Has the Climate Actually Changed?
A Structural Analysis of International Climate Politics 2001-2009

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20 November 2009

Abstract

This paper analyzes previous and ongoing politics of global climate change, from the US pullout of the Kyoto process in 2001 to the continuing negotiations on a new climate regime after the Kyoto Protocol's expiration at the end of 2012. Based on concepts derived from network theory, the paper first describes the evolution of international cooperation on the climate issue during the proscribed time period. Then, it systematically tests the effect of structural configurations that can be observed between the different international actors (national governments, international organizations and nongovernmental organizations) on international political cooperation on climate change. Following a neorealist argumentation, it can be shown that the relative economic power of an actor widely explains its structural position in international political cooperation on climate change. Whereas the role of institutions is difficult to assess with the political event data analyzed in this study, the paper finds strong statistical support for reciprocity and transitivity network effects in the evolution of international politics of climate change since the Kyoto Protocol entered into force in 2005. The analysis is based on a dynamic social network analysis of political events using simulation investigation for empirical network analysis (SIENA) techniques. The underlying event data set was coded with the news stream of the Agence France Presse by applying the Kansas Event Data (KEDS) coding system.

Paper prepared for presentation at 2009 Amsterdam Conference on the Human Dimensions of Global Environmental Change, Theme 2: Agency in Earth System Governance, Panel 13: Networks in Earth System Governance, Volendam near Amsterdam, The Netherlands, 2-4 December 2009.

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1 Introduction

A divided and increasingly fragmented international political process to date has challenged attempts to address global climate change in an effective way. National governments face severe cooperation problems when negotiating and implementing effective measures to both mitigate and find joint ways to adapt to the expected risks of climate change. Climate stability is very similar to a common pool resource with unlimited access, whereas the costs of exploitation (due to social activities that are harmful to climate stability) are borne by everybody, even though the costs may vary significantly between geographic regions and societal sectors (Paterson and Stripple 2007). As the current commitment period under the Kyoto Protocol to reduce climate relevant greenhouse gases (GHG) runs out in 2012, the pressure is mounting to intensify international efforts to find a new regime to mitigate climate change. But far-reaching emission cuts are costly, and both developed and developing countries have been divided over the political steps to be taken to address the climate crisis. It is therefore not a surprise that the conditions under which national governments might be willing to comply to an international climate protection regime with binding climate stabilization targets and effective restrictions on GHG emission has attracted much interest from policymakers and scholars (most recent contributions include: Depledge 2009; Buys et al. 2009; Kuik et al. 2009; Harris 2009; Stern 2009; Giddens 2009; Aldy and Stavins 2007; Biermann et al. forthcoming).

The research questions addressed in this paper read as follows: How have international politics on climate change evolved between 2001 and 2009? What network configurations can be observed, and how have they changed international politics on climate change over this period? The paper addresses these questions by analyzing the potential role of network effects in international cooperation to tackle climate change. Based on concepts derived from network theory, it describes first the evolution of international political cooperation on the issue of global climate change from a structural perspective. Then, it systematically tests the effect of these structural configurations between the involved international actors (national governments, international organizations and non-governmental organizations) on international political cooperation on climate change. Taking a network approach to international politics, and in particular the application of network analytic concepts and techniques, is a rather new undertaking (Hafner-Burton et al. 2009; Kahler 2009b). But, as the paper aims to demonstrate, this approach can make a significant contribution to understanding the international politics of a global political issue such as climate change. Even while international negotiations on a post-2012 framework have not yet come to resolution, such a dynamic analysis allows for an investigation of the shifts in international cooperation on the climate change issue as they can be observed over the last two or three years.

As a starting point, the paper takes first a more traditional perspective on international politics by testing the explanatory power of classical neorealist and neoliberal approaches to explain international cooperation (or, more accurately, the lack thereof) on the global climate issue. Following a neorealist argumentation, it can be shown that the relative economic power of a nation (in terms of its share of the world market) explains widely its position in the international political network on climate change. On the other hand, the neoliberal argument that international institutions such as the Kyoto Protocol have strengthened international cooperation on the climate issue cannot be supported with the political event data that underlies this study. Then, taking a dynamic perspective and focusing on the network structure that can be observed in the international politics of climate change, the paper finds evidence for network effects to play a crucial role in the evolution of material cooperation between nations on the climate issue. Using simulation investigation for empirical network analysis (SIENA) techniques, the study finds strong statistical support for reciprocity and transitivity effects in the evolution of the international cooperation network on climate change after the Kyoto Protocol took effect in February 2005 to the beginning of the post-Kyoto climate negotiations initiated at the United Nations Climate Conference in Bali in December 2007.

The paper proceeds as follows: In the section below, I outline briefly the problem of global climate change and summarize the current developments in the international politics of climate change. In Section 3, I will discuss the related scholarly debate on political cooperation (or the lack thereof) on the issue and will introduce the network approach taken in this paper. Hypotheses that will be tested later in the paper will be formulated. Section 4 introduces the political event data set analyzed in this study and outlines the methods that were used to test the hypotheses. In Section 5, the results of the analysis will be presented and discussed. I will conclude with an outline of the potential theoretical implications of the results, pinpoint the strengths of the analysis and some of the shortcomings, and will provide an outlook on further research.

2 The Climate Change Challenge

Warming of the climate system is considered today as unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice as well as the rising global average sea levels (IPCC 2007a: 30). Human activity as a driver behind observed climatic changes is hardly disputed anymore. The main man-made factor causing global warming is carbon dioxide (CO_2) emissions resulting from burning fossil fuels, which contain the CO_2 that the original plants absorbed from the atmosphere. When it comes to the contribution of individual countries, China and the US are the biggest sources of greenhouse gases (GHG) today. Per capita, however, emissions of China are still about one quarter (India one tenth) of those of the United States. Australia, Canada and western European are the other big emitters of GHG, both absolutely and per capita (UNFCCC 2008b).

While scientists have been studying changes in climate conditions for over a hundred years, climate change did not emerge as a salient issue on the political agenda until the late 1980s (DeSombre 2007: 9). The 1992 Rio Convention on Climate Change (United Nations Framework Convention on Climate Change, UNFCCC) sets an overall framework for intergovernmental efforts to tackle the challenge posed by climate change. It recognizes that the climate system is a shared resource whose stability can be affected by industrial and other emissions of carbon dioxide and other GHG (UNFCCC, Preamble). But already at the first Conference of the Parties (COP) in 1995, signatories to the UNFCCC had to acknowledge that the voluntary approach of the UNFCCC (stabilizing emissions at 1990 levels by the year 2000) was failing and agreed to negotiate binding commitments to reduce emissions. With the Kyoto Protocol, delegates from 160 countries agreed—for the first time—on binding emissions cuts for 37 industrialized countries and the European Community (so-called Annex I parties), with an average of 5.5 percent against 1990 levels to be met over the five-year period 2008-2012 (Kyoto Protocol, Annex B).

Unlike the (unbinding) UNFCCC, the Kyoto Protocol was highly contested, both among industrial nations and between industrialized and developed countries. The ratification process almost failed; several COP meetings with continued discussions around rules and guidelines for implementing the Protocol were held (Bodanski 2001; Henry and McIntosh Sundstrom 2007). Although the protocol was originally supported by the Clinton-Gore administration, US President George W. Bush and the Republican dominated US Congress repudiated later its targets. As a consequence, the United States never ratified the protocol and also worked against its implementation by discouraging other governments from doing so (Depledge 2005; Harrison 2007). Australia, then second biggest emitter of greenhouse gases, had not ratified the protocol until the new government under liberal Prime Minister Kevin Rudd reversed the policy in December 2007 (Christoff 2005, 2008; Crowley 2007). As of today, 189 countries and the European Union (EU) have ratified the protocol (according to the Secretariat of the UNFCCC, status of ratification as of 6 November 2009). The new US government under President Barack Obama decided to not ratify the protocol due to its soon expiration in 2012. But the new administration in Washington has assured that the US will take a leading role on climate change again and will engage constructively in the ongoing negotiations on an effective post-2012 agreement.

The Kyoto Protocol shows mixed results at best. Emissions by the 40 industrialized countries committed to Kyoto are down 5 percent as compared with 1990 levels and, thus, just about to meet the target set under Kyoto (UNFCCC 2008a). But there is little evidence that the reduction has to do with climate policy. Achievements in lowering emissions are mainly due to structural changes in eastern European economies as a consequence of the collapse of the Soviet Union. The transition to market economies and the reduced dominance of heavy industry in those economies have both contributed to a significant increase in energy efficiency and, as a consequence, lower GHG emissions. In addition, some European countries have moved away from coal in power generation to less carbon intense gas or nuclear energy production. Without the emission reductions resulting from these developments in transition countries, GHG emissions of Annex I parties would have grown by almost 10 percent since 1990 (UNFCCC 2008a: 6). As another big drawback of the Kyoto Protocol, its binding measures do not apply to China, India and other emerging economies that are projected to account for the vast part of the emissions growth in the next few decades (Blandford et al. 2008). With the current Kyoto commitment period running out in 2012, the parties to UNFCCC agreed at the COP 13 Bali meeting in December 2007 to step up efforts to combat climate change and to launch formal negotiations on regulations for the era after 2012. This process was set to be concluded at the COP 15 Climate Change Conference in Copenhagen in December 2009 (UNFCCC 2008b). But latest developments indicate that it is very unlikely that parties will be able to agree on new reduction targets, appropriate means to support poor countries to adapt to climate change and ways to further promote green technologies already at the Copenhagen summit.

3 The Politics of Climate Change and Network Effects

The academic study of the politics of climate change grew rapidly in the early 1990s as scholars turned their attention to the Rio Earth Summit with the creation of the UNFCCC and the subsequent negotiations on the Kyoto Protocol (Mintzer and Leonard 1994; Luterbacher and Sprinz 2001; Schröder 2001). Scholarly work on international environmental politics has strongly focused on the study of the conditions for successful cooperation to address international environmental issues (for an overview, Paterson 2006). But with regard to climate change, both empirical evidence and theoretical contributions have shown that achieving cooperation over global climate change is more difficult than over other international issues such as trade or more regionally bound environmental problems (Ward 1996; Grundig et al. 2001). Explanations based on a rational choice approach have made clear that this lack of cooperation is rooted in the specific characteristics of the issue as a 'common good' or 'common-pool resource' problem (Dietz et al. 2003; Hardin 1968). As Harrison and McIntosh Sundstrom (2007: 1) recently put it, climate change represents a 'tragedy of the commons' on a global scale. The earth's atmosphere gets over-exploited because polluters gain material advantage from the activities that contribute to global warming but suffer only a fraction of the environmental costs. In return, nations and their constituencies typically are unwilling to reduce their greenhouse gas emissions unilaterally, because in doing so they would pay the full price of their efforts but gain only a fraction of the benefits.

Based on the fundamental assumptions of the neorealist school in International Relations (IR), one could also expect that international politics on climate change be widely shaped by the comparative power among nation-states (Waltz 1979). In particular economic power and climate change incorporate many critical connections. Larger economies have significantly higher energy consumption and, therefore, contribute disproportionally to global warming due to considerably larger amounts of GHG emissions (as acknowledged in Article 3, paragraph 1, of the UNFCCC). Under the Kyoto Protocol, developed countries are held accountable for current levels of GHG in the atmosphere and, consequently, have to bear the main burden to reduce emissions (principle of 'common but differentiated responsibilities,' Article 10 of the Kyoto Protocol). It can be assumed that economically powerful nations also take a more central position in the international politics of climate change than economically less powerful nations (Hypothesis 1).

A nations' structural position in the international politics of climate change depends mostly on its economic power vis-à-vis other nations. (Hypothesis 1)

Neoliberalism represents a second mainstream in IR theory. It counters the realist approach by postulating that preferences of the acting nation-states rather than restrictions of the international system are central determinants of international policy outcomes (Keohane and Nye 1977). Advocates of neoliberalism do not deny the anarchic structure of the international system on principle but argue that its relevance and consequences are overestimated by neorealists. Instead, neoliberals (or 'neoinstitutionalists') turn their focus to the study of the conditions for successful cooperation on international issues. Claiming that nation-state interests may converge and allow for cooperative behavior, liberal approaches are particularly interested in institutions that facilitate such collectively profitable arrangements and compromises (Breitmeier et al. 2006; Keohane 1998; Young 2002). International institutions to address global climate change such as the UNFCCC and the Kyoto Protocol should provide a venue for repeated and reciprocal cooperation by mitigating the anarchical structure of the international political system (Hypothesis 2).

Kyoto-members show a higher level of political cooperation on global climate change than non-Kyoto-members. (Hypothesis 2)

But the history of environmental politics has also shown that both interest and issue based approaches (when applied in isolation from other potentially explaining factors) hardly explain the outcome of political processes. Other explaining factors discussed in the literature with reference to the climate change challenges include regime type (Miles et al. 2001), the number of involved actors (Snidal 1995), issue linkages (Keohane and Nye 1987, 1977), inter-linkages between domestic and international politics (Schreurs 2002; Paterson 1996; Litfin 2000; Depledge 2005; Harrison and McIntosh Sundstrom 2007), values and norms and the structure of public debates (Cass 2006; Pettenger 2007) or social networks (von Stein 2008; Ward 2006).

In the analysis that follows I will particularly focus on the potential role that network effects in international cooperation on the climate change issue could have played over the last decade. As a phenomenon, networks have always been a characteristic of international relations and politics. But a stronger analytical perspective on networks in IR is rather new (Hafner-Burton et al. 2009; Kahler 2009b; Ward 2006). Original work includes network analyses of cooperation and conflict in inter-state trade (Faber 1987; Hoff and Ward 2007) and studies on the role of direct and indirect connectedness of nations in cases of economic sanctions (Hafner-Burton and Montgomery 2008; Martin 1992). Maoz and colleagues (2006; 2007), Ward et al. (2007), Dorussen and Ward (2008) and Kahler (2009b) have recently made other significant contributions to the attempt to re-orientate the literature from a network perspective.

With regard to the politics of transboundary environmental problems such as climate change, a network perspective complements existing structural approaches to international relations that focus on actor attributes and static equilibriums (Hafner-Burton et al. 2009; Kahler 2009a). As in other structural approaches to international relations (particularly neorealism and neoliberalism), a network perspective on international politics is generally interested in the effects of structural configurations on the behavior of individual and collective actors (mainly nation-states, but also international organizations, non-governmental organizations and other types of international actors). Probably most elaborated in sociology (Burt 1992; Coleman 1974; Wellman and Berkowitz 1988; White 1992), network analysis focuses on the relationship between different actors (or agents) and claims that the behavior of these actors results in changing network configurations between the actors, which, in turn, set new preconditions for future actor behavior. Other fields in political science have successfully applied this conception to the study of political mobilization (Tarrow 2005; Della Porta et al. 1999; Tarrow 1998; Keck and Sikkink 1998). The governance literature incorporated the concept mostly as an attempt to take better into account the increasing importance of nongovernmental organizations, the private sector, and other actors from civil society in public policymaking (Coleman and Perl 1999; Koppenjan and Klijn 2004; Reinicke and Deng 2000; Sikkink 2009; Väyrynen 1999).

More specifically, I will test three different types of network effects that could explain the evolution of the international politics of climate change over the last years: reciprocity, transitivity and structural balance.

Reciprocity describes the degree to which an actor has reciprocated connections to other actors. It is a widely studied behavioral pattern in the social sciences. But scholars still disagree about whether reciprocity in an international relationship should actually produce greater cooperation over time (see theoretical discussion and empirical tests for the conflicts in the Middle East and Balkans in Goldstein and Pevehouse 1997; Goldstein et al. 2001). Network analysts, on the other hand, argue that there is almost always a tendency towards reciprocity in social relations of any kind, thus representing a basis feature of most social networks (Wasserman and Faust 1994: Chapter 13).

Transitivity is another essential feature of most social networks (Wasserman and Faust 1994: Chapter 6). Transitivity, or transitive closure, describes the tendency in networks that friends of friends become friends, or enemies of enemies become friends. In graph terminology, this tendency means that a triad with two paths tends to be closed. Accordingly, a significant trend towards transitivity can be observed in international political cooperation when many actors (egos) share cooperation partners (alter) but do not cooperate yet directly with each other. Based on the concept of transitivity, one would assume that these actors (egos) tend towards cooperation with these other actors (alters) to which they have had only an indirect connection thus far. Transitivity in dyadic relationships (i.e., the question to what degree common friends and enemies affect the behavior of international actors) has recently been analyzed by Maoz et al. (2007) and Crescenzi (2007). However, findings from empirical tests are mixed. Maoz et al. (2007) found that international interactions over 186 years exhibit significant relational imbalance that contradicts the concept of transitivity. Crescenzi's (2007) study suggests that spatial interdependence is an important part of a state's decision regarding conflict, even though not the only one.

Structural balance or *structural equivalence* is another effect closely related to transitivity (Burt 1982). This effect describes the tendency to have and create ties to other actors who make similar choices. This would mean that actors take a certain role in the network, based on their structural position, and act accordingly. Structural balance has always been an important element of international relations theory (e.g., Griffiths 2007). Several studies have shown that structural balance can provide an explanation for the behavior of nations during various international crises, but not always with a 'good' outcome: the search for balance in a system, as history has shown many times, can lead to serious conflicts between implacably opposed alliances. Also regarding cooperation on a global environmental issue such as climate change, structural balance is not necessarily a desirable structural configuration. The building of rather homophile blocs that oppose each other would run contrary to a universal climate regime, which is widely seen as the most effective long-term strategy to tackle the issue.

This leads to a third hypothesis on the conditions for international cooperation on climate change (Hypothesis 3).

The evolution of international cooperation on climate change depends (at least partly) on the structural configuration between the different international actors, particularly the degree of reciprocity, transitivity and structural balance between them. (Hypothesis 3)

Methodologically, network analysis not only delimits a field of a structural view on international politics but also enables the empirical investigation of international political networks. The research stream of Social Network Analysis (SNA, Carrington et al. 2005; Scott 2000; Wasserman and Faust 1994) provides a wide set of techniques and measurements to analyze this relational type of data. Whereas traditional statistical methods typically analyze actor attributes and treat actors as independent from each other (at least methodologically), SNA focuses on the relations between these actors (e.g., in terms of cooperation, conflict, group membership, event participation, or resource flows). By combining quantitative data analysis with more descriptive-interpretative approaches to understanding political processes, SNA could also provide something like a third way between the predominantly qualitative studies on environmental politics (Mitchell and Bernauer 1998) and quantitative cross-sectional research on international environmental policy (Mitchell 2002; Wettestad 2006).

Thus, a network approach to international politics stresses the role of the connectivity between different actors both at the level of individual actors (micro-level) and the level of the network as a whole (macro-level). This perspective is different from neorealist and neoliberal approaches in its explicit focus on inter-linkages between network characteristics and the behavior of individual or collective actors in the network. As outlined above, network theories claim that properties of relational patterns between actors cannot be reduced to the properties of individual actors but are a consequence of the properties of the whole network of actors (Scott 2000). Accordingly, the behavior of the actors in the international politics of climate change can be expected to depend on the behavior of other actors in the network with which the relevant actor(s) is (are) connected and the configuration of the overall network structure.

4 Data and Methods

4.1 Data Set

Network data on international environmental politics are still rare (for the few exceptions, see von Stein 2008; Ward 2006). On the other side, the research stream of foreign policy analysis has a long tradition in paying particular attention to political dynamics with a distinct methodological focus (Hudson 2005; Neak et al. 1995). Political event data as the empirical foundation of many such studies of international political dynamics (Schrodt 1995) can be utilized also for the study of international environmental politics. Event data encode 'who did what to whom and when' and, thus, describe dyadic interaction patterns between various types of individual and collective actors. Strengths and weaknesses of event data for empirical analysis have been widely discussed in the literature (Schrodt 1995; Schrodt and Gerner 1994; Gerner et al. 1994; Hayes 1973; Merritt 1994; Duffy 1994; Huxtable and Pevehouse 1996; Sommer and Scarritt 1999; King and Lowe 2003). Due to its dyadic structure, event data can easily be aggregated to network data and analyzed using concepts and methods from SNA (Hämmerli et al. 2006; Hoff and Ward 2004; Widmer and Troeger 2004).

Due to widely lacking of network data on international environmental politics in general and the politics of climate change in particular, I recently developed a new data set building on the concepts and methods of event data analysis (using the Kansas Event Data System, see Gerner et al. 1994; Schrodt et al. 1994). The data set includes all the political events related to global climate change that have been reported in lead sentences (the declarative sentence at the beginning of a news report) of the international news stream of the Agence France Presse (AFP) since January 2001. Validity tests reveal that the data set covers interactions between international actors on the climate issue quite accurately. Such interactions have been quite well reported recently by the international media, particularly since 2000, and therefore provide rich data source to monitor international climate politics (for a detailed depiction of the data coding and the resulting data set, see Hirschi 2008).

Since both event data and network data share in essence the same unit of analysis (the 'event' or the 'tie' between two actors, respectively), the combination of event data analysis and network analysis is almost self-evident: political events that have occurred between international actors can be defined as a relationship between those actors, whereas the aggregation of all reported events between international actors over certain period in time can be displayed as a network structure that has emerged between these actors as a result of the various political events. Network data generated from event data have two big advantages over network data coded from co-membership, for example, in international organizations (as used in von Stein 2008; Ward 2006). First, because event data are based on observed (reported) interactions between actors, they measure actual behavior and not just assume it due to a shared membership in an organization. Second, since event data is coded into source and target actors of these interactions, network data from event data includes directed graphs which can be used to analyze behavioral patterns in the form of 'who initiates what action towards whom and when.' Therefore, this type of network data includes more detailed information than affiliation data based on co-membership, which is typically undirected.

4.2 Network Delimitation

A crucial assumption of the actor-based model that will be used in the following analysis of network dynamics in international climate politics is that the network ties (the links between the network actors) are not punctual *events* but rather network *states* with a tendency to endure over some time (Snijders et al. 2009: 4). The event-based network data used for this study therefore needs to be aggregated to meaningful policy phases that describe each a particular stage in the recent development of international politics on global climate change. This aggregation will be done along the different phases of the evolution of the international climate protection regime under the UNFCCC and the Kyoto Protocol:

The first phase from December 2001 to mid-February 2005 is shaped by the political events related to the ratification of the Kyoto Protocol, starting after the seventh conference of the UNFCCC parties (COP 7) in Marrakesh and lasting until February 2005 when the agreement entered into force. The second phase comprises the implementation of the Kyoto Protocol after it entered into force in February 2005 until the COP 12 and the second meeting of Parties to the Kyoto Protocol (CMP 2), held in Nairobi in November 2006. At this session, the parties agreed that the next round of pledges to cut greenhouse gases would take place in 2008. Then follows a transition year, the third phase, with IPCC's 4th Assessment Report released in spring 2007 and the awarding of the 2007 Nobel Peace Prize jointly to the IPCC and former US Vice-President and environmentalist Al Gore. The fourth phase than starts with the COP 13 held in Bali, Indonesia, in December 2007 where the parties agreed to step up efforts to combat climate change and to adopt a number of decisions, which together made up the 'Bali Road Map' (UNFCCC 2008b) and should conclude eventually in a post-Kyoto climate regime for the post-2012 era.

The dynamic network analysis carried out to test Hypothesis 3 focuses on two distinct stages in the recent evolution of international politics of climate change. The first stage comprises the implementation of the Kyoto Protocol after it entered into force in February 2005 and ends with the publication of the IPCC's (2007a) 4th Assessment Report in spring 2007. This report brought clearly new momentum for political action on climate change, as scientists were more confident than ever before that human beings cause global warming. Instead of being merely "likely", the conclusion was now "very likely" (which means more than 90 percent chance in IPCC terms). Most importantly, the amount of carbon in the atmosphere would increase in a faster rate even than before, and temperature increases would be considerably higher than they have been so far, calling for aggressive political measures to curb fossil fuel emissions immediately (IPCC 2007b). The second stage then starts with the COP 13 meeting held in Bali in December 2007 and covers the current negotiations for a post-2012 climate change regime with the COP 14 held in Poznan, Poland, 2-13 December 2008, and more recent meetings in Bonn, Germany, held in March, April and June 2009 as well as the G8 summit in L'Aquila, Italy, at the end of July 2009. Most recent international political events are included until 15 August 2009.

4.3 Methods

For the analysis that follows, different methods and techniques will be applied to test the hypotheses formulated in Section 3 (Table 1). Hypothesis 1 will be tested with a linear regression (Wooldridge 2003: 46-7) using merchandise export data (WTO 2002-2008) for every nation throughout the years 2001-2007 (mean values in US dollars) and normalized degree centralities for the nations based on the political event data for the same period. Hypothesis 2 will be investigated by comparing the mean cooperation degree for Kyoto members and non-members after the Kyoto Protocol took effect in February 2005 until November 2006 (COP 12 CMP 2 held in Nairobi, Kenya) using a t-test (Wooldridge 2003: 119-21). The particular type of data used in the dynamic network analysis to test Hypothesis 3 is referred to as network panel data (Snijders et al. 2009). Based on the assumption that a network evolves as stochastic processes driven by choices of the network actors, networks dynamics are typically modeled as a continuous-time process. Network changes are assumed to be continuous and proceed in small one by one steps, even tough network changes are observed at discrete moments in time (Holland and Leinhardt 1977; Snijders 2005). These actor-based models predict network changes in part endogenously as a function of the current network structure ('network effects'), and in part exogenously, as a function of characteristics of the actors ('actor covariates') and of characteristics of pairs of actors ('dyadic covariates').

Table 1: Variables, Indicators, Data and Tests

Variable	Indicator	Data	Method
Relative economic power	World market share	Merchandise exports 2001-2007 in USD, WTO	Cross-sectional; correlation analysis (linear regression)
Network position (embeddedness)	Normalized degree centrality (Freeman 1979)	Climate event data 2001-2009	
Kyoto member/non-member	Kyoto Protocol ratified/not-ratified	UNFCCC, Status of ratification	Cross-sectional; group mean-comparison (t-test)
Degree of cooperation	Aggregated cooperation scores (Goldstein 1992)	Climate event data 2001-2009	
Reciprocity, transitivity, structural balance; actor-covariates	Network and actor characteristics at t_1	Climate event data 2001-2009	Longitudinal network analysis (SIENA)
Evolution of cooperation network	Network changes $t_1 \rightarrow t_2$	Climate event data 2001-2009	

Given that the relationships within the network describe rather states than incidental events, it is further assumed that changes in the network can be interpreted as the outcome of a Markov process. That is, for any point in time, the probability distribution of the future network given current and past states of the network is a function only of the current network. This means that all relevant information is assumed to be included in the current state of the network and in meaningful explanatory variables (in the form of actor attributes, or 'actor-covariates') that incorporate relevant information from the past. Given that the network in this study is analyzed at a particular point in time (x_t) but was formed over a specific phase that represents a specific stage in the recent development of the international climate protection regime, the Markov assumption seem reasonable. A cooperative tie $i \rightarrow j$ is either present or absent, depending if the two actors engaged in material cooperation with each other during the particular policy phase or not (values of 1 or 0).[2] The tie variables constitute the network, represented by its n x n adjacency matrix $x = (x_{ij})$, where n is the total

[2] An extension to valued networks would be theoretically sounder, and could make the Markov assumption even more plausible. But this is a topic of current research in the study of network dynamics and has not been fully implemented in the SIENA package yet (Snijders et al. 2009).

number of actors in the network (for further details on the model specification and model building strategy, see Snijders 2005; Snijders et al. 2007; Snijders et al. 2008; Snijders et al. 2009).

5 Changing Structural Configurations in Climate Politics

Conflict and cooperation structures in the international politics of climate change within and between the different policy phases outlined above differ significantly (Table 2, below). Within every phase, the cooperation network (composed of all cooperative events that have occurred between the various actors during the phase) is distinctively larger than the conflict network (composed of all the conflictive events between the actors during the same period). With similar densities, interaction intensities in both network types remained rather stable over time. However, network density can hardly be compared across different networks because it depends highly on the size of the network (Scott 2000: 74). Because higher densities in larger networks are generally more difficult to achieve, smaller networks usually show higher densities than bigger networks. Taking this into account, there are good reasons to believe that the international climate policy network became more cooperative over time by showing a rather constant density in an expanding network. The conflict network, on the other hand, evolved as could be expected; an increase in network size came with a decreasing density of the network, indicating that the conflict level in international politics on climate change remained overall rather stable.

Table 2: Network Characteristics in International Climate Politics 2001-2009

Phase	Period	Mode	Size	Density (Ties)	Centralization
Kyoto Ratification (38.5 Months)	12/2001- 2/2005	Cooperation Conflict	55 27	0.05 (144) 0.09 (60)	0.20 0.49
Kyoto Implementation (21.5 Month)	2/2005- 11/2006	Cooperation Conflict	50 28	0.06 (158) 0.07 (56)	0.32 0.44
Kyoto Transition (12 Months)	12/2006- 11/2007	Cooperation Conflict	83 47	0.05 (312) 0.05 (118)	0.28 0.29
Post-Kyoto Process (18 Months)	12/2007- 6/2009	Cooperation Conflict	74 46	0.06 (300) 0.05 (104)	0.29 0.29

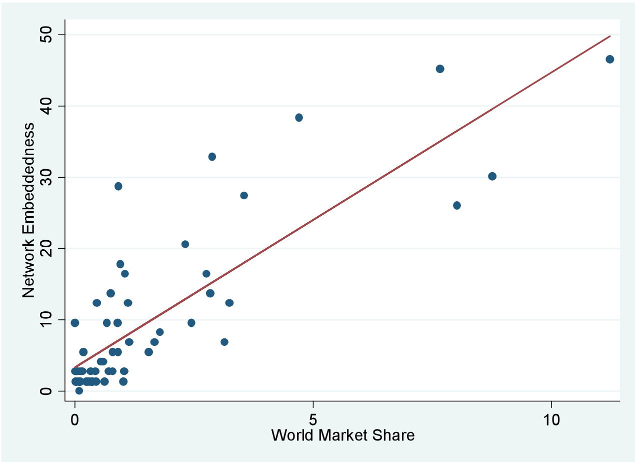
Between the different phases, two developments at the macro-level of the cooperation and conflict networks on climate change are critical. First, the size of both network types expanded significantly from the implementation phase of the Kyoto Protocol after February 2005 to the year 2007 when the issue of climate change gained new momentum. In both networks, the range of involved actors has widened. It remains an open question as to what degree these network extensions are actually due to actual developments in international politics or rooted mainly in increased public attention paid to the climate issue. A comparison of the frequency of events recorded in the data set with official chronologies on the international climate regime negotiation process suggests the first, even though this question still remains to be examined more closely.

The second main development involves a changing degree of network centralization throughout the different policy phases. The cooperation network became more centralized after the Kyoto Protocol's ratification in February 2005. Prior to this event, the structural configuration of the cooperation network was highly decentralized, with the US, the UN, Russia and Japan showing similar positions in the network center (normalized degree centralities between 24.1 and 16.7). After the ratification of the Kyoto Protocol, the structural configuration was more centered on two or three actors. The US has consistently taken a central network position, together with changing partners in the network center: Great Britain (36.7) during the implementation phase of the Kyoto Protocol; the UN (22.0) and Germany (19.5) during the transitional phase of 2007; and Japan (34.2) and the European Union (28.8) in the ongoing post-Kyoto process. On the other hand, network centralization in the case of conflictive relations decreased significantly after the implementation of the Kyoto Protocol. This development indicates clearly that the conflict structure of international climate politics became more diverse throughout the different policy phases. During the ratification and implementation process of the Kyoto Protocol, around half of the recorded conflicts in the network involved the United States. In the following phases, also Japan, the EU, China and the UN were more frequently involved in conflictive events.

How can these changes in the configuration of cooperative and conflictive network structures be explained? Following a neorealist approach to international politics, one could claim that the position of a country in the international climate policy network is mainly dependent on its relative economic power (Hypothesis 1). In fact, a linear regression reveals that a country's embededdedness in the climate network highly correlates with its economic power vis-à-vis the other nations if the country's share in international trade of goods is considered (Figure 1). The parameter estimates of the regression model are highly significant, and the model predicts the actors' network embeddedness based on their world market share fairly well (Table 5, Appendix). Based on this test, Hypothesis 1 can be confirmed. The international climate policy network is highly dominated by the big industrialized nations and economically fast growing countries such as China, India and Brazil. Most centrally embedded in the network structure are the European Union and the United States, followed by Japan, Great Britain, Germany, Australia and France. China, most embedded from the group of countries with emerging economies, shows a similar connectivity with other actors in the network. Russia, India and Brazil follow behind.

However, this analysis is not dynamic and includes only very general characteristics of the structural configuration of the climate policy network throughout the whole period from December 2001 to June 2009.

Figure 1: Scatter Plot of Network Actors with Regression Line

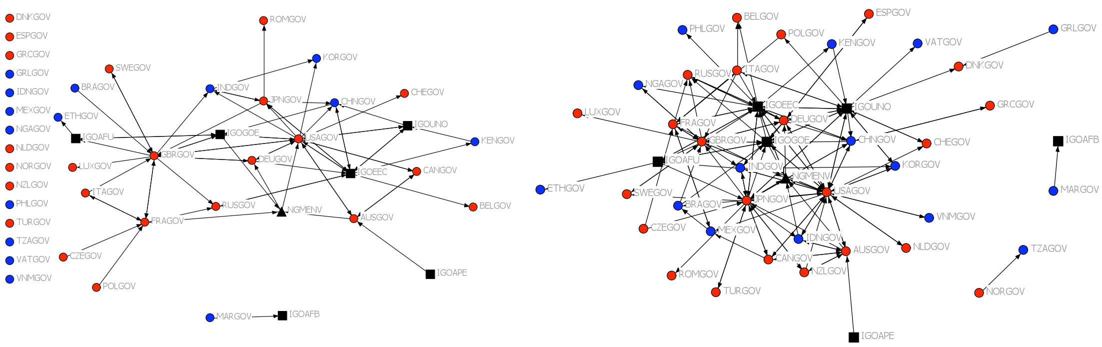


To what degree cooperative and conflictive structures changed due to institutional changes or network effects will be addressed next. Hypothesis 2, based on the neoliberal school of thought, claims that international institutions such as the Kyoto Protocol are expected to have a positive impact on the interactions among international actors, particularly their willingness to cooperate with other international actors. When cooperation levels of Kyoto members and non-members during different time periods are compared, one can actually observe differences in the countries' cooperative behavior after the Kyoto Protocol came into force in February 2005 (Table 6, Appendix). But contrary to the initial expectation, the countries that had not (yet) ratified the Kyoto Protocol at that time showed an increase in cooperation after the Protocol entered into force, while the countries that had ratified the Protocol did not show such an increase. These observed differences might be the result of an external effect of the Kyoto regime on non-regime members (Haas et al. 1993; Krasner 1982b, 1982a). However, since the observed differences between the behavior of Kyoto members and non-members are not statistically significant, Hypothesis 2 cannot be confirmed.

The lack of significant differences in the cooperative behavior of Kyoto members and non-members could also be due to a measurement problem. Event data—as used in this study to observe and systematize behavioral patterns between international actors—has difficulties to break down multilateral cooperation within an institutionalized international framework into the underlying interactions between delegates of the different participating actors (mostly national governments). News agencies—the main source of event data as used in this paper—certainly report such multilateral negotiations, but often just by giving reference to the international organization or regime in which these negotiations take place (e.g., by reporting that "the parties to the UNFCCC met to find an agreement on a post-2012 climate regime"). As a consequence, event data coding just picks up the name of the international framework but not the individual actors that actually cooperate by participating in such negotiations. But when the position of international institutions in the international climate policy network is analyzed over time, one can observe a strengthening of the role of the UN. Its connectivity with the other actors in the main component of the network (closeness-centrality) increased steadily over the years, and so did the organization's middle-position between other actors in the network (betweenness-centrality) recently.

To test the potential effect of network characteristics on cooperative patterns in international politics on climate change (Hypothesis 3), we have to take a dynamic perspective by analyzing the evolution of international cooperation on climate change over time. More precisely, the dynamic perspective will be taken by comparing the cooperative ties (material cooperation on the matter of climate change between international actors) at the two distinct stages as delimited in Section 4.2. Figure 2 below provides a graphical representation of the structure of these cooperative ties during these two stages. The first stage includes the implementation of the Kyoto Protocol covering the period from 15 February 2005 until 4 May 2007; the second stage covers the ongoing negotiations on a post-2012 climate regime starting with the Bali Climate Conference in December 2007 up to 15 August 2009. These two 'snapshots' depict the structural outcome of cooperative events that have occurred between the different actors over the two network stages.

Figure 2: Evolution of Material Cooperation, Kyoto Implementation to post-Kyoto Process



t_1: Kyoto Implementation, Feb 2005-May 2007 t_2: post-Kyoto Process, Dec 2007-Aug 2009

The data shows that the structure of the network changed rapidly between these two stages. The US government (USAGOV), even though not a Kyoto-member, had already been the most central actor during the implementation stage of the Kyoto Protocol (t_1) and later further intensified its effort to take a more cooperative approach toward the climate change issue (t_2). This was the time when the political debate on climate change in the US started to shift. At the federal level, the Bush administration still favored voluntary measures and the use of technologies instead of mandatory emission cuts. But at the state level, some governments enacted mandatory carbon controls and other programs to reduce emissions. Internationally, the US government further increased its cooperative ties with other nations. Meanwhile, with the formal launch of new international climate negotiations for the post-Kyoto era, the UN (IGOUNO) and the EU (IGOEEC) have gained importance. The German government (DEUGOV) has distinguished itself more and more as a leader in the promotion of renewable energy technology and is moving more to the network center. Holding the G8 presidency in 2007, the German government put the climate change issue on the agenda of the organization's annual summit. So did Japan (JPNGOV) in the following year, and established itself again as a central actor in the international political network on climate change.

Table 3: Number of Changes Between Observations

Period	0 → 0	0 → 1	1 → 0	1 → 1	Missing	Total
$t_1 - t_2$	1830	80	47	23	0	1980
$t_1 - t_2$* (corrected)	1830	80	0	70	0	1980

The dynamics within the network between the two stages at t_1 and t_2 are summarized in Table 3. The table indicates the number of changes in material cooperation between the different network actors: 0 → 0 stands for the total of theoretically possible cooperative ties that were absent at both observations; 0 → 1 and 1 → 0 include the number of cooperative ties that were newly created or abolished, respectively, between the two stages of the network; 1 → 1 is the number of cooperative relations that have been sustained from period t_1 to period t_2. Thus, over the period from February 2005 when the Kyoto Protocol entered into force to mid-August 2009, 80 new cooperative relationships emerged. Forty-seven formerly cooperative relationships dissolved during the same period. Twenty-three cooperative relationships lasted over the whole period from February 2005 to August 2009. However, to increase the stability of the network and, thus, the applicability of the model to estimate the dynamics in the international climate policy network (compare, Snijders et al. 2009: 12), negative network changes (1 → 0) were excluded from the analysis. That is, the analyzed network structure at t_2^* also includes the cooperative ties already built up during the first stage of the network at t_1 and additionally displays the new cooperative ties between the actors that have emerged during the second stage of the network. This adjustment corrects the volatility of the underlying event data by regarding political events that include material cooperation (in the form of an agreement, the granting of economic or financial assistance, or the engagement in diplomatic cooperation) rather as the initiation of the cooperative *phase* between the involved actors than as a *punctual* incident. This correction increases the stability of the international climate policy network significantly, displayed by an acceptable Jaccard index (Batagelj and Bren 1995) of 0.467.

In Section 3 I assumed—based on concepts from social network analysis—that different network effects (reciprocity, transitivity and structural balance) as well as actor attributes ('actor covariates') of the acting (ego) and targeted actors (alter) could play a role in these choices. In the following, I will present the results of the significance of these different potential effects for the evolution of the international climate policy network provided by the proposed actor-oriented model. The results are presented in four consecutive steps. In a first step, only the model for the rate parameter λ will be presented. It represents the expected number of relational changes one actor makes from t_1 to t_2^* based on the estimation. In a second step, I will add the different proposed structural effects to the model. In a third step, the actor covariates that could have an effect are included. In a fourth step, insignificant effects will be dropped from the model and the final model estimated.

The rate model for parameter λ indicates the speed by which an actor gets the opportunity for changing his outgoing ties. With a rate function of 1.92 in the rate model, an actor gets on average around two opportunities for changing his cooperative ties between the two observations at t_1 and t_2^*. It means that we expect around two tie changes per actor from the first to the second stage of the international climate policy network.[3] The question is now to what degree these changes are dependent on network and actor-covariate effects. A reciprocity effect can be assumed in the formation of new cooperative ties when an actor (ego) who gets a chance to change his ties is more likely to establish a tie with another actor (alter) that has already a cooperative tie to ego. Model 1 in Table 4 shows that such a reciprocity effect is significant at the 0.01 level. This means that actors in the international politics of climate change rather form new cooperative ties to actors that have already proven to be cooperative.

[3] The rate function reflects the expected changes based on the simulation and may therefore slightly differ from actual changes in the network.

Table 4: Results of Dynamic Network Modeling

Formation of Cooperative Ties (Material Cooperation) Among International Actors						
	Rate Model	Model 1	Model 2a	Model 2b	Model 3	Final Model
Rate λ	1.92***	1.78***	1.77***	1.78***	1.79***	1.79***
	(0.21)	(0.19)	(0.18)	(0.20)	(0.20)	(0.19)
Outdegree		3.51	4.51	5.31	2.15	1.88
		(11.51)	(99.00)	(32.68)	(11.07)	(4.82)
Reciprocity		3.63***	5.02**	3.75***	3.85***	3.79***
		(0.43)	(2.35)	(0.64)	(0.64)	(0.64)
Trans. Triples			1.75*			
			(0.98)			
Trans. Ties				1.52***	1.58***	1.59***
				(0.32)	(0.41)	(0.35)
Balance						
Actor Type					-0.15	
					(0.49)	
Annex I					-0.50	
					(0.46)	
Emerge					-1.17**	-1.13***
					(0.49)	(0.39)
Income					-0.30	
					(0.50)	
Polluter					0.88	
					(0.58)	

Note: Standard errors between brackets; estimations based on 1470 simulation runs.
* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

Model 2a includes additionally a transitivity effect. The concept of transitivity assumes that two actors (ego) that share a cooperative partner (alter) in the network will tend to cooperate directly in a later stage of the network because they have an intermediary alter in common. Or, from the perspective of one individual actor: when alter *j* cooperates with alter *k* and this actor ego cooperates with alter *k*, then alter *k* is a reliable source of information about the trustworthiness and reputation of alter *j* and ego is more inclined to cooperate with alter *j* than in a situation where ego does not have a cooperative relationship with alter *k*. Accordingly, the transitivity effect suggests that actors in the international climate policy network tend to choose new cooperation partners to close such transitive dryads. The results show that a transitive tipples effect is significant at the 0.1 level. This means that actors in the network are more likely to choose another actor to send a cooperative tie to when a transitive triplet can be closed, that is, a cooperative partner of an already existing cooperative partner (alter) can become a new cooperative partner of ego ("a friend of a friend becomes a friend"). The statistical significance of this effect is rather weak, though.

Model 2b therefore includes a different type of transitivity effect, the transitive tie effect. This effect is similar to the transitive triplets effect, but instead of considering how many two-paths in potential transitive triplets exist for every other actor in the network, it only considers whether there is at least one such indirect connection. In other words, when an actor (ego) has to decide whether to cooperate with another actor (alter) or not, it does not matter how many indirect connections to other actors in the network he could 'close' with such a cooperation (by establishing transitive triplets). Instead, the fact that one intermediary exists is enough to contribute to the tendency to formulate a cooperative tie. As the results of the parameter estimation show, this weaker form of the transitivity effect is highly significant in the evolution of the international climate policy network.

The third network effect that was assumed, the effect of structural balance, has not proven to be significant. Such an effect could have played a role when actors in similar positions in the network had made choices similar to other actors in the network with whom they are more likely to form cooperative ties. Moreover, the inclusion of the structural balance effect in the estimation had the effect that the algorithm did not converge, which was a critical precondition for the estimation of the model parameters. The parameter was therefore dropped from the model.

Model 3, finally, controls for the different actor attributes ('actor covariates') that were expected to have an influence on how actors in the network chose their cooperative ties. The results show that whether or not the actor (ego) who has to decide to send a cooperative tie to another actor (alter) in the network is a state with an emerging economy has a significant effect on the actor's choice (indicated with a dummy variable labeled 'Emerge'). Since the effect is negative, this means that the governments of countries with emerging economies (in particular Brazil, Russia, India and China) tend rather to establish cooperative ties with governments not from the same group of countries. The effect works both ways; governments not from this group of countries rather form new cooperative ties with emerging powers than other actors in the network. This effect is contradictory to the initial expectation that governments tend to increase cooperation with other countries from the same economic bloc due to assumed similar economic and political interests. Instead, the effect shows clearly that the intensified cooperative effort towards countries with emerging economies is projected to account for the vast part of the GHG emissions growth in the next few decades. Whether ego or alter are Annex I countries or not, whether they belong to the same group of rather high or low income countries, or whether they show a similar share of CO_2 emissions per capita, none demonstrated a significant effect on the evolution of the analyzed network structure of international politics on the climate issue.

6 Conclusion

The systematic analysis of the structural configuration in the international climate policy network from December 2001 to June 2009 unfolds some crucial changes in international politics on climate change. Most significant are the changes between the Kyoto process, including the phases of the ratification and implementation of the Kyoto Protocol, and subsequent phases. At the level of the international climate politics network as a whole, increasing cooperation between the various actors could be observed. The cooperative patterns also show a relatively high stability, which emanates from a rather high share of reciprocated actions. Conflict structures, on the other hand, remained rather constant but showed higher fluctuation within the different policy phases.

A systematic test of the various actors' involvement in the international politics of climate change confirms clearly that the international political process on climate change is widely shaped by the economically most powerful nations, mainly the US, western Europe, Japan, and—increasingly—China. However, this neorealist approach has to be put into perspective when explaining observed cooperative patterns between international actors on the climate change challenge. Whereas the role of institutions (neoliberal explanation) is difficult to assess with event data as it has been used in this analysis, network effects could be observed.

The systematic test of network effects in the development of international cooperation on climate change has found strong statistical support for reciprocity and transitivity effects in the formation of new cooperative ties between international actors on the issue of climate change. Actor attributes (so-called 'actor covariates') played a role too. The data show that cooperation becomes more likely when a relationship between two actors includes one actor from a country with an emerging economy (in particular Brazil, Russia, India and China). Other actor characteristics such as rich versus poor countries or the degree of a country's current per capita contribution to global CO_2-emissions has not proven to be statistically significant. Such effects of network closure could become even more important in the future when the need for political action on the climate issue will increase because network closure is argued to have mainly two functions for social actors (Burt 2001). First, it affects access to information. More information on the drivers and the risks of climate change as well as other actors' strategies to address these challenges could have a positive effect on the political cooperation to tackle the climate crises. Second, network closure facilitates sanctions that make it less risky for actors in the network to trust one another.

A network approach to international climate politics using event data has proven to be beneficial mainly in three ways. Firstly, a network approach to international climate politics focuses on the interconnectivity between the various international actors concerned with international climate policies. By regarding the various actors and their behavior as dependent on each other, a network approach to international politics complements other structural approaches to international relations (in particular neorealism and neoliberalism). Secondly, a network theoretical perspective on international politics is generally interested in the effects of structural configurations between political actors on the behavior of those actors (mainly nation-states, but also international organizations, non-governmental organizations and other types of international actors). But unlike, for example, the neorealist concept of structure, network analysis defines structures as emergent properties of persistent patterns of relations between actors that must be measured empirically and not just be assumed. Thirdly, network analysis not only delimits the field of a structural view of international politics on environmental problems such as climate change but also enables their empirical investigation by applying a wide set of tools and techniques from SNA.

The SIENA model using Markov chains and simulation techniques has demonstrated potential for the analysis of network data generated from political event data. It assumes a continuous-time evolution of a complete network but models network changes made at discrete time points as the outcome of a Markov chain. Although the model is rather designed for networks of enduring states and less so for event-type relations, the model allows for an application when the data is aggregated to specific network stages that describe the state of the network during a particular phase. But the application of SIENA demonstrates a strong reduction of the information originally included in the event data. Instead of the ordinal event codes assigned to rather conflictive or cooperative political events between the different actors, the network data eventually analyzed with SIENA included only dichotomized data on one particular type of relation (cooperation) as required for the application of the model. New methodological contributions have started to address this particular limitation of the actor-based model as it was applied in this paper. Butts (2008) has recently proposed a general framework for modeling relational events more specifically. Brandes et al. (2009) extended this approach by modeling the conditional quality of events, allowing for modeling the factors that influence the frequency and quality of interactions in a network.

Appendix

Table 5: Regression Results

Dependent Variable = Network Embeddedness			
	Coefficient	Standard Error	99% Confidence Interval
World Export Share	4.14***	0.36	[3.18,5.1]
Constant	3.33***	0.98	[0.71,5.94]
R^2		0.70	
N		59	

*** $p < 0.01$

Table 6: Mean Cooperation Scores Kyoto-Members/Non-Members

Phase: Kyoto Implementation	Mean Score Kyoto Members (N=48)	Mean Score Kyoto Non-Members (N=17)	Difference	Significance (T-Test)
Absolute cooperation score to all	4.1	5.1	0.98	0.740
Change in cooperation score to all	0.14	0.3	0.26	0.392
Absolute cooperation score to members	3.6	4.5	0.87	0.702
Absolute cooperation score to non-members	1.0	0.5	0.50	0.581
Change in cooperation score to members	0.08	0.13	0.05	0.530
Change in cooperation score to non-members	0.01	-0.01	-0.02	0.760

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