since the trade gains and losses cancel out in equilibrium. This crucial equation shows the equilibrium results for the price and hence total amount of permits. Once distributional preferences are introduced, a corresponding equation allows us to see the change of price and total amount of permits.

1st stage

Countries only participate in such a treaty if it makes them better of compared to the Nash solution of the initial public bad problem where countries just strategically choose their emissions. Therefore, the set of possible coalitions is small, especially when countries are heterogeneous. In the following, we assume existence of a non cooperative permit market when we add distributional preferences to the social welfare function of countries.

4.3 Social Preferences

Until now, we only considered standard preferences about benefits of emissions and damages of total emissions. Next, we introduce the idea that countries not only care about their welfare, but also about distributional issues. For the sake of generality, we define a term $\theta_i(\omega_i, \omega_{-i})$ for the non standard preferences at the second stage.

$$B_i(e_i(\omega)) - D_i(\omega) + p(\omega)(\omega_i - e_i(\omega)) - \theta_i(\omega_i, \omega_{-i}) \tag{4.10}$$

This term depends on the choice of permits ω_i by player i and of the choice of the other players $\omega_{-i} = \{w_j\}_{j \neq i}$. This adds a further non monetary cost that countries incur when they deviate from a distributional norm, which we further define in the next section. Since the results of the 3rd stage are not affected by this change, we directly look at the FOCs of the maximization of the 2nd stage:

$$B_i'(e_i(\omega)) + p'(\omega)(\omega_i - e_i(\omega)) = D_i'(\omega) + \frac{\partial \theta_i(\omega_i, \omega_{-i})}{\partial \omega_i} \qquad i = 1, ..., n \tag{4.11}$$

We investigate two questions of concern: The direct effect on a country (4.11) and, more to our interest, the aggregate effect on the price and hence the total amount of permits (4.12). For the first effect, high marginal damages of equity decide whether or not a country is a net seller or buyer of permits. We observe the second effect, when we sum up (4.11) to get.

$$np = \sum D_i'(\omega) + \sum \frac{\partial \theta_i(\omega_i, \omega_{-i})}{\partial \omega_i} \tag{4.12}$$

This is similar to (4.9) but also considers the distributional considerations for the realization of the price. If the sum of the last term turns out to be positive (negative) it increases (decreases) the price and decreases (increases) the amount of permits. This result is similar to Eyckmans and Kverndokk (2010) who include the role of identity for a country in the same set up as we do. Further investigation of distributional preferences, i.e. inequality aversion, yields insights on the environmental effect of linked permit markets, since ideas of fairness and moral concerns play a huge role in international environmental negotiations.

At the 1st stage countries decide to participate or not compared to an outside option without a permit market. For simplification, we assume existence of a non cooperative permit market, as we are interested in the environmental impact of distributional preferences.

4.4 The Impact of Inequality Aversion

The previous section established the general framework of the model without specifying the functional form of the distributional preferences. In the following, we apply the well known inequality aversion introduced by Fehr and Schmidt (1999). As shown in the introduction, ample evidence indicates the importance of inequality aversion in general and in international climate negotiations. This simple and instructive way to model inequality aversion helps to understand how moral considerations influence the environmental outcome of our model.

In the general version, inequality aversion implies that players dislike having more or less of a good or payoff compared to the other players. Based on this, we look at two cases: 1. Permits as the good of the public good game as the reference point for inequality aversion. 2. Social welfare as the payoff of the public good game as the reference point for inequality aversion.

4.4.1 Inequality Aversion with Respect to Permits

In the first case, countries incur costs for having more or less permits than other countries due to inequality aversion. Governments could perceive ω_i as a currency or good from which countries profit, so they care about its distribution. Furthermore, permits could serve as a form of compensation and countries would care about the distribution, especially since high damage countries are net buyers. Another justification is that permits are a more tangible and comparable object for governments than the welfare of other countries. This leads to the following functional form of $\theta_i(\omega_i, \omega_{-i})$:

$$\theta_i(\omega_i, \omega_{-i}) = \alpha_i \sum_{j=1}^{n} Max\,[\omega_j - \omega_i, 0] + \beta_i \sum_{j=1}^{n} Max[\omega_i - \omega_j, 0] \tag{4.13}$$

The first part of this function implies that country i suffers costs when other countries have more permits than it does, which we call disadvantageous inequality. The second part represents the costs when other countries have less permits than country i, which we call advantageous inequality. Countries are more affected by disadvantageous inequality than by advantageous inequality. Therefore, we assume that the respective parameter of the disadvantageous inequality α_i is larger than the parameter of the advantageous inequality β_i. To look at the impact of this specification, we have to differentiate it with respect to ω_i and replace the Max operator. For this, we assume a ranking of permit allocations ex ante that has to hold in equilibrium ex post, which we test in the numerical examples.

$$\omega_1 \geq \omega_2 \geq ... \geq \omega_{i-1} \geq \omega_i \geq \omega_{i+1} \geq ... \geq \omega_n \tag{4.14}$$

Then, the distributional function changes into

$$\theta_i(\omega_i, \omega_{-i}) = \alpha_i \sum_{j=1}^{i-1} (\omega_j - \omega_i) + \beta_i \sum_{j=i+1}^{n} (\omega_i - \omega_j) \tag{4.15}$$

which we differentiate with respect to ω_i for the marginal effect of an additional permit on the inequality aversion costs of a country.

$$\frac{\partial \theta_i(\omega_i, \omega_{-i})}{\partial \omega_i} = \alpha_i \sum_{j=1}^{i-1} -1 + \beta_i \sum_{j=i+1}^{n} 1 \tag{4.16}$$

$$= (n-i)\beta_i - (i-1)\alpha_i \tag{4.17}$$

This equation shows that an additional permit decreases disadvantageous inequality but increases advantageous inequality. The effect of an additional permit on the country with the most / least permits is strictly positive / negative, namely: $(n-1)\beta_1$ and $-(n-1)\alpha_n$. For the other countries the marginal effect depends on the position in the ranking and the values of α_i and β_i. The effect tends to reduce inequality costs for countries with few permits ($i \to n$) and increases inequality costs for countries with many permits ($i \to 1$).

The aggregate effect on the price is defined by the sum of $\frac{\partial \theta_i(\omega_i, \omega_{-i})}{\partial \omega_i}$, which is:

$$\sum_i^n \frac{\partial \theta_i(\omega_i, \omega_{-i})}{\partial \omega_i} = \sum_1^n (n-i)\beta_i - \sum_i^n (i-1)\alpha_i \tag{4.18}$$

$$= (n-1)\beta_1 - (n-1)\alpha_n + ... + \beta_{n-1} - \alpha_2 \tag{4.19}$$

If this sum is negative, the price decreases which increases the total amount of permits (conversely if it is positive). Looking at the above equation, this depends on the balance of the marginal changes of the advantageous, $\sum_1^n (n-i)\beta_i$, and disadvantageous, $\sum_i^n (i-1)\alpha_i$, inequality aversion. If the latter outweighs the former the sum is negative. Looking at (19), each positive term of β_i has a negative counterpart with α_{n-i+1}. Therefore, the advantageous part is dominated when

$$\alpha_{n-i+1} \geq \beta_i, \quad \forall\, i \neq n \quad and > for\ at\ least\ one\ i. \tag{4.20}$$

This is always true when the smallest α_i is still bigger than the largest β_i or put mathematically if $Min(\alpha) > Max(\beta)$. For more general results, we would need to know the exact distribution of α and β to determine the sign of the sum. One could place further assumptions on the distribution of α and β without any gain of insight.

Since there is some evidence for homogeneous inequality aversions, we also look at constant parameters for α and β to substantiate the result of a negative environmental impact.[3] This simplifies (4.19) to:

$$\sum_{i}^{n} \frac{\partial \theta_i(\omega_i, \omega_{-i})}{\partial \omega_i} = \frac{n(n-1)}{2}(\beta - \alpha) \tag{4.21}$$

This is always negative since we assumed $\alpha > \beta$. Therefore, the price decreases in equilibrium as inequality aversion increases the demand of those on the lower end of the ranking more than it decreases the demand of those on top of the ranking.

4.4.2 Inequality Aversion With Respect to Social Welfare

In the following, we consider the case when countries use social welfare of the underlying public good game as the reference point of inequality aversion. We define social welfare as:

$$\pi_i(\omega_i) = \pi_i(\omega_i, \omega_{-i}) = B_i(e_i(\omega)) + p(\omega)(\omega_i - e_i(\omega)) - D_i(\omega) \tag{4.22}$$

The distributional function follows:

$$\theta_i(\omega_i, \omega_{-i}) = \alpha_i \sum_{j=1}^{n} Max\left[\pi_j(\omega_j) - \pi_i(\omega_i), 0\right] + \beta_i \sum_{j=1}^{n} Max[\pi_i(\omega_i) - \pi_j(\omega_j), 0] \tag{4.23}$$

The first part represents disadvantageous inequality aversion when other countries are richer than country i, the second part advantageous aversion when other countries are poorer than country i. The respective α_i is still

[3] see for instance Dannenberg et al. (2010), Engel (2011), or Oosterbeek et al. (2004).

larger than the respective β_i. We assume a ranking of social welfare ex ante that has to hold ex post in equilibrium to replace the Max operator.

$$\pi_1(\omega_1) \geq \pi_2(\omega_2) \geq ... \geq \pi_{i-1}(\omega_{i-1}) \geq \pi_i(\omega_i) \geq \pi_{i+1}(\omega_{i+1}) \geq ... \geq \pi_n(\omega_n) \tag{4.24}$$

Then, the distributional function changes to:

$$\theta_i(\omega_i, \omega_{-i}) = \alpha_i \sum_{j=1}^{i-1} (\pi_j(\omega_j) - \pi_i(\omega_i)) + \beta_i \sum_{j=i+1}^{n} (\pi_i(\omega_i) - \pi_j(\omega_j)) \tag{4.25}$$

We differentiate with respect to ω_i for the marginal effect of an additional permit on the distributional function for country i. From the base model we use the FOC given in (4.8) for $\frac{\partial \pi_i}{\partial \omega_i}$. For $\frac{\partial \pi_j}{\partial \omega_i}$ we get a similar expression without the direct price effect.

$$\frac{\partial \pi_j(\omega_j)}{\partial \omega_i} = p'(\omega)(\omega_j - e_j(\omega)) - D'_j(\omega) \tag{4.26}$$

We can now derive the individual effect by taking the derivative: $\frac{\partial \theta_i(\omega_i, \omega_{-i})}{\partial \omega_i}$. Instead of writing out the equation we analyze it Table 4.1.[4] We identify three different effects presented in each row. The two columns show the position of country i compared to richer countries, $j < i$, and poorer countries, $j > i$. Surprisingly, we will see that this does not matter for the first and the third effect.

The first row shows what call the trade effect. Compared to richer countries (left column $j < i$) the sum of the trade balances should be positive as richer countries tend to be larger net sellers than country i. Bearing in mind that $p'(\omega) < 0$ and $\alpha > 0$ the whole term is negative. The same logic applies to the right hand side column ($j > i$). Country i tends to be a larger net seller than the poorer countries so that the sum should be positive. Due

[4] The whole equation comprises the sum of all six parts of Table 4.1.

Table 4.1: Individual effect of inequality aversion

	Richer Countries $j < i$	Poorer Countries $j > i$
Trade effect	$\alpha_i p'(\omega) \sum_{j=1}^{i-1}((\omega_j - e_j) - (\omega_i - e_i))$	$\beta_i p'(\omega) \sum_{j=i+1}^{n}((\omega_i - e_i) - (\omega_j - e_j))$
Price effect	$\beta_i(n-i) * p$	$-\alpha_i(i-1)p$
Damage effect	$\alpha_i \sum_{j=1}^{i-1}(D'_i(\omega) - D'_j(\omega))$	$\beta_i \sum_{j=i+1}^{n}(D'_j(\omega) - D'_i(\omega))$

to $p'(\omega) < 0$ and $\beta > 0$ this cell is also negative. Including inequality aversion sets an incentive to increase permits, because it decreases the inequality costs from the trade balance due to the price reduction. This results holds in general if we isolate trade terms as the basis of the inequality aversion.

The price effect can be seen in the second row. It reduces the costs of disadvantageous inequality by $(i-1)\alpha_i p$ but increases costs of advantageous inequality by $(n-i)\beta_i p$. So depending on the position in the ranking and the ratio of α_i and β_i this can be positive or negative.

The third row explains the damage effect. Richer countries, $j < i$, tend to have lower marginal damages than country i whereas poorer countries, $j > i$, have higher marginal damages. This is why, both sums tend to be positive and this result would hold in general if we isolate damage differences as the basis of the inequality aversion. Issuing an additional permit increases the gap compared both to richer and poorer countries decreasing the incentives to issue more permits.

There is no simple analytic expression of the net effect that shows what effect would dominate. It is intuitive that the individual net effect is positive for rich countries which would relinquish permits and negative for poor countries which would issue more permits. While looking at the aggregate effect, we have to resort to constant α and β. Keeping heterogeneous parameters yields a very messy term that cannot be interpreted. The aggregate effect unfolds as:

$$\sum_1^n \frac{\partial\theta_i(\omega_i,\omega_{-i})}{\partial\omega_i} = (\alpha+\beta)\sum_1^n(2i-n-1)D_i' - p'(\omega)(\alpha+\beta)\sum_1^n(2i-n-1)(w_i-e_i) - (\alpha-\beta)\frac{(n-1)n}{2}p \tag{4.27}$$

This term shows that the trade balance and the direct price effect decrease the price whereas the damage considerations increase it. Taking the sum over n of $(2i-n-1)$ means that each element is multiplied by $-(n-1)$ for $i=1$ up to $(n-1)$ for $i=n$. At first the terms enter negatively and towards n positively. As the marginal damages tend to increase with i the lower terms are multiplied by a negative number and later by a positive number when $i \to n$. Hence, the sum is positive.

The sum of second term is negative as for $i \to 1$ countries tend to have positive trade balance which is multiplied by a negative number. When $i \to n$ the trade balances turn negative but are multiplied by a positive number. This is then multiplied by a negative p' and -1, so that the whole term decreases the price. Both the trade effect and the price effect, which is negative as long as $\alpha > \beta$, decrease the price. Unfortunately, we cannot say which effect dominates the other.

4.5 Numerical Examples

In this section we use numerical examples to illustrate the outcome differences due to inequality aversion. Contrary to the previous section, we have to assume specific functional forms of the benefits from emissions and the damages. We opt for a quasi quadratic form of the benefits and linear or quadratic damages in total emissions or permits.[5]

$$B_i(e_i, b_i) := e_i\,(b_i - \frac{e_i}{2}) \tag{4.28}$$

$$D_i(E, d_i) := d_i\,E \tag{4.29}$$

$$D_i(E, d_i) := \frac{d_i}{2}\,E^2 \tag{4.30}$$

We first analyze inequality aversion with respect to permits and then with respect to social welfare. For now, we rely on a two player set up since we can use graphs for illustrations, but also show numerical results for three players.

Using Maxima (2014) and Maple (2014) we set up the third and the second stage[6] of the model and solve it for two players only. From before we know that neither the choice of inequality aversion nor the choice of damage function matters for the 3rd stage. Therefore, we can solve the 3rd stage for both cases, where firms maximize their profits according to the following problem:

$$\max_{e_i}\; B_i(e_i) + p(\omega_i - e_i) \qquad with \qquad i = \{1, 2\} \tag{4.31}$$

Taking the derivative and solving for e_i gives $e_i^* = a_i - p$. We use the market clearing condition $\omega = \sum \omega_i = \sum e_i(p) = E$ to solve for emissions and the price on the third stage.

$$p(\omega) = \frac{a_1 + a_2 - \omega}{2} \tag{4.32}$$

$$e_1^*(\omega) = \frac{\omega + a_1 - a_2}{2} \tag{4.33}$$

$$e_2^*(\omega) = \frac{\omega + a_2 - a_1}{2} \tag{4.34}$$

4.5.1 Inequality Aversion with Respect to Permits

Before we start analyzing inequality aversion, we note that the price of the reference case is always the special case of the price including inequality aversion

[5] Linear damages provide some results that are easier to interpret with economic intuition, although quadratic damages might be more realistic.

[6] We still assume existence of the permit market.

when $\alpha = \beta = 0$. For completeness the reference price given the functional forms is:

$$p^{Ref} = \frac{(b_2 + b_1)\ (d_2 + d_1)}{2\ (d_2 + d_1 + 1)} \tag{4.35}$$

Taking the results from the 3rd stage, we go on to maximize the countries' welfare including inequality aversion and the assumption that $\omega_1 \geq \omega_2$. We assume quadratic damages as in (4.30) in the following, but discuss linear damages when they provide insights. Each country maximizes:

$$\max_{\omega_1} B_1(e_1^*, a_1) + p^*(\omega)\,(\omega_1 - e_1^*) - D_1(\omega, d_i) - \beta_1\,(\omega_1 - \omega_2) \tag{4.36}$$

$$\max_{\omega_2} B_2(e_2^*, a_2) + p^*(\omega)\,(\omega_2 - e_2^*) - D_2(\omega, d_2) - \alpha_2\,(\omega_1 - \omega_2) \tag{4.37}$$

Solving this problem, we calculate the price p^{IA}.

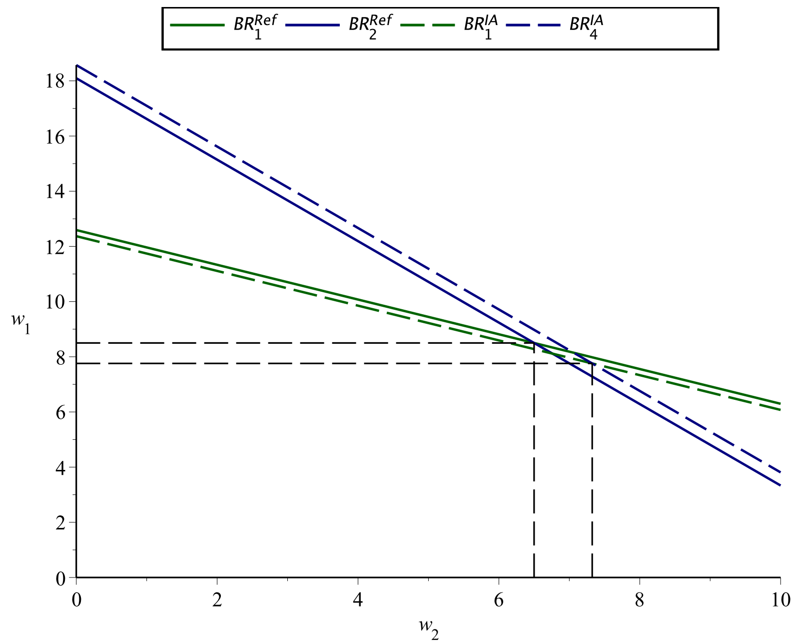
$$p^{IA} = \frac{(b_2 + b_1)\ (d_2 + d_1) + \beta - \alpha}{2\ (d_2 + d_1 + 1)} \tag{4.38}$$

Comparing p^{ref} with p^{IA}, shows that the price goes down as long as $\alpha > \beta$, as was stated in Section 4.4.1. The new equilibrium only exists if $\omega_1^* \geq \omega_2^*$. Since this condition is not very intuitive, we do not show it here. Generally, existence is more likely to hold the larger the benefit parameter b_1 is compared to b_2 and similarly the lower the respective damage parameter d_1 and the higher d_2 are. Furthermore, α and β should not be too high. Using only linear damages as in (4.29), we get a very intuitive condition.

$$d_2 - d_1 + b_1 - b_2 > 2\,(\beta + \alpha) \tag{4.39}$$

The difference in the benefit and damage parameters have to be higher than twice the sum of α and β for the ranking to hold. Figure 4.1 concludes this part. It uses the following parameter values: $a_1 = 16$, $a_2 = 20$, $d_1 = 0.6$, $d_2 = 0.8$, $\alpha = 0.5$, and $\beta = 0.3$, to draw the reaction functions of both countries. The intersections are the two different equilibria with and without inequality aversion . The parameters imply that country two profits more from emissions, but is more affected by damages than country one.

Figure 4.1: Reaction functions of both countries. Solid line reference case, dotted lines with inequality aversion.



As assumed the disadvantageous inequality aversion α is stronger than the advantageous β.

In the reference case, the solid lines, the intersection of the reaction curves occurs at $\omega_1 = 8.5$ and $\omega_2 = 6.5$. Taking account of inequality aversion the intersection changes to $\omega_1^{IA} = 7.757$ and $\omega_2^{IA} = 7.325$ which indeed is more equal than before. We can see how inequality aversion shifted the reaction function of the poorer country upward and downward for the richer country.

4.5.2 Inequality Aversion with Respect to Social Welfare

For this part, we have to assume that the social welfare of country one is higher than the social welfare of country two: $\pi_1(\omega_1) \geq \pi_2(\omega_2)$. The two countries face the following maximization problems at stage two:

$$\begin{aligned}\max_{\omega_1} \quad & B_1(e_1^*, a_1) + p^*(\omega)\,(\omega_1 - e_1^*) - D_1(\omega, d_1) \\ & - \beta_1 \Big(B_1(e_1^*, a_1) + p^*(\omega)\,(\omega_1 - e_1^*) - D_1(\omega, d_1) \\ & - B_2(e_2^*, a_2) + p^*(\omega)\,(\omega_2 - e_2^*) - D_2(\omega, d_2) \Big)\end{aligned} \tag{4.40}$$

$$\begin{aligned}\max_{\omega_2} \quad & B_2(e_2^*, a_2) + p^*(\omega)\,(\omega_2 - e_2^*) - D_2(\omega, d_2) \\ & - \alpha_2 \Big(B_1(e_1^*, a_1) + p^*(\omega)\,(\omega_1 - e_1^*) - D_1(\omega, d_1) \\ & - B_2(e_2^*, a_2) + p^*(\omega)\,(\omega_2 - e_2^*) - D_2(\omega, d_2)) \Big)\end{aligned} \tag{4.41}$$

We stick to quadratic damages and solve the problem which yields the following price:

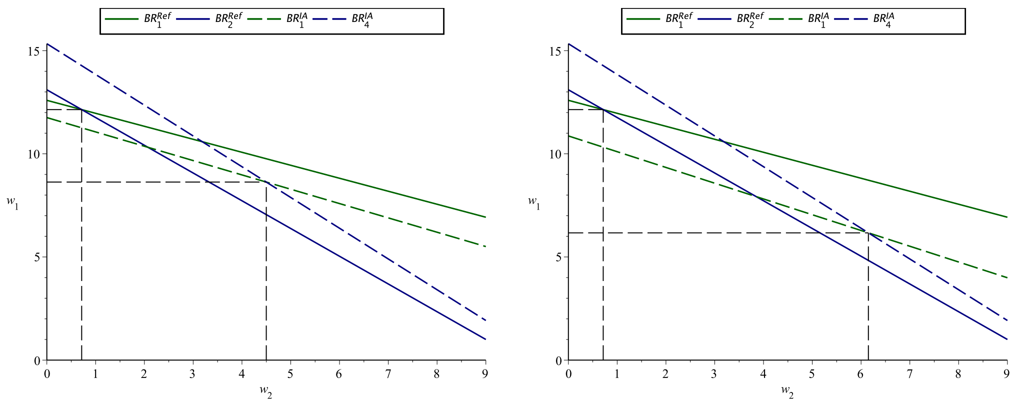
$$p^{IA} = \frac{(b_2 + b_1)\ (d_2 + d_1)\ (\beta - \alpha - 1)}{4\,\alpha\,\beta + 2\,d_2\,\beta + 2\,d_1\,\beta + 3\,\beta - 2\,d_2\,\alpha - 2\,d_1\,\alpha - 3\,\alpha - 2\,d_2 - 2\,d_1 - 2} \tag{4.42}$$

We find an unambiguous effect for the change of p^{IA} with respect to α or β. With an increasing α the poor country feels stronger about the inequality and issues more permits which decreases the price. Vice verse, an increasing β means that the rich country feels stronger about the advantageous inequality and issues less permits which increases the price. Unfortunately both the price difference and the equilibrium condition, $\pi_1(\omega_1^*) \geq \pi_2(\omega_2^*)$, do not provide any meaningful insights, so that we do not present them. Turning to linear damages in emissions offers some insight when the price difference is positive or negative.

$$\frac{(d_2 + d_1)\ (4\,\alpha\,\beta + \beta - \alpha)}{4\ (4\,\alpha\,\beta + 3\,\beta - 3\,\alpha - 2)} > 0 \tag{4.43}$$

There are four possible cases. If both the counter and the denominator are jointly positive or negative the price difference is positive, hence $p^{IA} < p^{Ref}$. If their sign differs then the difference turns out to be negative and $p^{IA} > p^{Ref}$.

Figure 4.2: Comparison of two cases of inequality aversion with respect to social welfare. Solid line reference case, dotted lines with inequality aversion.



(a) β=0.1, price goes down. (b) β=0.2, price goes up.

A three dimensional plot tells us that the price decreases with very low and very high values of β and increases with β in between 0.2 to 0.6 and not too high α.

To show the different outcome of an price increase and decrease figure 4.2 uses the following variables that are slightly different to the permit case: $a_1 = 16$, $a_2 = 20$, $d_1 = 0.6$, $d_2 = 1.28$, $\alpha = 0.3$, and $\beta = 0.1$. For these variables the price would decrease, but if we raise β to 0.2 the price would increase compared to reference case.

We can see that the green reaction function shits upward more on the right side, when β increases. The intersection on the right side is moved much further to the ride and emissions for country one go down by almost half and increase to almost the same level as country two. On the left side the emissions for country one go down as well but not that much as before while they increase even more for country two. This is why, the price is lower in this case than in the reference case and total emissions increase. To end this section, we present a table with results for three players and inequality aversion with respect to social welfare.

The reference price is $p^{Ref} = 2.1875$ which goes down to $p^{IA} = 2.145$

Table 4.2: Numerical Example of a non cooperative permit market with inequality aversion with respect to social welfare and three players

Country	b_i	d_i	w_i^{Ref}	w_i^{IA}	
i				$\beta = 0.1$	$\beta = 0.2$
1	6	0.1	7.094	5.071	2.895
2	5.5	0.2	3.312	3.118	3.047
3	6	0.3	0.531	2.560	3.749

with $\beta = 0.1$ and increases to $p^{IA} = 2.507$ with $\beta = 0.2$. The distribution of permits is more equal but with the low β the richest countries does not relinquish as many permits as the poorer countries issue to catch up. This changes with the high β.

4.6 Conclusion

We demonstrate the influence of distributional preferences, i.e., inequality aversion, on the outcome of a non cooperative permit market. In order to do this, we look at two cases: Inequality aversion with respect to the allocation of permits or social welfare. In the first case we show that stronger disadvantageous inequality aversion is likely to increase the total amount of permits. In this regard, concerns about disadvantageous inequality induce poor countries to issue more permits than the rich countries relinquish due to concerns about advantageous inequality. While this might seem obvious for the first case it is less obvious for the second case and the different effects are insightful to explain how inequality aversion would influence the process.

Considering inequality aversion with social welfare as the reference point, we show three different effects. On one hand, the increasing differences of marginal damages decrease incentives to issue permits. On the other hand, trade balances matter less as increasing permits reduces the price which sets incentives to issue more permits. The direct price gain from issuing permits increases the total permit amount since disadvantageous inequality aversion is stronger than advantageous inequality aversion. The equilibrium results depend on the magnitude and balance of the three different effects. Nevertheless, we show that inequality aversion is likely to aggravate the environmental problems of a non cooperative permit market when disadvantageous inequality aversion outweighs advantageous inequality aversion.

In the future this should be considered as motives of fairness play an important role in negotiations. Especially if it turns out that jealousy trumps altruism, so that the environmental outcome is worse.

References

Adger, W. N., N. W. Arnell, and E. L. Tompkins (2005). Successful adaptation to climate change across scales. *Global environmental change 15*(2), 77–86.

Adger, W. N. and J. Barnett (2012). Four reasons for concern about adaptation to climate change. *Environment and Planning A 41*(12), 2800–2805.

Adger, W. N., S. Dessai, M. Goulden, M. Hulme, I. Lorenzoni, D. R. Nelson, L. O. Naess, J. Wolf, and A. Wreford (2009). Are there social limits to adaptation to climate change? *Climatic change 93*(3-4), 335–354.

Aldy, J. and R. Stavins (2007). *Architectures for Agreement: Addressing Global Climate Change in the Post-Kyoto World*. Cambridge University Press.

Aldy, J., R. Stavins, and H. P. on International Climate Agreements (2010). *Post-Kyoto International Climate Policy: Implementing Architectures for Agreementa*. Cambridge University Press.

Aldy, J. E., S. Barrett, and R. N. Stavins (2003). Thirteen plus one: A comparison of global climate policy architectures. *Climate policy 3*(4), 373–397.

Babcock, L. and G. Loewenstein (1997). Explaining bargaining impasse: The role of self-serving biases. *The Journal of Economic Perspectives 11*(1), 109–126.

Bahn, O., M. Chesney, J. Gheyssens, R. Knutti, and A. Pana (2014). Is there room for geoengineering in the optimal climate policy mix?

Baldwin, L. and K. R. Richards (2010). Institutional support for an international forest carbon sequestration agreement. *Harvard Project on International Climate Agreements Discussion Paper 41*.

Barrett, S. (1994). Strategic environmental policy and intrenational trade. *Journal of Public Economics 54*(3), 325–338.

Barrett, S. (2002). Towards a better climate treaty. *World Economics Journal 3*(2).

Barrett, S. (2003). *Environment and statecraft: The strategy of environmental treaty-making*. Oxford University Press.

Barrett, S. (2005). The theory of international environmental agreements. *Handbook of environmental economics 3*, 1457–1516.

Barrett, S. (2008a). The incredible economics of geoengineering. *Environmental and Resource Economics 39*(1), 45–54.

Barrett, S. (2008b). A portfolio system of climate treaties. *DP, paper*, 08–13.

Barrett, S. and K. Graddy (2000, 10). Freedom, growth, and the environment. *Environment and Development Economics null*, 433–456.

Barrett, S. and R. Stavins (2003). Increasing participation and compliance in international climate change agreements. *International Environmental Agreements 3*(4), 349–376.

Basic-Experts (2011). Equitable access to sustainable development: Contribution to the body of scientific knowledge. *BASIC expert group: Beijing, Brasilia, Cape Town and Mumbai,*.

Bickel, J. E. and S. Agrawal (2011). Reexamining the economics of aerosol geoengineering. *Climatic Change*, 1–14.

Bodansky, D. (2007a). International sectoral agreements in a post-2012 climate framework. *Pew Center on Global Climate Change Working Paper*.

Bodansky, D. (2007b). *Targets and timetables: Good policy but bad politics? In J.E. Aldy and R.N. Stavins (Ed.), Architectures for Agreement: Addressing Global Climate Change in the Post-Kyoto World*. Cambridge University Press.

Bodansky, D., S. Chou, and C. Jorge-Tresolini (2004). *International climate efforts beyond 2012: A survey of approaches*. Pew Center on Global Climate Change Arlington, VA.

Bodansky, D., E. Diringer, J. Pershing, and X. Wang (2004). Strawman elements: Possible approaches to advancing international climate change efforts. *Pew Center on Global Climate Change, Arlington, VA. Available at http://www. pewclimate. org/pocantico. cfm*.

Böhringer, C. and C. Vogt (2004). The dismantling of a breakthrough: The kyoto protocol as symbolic policy. *European Journal of Political Economy 20*(3), 597–617.

Bolton, G. E. and A. Ockenfels (2000). ERC: A theory of equity, reciprocity, and competition. *American economic review*, 166–193.

Bosetti, V., C. Carraro, A. Sgobbi, and M. Tavoni (2008). Modelling economic impacts of alternative international climate policy architectures: A quantitative and comparative assessment of architectures for agreement.

Bouwer, L. M. and J. C. Aerts (2006). Financing climate change adaptation. *Disasters 30*(1), 49–63.

Bradley, R., K. A. Baumert, B. Childs, T. Herzog, and J. Pershing (2007). Slicing the pie: Sector-based approaches to international climate agreements. *Washington, DC: World Resources Institute*, 1–7.

Bretschger, L. (2013, 10). Climate policy and equity principles: Fair burden sharing in a dynamic worldd. *Environment and Development Economics 18*, 517–536.

Brown, D. (2014). 10 reasons why "contraction and convergence" is still the most preferable equity framework for allocating national GHG targets. Ethics and Climate Blog by D. Brown.

Cai, B., T. A. Cameron, and G. R. Gerdes (2010). Distributional preferences and the incidence of costs and benefits in climate change policy. *Environmental and Resource Economics 46*(4), 429–458.

Caney, S. (2005). Cosmopolitan justice, responsibility, and global climate change. *Leiden journal of international law 18*(04), 747–775.

Cao, J. (2008). Reconciling human development and climate protection: Perspectives from developing countries on post-2012 international climate change policy. Technical report, Discussion Paper 08-25. Cambridge, MA, USA: Harvard Project on International Climate Agreements, Belfer Center for Science and International Affairs, Kennedy School of Government, Harvard University.

Cappellari, L. and S. P. Jenkins (2003). Multivariate probit regression using simulated maximum likelihood. *The Stata Journal 3*(3), 278–294.

Carbone, J., C. Helm, and T. Rutherford (2009). The case for international emission trade in the absence of cooperative climate policy. *Journal of Environmental Economics and Management 58*(3), 266–280.

Carlsson, F., M. Kataria, A. Krupnick, E. Lampi, Å. Löfgren, P. Qin, S. Chung, and T. Sterner (2012). Paying for mitigation: A multiple country study. *Land Economics 88*(2), 326–340.

Carraro, C. and D. Siniscalco (1993). Strategies for the international protection of the environment. *Journal of public Economics 52*(3), 309–328.

Cazorla, M. and M. Toman (2001). International equity and climate change policy. *Climate Change Economics and Policy: An RFF Anthology*, 235.

Cicerone, R. J. (2006). Geoengineering: Encouraging research and overseeing implementationc. *Climatic Change 77*(3), 221–226.

Clarke, L., K. Calvin, J. A. Edmonds, P. Kyle, and M. Wise (2008). Technology and international climate policy. Technical report, Dec. 2008, Discussion Paper 08-21, The Harvard Project on International Climate Agreements, 37 pages.

Congleton, R. (1992a). Political institutions and pollution control. *The Review of Economics and Statistics*, 412–421.

Congleton, R. D. (1992b). Political institutions and pollution control. *The Review of Economics and Statistics 74*(3), pp. 412–421.

Cooper, D. and J. H. Kagel (2009). Other regarding preferences: A selective survey of experimental results. *Handbook of experimental economics 2*.

Cooper, R. N. (2007). *Alternatives to Kyoto: The case for a carbon tax. In J.E. Aldy and R.N. Stavins (Ed.), Architectures for Agreement: Addressing Global Climate Change in the Post-Kyoto World.* Cambridge University Press.

Crutzen, P. J. (2006). Albedo enhancement by stratospheric sulfur injections: A contribution to resolve a policy dilemma? *Climatic change 77*(3), 211–220.

Dannenberg, A., B. Sturm, and C. Vogt (2010). Do equity preferences matter for climate negotiators? An experimental investigation. *Environmental and Resource Economics*, 1–19.

Datta, A. and E. Somanathan (2011). Climate policy and innovation in the absence of commitment. Technical report, Citeseer.

Davis, S. and K. Caldeira (2010). Consumption-based accounting of CO_2 emissions. *Proceedings of the National Academy of Sciences 107*(12), 5687–5692.

Economist Intelligence Unit (2013). Democracy index 2012: Democracy at a standstill. *Retrieved from the Economist Intelligence Unit database*.

Engel, C. (2011). Dictator games: A meta study. *Experimental Economics 14*(4), 583–610.

Eyckmans, J. and S. Kverndokk (2010). Moral concerns on tradable pollution permits in international environmental agreements. *Ecological Economics 69*(9), 1814–1823.

Fehr, E. and K. Schmidt (1999). A theory of fairness, competition, and cooperation. *The Quarterly Journal of Economics 114*(3), 817–868.

Fischbacher, U. and S. Gächter (2010). Social preferences, beliefs, and the dynamics of free riding in public goods experiments. *The American Economic Review 100*(1), 541–556.

Fischer, C. and R. D. Morgenstern (2006). Carbon abatement costs: Why the wide range of estimates? *The Energy Journal 27*(2), 73–86.

Frankel, J. (2007). Formulas for quantitative emission targets. *In J.E. Aldy and R.N. Stavins (Ed.), Architectures for Agreement: Addressing Global Climate Change in the Post-Kyoto World*.

Freedom House (2013). Freedom in the world index. *Washington, DC*.

Friedman, M. (1953). The methodology of positive economics. *Essays in positive economics 3*(3).

Gardiner, S. M. (2010). Is “arming the future” with geoengineering really the lesser evil? Some doubts about the ethics of intentionally manipulating the climate systemc. *Climate Ethics: Essential Readings*, 284–314.

Gersbach, H. and R. Winkler (2011). International emission permit markets with refunding. *European Economic Review 55*(6), 759–773.

Godal, O. and B. Holtsmark (2011a). On efficiency gains from emissions trading: Have they been exaggerated? *CREE Working Papers 06*.

Godal, O. and B. Holtsmark (2011b). Permit trading: Merely an efficiency-neutral redistribution away from climate-change victims? *The Scandinavian Journal of Economics*.

Goes, M., N. Tuana, and K. Keller (2011). The economics (or lack thereof) of aerosol geoengineering. *Climatic change 109*(3-4), 719–744.

Goeschl, T., D. Heyen, and J. Moreno-Cruz (2013). The intergenerational transfer of solar radiation management capabilities and atmospheric carbon stocks. *Environmental and resource economics 56*(1), 85–104.

Good, I. J. (1982). Comment (on patil and taillie: Diversity as a concept and its measurement). *Journal of the American Statistical Association 77*(379), 561–3.

Grüning, C. and W. Peters (2010). Can justice and fairness enlarge international environmental agreements? *Games 1*(2), 137–158.

Hall, D. S., M. Levi, W. A. Pizer, and T. Ueno (2008). Policies for developing country engagement. *Harvard Project on International Climate Agreements Discussion Paper* (2008-15).

Helm, C. (2003). International emissions trading with endogenous allowance choices. *Journal of Public Economics 87*(12), 2737–2747.

Heston, A., R. Summers, and B. Aten (2012). Penn world table version 7.1. Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania (CICUP).

Hjerpe, M., Å. Löfgren, B.-O. Linnér, M. Hennlock, T. Sterner, and S. C. Jagers (2011). Common ground for effort sharing? Preferred principles for distributing climate mitigation effortsg.

Holtsmark, B. and D. Sommervoll (2012). International emissions trading: Good or bad? *Economics Letters*.

Iwata, H. and K. Okada (2010). Greenhouse gas emissions and the role of the kyoto protocol. *Environmental Economics and Policy Studies*, 1–18.

Johansson-Stenman, O. and J. Konow (2010). Fair air: Distributive justice and environmental economics. *Environmental and Resource Economics 46*(2), 147–166.

Kalnay, E. and M. Cai (2003). Impact of urbanization and land-use change on climate. *Nature 423*(6939), 528–531.

Kaufmann, D., A. Kraay, and M. Mastruzzi (2012). Worldwide governance indicators 2011. *World Bank. Washington: World Bank Group*.

Keohane, R. and K. Raustiala (2008). Toward a post-kyoto climate change architecture: A political analysis. *UCLA School of Law, Law-Econ Research Paper* (08-14).

Keohane, R. O. and D. G. Victor (2011). The regime complex for climate change. *Perspectives on politics 9*(1), 7–23.

Kesternich, A., A. Löschel, and A. Ziegler (2014). Negotiating weights for burden sharing rules among heterogeneous parties: Empirical evidence from a survey among delegates in international climate negotiations. *ZEW-Centre for European Economic Research Discussion Paper* (14-031).

Klinsky, S. and H. Dowlatabadi (2009). Conceptualizations of justice in climate policy. *Climate Policy 9*(1), 88–108.

Konow, J. (2000). Fair shares: Accountability and cognitive dissonance in allocation decisions. *The American Economic Review 90*(4), 1072–1091.

Konow, J. (2003). Which is the fairest one of all? A positive analysis of justice theories. *Journal of economic literature 41*(4), 1188–1239.

Kuik, O., L. Brander, and R. S. Tol (2009). Marginal abatement costs of greenhouse gas emissions: A meta-analysis. *Energy Policy 37*(4), 1395–1403.

Lange, A. (2006). The impact of equity-preferences on the stability of international environmental agreements. *Environmental and Resource Economics 34*(2), 247–267.

Lange, A., A. Loschel, C. Vogt, and A. Ziegler (2010). On the self-interested use of equity in international climate negotiations. *European Economic Review 54*(3), 359–375.

Lange, A. and C. Vogt (2003). Cooperation in international environmental negotiations due to a preference for equity. *Journal of Public Economics 87*(9-10), 2049–2067.

Lange, A., C. Vogt, and A. Ziegler (2007). On the importance of equity in international climate policy: An empirical analysis. *Energy Economics 29*(3), 545–562.

Leist, A. (2011). Klima auf Gegenseitigkeit. *Klimawandel und Intergenerationelle Gerechtigkeit, Jahrbuch für Wissenschaft und Ethik*.

Lutter, R. (2000). Developing countries' greenhouse emissions: Uncertainty and implications for participation in the kyoto protocol. *The Energy Journal Vol. 21, No. 4*, pp. 93–120.

MacCracken, M. C. (2006). Geoengineering: Worthy of cautious evaluation? *Climatic Change 77*(3), 235–243.

MacKenzie, I. (2011). Tradable permit allocations and sequential choice. *Resource and Energy Economics 33*(1), 268–278.

Maple (2014). Maple, a computer algebra system. Version 18.00.

Mattoo, A. and A. Subramanian (2012). Equity in climate change: an analytical review. *World Development*.

Maxima (2014). Maxima, a computer algebra system. Version 5.34.1.

McCarthy, J. J., O. F. Canziani, N. A. Leary, D. J. Dokken, and K. S. White (2001). *Climate change 2001: Impacts, adaptation, and vulnerability: Contribution of Working Group II to the third assessment report of the Intergovernmental Panel on Climate Change*. Cambridge University Press.

McKibbin, W. and P. Wilcoxen (2008). Building on kyoto: Towards a realistic global climate change agreement. *The Brookings Institution*.

Meinshausen, M., N. Meinshausen, W. Hare, S. Raper, K. Frieler, R. Knutti, D. Frame, and M. Allen (2009). Greenhouse-gas emission targets for limiting global warming to 2°C. *Nature 458*(7242), 1158–1162.

Miller, D. (2008). Global justice and climate change: How should responsibilities be distributed. *The Tanner Lectures on Human Values, delivered at Tsinghua University, Beijing*, 24–5.

Najam, A., S. Huq, and Y. Sokona (2003). Climate negotiations beyond kyoto: Developing countries concerns and interests. *Climate Policy 3*(3), 221–231.

National Academy of Sciences (1992). *Policy Implications of Greenhouse Warming: Mitigation, Adaptation, and the Science Base*. The National Academies Press.

Neumayer, E. (2000). In defence of historical accountability for greenhouse gas emissions. *Ecological economics 33*(2), 185–192.

Neumayer, E. (2002). Do democracies exhibit stronger international environmental commitment? A cross-country analysis. *Journal of peace research 39*(2), 139–164.

Newell, R. G. (2008). International climate technology strategies. *Harvard Project on International Climate Agreements Discussion Paper* (2008-12).

Nordhaus, W. D. (2007). A review of the "stern review on the economics of climate change". *Journal of Economic Literature*, 686–702.

Noss, R. F. (2001). Beyond kyoto: Forest management in a time of rapid climate change. *Conservation Biology 15*(3), 578–590.

Nyborg, K. (2014). Reciprocal climate negotiators: Balancing anger against even more anger. Technical report, Working paper Department of Economics, University of Oslo.

Olmstead, S. M. and R. N. Stavins (2012). Three key elements of a post-2012 international climate policy architecture. *Review of Environmental Economics and Policy 6*(1), 65–85.

Oosterbeek, H., R. Sloof, and G. Van De Kuilen (2004). Cultural differences in ultimatum game experiments: Evidence from a meta-analysis. *Experimental Economics 7*(2), 171–188.

Paavola, J. and W. Adger (2006). Fair adaptation to climate change. *Ecological Economics 56*(4), 594–609.

Pachauri, R. K., S. Gardiner, S. Caney, D. Jamieson, and H. Shue (2010). *Climate ethics: Essential readings*. Oxford University Press.

Panayotou, T. (2003). Economic growth and the environment. *Economic survey of Europe*, 45–72.

Peters, G. and E. Hertwich (2008a). CO_2 embodied in international trade with implications for global climate policy. *Environmental Science & Technology 42*(5), 1401–1407.

Peters, G. and E. Hertwich (2008b). Post-kyoto greenhouse gas inventories: Production versus consumption. *Climatic Change 86*(1), 51–66.

Peters, G. P., J. C. Minx, C. L. Weber, and O. Edenhofer (2011). Growth in emission transfers via international trade from 1990 to 2008. *Proceedings of the National Academy of Sciences 108*(21), 8903–8908.

Pew Center for Global Climate Change (2005). International climate efforts beyond 2005: Report of the climate dialogue at pocantico. *Pew Center for Global Climate Change, Arlington VA*.

Philibert, C. and J. Pershing (2001). Considering the options: Climate targets for all countries. *Climate Policy 1*(2), 211–227.

Plantinga, A. J. and K. R. Richards (2008). International forest carbon sequestration in a post-kyoto agreement. *Harvard Project on International Climate Agreements Discussion Paper 11*.

Posner, E. and D. Weisbach (2010). *Climate change justice*. Princeton University Press. Princeton University Press.

Rabin, M. (1993). Incorporating fairness into game theory and economics. *The American economic review*, 1281–1302.

Ringius, L., A. Torvanger, and A. Underdal (2002). Burden sharing and fairness principles in international climate policy. *International Environmental Agreements: Politics, Law and Economics 2*(1), 1–22.

Roodman, D. (2009). Estimating fully observed recursive mixed-process models with cmp. *Center for Global Development Working Paper 168*, 1–57.

Samuelson, P. and W. Nordhaus (2010). *Economics*. McGraw-Hill.

Sasaki, N. and F. E. Putz (2009). Critical need for new definitions of "forest" and "forest degradation" in global climate change agreements. *Conservation Letters 2*(5), 226–232.

Sawa, A. (2008). A sectoral approach as an option for a post-kyoto framework. *The Harvard Project on International Climate Agreements Discussion Paper*, 08–23.

Schelling, T. (1960). The strategy of conflict. *Cambridge, Mass.*

Schelling, T. C. (1996). The economic diplomacy of geoengineering. *Climatic Change 33*(3), 303–307.

Schmidt, J., N. Helme, J. Lee, and M. Houdashelt (2008). Sector-based approach to the post-2012 climate change policy architecture. *Climate policy 8*(5), 494–515.

Slechten, A. and V. Verardi (2014). Measuring the impact of multiple air pollution agreements on global CO_2 emissions. *Lancaster University Economics Working Paper Series 10*.

Somanathan, E. (2008). What do we expect from an international climate agreement? A perspective from a low-income country. Technical report, Discussion Paper 08-27, Harvard Project on International Climate Agreements, Belfer Center for Science and International Affairs, Harvard Kennedy School, December.

Sprinz, D. and T. Vaahtoranta (1994). The interest-based explanation of international environmental policy. *International Organization 48*(01), 77–105.

Stern, N. H., G. Britain, and H. Treasury (2006). *Stern Review: The economics of climate change*, Volume 30. HM treasury London.

Sterner, T. and U. M. Persson (2008). An even sterner review: Introducing relative prices into the discounting debate. *Review of Environmental Economics and Policy 2*(1), 61–76.

Stocker, T., D. Qin, G. Plattner, M. Tignor, S. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, and P. Midgley (2013). Ipcc, 2013: Summary for policymakers. *In Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change(Cambridge Univ. Press, Cambridge, UK, 2013).*

Teng, F., W. Chen, and J. He (2008). *Possible development of a technology Clean Development Mechanism in a post-2012 regime.* Harvard Project on International Climate Agreements.

UNFCCC (1995). Proposed elements of a protocol to the united framework convention on climate change, presented by brazil in response to the berlin mandate, paper no.1: Brazil.

UNFCCC (1992). United nations framework convention on climate change.

United Nations Environmental Programme (2012). The montreal protocol and the green economy: Assessing the contributions and co-benefits of a multilateral environmental agreement.

Urpelainen, J. (2012). Geoengineering and global warming: A strategic perspective. *International Environmental Agreements: Politics, Law and Economics 12*(4), 375–389.

U.S Energy Information Administration (2010). International energy statistics. Link to EIA data source.

Victor, D. G., M. G. Morgan, J. Apt, J. Steinbruner, and K. Ricke (2009). The geoengineering option: A last resort against global warming? *Foreign Affairs*, 64–76.

Vogt, C. (2002). On the political economy of international environmental agreements – some theoretical considerations and empirical findings. *C. Böhringer, M. Finus and C. Vogt, Controlling Global Warming-*

Perspectives from Economics, Game Theory and Public Choice, Edward Elgar, Cheltenham, 178–213.

Wigley, T. M. (2006). A combined mitigation/geoengineering approach to climate stabilization. *Science 314* (5798), 452–454.

Wråke, M., D. Burtraw, Å. Löfgren, and L. Zetterberg (2012). What have we learnt from the european union's emissions trading system? *AMBIO: A Journal of the Human Environment*, 1–11.

Curriculum Vitae

Born on December 19, 1983 in Cologne, Germany

1993-2003	Abitur Schlossgymnasium Benrath
2003-2004	Military Service at Musikkorps der Bundeswehr
2004-2010	Master of Science in Economics / Diplomvolkswirt, University of Münster
2006-2007	Exchange year at Sup de Co Montpellier, France
2010-2015	Doctoral studies in economics and assistant at ETH Zurich