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EQUITY RULES IN CLIMATE NEGOTIATIONS

AN ANALYSIS OF SUBMITTED PLEDGES BY THE EUROPEAN UNION, THE UNITED STATES OF AMERICA, THE RUSSIAN FEDERATION, AND CHINA WITHIN THE FRAMEWORK OF THE PARIS AGREEMENT.

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Abstract

The influence of equity principles on negotiations and cooperative behaviour of countries has experienced an increasing interest in the context of climate negotiations. In general, it is assumed that countries act purely in their material self-interest to reach the climate target of limiting the increase of global average temperature to maximally 2°C. Only a few studies have examined countries' preferences on specific equity rules. To further advance research in this field, this thesis aims to extend previously conducted analyses and predictions about a self-interested use of equity rules. The analysis of submitted pledges by the European Union, the United States of America, and China to the Paris Agreement, the outcome of the latest United Nations climate negotiations, did not indicate a purely self-interested use of equity rules. In contrast, the Russian Federation displayed a non-cooperative behaviour by actually pledging to increase its greenhouse gas emissions in the future.

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Abbreviations

ABI	Ability-to-Pay
BAU	Business-As-Usual
CBDR	Common but Differentiated Responsibilities
CO_2	Carbon Dioxide
COP	Conference of the Parties
EGA	Egalitarian
EPA	US Environmental Protection Agency
ERT	Emission Reduction Target
EU	European Union
GDP	Gross Domestic Product
GHG	Greenhouse Gases
Gt	Gigatonne
IEA	International Energy Agency
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
LDC	Least Developed Countries
LULUCF	Land Use, Land Use Change and Forestry
MAC	Marginal Abatement Cost
MtC	Megatonne of Carbon
NIDC	Nationally Determined Contribution
OECD	Organization for Economic Co-operation and Development
OHCHR	Office of the High Commissioner for Human Rights
POL	Polluter-Pays
SIDS	Small Island Development States
SOV	Sovereignty
tC	Tonnes of Carbon
UN	United Nations
UNCED	United Nations Conference of Environment and Development
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
USA	United States of America
USD	US Dollar
WCED	World Commission on Environment and Development

1 Introduction

> *"The key challenge is to devise an agreement or a set of arrangements that attracts wide participation including all countries with significant sources of emissions, and achieves deep and lasting reductions in emissions from all sectors" (Stern 2006, p. 460).*

Only recently, on the 4th November 2016, the Paris Agreement entered into force. The global community's commitment to enhance collective action against global warming is one of the most important outcomes of climate negotiations within the framework of the United Nations (UN). The ratification process was surprisingly fast, underlining the global community's will to stem anthropogenic climate change. Even though the Paris Agreement is in force, many debates are still underway over key issues on how to achieve mechanisms to limit the increase of global average temperature to maximally 1.5°C to 2°C. From the very beginning of negotiations, one of the main questions has been the equitable distribution of the burdens of achieving such a climate target and debates on equity have been intense. In the past, climate negotiations failed to establish binding greenhouse gas reduction targets. This was mainly based on developed countries that got rich on carbon intensive growth argued with less developed countries which asserted not being responsible for historical emissions that have been leading to the observed increase in global average temperature. Despite the Paris Agreement, this debate is still ongoing and illustrates the differences in how countries define fairness or perceive equity in burden sharing of abatement costs.

Common but differentiated responsibilities, historical responsibility, future responsibility, polluter-pays principle, *fairness*, or *principle of capacity* are only some of the terms referring to equity principles in climate negations. The lack of consensus on equity is caused by its characteristic to compromise ethical and moral principles. Falk et al. (1993, p. 2) provide a broader perspective on equity by stating that:

> "[e]quity derives from a concept of social justice. It represents a belief that there are some things which people should have, that there are basic needs that should be fulfilled, that burdens and rewards should not be spread too divergently across the community, and that policy should be directed with impartiality, fairness and justice towards these ends."

In practice, the terms equity and fairness receive their meaning depending on the context in which they are used (Metz 2000, p. 113).

Environmental agreements are by necessity voluntarily and there is no institution in place that could enforce compliance by all Parties. Therefore, a game-theoretical analysis of (in)actions in climate negotiations has received increasing attention (Finus 2002, p. 9). In this context, applying a game-theoretical approach allows insights into incentive structures of environmental agreements and to examine questions concerning: (1.) Conditions under which an agreement might be ratified, (2.) emission reduction targets to which participants in climate negotiations might agree up on, and (3.) whether such an environmental agreement can be established with a large number of participants (Finus 2002, p. 9). In the setting of a voluntarily signed environmental agreement, cooperation as well as compliance across countries is needed to reduce emissions in order to reach the climate target of limiting global warming to maximally 2°C. Ringius et al. (2002, p. 3) concluded that a consensus is required about perceptions of fairness among participants in climate negotiations in order to enhance cooperation and compliance in climate negotiations and in environmental agreements, respectively.

There is a large number of publications reviewing general equity principles applied in climate negotiations as well as their implications at the country level which suggest that self-serving bias is common in climate negotiations (Rose 1990, Ringius et al. 1998, 2002; Cazorla & Toman 2000; Böhringer & Helm 2008). However studies examining countries' preferences for specific equity principles are rare and only a few showed that individual perceptions of what is fair are aligned with material self-interest (Lange et al. 2010; Carlsson et al. 2013; Brick & Visser 2015).

The present thesis aims to outline how the importance of equity in climate negations has evolved. Further, the thesis examines whether countries acted in pure self-interest during climate negotiations leading to the Paris Agreement and thus favoured equity principles that minimize abatement costs in order to reach the climate target.

Perceptions of what is fair and unfair between countries are constantly changing and these changes are reflected in the climate negotiations held under the umbrella of the UN (chapter 2). Conventional game theory, which is an important foundation for analyzing and explaining problems of collective behaviour in general, and climate negotiations in particular, predicts that participants in climate negotiations will only cooperate and ratify an environmental agreement, if it serves their own wealth maximization and personal goals (chapter 3).

Commonly, important provisions and pledges in environmental agreements such as the Paris Agreement are not enforceable under international law. From an economic perspective, a voluntary contract design favours a self-serving behaviour and free-riding at the expense of others who are taking action to protect the climate. Nevertheless, today's global community has shown a cooperative behaviour leading to (formal) collective action against global warming within the framework of the Paris Agreement. Therein, equity criteria have shaped negotiations and the resulting pledges to act. As a result, conventional game theory might underestimate behavioural aspects of important equity rules and its effects on human actions and inactions (chapter 4). This applies in particular to the Paris Agreement that is based on voluntary pledges reflecting each country's own perception of equity principles (chapter 5). Lange et al. (2010) suggested that a country's material self-interest will ultimately lead to the support of the equity principle which distributes the burdens of reaching the climate target at minimal abatement costs. The European Union (EU), the United States of America (USA), the Russian Federation and G77 including China were at the core of their analysis (Lange et al. 2010). In this context, it is aimed to extend the existing literature on the countries' actual preference and use of specific equity rules in climate negotiations. Against that background, calculations, assumptions, and predictions stated by Lange and co-workers were extended and applied to voluntary pledges submitted by the EU, the USA, the Russian Federation, and China within the framework of the Paris Agreement (chapter 6). Based on calculations in chapter 6 and final pledges to the Paris Agreement, it is determined whether countries actually applied self-serving equity rules, as predicted, or rather followed an approach that requires further explanation beyond conventional game theory.

2 The History of Equity in International Climate Negotiations

> *"(…) change in the Earth's climate and its adverse effects are a common concern of humankind" (UNFCCC 1992, p. 2).*

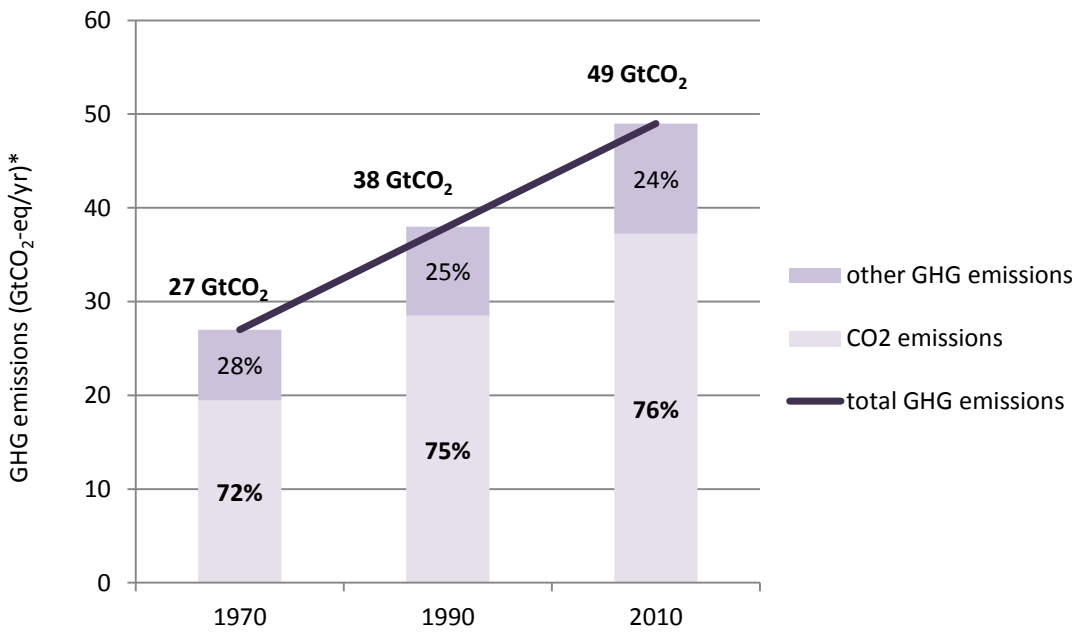
Climate change became a target of international environmental activities in the late 1980s and early 1990s with the discovery of the ozone hole (Bodansky 2001, p. 23). Since then, climate change has been recognized as an international policy problem that required a global response strategy (Hoffmann 2013, p. 8). In 1987, the World Commission on Environment and Development (WCED), also known as the Brundtland Commission, introduced the dominant conceptual framework of *sustainable development* in its report *Our Common Future* (Bernstein 2013, p. 130). Until today, its definition of sustainable development is valid and has become the basis of international environmental strategies. Thus, sustainable development aims "(...) to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987, p. 16). Already then, the question of equitable use of natural resources was addressed by stating that "(m)eeting essential needs requires not only a new era of economic growth for nations in which the majority are poor, but an assurance that those *poor get their fair share of the resources* required to sustain that growth" (WCED 1987, p. 16). Furthermore, the need for action of the entire international community due to the global effects of climate change had been stressed (WCED 1987, p. 44). The diverse and unequal regional and local distribution of climate change effects, however, had been neglected. The guiding principle of international response strategies to meet the challenges of climate change was that *all states* should cooperate in finding a global solution where *all states* take responsibilities for carrying out that global solution depending on the states' developmental levels (Hoffmann 2013, p. 8). Already from the very beginning, the climate change problem was stated as an emissions problem (ibid.). Hence, emissions of carbon dioxide (CO_2) have become of particular concern of today's climate change debates and policies.

2.1 Carbon Emissions as Target of Policy Responses to Climate Change

The direct link between human influence on the climate system and an increase in global temperatures and its contribution to climate change has been widely recognized by the global community and led to a variety of policy responses and international treaties (Dyer

2014, p. 362; IPCC 2015, p. 2). A rise in global temperatures has economic, social, and environmental impacts affecting human well-being around the world (IPCC 2015, pp. 2–16). One observed change in the climate system includes an increasing average temperature of the Earth's surface (IPCC 2015, p. 2). The focus of today's policy responses on how to fight climate change focuses on anthropogenic greenhouse gas (GHG) emissions (ibid). *GHG emissions* is used as a general term referring to CO_2, methane, nitrous oxide, and the F-gases (Hydrofluorocarbons, Perfluorocarbons, Sulphur hexafluoride) as defined in the Kyoto Protocol under the umbrella of the United Nations Framework Convention on Climate Change (UNFCCC) (UNFCCC 1998). CO_2 amounts to the greatest share of total annual anthropogenic GHG emissions causing human influenced climate system changes (IPCC 2015, pp. 5–6).

Figure 1: Total annual anthropogenic GHG emissions 1970/1990/2010.



*Gigatonne (Gt) of CO_2-equivalent per year

Source: Own calculations and illustration based on IPCCC (2015, p.5).

Anthropogenic GHG emissions in general and CO_2 emissions in particular have constantly increased between 1970 and 2010, including an increase in CO_2 emissions in absolute terms but also in relation to total GHG emissions. Accounting for roughly 70% of total GHG emissions, the energy sector is the largest source of emissions among all human activities

(International Energy Agency (IEA) 2015, p.7).[1] This brings both the energy sector and CO_2 emissions into focus of today's discussions on how to reach global action to combat climate change.

2.2 The United Nations Framework for International Cooperation to Combat Climate Change

Already in 1992, when there was still less scientific evidence regarding climate change and its emergence, and impacts, the international treaty UNFCCC (hereafter also referred to as *the Convention*) was adopted. The Convention laid the foundations for intergovernmental climate negotiations under the framework of the UN (UNFCCC 2014f).

The following sections aim to highlight the historical developments of the UN multilateral treaty-making process that have been equated with global climate change governance (Hoffmann 2013, p. 7). Therein, the focus lies strictly on linking the major outcomes of UN negotiations' debates on and applications of equity principles.

2.2.1 Rio de Janeiro (1992)

In 1972, 114 countries agreed on 26 non-binding guiding principles demanding collective action to preserve and enhance the human environment at the UN Conference on the Human Environment (O'Neill 2009, p. 27; UNEP 1972). In 1992, 20 years later, the UN Conference of Environment and Development (UNCED), which is better known as the Earth Summit, constituted the second global environment conference under the umbrella of the UN (UN 2016a). The Earth Summit's outcomes, the Stockholm and Rio Declarations, laid the conceptual and political foundations for future environmental policy instruments. Although these Declarations are not legally binding, they brought the issue of environmental degradation and climate change on the international policy agenda and officially on the UN agenda (O'Neill 2009, p. 77). The Stockholm Declaration did not explicitly mention equitable or fairness principles, however, the Conference is seen as the beginning of the debate of the interlinkage between environmental protection and economic development (O'Neill 2009, p. 28). Even though the Stockholm Declaration did recognize the need of economic

[1] "The energy sector includes emissions from "fuel combustion" (the large majority) and "fugitive emissions", which are intentional or unintentional releases of gases resulting from production, processes, transmission, storage and use of fuels (e.g. CH4 emissions from coal mining)" (IEA 2015, p. 7).

development for developing countries, the relationship between environmental and developmental goals became of major importance during the Earth Summit (ibid.).[2] One of the cornerstones of the Rio Declaration was the introduction of the concept of *common but differentiated responsibilities* (CBDR).

Principles 7 of the Rio Declaration states that:

> "States shall cooperate in a spirit of global partnership to conserve, protect and restore the health and integrity of the Earth's ecosystem. In view of the different contributions to global environmental degradation, *States have common but differentiated responsibilities.* The *developed countries acknowledge the responsibility* that they bear in the international pursuit to sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command" (UNEP 1992).

The principle reflects the importance that the greatest possible cooperation is needed to combat climate change. In achieving this goal, all countries have responsibilities to contribute to global action accordingly. Most importantly, different responsibilities and capabilities for developed and developing countries concerning sustainable development and global environmental degradation are presented (see footnote 2). Additionally, the evolving principle of CBDR was accompanied by a *polluter-pays (POL) principle* (Principle 16 of the Rio Declaration) claiming that "(…) the polluter should, in principle, bear the cost of pollution, with due regard to the public interest and without distorting international trade and investment" (UNEP 1992). Stating this, the POL principle promotes an internalization of the environmental cost and favours market mechanisms such as emission trading or privatization (Bernstein 2013, p. 133; see also paragraph 4.1). Until today, the POL principle is a leading principle in environmental law.

After all, the Earth Summit's most remarkable outcome for future climate negotiations was the adoption and opening for signature of the UNFCCC.

[2] The conducted analysis on equity rules in climate negotiations is mainly based on a classification between Annex I and Non-Annex I countries as used by the UNFCCC and its underlying treaties and protocols. In the context of this thesis, the working term *developing countries* is used as a general term relating to the majority of Non-Annex I countries despite their individual development status. Countries with economies in transition might display characteristics of developed as well as developing countries and are thus explicitly mentioned if a differentiation is required within the context. There is no official definition or classification by the UN. See pp. 8-9 for a more detailed description of UN classifications. A general discussion on how to define developed and developing countries does not lie within the scope of this thesis.

Objective

The Convention's main objective as declared in Article 2 is the "(...) stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (UNFCCC 1992, p. 9). In the same Article it was further stated that the achievement of the main objective should not limit "(...) economic development to proceed in a sustainable manner". It is noticeable that the Convention's text leaves space for a wide range of interpretation, as it neither specifies a level of stabilization of GHG nor emission reduction targets (ERTs). It also seems to concentrate on *global* GHG concentrations only, instead of individual emissions (Ringius et al. 2002, p. 8). Due to the absence of a specified time-frame, the objective's achievement is not date-oriented (Schröder 2001, p. 20).

Principles of Equity

The UNFCCC clearly stresses the equity debate between countries as several fairness principles were outlined throughout the Convention (Bosello et al. 2001; Ringius et al. 2002). The fundamental principle of CBDR can be found in the preamble of the Convention's text, as well as in Articles 3(1) and 4(1).

> "The Parties should protect the climate system for the benefit of present and future generations of humankind, *on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities*. Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effect thereof" (UNFCCC 1992, Article 3(1), p. 9).

In addition to the intergenerational aspect of equity, the Convention recognizes the important role of developed countries in "[n]oting that the largest share of historical and current global emissions of greenhouse gases has originated in developed countries (…)" (UNFCCC, p. 2) and that they "(…) have to bear a disproportionate or abnormal burden under the Convention (…)" (UNFCCC 1992, Article 3(2), p. 9). The UNFCCC created a framework that defined different obligations for three groups of countries:

Annex I lists 24 Parties that are members to the Organisation for Economic Co-Operation and Development (OECD)[3] and the European Community (now: the European Union)

[3] Excluding Mexico and the Republic of Korea.

plus 12 Central and Eastern European countries with economies in transition[4] (UNFCC 1992, p. 32).

Annex II lists all Annex I countries excluding those with economies in transition, i.e. all OECD countries as of 1992 (UNFCCC 1992, p. 33). Annex II countries are obliged to "(...) provide new and additional financial resources to meet the agreed full costs incurred by developing countries" as well as technology transfer (UNFCCC 1992, Article 4(3), pp. 13-14).

Non-Annex I Parties are all Parties that are not specified under Annex I, which are mostly classified as developing countries (UNFCCC 2014h).

In practice, the terms Annex I, Annex II, and Non-Annex I are used interchangeably for developed (Annex I and Annex II countries) and developing (mostly Non-Annex I countries) countries.

In line with the Convention's aim to assign developed countries the greater share of the burden of combating climate change and to stabilize GHG concentrations, Article 4(2)(a) of the Convention obliges Annex I Parties to "(…) adopt national policies and take corresponding measures on the mitigation of climate change by limiting its anthropogenic emissions of greenhouse gases (...)" with a more specified target in Article 4(2)(b) to "(…) [return] individually or jointly to their 1990 levels these anthropogenic emissions of carbon dioxide (…)" (UNFCCC 1992, p. 12).

Summing up, the Convention that entered into force on 21 March 1994 has introduced the issue of equity in the context of climate change and in 2016 still constitutes the legal and institutional framework to enhance action to combat climate change on a global level (UNFCCC 2014e).

2.2.2 COP1 (Berlin, 1995)

The first meeting of the Conference of the Parties (COP1) of the UNFCCC was held in Berlin in spring 1995. Parties to the UNFCCC (hereafter also referred to as *Parties to the Convention* or *the Parties*) reviewed the above stated commitments of Articles 4(2)(a) and 4(2)(b) to the

[4] Including the Russian Federation.

UNFCCC based on the latest scientific knowledge on climate change, entailing a review of ERTs and timetables (Schröder 2001, pp. 59). The outcome of COP1 laid the foundations for the Kyoto Protocol: a new committee was commissioned to negotiate an updated protocol or another legal document in order to reinforce the Annex I Parties' commitments for a post-2000 period (Bodansky 2001, p. 26; Schröder 2001, pp. 59).

The resulting negotiation process was shaped by seventeen submitted government-proposed sharing agreements (Ringius et al. 2002, p. 13). Individual proposals that were discussed during that process referred to several equity principles (ibid.). Brazil, for example, proposed reduction commitments based on historical responsibilities and promoted the POL principle. The EU and Switzerland proposed the convergence of per capita emissions over time, such that all countries would reach the same per capita emissions level at some point, whereas Poland and Estonia focused on ERTs based on gross domestic product (GDP) per capita and thus promoted the ability-to-pay principle (Ringius et al. 2002, p. 14).[5] However, no consensus could be reached. Developing countries rejected binding ERTs maintaining that countries with high 1990 emissions should take their responsibility for climate change and that they were not financially able to pay for emission reductions (Cazorla & Toman 2000, p. 1; Böhringer & Helm 2008, p. 261).

2.2.3 COP3 (Kyoto, 1997)

The two-and-a-half-year complex negotiation process that started at COP1 led to the adoption of the Kyoto Protocol (hereafter also referred to as *the Protocol*) in December 1997 (Schröder 2001, pp.63). The rejection of binding ERTs by developing countries led to the Protocol's key characteristic: developing countries do not have any obligations to reduce or even control their GHG emissions under the Protocol (Ringius et al. 2002, p. 16). This outcome was mainly caused by the developing countries' perception of historical responsibilities for increasing GHG emissions. According to their main argument, they only have minor historical responsibilities and therefore no obligations for reducing or limiting their GHG emissions (Böhringer & Helm 2008, p. 261). On the other hand, most developed countries did accept their historical responsibilities and the principle of CBDR under Article 10 of the Kyoto Protocol in order to achieve sustainable development (UNFCCC 1998). Hence, the Protocol established individually binding and quantified ERTs for all Annex I

[5] For a detailed explanation on the most prominent equity rules in climate negotiations see section 4.1.

Parties but failed to establish any targets for Non-Annex I Parties (Schröder 2001, p. 64). As a result, some industrialized countries that were well integrated into the global economy feared facing competitive disadvantages because of emission reduction targets compared to less developed countries with no limits on emissions (Cazorla & Toman 2000, p. 5). Particularly harsh criticism was voiced by the USA. Simultaneously to the Kyoto negotiation process, a resolution was passed to the US Senate stating that the USA should not sign any agreement under the framework of the UNFCCC in which developing countries did not have the same obligations and binding emission targets to reduce GHG emissions in the same time period as the USA; or indeed any other agreement that might harm the US economy (The Senate of the United States 1997; Böhringer & Helm 2008, p. 261). Thus, it is not surprising that the US changed its attitude towards their obligations under the Protocol withdrew from the Protocol in 2001 (O'Neill 2009, p. 80).[6]

One might assume, that the concept of CBDR was only stressed by less developed countries, however this was not the case: Australia argued that they should be excluded from high ERTs due to its natural resource abundance and its reliance on fossil fuel exports (Chasek et al. 2014, p. 159). Their bargaining power led to a major exception of emission targets of an Annex I country. Australia was allowed to increase its emissions by 8% from 1990 levels (UNFCCC 1998, p. 20). The Protocol further specified that Iceland (+ 10%) and Norway (+1%) could also increase their emission levels whereas New Zealand, the Russian Federation, and Ukraine should keep their emission levels at values from 1990 (see Annex B of UNFCCC 1998). In line with reductions targets such as by Germany (a decrease of 8%), Poland (a decrease of 6%), or Japan (a decrease of 6%) (ibid.). The overall aim was to reduce global collective emissions "(...) by at least 5 per cent below 1990 levels in the commitment period 2008 to 2012" (UNFCCC 1998, Art. 3). These targets were solely outcomes of nations' bargaining powers and their perceptions of CBDR and equity instead of formulas based on objective criteria (Chasek et al. 2014, p. 159). Article 25(1) of the Protocol determines that (1.) the Protocol should enter into force after at least 55 Parties to the Convention had ratified the Protocol (2.) covering at least 55% of total CO_2 emissions of 1990 levels of Annex I Parties. Due to the withdrawal of Canada, the refusal to accept binding emission targets by

[6] The former president George W. Bush justified the decision with the following words: "I oppose the Kyoto Protocol because it exempts 80 percent of the world, including major population centers such as China and India, from compliance, and would cause serious harm to the US economy" (Chasek et al. 2014, p. 160).

the USA, and the classification of China as a Non-Annex I country, some of the biggest GHG emitter did not ratify the agreement. As a consequence, big attention was drawn to other great emitters, such as the member states of the EU, or Japan to fulfil the Protocol's first provision criteria (Chasek et al. 2014, p. 161). Only with the ratification by the Russian Federation in December 2004, the threshold of 55 Parties to the Protocol was reached and the threshold of targeted emission reductions of Annex I Parties was exceeded (UNFCCC 2014j). Finally, the Protocol entered into force in February 2005, ten years after the start of the negotiating process at COP1. In 2016, 84 Parties had ratified the Protocol to the UNFCCC (ibid.).

The Protocol's complex and lengthy negotiating process leading to binding ERTs for Annex I countries only and covering a commitment period from 2008 until 2012, showed without precedent how perceptions of fairness due to country specific key-characteristics (see also paragraph 4.2) in combating global climate change differ and affect climate negotiations and their outcomes (Cazorla & Toman 2000, p. 3).

2.2.4 COP13 (Bali, 2007) and COP15 (Copenhagen, 2009)

While European countries had already pledged for high binding ERTs during the Kyoto negotiation process, other big emitters such as the USA, China, India, Brazil, and major oil-producing states were hesitant and more concerned about their share of burden of emissions reduction targets and their effect on economic growth. Especially China and India insisted that developed countries should take the lead in mitigating climate change due to their large historical responsibility (Hoffmann 2013, p. 9). Taking into account the negative position of the USA during the Kyoto negotiation process towards ERTs applying to developed countries only, it is not surprising that COP15 held in Copenhagen failed to set new legally binding emission targets beyond the first commitment period of the Kyoto Protocol (Clémencon 2016, p. 6; Hoffmann 2013, p. 10).

The Copenhagen meeting produced the Copenhagen Accord emphasising the urgency to "(...) combat climate change in accordance with the principle of common but differentiated responsibilities and respective capabilities" once more (UNFCCC 2010, p. 5). Furthermore, Parties to the Convention shall recognize "(...) the scientific view that the increase in global temperature should be below 2°C, on the basis of equity and in the context of sustainable

development, enhance our long-term cooperative action to combat climate change" (UNFCCC 2010, p.5). Since the Copenhagen Accord the target to keep global warming to below 2°C has become consensus and should be achieved "(…) on the basis of equity" (UNFCCC 2010, p. 5). The Accord drew attention to the equity debate between developed and developing countries. As legally binding ERTs applicable for Annex I countries only caused disagreement between the biggest emitters of the Convention's Parties, the Accord accepted the concept of *National Appropriate Mitigation Activities* that had been adopted in the Bali Action Plan at COP13 in 2007 (Hoffmann 2013, p. 10). This concept allows Annex I as well as Non-Annex I countries to individualize their ERTs. In contrast to a collective target only applicable for Annex I countries, this approach attempts to smooth disagreements concerning the equity debate by allowing countries to self-determine their share of the burden of combating global warming (ibid). As a result, Annex I Parties shall further increase their ERT as intended under the Kyoto Protocol, whereas Non-Annex I countries, which did not have any obligations under the Kyoto Protocol, shall implement mitigation actions while small island developing states and least developed countries shall undertake voluntary actions on the basis of support by developed countries (UNFCCC 2010, p. 6).

Until 2016, only 63 Parties to the Convention, thereof 16 Annex I Parties (including the EU) and 47 Non-Annex I Parties, submitted information related to the Accord (UNFCCC 2014b, 2014c). Despite the USA's refusal to ratify the Kyoto Protocol, the Copenhagen Accord brought one of the biggest emitters back to the international stage of climate negotiations. The USA submitted ERTs to the Accord, due to its informal character, legislative changes, and the expressed intention of Non-Annex I countries to set up mitigation action targets.

2.2.5 COP16 (Cancun, 2010), COP17 (Durban, 2011), and COP18 (Doha, 2012)

After the failure to set up a new legally binding agreement applicable after Kyoto from 2012 onwards, UN climate negotiations further focused on the concept of individual national pledges. Decisions adopted in Cancun (COP16) stressed historical responsibilities of developed countries and their large share of historical global GHG emissions which have been leading to observed adverse effects thereof (UNFCCC 2011). Neither at the meeting in Cancun nor in Durban could Parties agree on a legally binding document following the Kyoto's first commitment period after 2012. Nevertheless, Parties agreed on three characteristics that a new agreement should entail: (1.) it should be a legally binding

document applicable to all, (2.) it should be based on the concept of equity and differentiation among Parties, and (3.) it should establish a periodically review of pledges in order to ensure transparent monitoring of national ERTs (Clémencon 2016, p. 8).

Only a few weeks before the end of the Kyoto Protocol's first commitment period, COP18 took place in Doha in December 2012. Intense climate negotiations of the Parties to the Convention resulted in the ratification of the Doha Amendment and the establishment of a second commitment period between 2013 and 2020 under the Kyoto Protocol (Chasek et al. 2014; UNFCCC 2014d). Annex I countries updated their legally binding quantified ERTs as stated in the original Kyoto Protocol from 1997 (UNFCCC 2013). As had been already criticised under the original Kyoto Protocol, the Doha Amendment did not contain binding ERTs for Non-Annex I countries. The Amendment still focused on the concept of CBDR, the historic responsibilities of developed countries, and their financial support of developing countries in climate change mitigation and adaptation. However, all Parties agreed upon a timetable towards a universal climate change agreement to be adopted by 2015 (UNFCCC 2012).

2.2.6 COP19 (Warsaw, 2013) and COP21 (Paris, 2015)

In line with the adopted time table towards a universal climate agreement by 2015, all Parties approved during COP19 in Warsaw, Poland, in December 2013:

> "(...) to initiate or intensify domestic preparations for their intended nationally determined contributions (...) in the context of adopting a protocol, another legal instrument or an agreed outcome with legal force under the Convention applicable to all Parties (...) by the first quarter of 2015 (...)" (UNFCCC 2014i, p. 4).

The submission of Intended Nationally Determined Contributions (INDCs) paved the way for climate negotiations which focused on a legal instrument applicable to all Parties of the UNFCCC from 2020 onwards. These negotiations were held in Paris from 30 November to 11 December 2015 and constituted COP21. COP21 concentrated strongly on fostering universal cooperation by promoting a universal bottom-up approach. Each Party was asked to formulate its own priorities and ambitions to reduce its carbon emissions; an approach which was unlike the concept of equitable burden-sharing based on multilateral negotiated legally binding ERTs, applied during the negotiating process for the Kyoto Protocol (UNFCCC 2016; Clémencon 2016; Mbeva & Pauw 2016). On the one hand, such an approach aims to

foster the Parties' own delineation of responsibilities and capabilities in combating climate change (Clémencon 2016, p. 4; Mbeva & Pauw 2016, p. 15). On the other hand, such independent determination and freedom of choice have been a hurdle during the negotiating process in Paris. There was no official guideline for setting up INDCs that could have supported the Parties in formulating their own priorities and ambitions. Another factor that complicated the negotiating process was the revocation of classifying countries into Annex I, Annex II, and Non-Annex I which had been the basis for all climate negotiations since the establishment of the UNFCCC.

3 A Game Theory Perspective on Climate System Protection

> *"Game theory has been used to try to identify key criteria for the design of frameworks for international collective action on climate change" (Stern 2006, p. 452).*

The global concern to mitigate climate change and its far reaching impacts by reducing global emissions leads to the assumption that cooperation in the global environmental arena might be possible. Mutual concern, however, is no guarantee for cooperation (Underdal et al. 2012, p. 476). Most of the time cooperation involves accepting compromises and exchanging commitments. This especially applies if the number of negotiating partners is large (ibid.). In this context, game theory has become method for analyzing (in)actions between agents[7], for formulating assumptions and hypotheses about an agent's behaviour, and for predicting the final outcome of global environmental agreements (Finus 2002, p. 9).

The first section of this chapter introduces climate system protection as a global public good. This point of view is essential for applying a game-theoretical concept to the framework of climate negotiations. The public good characteristics of climate system protection are then linked to global social dilemmas. The theoretical concept of a participation game is

[7] To apply a game-theoretical framework to the issue of climate protection in climate negotiations, the terms participants, members, countries, and Parties to the Convention are used interchangeably and refer to the technical term *agent* in standard economic theory.

introduced and discussed to emphasize the problem of free-riding in the presence of cooperation within the framework of an international environmental agreement.

3.1 Climate System Protection as a Global Public Good

In general, there is agreement in the economic and social science literature that climate change mitigation and climate system protection are global public goods (see among others Bosello et al. 2001; Blanchard et al. 2003; Barrett 1994; Carraro 1997; Cazorla & Toman 2000; Lange et al. 2007; Underdal et al. 2012).

As already stated before in paragraph 2.1, the climate change problem was understood as an emissions problem from the very beginning of climate policies (Hoffmann 2013, p. 8). Climate-damaging GHG emissions do not respect borders but are spread throughout the atmosphere (Vogt 2002, p. 178). As a result, if harmful emissions are reduced by one emitter, other countries will also benefit from these efforts that aim to protect the global climate system. Hence, climate protection is non-excludable. A further characteristic of a public good is its non-rivalry. If one unit of climate protection is consumed by one country, benefits of climate protection to another country will not be lowered (ibid.). These theoretical characteristics of non-rivalry and non-excludability of climate system protection are extended to be intergenerational under the UNFCCC. As stated in Article 3, all countries "(...) should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity (…)" (UNFCCC 1992).

A game-theoretical framework introduces the issue of incentive problems of non-rival and non-excludable goods which hampers countries to cooperate in environmental negotiations. If a country acted totally rational, it would not consider any positive externalities of its emission reductions' actions on others (Vogt 2002, p. 178).[8] This behaviour would lead to ERTs too low to protect the climate and to enhance climate change mitigation. As known from standard economic theory, all agents would be better off, if all of them considered the positive externalities of their actions and thus cooperated. However, if agents realized this Pareto efficient outcome, every agent would have an incentive to deviate from such a

[8] The standard assumption from traditional game theory "(...) that players are *rational* in the sense that their expectations about each other's strategies can be summarized by probability distributions called *beliefs,* and that their preferences over uncertain outcomes can be described by assigning numerical *payoffs* to outcomes so that they maximize expected payoffs, given their beliefs" is adopted (Crawford 2014, pp. 346–347).

socially preferred outcome because it is always preferable to profit solely from the mitigation efforts undertaken by others while not contributing to such efforts oneself (ibid). Such an incentive to free-ride and still to profit from climate system protection is given to all countries equally resulting in the provision of the public good at a Pareto inferior level or even in not providing the good at all (Vogt 2002, p. 179). This effect is strengthened by the adverse effects of climate change and the structural differences of negotiating parties: in general, those countries suffering the most from climate change are not the biggest polluters (Bosello et al. 2001, p. 2). The problem of providing a global public good, such as the protection of the climate system, in which individual rationality and optimal outcomes for a group do not seem to be aligned, is a typical collective action problem (Ostrom 2009, p. 7).

3.2 The General Concept of Social Dilemmas

Attempts to reduce GHG emissions constitute a classic collective action problem. Non-cooperation actions in which a conflict between the short-term individual interest and the long-term collective interest occurs are commonly known as social dilemmas. Individuals act according to their self-interest to maximize their short-term material benefits by making independent choices and do not consider their actions' impacts on others (Ostrom 2009, p. 6). Theoretical considerations show that for such dilemmas, the socially optimal outcome is not determined by a Nash equilibrium derived from traditional non-cooperative game theory (see paragraph 3.3).[9] In contrast, a socially optimal outcome can only be achieved if the majority of participants in climate negotiations select a cooperative strategy. In this case, determining a cooperative strategy means joining, signing, ratifying, and complying with an environmental agreement.[10]

Literature on social dilemma is mainly based on and further developed for three types of dilemmas: The Prisoner's Dilemma, the Dilemma of providing public goods, and the Tragedy of the Commons (Kollock 1998, p. 185). In the previous chapter, climate protection has been classified as a global public good. The focus of this section lies on the social dilemma of providing public goods. The theoretical concept of the social dilemma of providing public

[9] A Nash equilibrium is "(...) a combination of strategies such that each player's strategy maximizes his expected payoff, given that of the others" (Crawford 2014, p. 347).

[10] By signing a treaty, signatories express the willingness to continue the treaty-making process. The ratification of a treaty, or Agreement, or Protocol, creates binding obligations on Parties (UN 2016b).

goods is based on the Prisoner's Dilemma. In the Nash Equilibrium of a Prisoner's Dilemma, each individual is maximizing their payoff whilst minimizing the other individuals' payoff (Rabin 2014, p. 309). Applied to the provision of pubic goods, the use of a public good without any contribution to its provision or conservation seems to be the best immediate outcome from the individual's point of view. The non-rival and non-excludable characteristics of a public good do not provide incentives to cooperate. As a result, if every individual acted the same way, i.e. with defection and non-cooperation, the public good would not be provided or maintained at all and every individual would be worse off compared to situations where cooperation takes place (Kollock 1998, p.187). The temptation not to cooperate seems rational to the individual but leads to a worse outcome to society. The typical problem of free-riding arises.

Hardin (1968) illustrated the arguments of the *Tragedy of the Commons* by using the well-known example of the rational herder. The individual herder benefits from his own animals using a pasture open to all but suffers when his or any other herder's animals cause degradation of the common pool resource when their cattle overgraze (Hardin 1968, p. 1244). Therefore, Hardin concluded: "Therein is the tragedy. Each man is locked into a system that compels him to increase his herd without limit – in a world that is limited" (ibid). Even though Hardin's findings focussed on common pool resources, whereas the present thesis focuses on climate protection by emission reductions as a global public good, his conclusions are essential. Hardin drew the attention explicitly to human factors that cause environmental damage: (1.) the increasing global population and the increasing per capita resource consumption leads to a depletion of natural resources and environmental services, and (2.) the way in which humans organize to deplete natural resources (Hardin 1968, pp. 1244–1245; Dietz et al. 2003, p. 1907).

In his work *The Logic of Collective Action* (1965), Olson intensively studied the general question on how a social dilemma can be overcome. According to Olson, the main obstacle towards overcoming the problem is that costs resulting from the contribution to the collective or public good are concentrated whereas benefits are scattered (Olson 1965, pp. 22–23; Ostrom 2009, p. 8). In his theory, Olson highlighted the differences in dealing with collective goods or externalities between members of a large group and members of a small group (Olson 1965, p. 2). It seems to be easier to enforce the own self-interest within

smaller groups. With increasing group size each individual's relative importance to contribute to the collective good decreases as well as its fraction of the value of the common good (ibid., pp. 24-25). Thus, Olson (1965, p. 3) concluded that "[i]n the sharing of the costs of efforts to achieve a common goal in small groups, there is however a surprising tendency for the *exploitation* of the *great* by the *small*". The member with the largest fraction of group gain will bear a disproportionate share of the cost of any group action (Olson 1965, pp. 28–29). Ostrom (2009, p. 8) calls Olson's theory a theory of *inaction* due to human behaviour and concluded that "[i]f many individuals decide to *free ride* on the actions of others, the *others* may stop contributing to the collective good. If more and more actors pull out, eventually no one contributes".

Hardin (1968) as well as Olson (1965) shaped the conventional theory of collective action problems and are crucial for analyzing social dilemmas with global impacts, such as climate system protection by reducing GHG emissions. Thus, in the following section cooperative and non-cooperative behaviour in climate negotiations will be introduced and visualized utilising the analytical framework of a two stages participation game.

3.3 The Participation Game

In the literature, participation in and compliance with international environmental agreements are mainly modelled using either a cooperative or a non-cooperative approach of game theory (Grüning 2010, pp. 9–11). The cooperative approach is based on the assumption that agreements are binding and an enforcement mechanism is in place (ibid). The lack of an enforcement mechanism in voluntary agreements, such as the UNFCCC, favours the use of a non-cooperative framework that can be extended by elements of the cooperative approach for modelling negotiations between sovereign states (ibid). The following explanations are based on and taken from (1.) analyses conducted by Carraro (1997) and Carraro and Siniscalco (1993) in which "(...) international negotiations are modelled as games in which sovereign countries bargain over emission control" (Carraro & Siniscalco 1993, p. 310) and (2.) further theoretical analyses conducted by Grüning (2010, pp. 11-15) that were based on (1.).

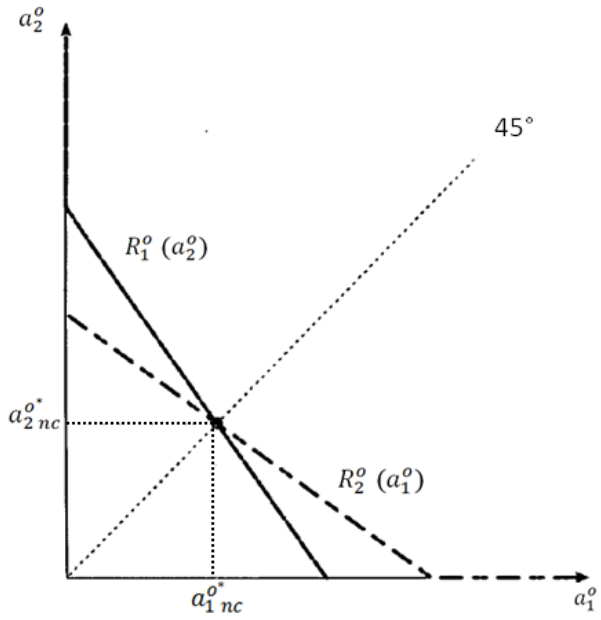
The following model of a participation game is based on the traditional *N* prisoners' dilemma (see paragraph 3.2). Carraro and Siniscalco (1993) considered *N* countries ($N \geq 2$) that have

full information while bargaining over emission control of a specific pollutant. Thereby, each country *i* benefits from using the environment as a factor of production as well as a sink for emissions. Hence, each country's own welfare is not only negatively affected by its own emissions but also by other countries' emissions. This leads to the welfare function that is determined by benefits arising from the use of the environment (e.g. production and consumption activities) and costs (or damages) resulting from pollution emissions. In the first stage, each country decides whether or not to cooperate with other countries in order to reduce total emissions. An underlying assumption is the non-binding character of the signed agreement. The first stage determines the number of signatories *S* and outsiders *O (= N – S).*

The second stage solves the coalition formation game. Grüning (2010, p. 11) called the second stage *abatement game* because signatories and outsiders determine their abatement strategies (also referred to as *abatement levels*) a^s and a^o simultaneously, taking into account the decision of all other countries. A sub-game perfect equilibrium can be determined by solving the game using backward induction. A country's individual payoff is depending on its benefit, which results from aggregate abatement, and on the cost from environmental protection.

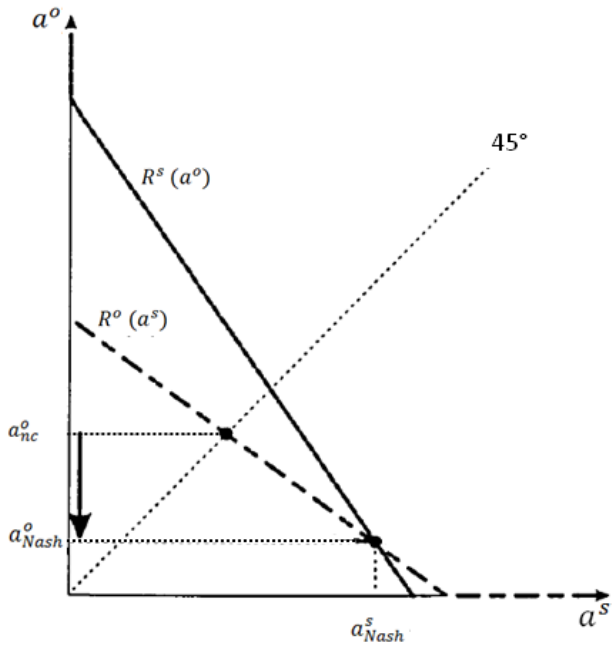
Later at the second stage, each country sets its abatement target. Outsiders behave totally non-cooperative- towards the cooperative coalition as well as towards other outsiders. An outsider's best response in order to maximize its payoff, given the abatements from the other countries, is the abatement level at which its own marginal benefits equals its marginal costs of abatement. In a scenario with no cooperation between countries, this response constitutes a Nash equilibrium. Figure 2 shows the reaction functions of two outsiders $R_1^o\ (a_2^o)$ and $R_2^o\ (a_1^o)$ based on their abatement strategies a_1^o and a_2^o, respectively. In this graph, the relative payoff of an outsider's reaction function is always decreasing. Thus, environmental policies are strategic substitutes. Further, the intersection of the two reaction functions shows the Nash equilibrium of the abatement level $a_{1\,nc}^{o^*}$ and $a_{2\,nc}^{o^*}$. Due to the assumption that all outsiders are identical, all abate at the same abatement level in the equilibrium. On account of simplification, only one representative country's payoff needs to be maximized. The optimal response of a cooperative country $R^s\ (a^o)$ and a non-cooperative country $R^o\ (a^s)$ is shown in Figure 3.

Figure 2: Nash Equilibrium without cooperation.



Source: Modified from Grüning (2010, p. 12).

Figure 3: Nash Equilibrium with cooperation.



Source: Modified from Grüning (2010, p. 13).

The new Nash equilibrium is the intersection of the signatories' abatement level a_{Nash}^s and the outsiders' abatement level a_{Nash}^o where the signatories' aggregate marginal benefit equals a country's individual marginal cost. Figure 3 clearly shows that if one country increases its abatement level, the other country's optimal response is to decrease its own abatement. This suggests that there are situations in which there is an incentive to free-ride at the expenses of the cooperative countries (Grüning 2010, p. 14). Further, marginal costs are the same inside as well as outside the agreement, whereas marginal benefits between signatories and outsiders depend on the coalition size. If an international environmental agreement is present, a_{Nash}^s exceeds a_{Nash}^o due to the internalization of environmental externalities. In the Nash equilibrium, the aggregate abatement level in presence of cooperation exceeds the aggregate abatement level in the absence of any cooperation (ibid., pp. 13-14). It is assumed that due to the self-enforcing character of international environmental agreements, two effects apply: (1.) Larger coalitions are favoured and the cooperative abatement level increases with an increase in number of signatories; and (2.) larger coalitions are destabilized by the size of the individual's gain from free-riding (Grüning 2010, p.14). These two effects work in different directions. These results change if only a small number of participants negotiate about and international environmental problem,

because then total cooperative and non-cooperative abatement levels are generally comparable (Grüning 2010, pp. 14-15). In this case, free-riding is credibly punished relative to the gains from a defective behaviour (ibid.). Conversely, this implies that the more countries are involved in international negotiations concerning environmental problems such as climate system protection, the more cooperative behaviour is destabilized and the participation rate is decreased (Grüning 2010, p.15).

Until today, the beginning of December 2016, 115 out of 197 Parties to the UNFCCC have ratified the Paris Agreement. The vast majority of the global community agreed on taking action to limit global warming to maximally 2°C above pre-industrial levels, given each country's individual pledges. Such a high participation rate cannot be explained by conventional game theory only. Theoretical considerations on collective actions problems applied to climate system protection need to be extended by behavioural aspects of human actions and inactions. The importance of equity on voluntary cooperative behaviour need to be recognized (Ostrom 2009, pp. 10–11).

4 The Importance of Equity Considerations for Cooperation

Equity principles or equity rules intend, to different degrees, to reinforce altruistic behaviour and to smooth the conflation of what is fair equals what benefits oneself. Such a self-serving bias towards the perception of equity leads to the underlying assumption that if a negotiated outcome is perceived as fair by all negotiating parties, its outcome is likely to be self-enforcing (Barrett & Stavins 2003, pp. 360; Rose 1990, p. 927). Equity or inequity arguments used in international climate negotiations can be a soft constraint of a negotiating party's purely self-interested behaviour (Lange et al. 2010, p. 361; Ringius et al. 2002, p. 3). In this case, a universal concept of equity with a unifying principle might enhance cooperation (Rose 1990, p. 927). Such an equity principle could be an effective tool for determining fair shares of abatement costs and benefits in climate negotiations (ibid.). Thus, literature on climate negotiations proposes that, instead of solely considering pure economic costs and benefits as usually assumed in conventional economic literature, participants'

incentives to cooperate in and comply with international climate negotiations are shaped by the applied equity criteria that influence the distribution of cost burdens of a respective climate target.

4.1 Dominating Equity Rules in International Climate Negotiations

The UNFCCC refers to several equity principles. The original text of the UNFCCC as well as the decisions and reports of the COPs include inter alia terms such *as fairness, equity, CBDR, historical responsibility, future responsibility, POL principle*, or *principle of capacity.* In this context, the terms fairness and equity are commonly used interchangeably and mainly refer to a normative approach towards equity. This section covers prevailing equity rules in climate negotiations, which will be later analysed using the outcomes of the COP in Paris.[11] In general, the majority of equity principles are classified by distinguishing whether the applied equity criterion's objective is chosen subject to the initial allocation of emissions, the allocation-based equity criterion, or subject to the final outcome based on the implementation of the policy instruments, the outcome-based equity criterion (Bosello et al. 2001, p. 11). The thesis aims to examine whether countries favoured equity principles that minimize abatement costs in order to reach the Paris climate target. The subsequent sections of the thesis and its analyses are thus based on the following prominent equity rules that have been used in international climate negotiations in the context of climate system protection:

The Egalitarian Rule[12]

The egalitarian (EGA) rule incorporates *equal per capita emissions* and allows emissions in proportion to the population. There is equal right for each individual to pollute or to be protected from pollution. *A country whose population amounts to x% of the global population should receive x% of global entitlements for GHG emissions*. The EGA rule seems to be mainly promoted by developing countries as it shifts the greatest abatement responsibility to developed countries that are characterized by high per capita emissions in contrast to developing countries.

[11] A detailed assessment of the whole range of equity rules applied in environmental negotiations cannot be covered within this work. For a general discussion on equity rules in climate negotiations see Cazorla and Toman (2000) and Ringius et al. (2002).

[12] All following definitions related to dominating equity rules are taken from Ringius et al. (2002, p.5), Lange et al. (2010, p.361) as well as from Cazorla and Toman (2000, p. 7).

The Sovereignty Rule

The sovereignty (SOV) rule incorporates *equal percentage reduction of current emissions* to maintain relative emissions levels between countries. There is equal right for all countries to pollute or to be protected from pollution. The status quo right is constituted by current level of emissions. *A country whose GHG emissions amount to x% of the global greenhouse gas emissions should get x% of the global entitlements for GHG emissions.* In its most strict form it promotes symmetrical cost burdens.

The Polluter-Pays Rule

The POL rule incorporates *equal ratio between abatement costs and emissions.* In addition, the economic burden is proportional to emissions. *A country whose GHG emissions amount to x% of global emissions should bear x% of global abatement costs*. It allows a reallocation of cost burdens over time.

The Ability-to-Pay Rule

The ability-to-pay (ABI) rule incorporates *equal ratio between abatement costs and GDP*. It implies that the greater a country's ability to pay, the greater its economic burden. *A country whose GDP amounts to x% of gross world product should bear x% of global abatement costs*.[13]

4.2 A Self-Serving View on Equity and Incentives to Cooperate in Climate Negotiations

The literature on international environmental agreements which focuses on a game-theoretical framework puts the emphasis mainly on the paradox of international agreements: An increase in global net benefits of cooperation increases the individual incentive to free-ride because countries know about the possibility to gain environmental benefits without paying the costs of climate system protection (Carraro 1997, p. 4; Cazorla & Toman 2000, p. 4). This line of thought is based on the assumption that states act purely rational trying to maximize their net benefits in an economically efficient way and thus acting as a national welfare maximizer (Vogt 2002, p. 179).

The main challenges of environmental agreements are voluntary participation and compliance. All too frequently, climate change related social, economic, and political

[13] A discussion on the problematic issue of not including a per capita proxy will follow in paragraph 6.2.3.

heterogeneity among countries participating in climate negotiations has led to differing perceptions of a country's burden to tackle climate change and thus to stalemates in negotiating processes. Research on a self-serving view of equity suggests that agents develop a self-interest bias in their perception of what is fair (Babcock & Loewenstein 1997, p. 111). Hoffmann (2013, pp. 6-7) considers the following problems as crucial hurdles in climate negotiations which additionally shape a country's bargaining position towards certain equity principles:

(1.) the world economy's dependence on fossil fuel affects processes across all sectors,

(2.) the dependence on fossil fuel is uneven between countries,

(3.) per capita GHG emissions differ significantly between countries,

(4.) countries that are responsible for a higher share of historical GHG emissions differ from those countries that will be responsible for the majority of future GHG emissions,

(5.) benefits of climate change protection will be received in the future while the costs of action occur now, and

(6.) impacts of ongoing climate change will be felt differentially across countries.

According to Babcock and Loewenstein (1997, pp. 110-111), negotiations are *unconsciously* affected by self-biased views due to distortions in perception of equity. In contrast, Lange et al. (2010, p. 361) considered *intentional* distortions of equity perceptions due to a *self-interested use* of equity. In their paper *On the Self-Interested Use of Equity in International Climate Negotiations* (2010), Lange et al. established the hypothesis "(...) that the respective parties use equity criteria in order to influence the negotiation process in their own (material) self-interest" (Lange et al. 2010, p. 360). The authors provided evidence for their hypothesis by conducting a survey among participants of climate negotiations on their perceptions of the negotiating positions of the EU, the USA, the Russian Federation, and G77 including China (hereafter: *G77/China*).[14]

An international treaty, such as the UNFCCC, can only work if members, participants, agents, or in this case, countries acting as Parties to the Convention agree on a technical framework

[14] Though, the country group G77 is characterized by a high heterogeneity, it is officially recognized by the UN (UNFCCC 2016b). The group was established in 1964 with the purpose to give a stronger voice to the developing countries within international negotiations (ibid.).

as the basis for their actions. Such a framework shapes a country's behaviour within a set of rules, norms, values, and procedures (Underdal et al. 2012, p. 478). These rules, norms, values, and procedures can frame collective identity and increase cooperative behaviour. The resulting action can deviate from an actor's self-biased view and material self-interested behaviour that one would expect in such cooperation situations according to conventional game theory (ibid.; see Figure 2 and Figure 3).

Therefore, it is assumed that the application of equity criteria in climate negotiations will lead to (1.) more motivation for participating and complying of countries that perceive themselves as *treated unfairly*, (2.) a framework that provides some soft constraints towards purely self-interested behaviour, and (3.) guidance in decision making where self-interest is no clear benchmark (Ringius et al. 2002, p. 3). Generally speaking, equity considerations aim to enhance participation and compliance with climate treaties and to increase cooperation by reducing incentives to free-ride (Bosello et al. 2001, p. 2).

Not only behavioural economics but also social psychology argues that material self-interest does not solely determine whether and to which extend an agent complies with an international environmental agreement. Reciprocity plays a significant role for cooperative behaviour (Underdal et al. 2012, pp. 477). Behavioural economics and social psychology suggest (1.) that in situations where the individual self-interest is not aligned equally with global social interest, cooperation is significantly higher than predicted by standard economic theory of the purely self-interested agent, which (2.) is a result of individuals acting on a conditional basis meaning that they behave more cooperatively if they observe cooperation by others (Underdal et al. 2012, p. 476).

General evidence from experimental *ultimatum games* suggests that most participants bargaining over the division of a *pie* offer around 40% of the total pie to the receiver while offers of below 25% of the pie are commonly rejected (Korth 2009, pp. 20–21). Further, experimental evidence from *public good games* suggest that the number of agents contributing to the provision of a public good increases with their expectation about the cooperative behaviour of others (ibid). Public good experiments conducted by Fischbacher et al. (2001) study the importance of conditional behaviour and support evidence that "(...) roughly 50% of the subjects show conditional behaviour such that the own contribution increases in the other group members' average contribution" (Fischbacher et al. 2001,

p. 398). Further, Finus (2002) concluded that there is indeed an incentive for countries to behave fully cooperative of climate change protection resulting in a higher global welfare and lower global emissions, outside the non-cooperative Nash equilibrium that represents the status quo before an international environmental treaty is signed (Finus 2002, pp. 12–15). One of his fundamental results showed that the difficulties in reaching cooperation are mainly caused due to the absence of a supranational institution that could enforce cooperation (Finus 2002, p. 15). Therefore, Finus (2002, p.15) concluded that an international environmental treaty that has to be signed voluntarily, (1.) signatories need to agree upon a technical framework on which their actions are based on, and (2.) the treaty needs to be enforced by the signatories themselves (ibid).

Kriss et al. (2011) conducted a controlled field experiment to demonstrate the role of self-serving biases in negotiations about emission reduction allocations for a China/USA scenario. Participants were either of US or Chinese citizenship and they had to "(…) specify how the countries should share the substantial economic sacrifices that they need to make (…)" in order to avoid the negative effects of climate change (Kriss et al. 2011, p. 605). Kriss et al (2011, p. 608) showed that differing perceptions of fairness caused stalemates in distributing the economic burden of climate change mitigation. The participant's perceptions of what they saw as a fair share of burden for their country differed and tended towards their own national material interests (ibid.). In order to examine whether their results of a self-serving bias in climate negotiations were influenced by the participants' awareness of national interest, Kriss and co-workers introduced the concept of *a veil of ignorance* derived by Rawls (1971). The researchers explored how participants judged allocations of economic burden in mitigating climate change as being fair without the awareness of national interests. The results, after the introduction of the veil of ignorance, led to completely different conclusions: removing the national self-serving bias leads very frequently to agreements (Kriss at al. 2011, p. 608).

Against the background of findings from Lange et al. (2007; 2010), Brick and Visser (2015, p. 80) tested "(…) the extent to which individuals' choice of equity principle reflects material self-interest (...)" using a public good game that was framed by a climate change context. Individuals participating in the experiment were from the EU, the USA, China, India, and South Africa, and integrated equity principles included the EGA, POL, and SOV rule (ibid.).

The experiment was designed, such that participants were provided with an endowment that they had to allocate between a public good or a private account, in which allocations to the public good account were framed as mitigation (ibid.) Further, "[w]hen the groups' total public good contributions equal or exceed the provision point, which is framed as the threshold for dangerous climate change, public good contributions are multiplied by some factor and divided equally among the players" (Brick & Visser 2015, p. 80). If contributions failed to meet the threshold, participants did not gain any returns from their contributions and the public good provision failed (ibid., p. 81). In line with findings by Lange et al. (2010), US and Chinese participants were found to choose the equity rule according to its material self-interest (Brick & Visser 2015, p. 93). Results regarding EU participants, however, deviated from findings by Lange et al. (2010) and predicted a preference inconsistent with a material self-interested EU.

Also, Carlsson et al. (2013) examined preferences for equity rules among individuals from the USA and China by using a choice experiment. In accordance with a self-interested use of equity rules, participants were found to favour the equity rule that induced minimal costs for their country.

On the other hand, a recent survey conducted in the USA by McEvoy and Cherry (2016) suggested that there was indeed a general support for unilateral action against climate change among US citizens. This surprising finding was neither consistent within a general game-theoretical framework of collective action problems, nor supported by experimental evidence from ultimatum or public good games as introduced above. Survey participants responded that (1.) the USA should take the leadership in tackling climate change, (2.) the USA has the moral obligation to act, and (3.) the USA being a great polluter has the responsibility to act (McEvoy and Cherry 2016, p. 3). The authors concluded that the individual willingness to support unconditional *domestic* climate change mitigation efforts does not depend on other countries' tendencies to free-ride on actions against global warming. The survey, however, might only give a limited insight in (US) behaviour considering the difficulties in translating the findings from a survey conducted on an individual person level into results on an aggregate level and that (voluntary) surveys are prone to selection biases.

Whether the hypothesis about a country's individual material self-interest and a country's support of the equity rule that induces minimal economic abatement costs can be verified by the actual result of climate negotiations will be examined in the subsequent sections of the thesis.

5 The Use of Equity Principles within the Paris Agreement

The Paris Agreement (hereafter also referred to as *the Agreement*) is the outcome of the latest UN climate negotiations (see chapter 2.2.6). Until today, at the beginning of December 2016, 193 Parties to the Convention have signed and submitted 163 INDCs covering 98.9% of global emissions (Climate Action Tracker 2016b; World Resources Institute 2016).[15] To enter into force, the Paris Agreement needed ratification by at least 55 Parties that represent at least 55% of global emissions (UNFCCC 2015b, Article 21(1)). This threshold was surpassed with the ratification by the EU, one of the biggest emitters, in mid-October 2016. At the beginning of December 2016, a total of 115 Parties representing 79% of global emissions have ratified the Agreement that recently entered into force on the 4th November 2016 (Climate Action Tracker 2016b; World Resources Institute 2016).[16]

5.1 Key Points of the Paris Agreement

The Paris Agreement as a universal agreement is solely based on voluntary pledges of Parties to the Convention. Such a bottom-up approach led to the following objectives and provisions.

5.1.1 Objectives

The Paris Agreement continues to emphasize the importance of the concept of equity and CBDR in its preamble:

> "The Parties to this Agreement, (...) in pursuit of the objective of the Convention, and being guided by its principles, *including the principle of equity and common but differentiated responsibilities and respective capabilities*, in the light of different national circumstances, [r]*ecognizing* that Parties may be affected not only by climate change,

[15] The European Union submitted one document applicable to all its 28 member states.
[16] See footnote 10 for background information on signatory and ratification status.

> but also by the impacts of the measures taken in response to it, [e]*mphasizing* the *intrinsic relationship* that climate change actions, responses and impacts have with *equitable access* to sustainable development and eradication of poverty (…)" (UNFCCC 2015b).

In recognizing this, signatory Parties to the Agreement aim to enhance global action as a response to the threat of climate change by "[h]olding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels (…)" (UNFCCC, Article 2(a)). Thus, for the first time in UN climate negotiations, the global community goes beyond the 2°C climate target and requests to enhance efforts to even limit the temperature increase to 1.5°C above pre-industrial levels. This objective focusing on mitigation efforts is accompanied by objectives focusing on adaption to climate change as well as on climate finance to support transitions towards low carbon and climate-resilient economies (UNFCCC 2015, Articles 2(b) and 2(c)). Significantly, an additional first time target is the long-term objective of "(...) achiev[ing] a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century" (UNFCCC 2015, Article 4). Such an objective can be interpreted as the need of global net emissions to reach zero between 2060-2080 (Clémencon 2016, p. 7).

5.1.2 The Issue of Self-Differentiation

For the first time, a new concept was introduced to the UN climate negotiations: Parties to the Agreement recognized "(...) the specific needs and special circumstances of developing country Parties" (UNFCCC 2015b, p. 1). At first glance, it might not seem that the statement introduced a new concept. So far, however, UN climate negotiations did not refer to developing country Parties. In contrast, the Paris Agreement refers to developed or developing countries only, eliminating a differentiation between Annex I, Annex II and Non-Annex I countries (UNFCCC 2015b). One reason for introducing a differentiation according to developed or developing Party could lie within the bottom-up approach of these negotiations. Now, countries had the possibility to classify themselves to one of the two categories depending on their obligations to combat climate change. Of course, this introduced flexibility as countries can move to the status of a developed country over time and thus taka more responsibility according to its capabilities. Simultaneously, responsibilities are less clear and there is no guidance as to when a country moves from one

development status to another. One often stated example to underline the complexities of self-categorisation is Qatar. In its INDC submission report, Qatar defined itself as a developing country (State of Qatar 2015). Additionally, the INDC report highlighted that Qatar is depending on natural resources and is concerned about possible negative impacts that instruments to combat climate change may cause (ibid.). Thus, it is not surprising that Qatar, despite having one of the highest per capita income and being one of the wealthiest nations worldwide, did not submit any ERTs due to its perception of being a developing country with hardly any historical responsibility (Mbeva & Pauw 2016, p. 8; World Bank 2016). [17] This example exposes the complex issues of self-perception: A country that is Party to the UNFCCC which theoretically has a high capacity in mitigating climate change does not see itself in the responsibility to take action according to its capabilities. Its perception of fairness leads to an underestimation of its possibilities or even an unwillingness to contribute to combating climate change.

5.1.3 The Issue of Compliance and Enforcement

The legal character of the Paris Agreement is controversial and requires a differentiated assessment. Not every provision of the Agreement is legally binding unlike the message circulated by the European Commission (2016b) might convey, that [i]*t was Europe that brokered the first-ever legally binding, global climate deal (...)"*. In contrast to the Kyoto Protocol (see paragraph 2.2.3), the Paris Agreement abandons legally binding ERTs "(...) based on the principle of fair and equitable burden sharing that takes a) historic and future emissions into account as much as b) vulnerability and economic capacity to reduce emissions (...)" (Clémencon 2016, p. 9). Instead of legally binding emissions allocations, voluntary compliance of individual deliveries is ought (Clémencon 2016, p. 10; Bodansky 2016, p. 142). Legal characteristics of the Agreement are reflected by a careful wording and phrasing of the Agreement's provisions. Words such as *shall* are generally used for legal obligations whereas *should* denotes that the provision is a recommendation only (Bodansky 2016, p. 145). Moreover, *acknowledge* or *recognize* generally denote statements by committing Parties (ibid.). What does this mean for the Parties' national determined contributions (NDCs) and their compliance? It does not lie within the scope of the thesis to

[17] Qatar's GDP per capita was 74,667 in current US$ in 2015. By comparison, Germany's GDP per capita was 41,219 in current US$ in 2015 (World Bank 2016).

examine the exact legal structure of the agreement. However, as previously discussed the careful wording and the lack of a compliance mechanism are of major importance in a game-theoretical framework (see paragraph 3.2).

An initial draft of a central part of the Agreement reads as follows:

> "Developed country Parties *shall* continue taking the lead by undertaking economy wide absolute emission reduction targets. Developing country Parties *should* continue enhancing their mitigation efforts, and are encouraged to move over time towards economy-wide emission reduction or limitation targets in the light of different national circumstances" (UNFCCC 2015a, Article 4(4)).

The final Agreement, however, only recommends that "(d)eveloped country Parties *should* continue taking the lead by undertaking economy wide absolute emission reduction targets (…)" (UNFCCC 2015b, Article 4(4)). With such a small change in wording, Parties are no longer obliged to comply with their own ERTs. Non-compliance does not lead to a breach of international law and compliance cannot be enforced.

Applying results from conventional game theory suggest that, legally binding ERTs would have led to greater self-compliance. Further, legally binding ERTs would have led to increased concern of non-compliance by other Parties (Bodansky 2016, p. 149). The risk to suffer damage to one's reputation and resulting adverse effects would have increased, making non-compliance costly (ibid.). It remains however unclear, how accurate the predictions from conventional game theory are concerning legally binding ERTs and their effects on the participation rate in the Agreement as well as the compliance with each Party's NDC. On the one hand, making the implementation of NDCs obligatory might promote greater commitment and greater compliance (Bodansky 2016, p. 149). On the other hand, such an obligation might weaken the ambition to join such an agreement or to submit strong NDCs, due to costs arising from non-compliance (ibid.). Considering the accountability and transparency mechanisms of the Agreement, poor performances will be declared and openly criticized raising reputational costs of too weak NDCs and non-compliance behaviour. As a consequence, legally binding obligations might not have been necessary and might have led to decreased participation and less ambitious NDCs.

5.2 Equity Principles in Submitted INDCs and NDCs

By the beginning of December 2016, 163 INDCs were submitted, representing 191 countries and covering 98.9% of global emissions (UNFCCC 2016a).[18] Nearly all countries of the global community have shown their ambitions to enhance climate action. Few exceptions include Libya, Nicaragua, Syria, and Uzbekistan. 114 out of 191 Parties to the Convention turned their INDCs into NDCs by ratifying the Paris Agreement and thus contributed to the entering into force of the Paris Agreement. Once a Party has ratified the Paris Agreement, its INDC becomes its NDC, usually, the content remains unchanged.

Most Parties included a narrative on explaining why they considered their INDC or NDC (hereafter referred to as *(I)NDCs*) to be fair and ambitious. The following paragraphs provide an overview of submitted (I)NDCs and their methodology in general as well as a more detailed view of some individual (I)NDCs. The further analysis of the use of equity rules in the Paris Agreement is strongly linked to calculations of economic abatement costs induced by (I)NDCs. The analysis concentrates on those countries and groups of countries that are relevant for the further course of the thesis: the EU, the USA, and the Russian Federation. In addition, China's submitted NDC will be analyzed due to its importance for the climate negotiations.

5.2.1 Methodology of (I)NDCs

In the run-up to COP21, there were no official guidelines on how Parties to the Convention should develop their INDCs (Mbeva & Pauw 2016, p. 11). This absence of guidance on structure and content of INDCs has resulted in a variety of interpretations and differences in submitted INDCs (ibid.).

Commonly, submitted (I)NDCs target estimated global levels of emissions for 2025 and/or 2030. These estimations were mostly related to either the base years 1990, 2000, or 2010 (UNFCCC 2016c, p. 22). Some Parties included absolute mitigation targets in relation to a specified base year; some included absolute mitigation targets that were not linked to any specific base year; some included relative mitigation targets below a business-as-usual (BAU) level; some included intensity targets based on GHG emissions per capita, and yet others included strategies and actions for reducing their GHG emissions (UNFCCC 2016c, p. 5). More

[18] The EU submitted one NDC document for all its 28 Member States.

generally speaking, 65.8% of Parties refer to a GHG target, 13.7% to actions only, 12.4% to GHG and non-GHG targets, 5.6% to GHG target and actions, and 2.5% to a non-GHG target (World Resources Institute 2016). Even though it has been commonly reported that submitted INDCs refer to GHG targets, some countries do cover all GHG gases as defined under the Kyoto Protocol (e.g. the EU, the USA, or the Russian Federation), while others refer only to some gases, such as CO_2 only (e.g. China) (World Resources Institute 2016). The differences in content and scope make comparisons among Parties difficult and (I)NDCs need to be interpreted with caution.

5.2.2 Brief Literature Review on Equity in submitted (I)NDCs

So far, literature on the implementation of equity (principles) in the Paris Agreement is of moderate size and include the *UNFCCC Updated Synthesis Report* (UNFCCC 2016c), the *UN Environment Programme (UNEP) Emissions Gap Report 2015* (2015) as well as reviews conducted by civil societies such as the *Climate Action Tracker* (Climate Action Tracker 2016b), and the *Climate Equity Reference Project (2015)*. Further, Mbeva and Pauw (2016) conducted an analysis on *Self-Differentiation of Countries' Responsibilities* based on submitted INDCs. Their review includes detailed examinations of self-differentiations in the context of fairness and equity.

Findings of the *Climate Equity Reference Project* (2015) showed that there is an equity gap between wealthy developed countries and poorer developing countries. They conducted an analysis of the Parties' submitted INDCs in preparation for COP21 according to the Parties' fair share of global mitigation efforts. In order to calculate a country's fair share, the country's *historical responsibility* as well as its *capacity* to contribute to global mitigation efforts were taken into account by weighting these two indicators equally (50/50) (Climate Equity Reference Project 2015, p. 2).[19] According to the Project's calculations, developed countries made pledges far below their fair shares, whereas some developing countries, such as China, Indonesia, or the Marshall Islands exceeded their fair share.[20] Countries with

[19] In this case, the share of national income needed to provide basic living standards serves as indicator for capacity. Calculations do not include the costs of abatement. Resulting rankings on a country's fair share are thus not comparable with results of the use of equity rules in submitted INDCs as stated in 6.2.

[20] The Climate Equity Reference Project classifies China's contribution to climate action as above its fair share. This, however, is contradictory to findings by e.g. Climate Action Tracker that classify China's actions as less ambitious. It is a good example of the problematic determination and calculation of what is perceived as fair and ambitious.

the biggest gap between their pledged climate action and their fair share as defined by the Project included: Russia (its INDC covers zero contribution towards its fair share), Japan (its INDC covers about 1/10 of its fair share), USA (its NDC covers about 1/5 of its fair share), and the EU (its INDC covers just over 1/5 of its fair share). In addition to the huge equity gap, global pledges were found to be insufficient to keep global warming below 2°C (Climate Equity Reference Project 2015).

The *UNEP Emissions Gap Report* (2015) came to the same conclusions: even if countries fully implemented their pledged INDCs, the target to keep the increase in global average temperature below 2°C until 2030 would not be met because of an emission gap of 12 Gt CO_2. Submitted INDCs rather project a scenario where global average temperature increases to below 3°C by 2100 (UNEP 2015). Furthermore, the UNEP Emissions Gap Report (2015) examined how Parties to the UNFCCC addressed the issue of equity and CBDR. Their analyses showed that out of 119 analyzed INDCs (by 1st October 2015), 52 (43.7%) INDCs made references to the Convention's objective as stated in Article 2 (see paragraph 2.2.1), 62 (52.1%) INDCs refer to the 2°C target, whereas 36 (30.3%) INDCs did not make any reference at all to the objectives (UNEP 2015).[21]

Climate Action Tracker's work (2016b) concentrated on the tracking of INDCs and especially their status of implementation into national policies. Similar to the Climate Equity Reference Project (2015), Climate Action Tracker's assessment included a country rating based on a country's fair share of effort to keep the increase in global average temperature below 2°C (Climate Action Tracker 2016b). As defined by Climate Action Tracker (2016d), their rating classification included categories such as *inadequate* (i.e. emission targets in this category are less ambitious than the 2°C range defined and if all governments adopted inadequate positions, warming would likely exceed 3–4°C), *medium* (i.e. pledges are not consistent with limiting global warming below 2°C as it would require many other countries to make a comparably greater effort and much larger reductions), *sufficient* (i.e. pledges are fully consistent with below 2°C limit and if all governments are sufficient, warming would be limited below 2°C with a likely probability), and *role model* (i.e. pledges are more ambitious than the 2°C range). China's efforts were ranked as medium, as were the USA's and the EU's efforts, whereas efforts put forward by the Russian Federation were ranked as inadequate.

[21] Multiple references of one country were possible.

In a more general manner, the *UNFCCC Updated Synthesis Report* (UNFCCC 2016c) provided an overview of the explanations given by Parties about their individual INDCs and why they considered them to be fair and ambitious. However, the report did not provide any insight into the individual Party's perceptions of equity.

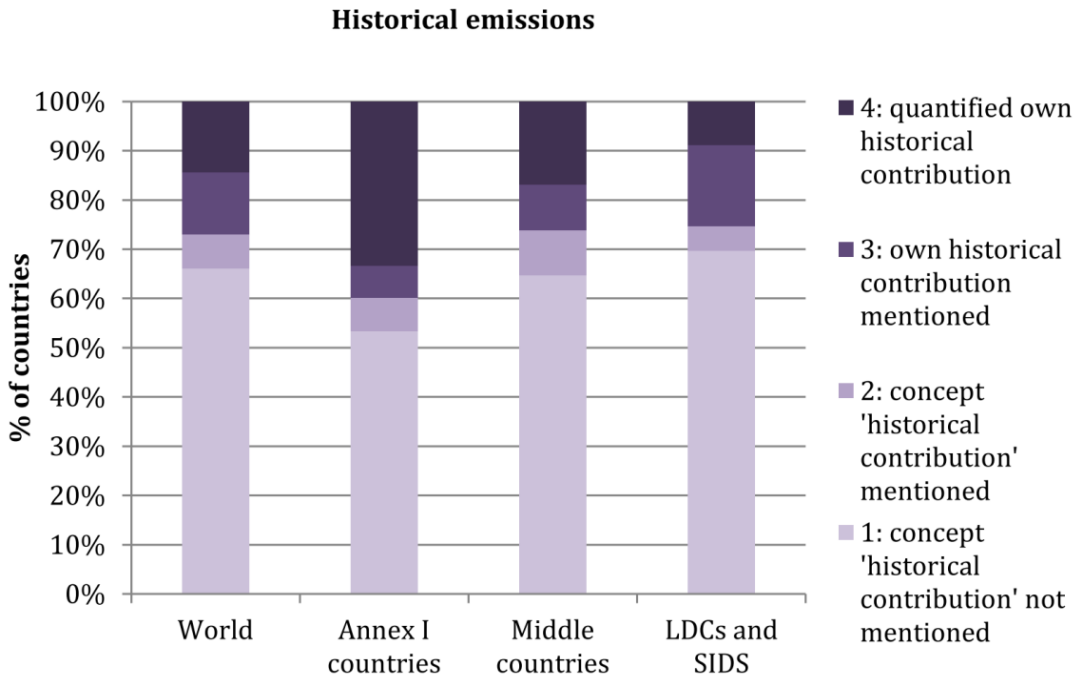
Mbeva and Pauw (2016) conducted an analysis on *Self-Differentiation of Countries' Responsibilities* based on INDCs. Their paper gave detailed insights into the development of the concept of CBDR in climate negotiations in general and focused on submitted INDCs in detail. Their analysis showed that 93% of submitted INDCs by Annex I countries' were less than 10 pages long, whereas only 31% of submitted INDCs by least developed countries (LDC) and small island development states (SIDS) were less than 10 pages long and 17% of INDCs submitted by such countries were longer than 20 pages.[22] The authors used the lengths of the submitted INDCs as a proxy indicator for the importance of equity for individual Parties (Mbeva & Pauw 2016). This approach is supported by the fact, that 94% of submitted INDCs addressed fairness and/or equity with noticeable exceptions by the USA, China, and Canada.[23] Further, Mbeva and Pauw (2016, p.18) showed that the majority of countries considered their mitigation efforts in terms of total emissions; most middle countries referred to their per capita emissions (i.e. an intensity target) or their emissions per unit of their GDP.[24] Interestingly, the concept of historical emissions played only a minor role in the consideration of emissions (Mbeva & Pauw 2016, p. 19). The majority of Parties provided information on their current emissions, stated either in total, per capita, or per GDP units.

As seen in Figure 4, middle countries that were characterized by a slow increase of emissions, did commonly mention or quantify their historical emissions. This applied inter alia to Bolivia, Bosnia-Herzegovina, and Mongolia. In contrast, countries with emissions increasing fast did not quantify their historical emissions. This applied inter alia to Brazil, China, Indonesia, Malaysia, Saudi Arabia, or South Korea (Mbeva & Pauw 2016, p. 19). For example, China a country characterized by rapidly rising emissions used self-differentiation

[22] Even though the Paris Agreement does not refer to Annex I countries, Mbeva and Pauw continue to differentiate countries according to the former official classification due to better clarity.
[23] As already mentioned, the terms fairness and equity are generally used interchangeably by the Parties.
[24] Mbeva and Pauw define three different country groups: 1.) Annex-I Parties 2.) LDCs and SIDS, and 3.) Middle countries that do not fit to either of the categories 1 or 2, representing a heterogeneous mixture of countries (Mbeva & Pauw 2016, pp. 17-18).

to define itself as a developing country and did not specify its historical emissions. Furthermore, China demanded developed countries to take historical responsibilities and to undertake ambitious, economy wide, and absolutely quantified ERTs by 2030 (People's Republic of China Department of Climate Change 2015, p. 17). India one of the world's biggest emitters only referred to the developed countries' historical responsibilities rather than to its own increasing emissions (Republic of India 2015, p. 2). As depicted in Figure 4, roughly one third of Annex I countries quantified their historical emissions; Annex I countries were the group with the greatest proportion of countries that had specified their historical emissions. LDCs and SIDS were least likely to mention their historical emissions. The analysis by Mbeva and Pauw (2016) further showed that emissions by Annex I countries were constantly decreasing while emission levels of middle countries were rapidly increasing. This development might highlight a rethinking of the equity debate and the general concept of historical emissions and related responsibilities (Mbeva & Pauw 2016, pp. 20-21).

Figure 4: Differentiation based on historical emissions as communicated in INDCs



Source: Taken from Mbeva & Pauw (2016, p. 20).

5.2.3 Individual Equity Principles in Submitted (I)NDCs

Most Parties included their own narrative explaining (1.) why their individual (I)NDC is fair and (2.) their obligations to contribute to climate change mitigation (UNFCCC 2016c). The following section highlights individual narratives on (1.) and (2.) by examining the communicated NDCs by the EU, the USA, and China that had already ratified the Paris Agreement, and the communicated INDC by the Russian Federation.

5.2.3.1 Communicated NDC by the EU

> *"Today the European Union turned climate ambition into climate action"*
> (European Commission 2016c).

The EU claims to be a global leader in climate action as Jean-Claude Juncker stated at a press conference announcing that the EU Parliament approved the ratification of the Paris Agreement and its NDCs. This announcement was stated in mid-October 2016 at a point in time when big polluters and policy makers such as China and the USA had already ratified the Agreement. Now, the EU claims that the "(...) Europeans are the world leaders on climate action. It was Europe that brokered the first-ever legally binding, global climate deal. It was Europe that built the coalition of ambition that made agreement in Paris possible (...)" (European Commission 2016c). The Paris agreement entered into force after it had been ratified by the EU, because then the required 55% emissions threshold had been also exceeded. It is unclear how other Parties to the Agreement which are heavily affected by global warming and its impacts view this EU's statement. In particular, as the statement did not mention that 62 countries accounting for almost 52% of global emissions had ratified the Agreement much earlier (European Commission 2016c).

The EU belongs to the top ten polluters of global emissions and was therein one of the last ones to ratify the Paris Agreement. Within the group of the top ten polluters, only Japan and the Russian Federation have still not yet ratified the Agreement as of December 2016. However, the ratification of the Agreement that applies to a political and economic union of 28 national states was fairly fast. That might be partly explained by the EU NDC targets themselves. These targets are identical with the new 2030 climate and energy framework which all EU member states had already agreed on before in October 2014 (European Commission 2016a). The EU and its Member States are committed to reduce their domestic GHG emissions by 40% from 1990 levels by 2030 (Latvian Presidency of the Council of the

European Union 2015). The EU target is a binding absolute base year target applying to all sectors. Even though the EU integrated a paragraph on how *fair and ambitious* their NDC is, they did not make any reference to equity principles such as historic responsibility or CBDR (Latvian Presidency of the Council of the European Union 2015). The included narrative on equity solely referred to the ERT that "(…) represents a significant progression beyond its current undertaking (…)" and emphasized that "[t]he EU and its Member States have already reduced their emissions by around 19% on 1990 levels while GDP has grown by more than 44% over the same period" (Latvian Presidency of the Council of the European Union 2015, p. 3). The NDC of the EU did not mention to which extent the Union accepted its own historic responsibility to take action against global warming or its responsibility towards those countries with less financial and technological assets.

As already indicated earlier, the civil society Climate Action Tracker (2016b) rated countries based on their fair share of effort to keep the increase in global average temperature below 2°C. Their assessment of the EU's fair share concluded that the EU failed to address fair and equitable emission reductions and thus its target was ranked as medium.

5.2.3.2 Communicated NDC by the USA

> *"Of course, the Paris Agreement alone won't solve the climate crisis. But it does establish an enduring framework (...)"*
> *(The White House President Barack Obama 2016).*

China and the USA announced the ratification of the Agreement jointly during the G20 meeting in China in September 2016; 15 years after the USA had withdrawn from the Kyoto Protocol (see paragraph 2.2.3). The ratification by these two Parties was a significant step towards the entering into force of the agreement, as these two big emitters accounted for approximately 40% of global emissions (The White House President Barack Obama 2016). The USA stated to reduce "(…) its greenhouse gas emissions by 26 - 28 per cent below its 2005 level in 2025 and to make best efforts to reduce its emissions by 28%" (The United States of America 2015). The base year GHG target applies to all sectors, including Land Use, Land Use Change and Forestry (LULUCF). To include LULUCF in the ERT increases the

uncertainty surrounding GHG targets excluding LULUCF due to difficulties in estimating the consequences of LULUCF (Climate Action Tracker 2016f).[25]

Climate Action Tracker (2016f) ranked the USA's efforts to contribute to global climate action as medium and being "(...) at the least ambitious end of what would be a fair contribution". The decision was mainly based on the absence of a reference concerning the USA's historic responsibility to take climate action and the NDC's inconsistency with "(...) limiting warming to below 2°C unless other countries make much deeper reductions and comparably greater effort than the USA" (Climate Action Tracker 2016f). The USA's self-assessment as stated in its NDC that its ERT *is fair and ambitious* was not met (The United States of America 2015, p. 1).

5.2.3.3 Communicated INDC by the Russian Federation

Russia's submitted INDC was sobering not only in terms of its length but also in terms of its content. The INDC provided solely the minimum of information that was required. According to Russia's point of view, it contributes best to the global aim of limiting global warming below 2°C by reducing its GHG emissions by 25%-30% from 1990 levels by 2030 (Russian Federation 2015, p. 3). However, the devil is in the detail. Analyzing Russia's GHG emissions between 1990 and now, it can be seen that emissions in 1990 were the highest than in any other year during the past century (UNFCCC 2014a). Considering Russia's current emissions, the submitted INDC will result in an actual increase in GHG emissions. Therefore, it is not surprising that Climate Action Tracker ranks Russia's INDC and its commitment as inadequate (Climate Action Tracker 2016e).

[25] LULUCF is used to offset emissions by e.g. reforestation activities, or curbing deforestation (UNFCCC 2014g). The problematic aspect of including LULUCD is the difficulty to quantify GHG removals and emission reductions resulting from activities of LULUCF, especially when unpredictable natural disasters such as fires or diseases might release GHG into the atmosphere (ibid.).

5.2.3.4 Communicated NDC by China

> *"As a responsible developing country, China will stand for the common interests of all humanity and actively engage in international cooperation to build an equitable global climate governance regime that is cooperative and beneficial to all." (People's Republic of China Department of Climate Change 2015, p. 15).*

China's submitted NDC does not only differ from other (I)NDCs by its number of pages but also by its target setting. In its detailed 20-pages long submission, in comparison, the USA only submitted five pages, China explained how it aims to achieve sustainable development for its population of more than 1.3 billion and how this will affect its climate action (People's Republic of China Department of Climate Change 2015, p. 2). Firstly, China clarified that it defines itself as a developing country that tries to achieve several objectives such as poverty eradication, improvement of living standards, as well as environmental protection and combating climate change. At the same time, China stressed its right to develop, meaning the process of industrialization and urbanization (ibid). Nevertheless, these developmental processes should be driven by a sustainable development ensuring energy, economy, ecology, and food security (ibid.) According to China's point of view, this can only be ensured if a green, low-carbon, and recycled developmental path is implemented into its national policy. Thus, in its NDC China determined its climate actions to be effective by 2030 as follows:

> "To achieve the peaking of carbon dioxide emissions around 2030 and making best efforts to peak early; to lower carbon dioxide emissions per unit of GDP by 60% to 65% from the 2005 level; to increase the share of non-fossil fuels in primary energy consumption to around 20%; and to increase the forest stock volume by around 4.5 billion cubic meters on the 2005 level"
> (People's Republic of China Department of Climate Change 2015, p. 5).

Alongside Chile, India, Israel, Malaysia, Tunisia, and Turkmenistan, China was one of the very few but highly populated countries that set an intensity CO_2 target. Further, China forecasted the peak of GHG emissions by around 2030. At that time, other countries aimed to reach a historic low in emissions.

Thus, Climate Action Tracker ranked Chinas efforts to combat climate change as medium. This classification, however, only applies if all of China's measures against climate change are taken into account. If the classification was based on the intensity target alone, then China's

efforts would be ranked as inadequate (Climate Action Tracker 2016a). In the end, Climate Action Tracker drew the conclusion for China as for the majority of big polluters: their (I)NDCs were not sufficient to limit global warming to below 2°C unless other countries cut their emissions even more and thus undertake comparably an even greater effort (ibid.) Such efforts were openly demanded by China as it suggested that developed countries to take the lead in climate action in accordance with the Convention and its principle of CBDR and related historical responsibilities (Climate Action Tracker 2016a; People's Republic of China Department of Climate Change 2015, p. 15). Additionally, China called for more support and assistance in areas such as finance, technology, and capacity building to allow developing countries a climate friendly sustainable development. In contrast to its demands of developed countries to undertake economy-wide absolute quantified ERTs, China only requested diversifying enhanced mitigation targets from developing countries, including itself.

Table 1: Summary of formulated (I)NDCs by the EU, the USA, the Russian Federation, and China.

	Formulated (I)NDCs
EU	Reducing domestic GHG emissions by 40% from 1990 levels by 2030.
USA	Reducing GHG emissions by 26-28% from 2005 levels by 2025.
Russian Federation	Reducing GHG emissions by 25-30% from 1990 levels by 2030.
China	Lowering carbon intensity of GDP by 60-65% below 2005 levels by 2030.

Source: Own illustration based on examined (I)NDCS.

6 The Use of Equity Rules in Submitted (I)NDCs

Lange et al. (2010) discussed the self-interested use of equity arguments in climate negotiations. Their argumentation was based on a world-wide survey of agents involved in global climate negotiations showing that "(...) the perceived support of equity criteria is the stronger, the less costly this criterion is compared to alternatives" (Lange et al. 2010, p. 370). In order to support their argument, they developed a cost ranking of equity rules that predicted a self-interested use of equity. Lange et al. (2010) based their cost ranking on formulas for optimal emission permit allocations for each equity rule (EGA, SOV, POL, ABI; see paragraph 4.1 and Table C.3) for the separate countries and groups of countries such as the EU, the USA, the Russian Federation, G77/China.

In the following, findings for arguments by Lange et al. (2010) will be examined before their formulas for the equity rules EGA, SOV, POL, and ABI are used to calculate the abatement costs induced by individual ERTs pledged by the EU, G77/China, the Russian Federation, and the USA. The aim is to verify the predictions and findings made by Lange et al. (2010).

6.1 Predictions about Supported Equity Rules According to Lange et al. (2010)

The economic costs of abatement induced by prominent equity rules in order to reach the climate target to limit global warming to 2°C served as a baseline for Lange et al. (2010) to formulate predictions on which equity rule would be preferred by a material self-interested EU, USA, G77/China, or Russian Federation. These theoretically derived predictions were then linked to descriptive statistics based on findings from a survey. The survey was conducted among participants in global climate policies and investigated their perceptions of the negotiating positions of the EU, USA, Russian Federation, and G77/China. Then Lange et al. (2010) undertook an econometric analysis which underpinned their hypothesis of the self-interested use of equity in climate negotiations.

6.1.1 Methodology

In order to calculate economic costs induced by the EGA, SOV, ABI, POL rules, Lange et al. (2010, p. 362) formulated the following assumptions: (1.) the aggregate emission target is exogenous; and (2.) an emissions trading system equalizes marginal abatement costs (MACs)

across all countries or groups of countries. Further, it was assumed that MACs are equalized at 80 USD2000 per tonne of carbon emissions (tC) which corresponds to a worldwide reduction from BAU emissions by 15%. According to Löschel (2016), the assumption to reduce global emissions by 15% from a BAU scenario had been in line with the aim to keep global warming below 2°C at the time of conducting the calculations in 2009. The formulas for equity rules require data on abatement costs, population size, baseline carbon emissions, and GDP for the EU, USA, Russian Federation, and G77/China, respectively (Lange et al. 2010, p. 362).[26] Lange et al. (2010, p. 370-371) derived their data (1.) using the *POLES* model provided by enerdata and from sources such as (2.) *The International Energy Outlook* (2005) by the US Department of Energy, and (3.) *The Climate Analysis Indicator Tool* by the World Resources Institute (2005). Data from the POLES model is not available free of charge and hampers the replication and further development of calculations.

The POLES model is used to make predictions about MACs curves (Enerdata 2012, pp. 5-6). The model for the energy sector covers 57 countries and regions. Based on certain carbon price levels for a given base year, country, and sector predictions about possible emission reduction levels are made. Further, the POLES model aims to analyze and predict the impacts of climate and energy policies on energy markets (ibid.). Usually, the MACs derived by the POLES model are assessed by introducing a *shadow carbon tax* in order to reach an ERT (Criqui et al. 1999, p. 586-588). Such a shadow carbon tax can correspond to the term carbon value, or as defined by Lange et al. (2010, p. 362), to an emissions trading system that equalizes MACs across countries.

Across countries MACs can differ significantly due to differences in structural factors: (1.) countries with low consumer energy taxes and prices experience greater effects of the same carbon value; (2.) carbon intensive economies can reduce their emissions at little cost by substituting power sources; and (3.) countries have varying potentials to develop carbon free energy sources such as renewable energy resources or differing industrial capacity for nuclear energy (Criqui et al. 1999, p. 586). Lange et al. (2010) assumed that any abatement scenario of each equity rule for the EU, the USA, the Russian Federation, and G77/China is implemented at minimal costs due to the country's material self-interest. The prominent

[26] The selection of countries and groups of countries examined by Lange et al. (2010) is mainly linked to the nationalities of survey participants.

equity rules chosen by Lange et al. (2010) (EGA, SOV, POL, and ABI; see paragraph 4.1 and Table C.3) concentrate on costs from abatement. Their calculations were based on the fixed climate goal to limit the maximum global average temperature increase to no more than 2°C above pre-industrial levels, an aim that can be reached if MACs are equalized at 80 USD2000/tC. As a consequence, the cost ranking of the respective equity rules did not depend on benefits from abatement and were therefore not considered (Lange et al. 2010, p. 361).

The presented approach chosen by Lange et al. (2010) was used to calculate optimal emission permits for each country or groups of countries induced by each equity rule, respectively. Following these calculations a cost ranking for each country and country group based on induced costs in % of GDP was conducted (Lange et al. 2010, pp. 363–364). Such a ranking aims to visualize predictions on the preferred use of the equity rule that would lead to the lowest abatement costs compared to any other equity rule in order to meet the climate target (Lange et al. 2010, p. 362).[27] These predictions were then compared with corresponding rankings regarding the expected incorporation of the equity rules by 230 surveyed agents involved in international climate policies. While the participation rates among agents holding a EU or G77/China nationality were fairly high (36.1% and 32.4%, respectively), participation rates among agents holding a Russian Federation or US nationality were fairly low (0.7% and 4.9%). Corresponding equity rules (EGA, SOV, POL, and ABI; see 4.1) were explained to the agents. Then, the first part of the questionnaire studied (1.) individual views on equity and (2.) the perceived importance of equity in the climate negotiations (answers in the range of *very high importance* to *no importance* were possible). The second part of the survey studied (1.) the agents' perceptions of the negotiating and equity positions of the EU, the USA, the Russian Federation, and G77/China and (2.) the degree to which each equity rule (EGA, SOV, POL, and ABI) should be integrated in any future climate negotiations (answers in the range of to a *very high degree* and to *no degree* were possible) (Lange et al. 2007, p. 550; Lange et al. 2010, p. 364).

[27] See Appendix C – Replication of Cost Rankings Induced by Equity Rules According to Lange et al. (2010) for a detailed view on calculations conducted by Lange et al. (2010). Results led to the presented cost rankings induced by the different equity rules.

6.1.2 Results

The subsequent section highlights predictions about a self-interested use of equity rules by the EU, the USA, the Russian Federation, and G77/China as depicted by Lange et al. (2010).

6.1.2.1 Predictions about the EU

Calculations conducted by Lange et al. (2010, p. 363) led to predictions on the EU's preferred use of equity rules:

$$\textbf{POL} \succ \textbf{ABI} \succ \textbf{SOV} \succ \textbf{EGA}$$

Based on a cost ranking, the EU should prefer the application of the POL rule in order to meet the climate target (Lange et al. 2010, p. 363). Such a preference resulted from the EU's relatively small share of global emissions as of 2002, which led to the lowest projected economic costs for abatement induced by the POL rule. [28] The ranking is followed by the ABI, SOV, and EGA rules. Therein, the EGA rule would be the least preferred equity rule, because it constitutes the most cost-intensive for the EU. This prediction was supported by survey findings (Lange et al. 2010, p. 373). The majority of respondents (78.2%; n=174) perceived the EU's position regarding the distribution of entitlements for GHG emissions being driven to a very high or a high degree by the POL rule:

$$\textbf{POL} \succ \textbf{ABI} \succ \textbf{SOV} \succ \textbf{EGA}$$

This result coincides with the prediction derived from the cost ranking (Lange et al. 2010, p.365).

6.1.2.2 Predictions about the USA

It was predicted that the USA would prefer the application of the ABI rule, followed by the POL and SOV rule when considering the projected economic costs of abatement (Lange et al. 2010, p. 364):

$$\textbf{ABI} \succ \textbf{POL} \succ \textbf{SOV} \succ \textbf{EGA}$$

Similar to the predictions for the EU, the EGA rule would be the least preferred equity rule according to the respective costs accrued. The preference to apply the ABI rule was based on

[28] Terms such as *current* or *today* in the context of work conducted by Lange et al. (2010) refer to the year 2002.

the formula for the ABI rule (see Table C.3) which only considers future GDP growth. If the formula was based on today's GDP, the USA would bear larger costs. These predictions did not fully correspond to the expected integration of equity rules by the interviewed agents. The agents' responses led to the following ranking (Lange et al. 2010, p. 373):

$$\textbf{SOV} \succ \textbf{POL} \succ \textbf{EGA} \succ \textbf{ABI}$$

The survey participants perceived the USA as being a supporter of the SOV rule (60.8%; n=171) which is in concordance with the USA's withdrawal from the Kyoto Protocol based on the absence of ERTs for all Parties to the Convention (Lange et al. 2010, p.365). Thus, the USA was perceived as supporting similar abatement efforts from all regions. In line with the calculated cost rankings, the EGA was not seen as highly supported by the USA (35.7%; n=171). The ABI rule ranked least (29.8%; n=171) even though its support would be the most beneficial and least costly in the long-run if the estimated economic growth of developing countries were to materialize.

6.1.2.3 Predictions about the Russian Federation

Similar to the EU and the USA, the Russian Federation would oppose the application of the EGA rule (Lange et al. 2010, p. 363):

$$\textbf{SOV} \succ \textbf{ABI} \succ \textbf{POL} \succ \textbf{EGA}$$

The lowest economic costs would be induced by the SOV rule, followed by the ABI rule. The assessment of the agents' responses showed the following expected integration of equity rules (Lange et al. 2010, p. 373):

$$\textbf{SOV} \succ \textbf{ABI} \succ \textbf{POL} \succ \textbf{EGA}$$

Thus, the assessment from survey participants was consistent with the implied cost ranking induced by the equity rules and reflected the prediction of the Russian Federation being self-interested in the use of equity criteria.

6.1.2.4 Predictions about G77/China

The country group G77/China is not only characterized by its heterogeneity but also by its large share of the global population. Thus, it is not surprising that the predicted preferred equity rule would be the EGA rule (Lange et al. 2010, p. 363):

EGA ≻ SOV ≻ ABI ≈ POL

Opposition against an application of the ABI or POL rules was predicted due to (1.) projections of high economic growth for the group of countries rising the projected costs induced by the ABI rule, and (2.) the predicted large increase in emissions for the group of countries raising the projected costs induced by the POL rule. The assessment of the agents' responses regarding G77/China lead to the following ranking (Lange et al. 2010, p.373):

ABI ≈ POL ≈ EGA ≻ SOV

The agents saw G77/China as supporting the EGA, POL, and ABI rule nearly to the same extend (59.5%; n=173; 61.0%; n=177; 65.5%; n=174; respectively) and the SOV rule as the last (29.1%; n=172). Despite the large costs of the ABI as well as POL rule, these rules perceive greater support than expected by underlying cost rankings (Lange et al. 2010, p. 373).

The findings between the unconscious self-serving bias in perceptions of fairness and the conscious self-interested support of equity rules seemed to differ based on the survey's assessment. Therein, Lange et al. (2010, p. 365) see a "(…) prerequisite for finding a self-interested use of equity: since regions differ in their cost rankings of equity criteria, a self-interested use requires that regions support the respective equity rules to a different degree". Therefore, an econometric analysis of significant effects (such as personal preferences for a specific equity rule, the role of participants in international climate policies, economic performance of the respective country, or the implied costs induced by the respective equity rule) on the perceived incorporation of the equity rules was performed. Results were, (1.) the EU was seen as being supporting an integration of the POL rule to a higher degree than the EGA rule at an one per cent significance level; (2.) G77/China was seen as being supporting the ABI rule to a higher degree than the SOV rule at an one per cent significance level; and (3.) the USA and the Russian Federation were seen as being supporting the SOV rule to a higher degree than any other equity rule (Lange et al. 2010, p.366). Further, the econometric analysis showed that the agent's view on the importance of incorporating a specific equity rule depended on personal characteristics (such as personal views on equity rules) and particularly on the economic performance of the agent's country. After introducing the variable *cost of equity rules,* the results strongly

supported the hypothesis that economic costs are a major determinant of the (relative) use of equity criteria by the respective regions and concluded that "(…) the perceived support of equity criteria is the stronger, the less costly this criterion is compared to alternatives". The results are consistent with the expected unconscious self-serving bias as well as the conscious self-interested use of equity (Lange et al. 2010, p. 367, p. 370).[29]

A comparison between predictions about and the actual use of a self-interested use of equity will be examined in the subsequent section by calculating actual abatement costs as induced by submitted (I)NDCs by the EU, the USA, the Russian Federation, and China.

6.2 Predictions about the Use of Equity Rules Implied by Abatement Costs as Induced by Actual (I)NDCs

The abatement cost rankings and predictions for individual countries stated by Lange et al. (2010) (see paragraph 6.1.2) were based on optimal emission permits in order to reach the climate target of limiting an increase in average global temperature to 2°C. Those optimal emission permits were not stated within their original paper *On the Self-Interested Use of Equity in International Climate Negotiations.* In order to examine whether countries or group of countries have purely acted in their material self-interest during the Paris negotiations, original calculations by Lange and co-workers were replicated and assumptions for the further use of the stated equity rule formulas were adopted.

6.2.1 Methodology

In a first step, calculations conducted by Lange et al. (2010) based on data provided in their paper were replicated. In doing so, stated equity formulas (see Table C.3) were rearranged in order to calculate each country's or group of countries' individual emission permits. In order to obtain the implied costs generated by each equity rule respectively, the induced emission reductions in relation to estimated emissions for 2020 were calculated and multiplied by the costs for abatement. These costs were then converted in % of GDP^{2020} and a cost ranking was conducted (see Appendix C – Replication of Cost Rankings Induced by Equity Rules

[29] For a detailed description of the econometric analysis see Lange et al. (2010, pp.365-70). For an in depth examination of costs induced by respective equity rules see Appendix C – Replication of Cost Rankings Induced by Equity Rules According to Lange et al. (2010).

According to Lange et al. (2010) for a detailed description and how cost rankings were derived).

In a next step, an attempt was made to extend calculations and predictions suggested by Lange and co-workers. However, their assumptions and calculations on abatement costs were not fully reproducible. For example, it is somewhat unclear which sectors and gases were covered in their modelling of abatement costs. The authors did not explicitly define whether *carbon emissions* cover only CO_2 emissions or whether all GHG emissions were converted in CO_2 equivalents (Lange et al. 2010, p. 362.; p. 367; p. 371). Hence, data sets provided by enerdata on the POLES model upon request could not be used to replicate and further develop abatement costs assumptions for the years 2025 and 2030 (Mima 8/31/2016). Data provided by the paper covered carbon emissions for the years 1990, 2002, and 2020 only (Lange et al. 2010, p. 371). In contrast, submitted (I)NDCs generally communicated GHG reduction targets for 2025 or 2030.

Thus, for further calculations it was assumed that an expressed reduction target of, for example, GHG by 25% of 1990 levels equals a reduction of carbon emissions by 25% of 1990 levels. To allow comparisons, calculations were made with carbon emission estimates for 2020, although most of the examined countries stated their climate target for 2025 or 2030. The fact that underlying carbon emission estimates influence the POLES model and resulting abatement cost assumptions required the application of those assumptions and thus made comparisons possible. For the purpose of this thesis, it was assumed that an increase in abatement costs from 2020 to 2025 and to 2030 will not be significant, which allowed the use of the abatement costs assumptions provided by Lange et al. (2010, p.371). Nevertheless, this approach limited explanatory calculations for the EU, the USA, and the Russian Federation. The group G77/China did not submit a joint (I)NDC document. However, the calculations aimed to get an idea whether China's NDCs might provide evidence for a self-interested use of equity rules. Thus, China's pledge was taken as being a joint G77/China pledge. It needs to be stressed that presented results only allow weak comparisons and must be interpreted with caution.

After the replication of cost rankings generated based on equity rules for the EU, the USA, the Russian Federation, and G77/China as conducted by Lange et al. (2010), interim results provided optimal emission permits under each equity rule for each country and group of

countries (see Appendix C – Replication of Cost Rankings Induced by Equity Rules According to Lange et al. (2010)). These optimal emission permits and implied abatement costs induced by the equity rules were compared with the climate targets as formulated in each country's individual (I)NDC. To make comparisons possible, (I)NDCs that were mostly pledged in ERTs required conversion into future emission permits under consideration of (1.) the base year's carbon emissions, (2.) carbon emission estimates for 2020, and (3.) current carbon emissions. Then, resulting future emission permits were used to calculate abatement costs. In a final step, abatement costs in % of GDP^{2020} were calculated with MACs of USD80/tC in accordance with the aim to limit global average temperature increase to 2°C. Table 2 summarizes adopted assumptions, which became necessary in order to allow comparisons between predictions about the self-interested use of equity rules as suggested by Lange et al. (2010) and actual Paris outcomes.

Table 2: Summary of Assumptions for further calculations on equity rules within the framework of the Paris Agreement.

Available data and assumptions by Lange et al. (2010)	Assumptions for further calculations within the thesis
• Abatement costs assumptions for 2020.	• No significant change in abatement costs; • Abatement cost assumptions for 2020 will also apply for 2025 and 2030.
• Estimates on carbon emissions for 2020.	• Carbon estimates for 2025 and 2030 will not vary significantly from 2020; • A reduction in xy% of GHG equals a reduction of the same amount of carbon and allows the use of available carbon estimates.
• Predictions and data about G77/China.	• China's NDC applies to G77/China. Predictions about G77/China can be used to derive predictions on China.

Source: Own illustration based on submitted (I)NDCs.

6.2.2 Results

The subsequent sections provide the results about the self-interested use of equity rules by the examined countries or group of countries during the Paris negotiations based on the methodology demonstrated in the previous section.

6.2.2.1 The Use of Equity Rules by the EU

The EU pledged to reduce its domestic GHG emissions by 40% from 1990 levels by 2030. In order to convert the pledge into comparable numbers, carbon emission estimates provided by Lange et al. (2010) and underlying assumptions as stated in Table 2 summarizes adopted assumptions, which became necessary in order to allow comparisons between predictions about the self-interested use of equity rules as suggested by Lange et al. (2010) and actual Paris outcomes. Assumptions for further calculations on equity rules within the framework of the Paris Agreement were taken into account and resulted in carbon emission reductions of 36.76% compared to 2002 level emissions. More precisely, the EU aims to reduce its emissions from 1,299 MtC to 737.4 MtC by 2030. Table 3 shows that total abatement costs for an emission reduction of 428.6 MtC equate to 34,288 Mio USD when MACs are equalized at USD80. That equals 0.217% of GDP^{2020}.

Lange et al. (2010, p.371) predicted abatement costs of 0.334% (in % of GDP^{2020}) induced by the EGA rule, 0.064% induced by the SOV rule, 0.056% induced by the ABI rule, and 0.044% induced by the POL rule in order to meet the climate target of limiting global average temperature increase to 2°C. Taking into account the economic costs of abatement induced by the equity rules respectively as well as an underlying self-interested use of equity, Lange and co-workers concluded that the EU would prefer the application of the POL rule to minimize costs of reaching the climate target (see paragraph 6.1.2.1). Applying the POL rule according to Lange et al. (2010) implied emission permits in the amount of 1,141.99 MtC. Results from the authors' survey assessment as well as from their econometric analysis promoted an application of the POL principle. Such a prediction is underpinned by the EU environment policy which incorporates the POL principle to prevent and remedy environmental damage (European Commission 2016b).

However, the present calculations based on the EU's pledges showed that emission permits induced by the predicted favoured POL rule clearly exceeded the EU's pledge to reduce its emission to 737.4 MtC. The EGA, SOV, and ABI rule induce *emission permits* of 569.48 MtC, 1,103.32 MtC, and 1,141.99 MtC, respectively. Thus, self-pledged ERTs are not in line with predicted ERTs of a purely self-interested EU. Neither calculations nor survey data nor results provided by the econometric analysis would have predicted such a result. It seems that the EU considered equity in their climate negotiation positions and takes the lead in

tackling climate change as demanded from developed countries under the UNFCCC. Even though the EU did not make any reference regarding equity principles, historic responsibility, or CBDR in their NDCs, its pledged ERTs attribute a rather less material self-interest and favour an application of the EGA rule in terms of emission permits. The EGA rule had mainly been promoted by developing countries during climate negotiations within the UN framework as it shifts greater abatement responsibility to developed countries that are characterized by high per capita emissions in comparison to developing countries (see paragraph 4.1). Predictions by Lange et al. (2010) on the EU's preferred use of the POL rule in climate negotiations based on the abatement cost ranking cannot be explicitly validated with the EU's pledged NDC and ERTs under the framework of the UNFCCC and the Paris Agreement. The finding derived in this thesis are in line with predictions about EU preferences that are not consistent with a material self-interested use of equity principles, as was previously concluded by Brick and Visser (2015, p. 94). The authors also predicted the use of the EGA rule which incorporates the largest contributions to climate change mitigation efforts.

6.2.2.2 The Use of Equity Rules by the USA

The USA pledged to reduce its GHG emissions by 26-28% from 2005 levels by 2025. Following the same approach as for the EU, converting the pledge into comparable statistics resulted in an emission reductions range of 407.68 MtC (-26%) to 439.04 MtC (-28%). Thus, total abatement costs add up to between 32,614.4 Mio USD and 35,123.2 Mio USD when MACs are equalized at USD80 as illustrated in Table 3. To achieve such abatement induces costs between 0.185% and 0.199% of estimated GDP^{2020}.

Lange et al. (2010, p. 371) predicted abatement costs (in % of GDP^{2020}) of 0.687% induced by the EGA rule, 0.072% induced by the SOV rule, 0.056% induced by the ABI rule, and 0.062% induced by the POL rule. The USA's pledge to reduce its emissions by 26-28% from 2005 levels and resulting abatement costs of 0.185-0.199% of GDP^{2020} exceeded any predicted abatement costs and respective emission permits induced by the SOV, ABI, or POL rule. The POL rule ranks second in the cost ranking as well as in the ranking of expected integration of equity rules. This is also consistent with US environmental law that applies the POL principle in all major US pollution control laws (Davies & Mazurek 2014, p. 47).

On the one hand, it seems that the USA opposed to pledge emission reductions that would induce minimal abatement costs. On the other hand, neither abatement costs nor emission permits induced by the EGA rule according to Lange and co-workers were met. There seems to be a tendency towards the EGA rule which might reflect the USA's aim to pledge 'fair and ambitious' climate targets as stated in its NDC. However, the USA's tendency towards an application of the EGA rule might not be as strong as seen by ERTs set by the EU.

6.2.2.3 The Use of Equity Rules by the Russian Federation

The Russian Federation formulated its INDC as a GHG base year target. By choosing 1990 as the base year for emission levels, it actually formulated an INDC that allows an increase in emissions by 2030. Reducing emissions by 25-30% from 1990 levels can be converted to an emissions increase of between 7.95% and 15.67% from 2002 levels by 2030. The Russian Federation does not seem to intend to contribute to global action against global warming but rather intends to increase its emissions by between 33 MtC and 65MtC from current emission levels as illustrated in Table 3. According to Lange et al. (2010, p.371), application of any equity rule would at least induce some emission reductions in order to meet the climate target.

The Russian Federation, however, actually pledged to increase its emissions. This was possible due to the lack of guidelines for the formulation of INDCs. If the Russian Federation does not modify its INDC, it will benefit from actions by the other countries. Such behaviour is clearly self-serving and a classical example for free-riding in climate negotiations. In contrast to the EU, the USA, or China the Russian Federation has not, as of December 2016, ratified the Paris Agreement yet. The Russian Federation's disregarded POL principle which is embodied in the Russian environmental law, underlines such free-riding behaviour (OECD 1999).

6.2.2.4 The Use of Equity Rules by China

The following results on the use of equity rules by China based on data for G77/China can only serve as an indication and have limited explanatory powers. China pledged to lower its carbon intensity of GDP by 60-65% below 2005 levels by 2030. Applied to G77/China this implies to reduce carbon emissions from 2,566 MtC in 2002 to between 1,539.6 MtC and

1,667.9 MtC by 2030. Such emission reductions will induce costs of 0.265% to 0.287% measured in % of GDP^{2020} when MACs are equalized at USD80.

These abatement costs exceed any abatement costs induced by equity rules according to Lange et al. (2010, p.371). If the EGA rule was applied, China would have even been able to increase its emissions. Abatement costs derived from China's NDC also exceed the EU's abatement costs induced by its submitted NDC (in % of GDP^{2020}).

Thus, China's pledge, if it were applicable to G77/China, would not indicate a self-interested use of equity rules during the Paris negotiations. Calculations conducted in this thesis which were based solely on total abatement costs induced by (I)NDCs suggest that China takes the lead in tackling climate change. This is despite its limited responsibilities and its self-classification of being a developing country. However, because this result is based on broad assumptions its explanatory power is limited.

Table 3: Results about total abatement costs induced by individual (I)NDCs compared to total abatement costs induced by equity rules according to Lange et al. (2010).

	Results derived in this thesis			**Results by Lange et al. (2010)**			
	Abatement (in MtC) to meet (I)NDCs	**Total abatement costs (in Mio USD) with MACs of USD80/tC**	**Total abatement costs (in % of GDP^{2020})**	**Total abatement costs (in % of $GDP^{2020)}$ induced by equity rules**			
				EGA	**SOV**	**ABI**	**POL**
EU	428.6	34,288	0.217	0.334	0.064	0.056	0.044
USA	407.68 439.04	32,614.4 35,123.2	0.185 0.199	0.687	0.072	0.056	0.062
Russian Federation	-65 -33	-5,200 -2,640	-0.146 -0.074	0.749	0.047	0.056	0.081
China (G77/China)	1,539.6 1,667.9	123,168.00 133,432.00	0.287 0.265	-0.423	0.042	0.056	0.055

Note: Negative reductions imply increases in emissions.

Source: Own illustration and calculations modified from Lange et al. (2010, p.371) and individual (I)NDCs.

6.3 Limitations of the Approach

The approach adopted from Lange et al. (2010) and further developed assumptions displayed weaknesses that limited the explanatory powers of results.

Absence of a Global Carbon Trading System

Lange and co-workers worked with a number of assumptions in order to calculate cost rankings for different equity rules and countries and group of countries. It is however debatable, to what extent specific assumptions were applicable to the real-life-problem of creating cooperation on the global level in order to reach the climate target of limiting the average temperature increase to maximally 2°C. Especially one assumption does not seem to meet requirements to apply formulas of equity rules on real-life outcomes such as the submitted (I)NDCs within the framework of the UNFCCC: The presence of an emissions trading system that can equalize MACs across all countries at 80 USD2000/tC. In October 2016, the current EU Emissions Trading System traded one tonne of carbon emission at approximately 6.30 USD2016 and thus far from the threshold of 80 USD2000 threshold (finanzen.net GmbH 2016).[30] A single global carbon market remains an ambition for the future.

Missing Per Capita Proxy under the ABI rule

The ABI rule and the formula which was derived by Lange et al. (2010, p. 363; see Table C.3) focuses on an equal ratio between abatement costs and GDP. The formula, however, does not include a per capita proxy. Countries with a large population base and a rapid increase of GDP bear a relatively large share of implied costs without consideration of implied costs per capita. The ABI rule as formulated by Lange et al. (2010) shifts the implied burden to countries such as India whose GDP is predicted to triple while its population base will continue to increase by 25% between 2010 and 2030 (Mima 8/31/2016). The ABI rule as formulated by Lange and co-workers assumes a slowly evolving balance between population and GDP growth. An application of the ABI rule without a per capita proxy might deepen the discussion concerning the "(...) equitable access to sustainable development and eradication of poverty (…)" (UNFCCC 2015b).

[30] Using the US Inflation Calculator (http://www.usinflationcalculator.com/), 80 USD2000 equal 107 USD2016.

Heterogeneity in the Group G77

As discussed in paragraph 4.2, social, economic, and political heterogeneity among countries bears a high risk to cause negotiation stalemates. Under the umbrella of the UN, developing countries organized themselves in the group G77 to establish common positions for negotiations and thus strengthen their negotiation powers. As of December 2016, 133 Parties belong to the loose coalition of G77 (UNFCCC 2016b). To consider a heterogeneous group of countries such as G77 entails the risk of losing significance for predictions. Unlike the EU, each member country of G77 submitted its own (I)NDC, which had been discussed and developed on a national level.

Lack of Reproducibility

The information provided in the paper *On the Self-Interested Use of Equity in International Climate Negotiations* by Lange et al. (2010) comprises the minimum required to replicate their findings on cost rankings implied based equity rules. The difficulty in reproducing their calculations lies in the data provided and the sparse explanations regarding interim steps to completely reproduce their approach. Lange and co-workers based their calculations on the POLES model to make assumptions for abatement costs. Data related to the POLES model is not available free of charge. However, enerdata provided some data upon request (Mima 8/31/2016). Further, Löschel (9/21/2016) provided clarification on the assumption that equalizing MACs across all countries at 80 USD2000/tC refers to the climate target to limit the increase of average global temperatures to maximally 2°C.

Lack of Application to Actual Outcomes of Climate Negotiations

When considering all points of criticism stated above, the question remains whether equity rules as formulated by Lange and co-workers (2010) can actually be applied to outcomes such as the (I)NDCs under the framework of the UNFCCC. In particular, the assumption of the presence of a global carbon trading market challenges the findings on equity rules in climate negations. The reverse argument implies that the global community needs the presence of a global trading market which is able to equalize MACs to at least USD80 per emitted tonne of carbon in order to prevent a rapid increase in global average temperatures.

7 Conclusion

"(...) learning is important to international cooperation. Indeed, it is inevitable"
(Barrett 2005, p. 17).

Individual perceptions of equity have shaped climate negotiations and their outcomes within the framework of the UNFCCC from the very beginning. For the first time, a bottom-up approach with voluntary self-pledged INDCs tried to adapt to these circumstances. The new approach was acknowledged with the ratification of the Paris Agreement by 115 out of 197 Parties to the UNFCCC. Environmental agreements are commonly characterized by a voluntary contract design, often hampering participation and compliance. The first obstacle, participation, could be overcome with the entering into force of the Paris Agreement. Time will now show whether each and every Party will comply with its self-pledged NDC to finally overcome the second obstacle. Conventional game theory, used to investigate collective action problems associated with climate change, most probably would have predicted a failure of climate negotiations already in the lead-up to the Paris Agreement. Such a prediction is not only supported by the absence of an institution that could enforce the Agreement's compliance under international law, but also by each country's self-designed (I)NDC. There was no official guidance in formulating individual pledges. This led to wide-ranging differences in (I)NDCs reflecting the Parties' individual perceptions of the burden of contributing to combat climate change by reducing its GHG emissions. Given this scenario, Lange et al. (2010) predicted a self-interested use of equity principles in order to achieve the climate target of limiting the maximum global average temperature increase to no more than 2°C above pre-industrial levels at minimal abatement costs. Comparing their hypotheses about favoured equity rules by the EU, the USA, the Russian Federation, and G77/China with individual (I)NDCs within the framework of the Paris Agreement led to different conclusions by this thesis.

During the history of climate negotiations, the USA followed an irregular line of argumentation on climate system protection, mostly caused by national politics. The USA withdrew from the Kyoto Protocol because they felt treated unfairly in comparison to countries that were not obliged to cut any emissions under the treaty. Thus, it would have come as no surprise if the USA, while formulating their NDC, had supported the ABI rule which would have induced minimal abatement costs for them. Their pledge to cut emissions

by 26-28% from 2005 levels, however, exceeds the minimal costs induced by the predicted ABI rule. Subject to the assumptions made, calculations led to the result that the USA did not strictly follow a self-interested use of equity while formulating its NDC. Based on the latest data provided by the US Environmental Protection Agency (EPA) (2016, p. 75), net GHG emissions were 8.6% below 2005 levels, as of the end of 2014. Current policy projections suggest that the USA is not likely to meet its pledge to reduce emissions by 26-28% from 2005 levels (Climate Action Tracker 2016f). Further, US climate policies depend on political and strategic decisions (ibid.). Arising dynamics on that level might lead to stalemates in US climate action and non-compliance with their ambitious NDC towards combating global warming.

In contrast to the current insufficient actions in US climate policies, the EU is predicted to follow its trend in decreasing GHG emissions under existing implemented policies (Climate Action Tracker 2016c). Under the 2030 timeframe which aims to reduce overall GHG emissions by 40% from 1990 levels, current policy projections expect a reduction of EU's domestic GHG emissions by 34-40% (ibid.). Subject to available data, the EU burdens itself with a greater share of abatement costs than predicted in order to meet its NDC. Such a result is not consistent with studies predicting a self-interested EU. However, further research is needed to examine to which extent the EU's efforts to combat climate change are driven by the negotiators altruistic behaviour, their individual perceptions of equity, and their concern of the adverse effects of climate change, or whether their negotiating positions were primarily driven by political strategies.

Although findings about China were derived from data applicable to G77/China, results allow drawing the limited conclusion that China is being driven by equity considerations. In its NDC, China announced "[t]o achieve the peaking of carbon dioxide emissions around 2030 and making best efforts to peak early" (People's Republic of China Department of Climate Change 2015, p. 5). Based on data from 2014 and the first three quarters of 2015, Green and Stern (Green & Stern 2016) suggested that China's *Five Year Plan for Economic Development (2016-2020)* towards a more sustainable and inclusive growth leads to a much slower increase in GHG emissions than predicted. This development is due to major structural transformations in the energy sector which currently accounts for the majority of domestic GHG emissions. China's GHG emissions are forecasted to peak before 2025 and thus meeting

its aim to make “(...) best efforts to peak early” (People's Republic of China Department of Climate Change 2015, p. 5; Green & Stern 2016, p.3). Recent legislative changes in the USA might not only lead to US stalemates in national US climate policies and compliance issues with the Paris Agreement, but might also enhance China’s role in combating climate change and its reputation in the global arena of climate policies.

Mitigation efforts by the USA, the EU, and China attract special attention due to the non-cooperative behaviour of one of the biggest emitters, the Russian Federation, which actually pledged to increase its GHG emission compared to 1990 levels. Overall however, it seems that it is not valid to assume that countries only use their bargaining power to support their pure material self-interest. Unilateral action against climate change does not necessarily depend on universal collective action.

Whether pledges to prevent a further increase in global average temperature are convincing enough to even enhance more cooperative and compliance behaviour need to be observed. As of beginning of December 2016, the Paris Agreement which is purely based on a *voluntary compliance* of *voluntarily pledged* NDCs was ratified by 60% of the Parties to the Convention. Now, the Agreement and the global community need to prove themselves by corresponding future actions.

A further and more detailed analyses on variables and characteristics that shape a Party’s conscious and unconscious perception towards equity would provide important insights to the question, how individual equity perceptions have actually shaped the formulation of submitted (I)NDCs. Findings might stimulate debates of equity in climate negotiations and could suggest solutions on how to successfully enhance global action associated with climate system protection in the long-run.

Appendix A – List of Annex I Parties to the UNFCCC

Table A.1: List of Annex I Parties to the UNFCCC.

Australia	France	Malta	Switzerland
Austria	Germany	Monaco	Turkey
Belarus	Greece	Netherlands	Ukraine
Belgium	Hungary	New Zealand	United Kingdom
Bulgaria	Iceland	Norway	United States
Canada	Ireland	Poland	
Croatia	Italy	Portugal	
Cyprus	Japan	Romania	
Czech Republic	Latvia	Russian Federation	
Denmark	Liechtenstein	Slovakia	
European Union (28)	Lithuania	Spain	
Finland	Luxembourg	Sweden	

Appendix B – A Brief Timeline of Important UN Climate Negotiations

1992 – The UNFCCC was adopted and opened for signature as part of the Earth Summit in Rio de Janeiro, Brazil. Signatories agreed to stabilize "(...) greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous interference with the climate system" UNFCCC, Article 2). The treaty is **not legally binding**.

1994 – The UNFCCC entered into force.

1995 – COP1 held in Berlin, Germany, agreed that commitments under the UNFCCC were inadequate to meet the Convention's objective (Article 2). In a decision, the Berlin Mandate, Parties agreed to negotiate strengthened commitments for developed countries. **Non-Annex 1 countries were exempted from additional obligations** under the decision**.**

1997 – COP3 was held in Kyoto, Japan, and the Kyoto Protocol was adopted. The Protocol includes **legally binding emission targets for developed countries (Annex I) only**. The targets cover the commitment period 2008-2012.

2007 – COP13 was held in Bali, Indonesia. The Bali Action Plan was established. Parties agreed to negotiate GHG mitigation actions after the Kyoto Protocol's first commitment period expires in 2012. **The Bali Action Plan did not require binding GHG targets for developing countries.**

2009 – COP15 was held in Copenhagen, Denmark. It **failed to reach agreement on binding commitments** after the Kyoto Protocol commitment period ends in 2012. The Copenhagen Accord on a long-term goal of limiting the maximum global average temperature increase to no more than 2°C above pre-industrial levels was announced. **No legally binding commitments were required by the Accord, but countries were asked to pledge voluntary National Appropriate Mitigation Activities.**

2011 – COP 16 was held in Cancun, Mexico. Parties officially **agreed to commit** the Copenhagen Accord's aim to limit global warming to 2°C.

2011 – COP 17 was held in Durban, South Africa. Parties decided to adopt a universal **legally binding climate agreement** by 2015, which should be **based on the concept of equity and CBDR** among Parties.

2012 – COP18 was held in Doha, Qatar. Parties agreed to establish **a second commitment period between 2013 and 2020 under the Kyoto Protocol**. A timetable to adopt a universal climate agreement by 2015 was set out.

2013 – COP19 was held in Warsaw, Poland. Parties agreed on a road map for a new climate agreement by 2015. This includes a **decision to communicate respective INDCs well in advance.**

2014 – COP20 was held in Lima, Peru. As a run-up to the climate negotiations in Paris in 2015, all Parties were once more urged to communicate their **Intended Nationally Determined Contributions** in advance.

2015 – COP21 was held in Paris, France. The Paris Agreement was adopted on 12 December 2015. Its main aim is to strengthen the Parties' goal to **keep global temperature increase well below 2°C above pre-industrial levels** and to seek efforts to limit it even further to 1.5°C. Parties are required to put their greatest effort into the implementation of their **Nationally Determined Contributions**. A differentiation according to Annex I and Non-Annex I countries no longer exists. **The treaty is only partly legally binding.**

2016 – November, 4. **The Paris Agreement entered into force.**

Appendix C – Replication of Cost Rankings Induced by Equity Rules According to Lange et al. (2010)

Table C.1: GDP, population, and carbon emissions for EU, G77/China, Russia, and USA for 1990/2002/2020.

	Year	EU	G77/China	Russia	USA	ROW*	World
GDP (Billion USD2000)	1990	8160	9871	2241	7113	5688	33073
	2002	10484	18449	1657	10075	6562	47227
	2020	15816	46555	3571	17634	11006	94582
Population (Million)	1990	498	3965	148	253	396	5260
	2002	513	4891	144	289	429	6266
	2020	514	6092	129	337	460	7532
Carbon Emissions (MtC)	1990	1229	1664	640	1361	959	5853
	2002	1166	2566	415	1568	942	6657
	2020	1299	4767	538	2035	1186	9825

*ROW = Rest of the World

Source: Own adjustment and illustration based on Lange et al. (2010, p.371).

Table C.2: Summary of abatement cost assumptions in 2020.

	Marginal Abatement Costs (USD2000/tC)						
	40	80	120	160	200	40	80
	Abatement (MtC)					Total Abatement Costs (Mio USD2000)	
EU	72	128	175	216	250	1400	4700
G77/China	502	860	1137	1365	1558	9500	30700
Russia	63	109	142	167	190	1200	3900
USA	155	270	362	437	502	2900	9800
ROW	64	112	151	181	209	1200	4000
World	856	1480	1967	2366	2709	16200	53100

Source: Own adjustment and illustration based on Lange et al. (2010, p.371).

Table C.3: Summary of equity rule formulas.

EGA:	$\frac{\bar{e}_j\,(p)}{POP_j{}^{2020}} = \frac{E^{2020} - A\,(p)}{POP^{2020}}$
SOV:	$\frac{\bar{e}_j\,(p)}{e_j{}^{2020}} = \frac{E^{2020} - A\,(p)}{E^{2020}}$
ABI:	$\frac{AC_j(p) + p\,[\,e_j{}^{2020} - a_j(p) - \bar{e}_j\,(p)]}{GDP_j{}^{2020}} = \frac{AC\,(p)}{GDP^{2020}}$
POL:	$\frac{AC_j(p) + p\,[\,e_j{}^{2020} - a_j(p) - \bar{e}_j\,(p)\,]}{e_j{}^{2020}} = \frac{AC\,(p)}{E^{2020}}$

Source: Own illustration based on Lange et al. (2010, p. 363).

In the following, it is demonstrated how Lange et al. (2010) calculated cost rankings induced by the respective equity rule when MACs are equalized at USD80/tC, corresponding to a worldwide reduction of BAU emissions by 15% in order to meet the goal to limit the average temperature increase to 2°C. The published paper by Lange and co-workers only provides the equity formulas as illustrated in Table C.3 as well as the resulting cost rankings as illustrated in Table C.4. Any interim results on how they calculated implied costs of abatement induced by the EGA, SOV, ABI, and POL rule are missing. Thus, the following section demonstrates in detail how Lange et al. (2010) calculated their cost rankings on which their hypotheses on a self-interested use of equity rules in climate negotiations are based. Calculations and interim results for the EU serve as an example. Calculations related to G77/China, Russian Federation, and USA follow the same approach.

List of Symbols

$j \in \{\text{EU}, \text{G77/China}, \text{Russia}, \text{USA}\}$

POP_j^{2020}	population level in 2020 for j
POP^{2020}	aggregated population level in 2020
GDP_j^{2020}	GDP level in 2020 for j
GDP^{2020}	aggregated GDP level in 2020
$\bar{e}_j(p)$	emission permit allocation for j which is induced by the respective equity criteria
$e_j(p)$	business as usual emissions for j
E^{2020}	aggregated emissions level in 2020
$a_j(p)$	optimal allocation of abatement for j
$AC_j(p)$	resulting abatement costs for j
$AC(p)$	aggregated resulting abatement costs
$A(p)$	aggregated level of the optimal allocation of abatement $a_j(p)$
TAC	total abatement costs
ABA	induced abatement by respective equity rule
MAC	marginal abatement costs

EGA Rule:

(1) $$\frac{\bar{e}_j\,(p)}{{POP_j}^{2020}} = \frac{E^{2020} - A\,(p)}{POP^{2020}}$$

$$\leftrightarrow$$

(2) $$\bar{e}_j\,(p) = \frac{E^{2020} - A\,(p)}{POP^{2020}} * \ {POP_j}^{2020}$$

Emission permits for the EU for 2020 induced by the EGA rule when MACs are equalized at USD80/tC:

(3) $$\bar{e}_{EU}\,(80) = \frac{E^{2020} - A\,(80)}{POP^{2020}} * \ {POP_{EU}}^{2020}$$

$$\leftrightarrow$$

(4) $$\bar{e}_{EU}\,(80) = \frac{9{,}825\ MtC - ,1480\ MtC}{7{,}532\ Mio} * \ 514\ Mio = 569.481\ MtC$$

Induced abatement for 2020 by the EGA rule when MACs are equalized at USD80/tC:

(5) $$Abatement_j = {e_j}^{2020} - \ \bar{e}_j\,(p)$$

$$\leftrightarrow$$

(6) $$ABA_{EU} = {e_{EU}}^{2020} - \ \bar{e}_{EU}\,(80)$$

$$\leftrightarrow$$

(7) $$ABA_{EU} = 1{,}299\ MtC - 569.481\ MtC = 729.519\ MtC$$

Projected abatement costs for 2020 by the EGA rule when MACs are equalized at USD80/tC:

(8) $$Total\ Abatement\ Costs = Abatement\ * Marginal\ Abatement\ Costs$$

(9) $$TAC_j = ABA_j * MAC$$

$$\leftrightarrow$$

(10) $$TAC_{EU} = ABA_{EU} * USD80/tC$$

$$\leftrightarrow$$

(11) $$TAC_{EU} = 729.519\ MtC\ * USD80/tC = 58{,}361.53\ Mio\ USD$$

Projected abatement costs for 2020 by the EGA rule when MACs are equalized at USD80/tC in % of ${GDP_{EU}}^{2020}$:

(12) $GDP_{EU}{}^{2020} = 15{,}816{,}000\ Mio\ USD$

$\leftrightarrow$

(13) $58{,}361.52\ Mio\ USD = \mathbf{0.369}\ \%\ \boldsymbol{of\ GDP_{EU}{}^{2020}}$

SOV Rule:

(14) $\frac{\bar{e}_j\,(p)}{e_j{}^{2020}} = \frac{E^{2020} - A\,(p)}{E^{2020}}$

$\leftrightarrow$

(15) $\bar{e}_j\,(p) = \frac{E^{2020} - A\,(p)}{E^{2020}} * \ e_j{}^{2020}$

Optimal emission permits for the EU for 2020 induced by the SOV rule when MACs are equalized at USD80/tC:

(16) $\bar{e}_{EU}\,(80) = \frac{E^{2020} - A\,(80)}{E^{2020}} * \ e_{EU}{}^{2020}$

$\leftrightarrow$

(17) $\bar{e}_{EU}\,(80) = \frac{9{,}825\ MtC - 1{,}480\ MtC}{9{,}825\ MtC} * \ 1{,}299.00\ MtC = 1{,}103.324\ MtC$

Induced abatement for 2020 by the SOV rule when MACs are equalized at USD80/tC:

(18) $\text{Abatement}_\text{j} = \text{e}_\text{j}{}^{2020} - \ \bar{\text{e}}_\text{j}\,(\text{p})$

$\leftrightarrow$

(19) $\text{ABA}_\text{EU} = \text{e}_\text{EU}{}^{2020} - \ \bar{\text{e}}_\text{EU}\,(80)$

$\leftrightarrow$

(20) ABA_EU= *1,299 MtC – 1,103.324 MtC = 195.676 MtC*

Projected abatement costs for 2020 by the SOV rule when MACs are equalized at USD80/tC:

(21) $\text{Total Abatement Costs}_\text{j} = \text{Abatement}_\text{j} * \text{Marginal Abatement Costs}$

$\leftrightarrow$

(22) $\text{TAC}_\text{EU} = \text{ABA}_\text{EU} * \text{MAC}$

$\leftrightarrow$

(23) $TAC_{EU} = 195.676\ MtC\ * USD80/tC = 15{,}654.11\ Mio\ USD$

Projected abatement costs for 2020 by the SOV rule when MACs are equalized at USD80/tC in % of ${GDP_{EU}}^{2020}$:

(24) $$\mathrm{GDP_{EU}}^{2020} = 15{,}816{,}000 \text{ Mio USD}$$

$$\leftrightarrow$$

(25) $$15{,}654.11 \text{ Mio USD} = \mathbf{0.099\ \%\ of\ GDP_{EU}}^{\mathbf{2020}}$$

ABI Rule:

(26) $$\frac{\mathrm{AC_j(p) + p\,[\,e_j}^{2020} - \mathrm{a_j(p) - \bar{e}_j\,(p)]}}{\mathrm{GDP_j}^{2020}} = \frac{\mathrm{AC\,(p)}}{\mathrm{GDP}^{2020}}$$

$$\leftrightarrow$$

(27) $$\mathrm{\bar{e}_j\,(p)} = \left(\frac{\mathrm{AC_j(p) + p\,[\,e_j}^{2020} - \mathrm{a_j(p)]}}{\mathrm{GDP_j}^{2020}} - \frac{\mathrm{AC\,(p)}}{\mathrm{GDP}^{2020}}\right) * \frac{\mathrm{GDP_j}^{2020}}{\mathrm{p}}$$

Optimal emission permits for the EU for 2020 induced by the ABI rule when MACs are equalized at USD80/tC:

(28) $$\mathrm{\bar{e}_{EU}\,(80)} = \left(\frac{\mathrm{AC_{EU}(80) + 80\,[\,e_{EU}}^{2020} - \mathrm{a_{EU}(80)]}}{\mathrm{GDP_{EU}}^{2020}} - \frac{\mathrm{AC\,(80)}}{\mathrm{GDP}^{2020}}\right) * \frac{\mathrm{GDP_{EU}}^{2020}}{80}$$

$$\leftrightarrow$$

(29) $$\bar{e}_{EU}\,(80) = \left(\frac{470\ Mio\ USD + 80\ USD\ [1{,}299\ MtC - 128\ MtC]}{15{,}816{,}000\ Mio\ USD} - \frac{5{,}310\ Mio\ USD)}{94{,}582{,}000\ Mio\ USD}\right) * \frac{15{,}816{,}000\ Mio\ USD}{80\ USD} = 1{,}118.758\ MtC$$

Induced abatement for 2020 by the ABI rule when MACs are equalized at USD80/tC:

(30) $$\mathrm{Abatement_j} = \mathrm{e_j}^{2020} - \mathrm{\bar{e}_j\,(p)}$$

$$\leftrightarrow$$

(31) $$\mathrm{ABA_{EU}} = \mathrm{e_{EU}}^{2020} - \mathrm{\bar{e}_{EU}\,(80)}$$

$$\leftrightarrow$$

(32) $$\mathrm{ABA_{EU}} = 1{,}299 \text{ MtC} - 1{,}118.758 \text{ MtC} = 180.242 \text{ MtC}$$

Projected abatement costs for 2020 by the ABI rule when MACs are equalized at USD80/tC:

(33) $$\text{Total Abatement Costs}_{\text{j}} = \text{Abatement}_{\text{j}} * \text{Marginal Abatement Costs}$$

$$\leftrightarrow$$

(34) $$\text{TAC}_{\text{EU}} = \text{ABA}_{\text{EU}} * \text{MAC}$$

$$\leftrightarrow$$

(35) $$\text{TAC}_{\text{EU}} = 182.242\ \text{MtC} * \text{USD80/tC} = 14{,}419.38\ \text{Mio USD}$$

Projected abatement costs for 2020 by the ABI rule when MACs are equalized at USD80/tC in % of GDP^{2020}: [31]

(36) $$\text{GDP}_{\text{EU}}{}^{2020} = 15{,}816{,}000\ \text{Mio USD}$$

$$\leftrightarrow$$

(37) $$14{,}419.38\ \text{Mio USD Mio USD} = \mathbf{0.091}\ \%\ \boldsymbol{of\ GDP^{2020}}$$

POL Rule:

(38) $$\frac{\text{AC}_{\text{j}}(\text{p}) + \text{p}\,[\,\text{e}_{\text{j}}{}^{2020} - \text{a}_{\text{j}}(\text{p}) - \bar{\text{e}}_{\text{j}}\,(\text{p})\,]}{\text{e}_{\text{j}}{}^{2020}} = \frac{\text{AC}\,(\text{p})}{\text{E}^{2020}}$$

$$\leftrightarrow$$

(39) $$\bar{\text{e}}_{\text{j}}\,(\text{p}) = \left(\frac{\text{AC}_{\text{j}}(\text{p}) + \text{p}\,[\,\text{e}_{\text{j}}{}^{2020} - \text{a}_{\text{j}}(\text{p})]}{\text{e}_{\text{j}}{}^{2020}} - \frac{\text{AC}\,(\text{p})}{\text{E}^{2020}}\right) * \frac{\text{e}_{\text{j}}{}^{2020}}{\text{p}}$$

Optimal emission permits for the EU for 2020 induced by the POL rule when MACs are equalized at USD80/tC:

(40) $$\bar{e}_{EU}\,(80) = \left(\frac{AC_{EU}(80) + 80\,[\,e_{EU}{}^{2020} - a_{EU}(80)]}{e_{EU}{}^{2020}} - \frac{AC\,(80)}{E^{2020}}\right) * \frac{e_{EU}{}^{2020}}{80}$$

$$\leftrightarrow$$

(41) $$\bar{e}_{EU}\,(80) = \left(\frac{470\ Mio\ USD + 80\ USD\,[1{,}299\ MtC - 128\ MtC]}{1{,}299\ MtC} - \frac{5{,}310\ Mio\ USD)}{9{,}825\ MtC}\right) * \frac{1{,}299\ MtC}{80\ USD} = 1{,}141.99\ MtC$$

[31] Due to the character of the ABI rule that a country whose GDP amounts to xy% of GDP should bear xy% of global abatement costs, results are denoted in % GDP^{2020}.

Induced abatement for 2020 by the POL rule when MACs are equalized at USD80/tC:

(42) $$\text{Abatement}_j = e_j^{2020} - \bar{e}_j(p)$$

$$\leftrightarrow$$

(43) $$ABA_{EU} = e_{EU}^{2020} - \bar{e}_{EU}(80)$$

$$\leftrightarrow$$

(44) $$ABA = 1{,}299\ MtC - 1{,}141.99\ MtC = 157.01\ MtC$$

Projected abatement costs for 2020 by the POL rule when MACs are equalized at USD80/tC:

(45) $$\text{Total Abatement Costs}_j = \text{Abatement}_j * \text{Marginal Abatement Costs}$$

$$\leftrightarrow$$

(46) $$TAC_{EU} = ABA_{EU} * MAC$$

$$\leftrightarrow$$

(47) $$TAC_{EU} = 157.01\ \text{MtC} * \text{USD80/tC} = 12{,}560.55\ \text{Mio USD}$$

Projected abatement costs for 2020 by the POL when MACs are equalized at USD80/tC in % of GDP_{EU}^{2020}:

(48) $$GDP_{EU}^{2020} = 15{,}816{,}000\ Mio\ USD$$

$$\leftrightarrow$$

(49) $$12{,}560.55\ Mio\ USD = \mathbf{0.079}\ \%\ \mathbf{of}\ \boldsymbol{GDP_{EU}^{2020}}$$

Table C.4 provides an overview on resulting cost rankings as calculated with the above demonstrated approach in comparison to resulting cost rankings as provided by Lange et al. (2010, p. 371). The results are not absolutely identical due to limited data and rounded values provided by Lange et al. (2010). That the above applied approach is valid can be proven by identical rankings of preferred equity rules as well as identical intervals between any costs induced by an equity rule (e.g. the interval between EGA and SOV rule for the EU as calculated by Lange et al. (2010) is identical to the interval between EGA and SOV rule for the EU from own calculations).

Table C.4: Comparison between calculations on cost rankings induced by equity rules.

	Equity Rule	Costs in % of GDP^{2020} according to Lange et al. (2010)	Cost Ranking of preferred equity rule according to Lange et al. (2010)	Costs in % of GDP^{2020} according to own calculations	Cost Ranking of preferred equity rule according to own calculations
EU	**EGA**	0.334	4	0.369	4
	SOV	0.064	3	0.099	3
	ABI	0.056	2	0.091	2
	POL	0.044	1	0.079	1
USA	**EGA**	0.687	4	0.754	4
	SOV	0.072	3	0.139	3
	ABI	0.056	1	0.123	1
	POL	0.062	2	0.129	2
Russian Federation	**EGA**	0.749	4	0.885	4
	SOV	0.047	1	0.182	1
	ABI	0.056	2	0.191	2
	POL	0.081	3	0.216	3
G77/China	**EGA**	-0.423	1	-0.341	1
	SOV	0.042	2	0.123	2
	ABI	0.056	4	0.138	4
	POL	0.055	3	0.137	3

Note: Due to the character of the ABI rule that a country whose GDP amounts to xy% of GDP should bear xy% of global abatement costs, results are denoted in % of GDP^{2020}. All other results for EGA, SOV, and POL rule are denoted in $\mathrm{GDP}_{\mathrm{j}}^{2020}$.

Source: Own illustration based on Lange et al. (2020, p.371) and own calculations.

Appendix D – Comparison between Predicted Emission Permits Induced by Equity Rules and Actual (I)NDCs

Table D.1: Emission permits under submitted (I)NDCs.

	Formulated (I)NDCs	Emission permits (in MtC) under (I)NDCs	Abatement from 2002 levels (in MtC) to meet (I)NDCs	Abatement (in % of emissions in 2002)
EU	Reducing domestic GHG emissions by 40% from 1990 levels by 2030.	737.4	428.6	36.76%
USA	Reducing GHG emissions by 26-28% from 2005 levels by 2025.	1160.32 1128.96	407.68 439.04	26% 28%
Russian Federation	Reducing GHG emissions by 25-30% from 1990 levels by 2030.	480 448	-65 -33	-15.67% -7.95%
China	Lowering carbon intensity of GDP by 60-65% below 2005 levels by 2030.	1,026.4 898.1	1,539.6 1667.9	60%[32] 65%

Note: Negative reductions imply increases in emissions.

Source: Own illustration and calculations modified from Lange et al. (2010, p. 371) and individual (I)NDCs.

Table D.2: Comparison between emission permits under submitted (I)NDCs and emission permits induced by equity rules when abatement costs are equalized at USD80/tC.

	Emission estimates (in MtC) for 2020	Emission permits (in MtC) under (I)NDCs	Emission permits (in MtC) induced by equity rules modified from Lange et al. (2010)			
			EGA	SOV	ABI	POL
EU	1,299	737.4	569.48	1,103.32	1,118.76	1,141.99
USA	2,035	1160.32 1128.96	373.38 MtC	1,728.46	1,763.75	1,750.02
Russian Federation	538	480 448	142.92	456.96	452.69	441.4
China	4767	1,026.4 898.1	6,749.57	4,048.92	3,964.04	3,968.70

Source: Own illustration and calculations modified from Lange et al. (2010, p.371) and individual (I)NDCs.

[32] Due to data availability and assumptions made, base year carbon emissions equal current carbon emissions. This leads to the result that the target of lowering carbon intensity of GDP by 60-65% equals emission abatements of the same amount. If data for current (2016) emissions was available, the amount of abatement in % of current emissions (2016) would differ.

Table D.3: Comparison between abatement under (I)NDCs and abatement (in % of current emissions) induced by equity rules when marginal abatement costs are equalized at USD80/tC.

	Abatement (in % of emissions in 2002) under (I)NDCs	Abatement (in % of emissions in 2002) induced by equity rules modified from Lange et al. (2010)			
		EGA	**SOV**	**ABI**	**POL**
EU	36.76	56.16	9.62	8.86	7.72
USA	26 28	81.65	15.06	13.33	14
Russian Federation	-15.67 - 7.95	73.43	3.98	4.19	4.75
China	60 65	-41.6	15.06	16.84	16.75

Note: Negative reductions imply increases in emissions.

Source: Own illustration and calculations modified from Lange et al. (2010, p.371) and individual (I)NDCs.

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Declaration of Authorship

By signing this declaration I confirm that I have completed the present thesis independently, without help from others and without using resources other than indicated and named. All phrases that are taken directly or indirectly from other sources (incl. electronic resources), quoted verbatim or paraphrased are indicated accordingly. I am aware that any violation of this declaration will result in the work being graded as 'failed' (0 grade points according to § 28 (2) 'Allgemeine Bestimmungen', ECTS-Grade F).

Marburg, 08.12.2016

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Milena V. Ostrower