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MULTILATERAL NEGOTIATIONS OVER CLIMATE CHANGE POLICY

By

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ABSTRACT

Negotiations in the real world have many features which tend to be ignored in policy modeling. They are often multilateral, involving many negotiating parties with preferences over outcomes that can differ substantially. They are also often multi-dimensional, in the sense that several policies are negotiated over simultaneously. Trade negotiations are a prime example, as are negotiations over environmental policies to abate carbon dioxide. We demonstrate how one can formally model this type of negotiation process. We use a policy-oriented computable general equilibrium model to generate preference functions which are then used in a formal multilateral bargaining game. The case study is to climate change policy, but the main contribution is to demonstrate how one can integrate formal economic models of the impacts of policies with formal bargaining models of the negotiations over those policies.

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INTRODUCTION

One fundamental problem in multilateral negotiations over CO_2 abatement policies is the existence of conflicting interests because those policies are public goods. Every country is better off if abatement of CO_2 emissions take place in all countries than if no abatement is undertaken. However, given that other countries are undertaking abatement the welfare of each country is higher if it does not undertake any abatement. Moreover, unilateral abatement policies are not effective.[1] A possible solution requires a negotiation setting in which any policy proposal can only be considered if proposed by a majority of the countries involved. In other words, if coalition formation in proposals and voting is accepted there may be less of a problem of individual free riding, since the proposal represents the interests of its proposers.

We evaluate one such institution for multilateral bargaining (MB) in several stages. First, using a computable general equilibrium (CGE) model (International Impact Assessment Model – IIAM) developed by Bernstein, Montgomery, and Rutherford (1997), we generate estimates of the welfare effects for OECD countries from several CO_2 abatement policies. An abatement policy consists of a quantity reduction in CO_2 emissions and a time limit. Second, using the welfare changes calculated in the first stage, we estimate political preference functions for each country. A political preference function specifies how the welfare of each country varies as the abatement policy moves away from the ideal vector of that country. Third, using the estimated preference functions we numerically evaluate the multilateral bargaining institution under alternative specifications with respect to the set of countries undertaking abatement, the trade regime allowed, and the presence or absence of a coordinating authority in the negotiations.

[1] There is an extensive list of studies on this issue. For a review see Pinto (1998). Harrison and Kristr m̄ (1998) provide a detailed evaluation for Sweden.

WELFARE IMPACTS OF ABATEMENT POLICIES

The IIAM is a dynamic, general equilibrium, multiregional, trade model with 25 regions. The model is formulated as two separate but compatible general equilibrium models. The first is a multiregional trade model that provides an approximation of the changes in international terms of trade that could result from CO_2 restrictions imposed on a subset of countries. The second is a general purpose small open economy model that is used to study the implications of changes in international prices for particular countries. The CO_2 restrictions to be evaluated consist of relative abatement in CO_2 emissions relative to 1992 levels, and a time limit to accomplish the required reduction. We simulated nine different scenarios shown in Table 1. For simplicity, the abatement year is referred to as the "breadth" of the abatement policy and the percent of abatement is referred to as the "depth" of the abatement policy.

Table 1: Abatement policies scenarios

Breadth /Depth	10%	15%	20%
2010	Scenario 1	Scenario 2	Scenario 3
2005	Scenario 4	Scenario 5	Scenario 6
2000	Scenario 7	Scenario 8	Scenario 9

The policy instrument considered in the IIAM are carbon emission permits that entitle the permit owner to release a certain amount of CO_2 during some time period. Restricting the amount of available permits allows governments to reduce the amount of CO_2 released. The permits may either be used by the country owning them, or they may be sold to another country that is carbon restricted. Therefore, we evaluate the welfare impacts[2] of each of the nine scenarios in Table 1 under two distinct situations regarding the possibility of trade in emission permits. The No Trade situation consists of not

[2] Welfare impacts are relative to the Business-as-Usual (BaU) scenario for each country from each abatement policy simulated, as measured by the equivalent variation in income in billions of 1992 US dollars. The BaU scenario corresponds to the absence of any policy initiative.

allowing the transaction of carbon permits among countries, and the Trade situation consists of allowing world trade in emission permits.

The IIAM model includes 25 countries/regions. For the purpose of evaluating the MB institution we are only interested in OECD countries.[3] Specifically, we consider two different sets of abating countries. Either all OECD member countries are carbon constrained, or only the USA and the EU are carbon constrained.

ESTIMATION OF PREFERENCES

We assume that countries have Euclidean preferences over the policy space. In other words, we assume that as the policy vector that is implemented moves away from an ideal point in the policy space, the utility of each country/region i, U(i), declines at a constant rate. The following equation shows the specific functional form assumed for each country/region preference function:

$$U(i) \;=\; \alpha(i) - \beta(i) * \sqrt{\sum_{j=1}^{2} \left(X(j) - A(i,j) \right)^{2}}$$

with i=1, 2, ..., 7, and j= breadth, depth.

U(i) is the utility for country i, measured as the percentage change in the country's equivalent variation at 1992 dollars, X(j)[4] is the breadth and depth of any policy vector. Preference functions are characterized by three parameters. The breadth and depth of the most preferred policy vector, A(i,j); the utility level attained by each country/region at the most preferred policy vector, α(i); and the rate of decline of utility as the policy vector moves away from the ideal point, β(i). Estimation of the parameters for each country/region was formulated with GAMS software and solvers described in

[3] In fact, based on past CO_2 negotiations, it is fairly plausible to assume that only OECD member countries will undertake or finance abatement policies.

[4] Specifically, X(1)= 2000, 2005, or 2010, and X(2)=10, 15, or 20%.

Brooke et al. (1992).[5] OECD member countries are grouped in seven sets: Australia (AUS), New Zealand (NZL), Japan (JPN), Canada (CAN), USA, European Union (EU – includes 12 countries), and EU3 (including Austria, Finland, and Sweden).

One problem with implementing multilateral negotiations over abatement policies consists of establishing a credible default outcome in the event that negotiations fail. Moreover, countries in the negotiations need to expect some benefit from CO_2 abatement policies, otherwise no agreement would be preferred to any agreement. We assume that if negotiations fail, countries suffer no welfare loss or gain, so that the welfare change is zero. Behind this is the assumption that global warming would induce no welfare change, and, as a corollary, the assumption that no welfare gain occurs because of reduced carbon emissions. However, developed countries have agreed to abate carbon emissions. By doing so, they implicitly attribute some benefit to abatement of carbon emissions. In order for the countries at the negotiation table to have any incentive to reach an agreement, the perceived welfare from a possible agreement must exceed the welfare they enjoy if negotiations fail. We therefore assume that benefits of abatement are 1% of welfare in every country. This ensures that each country in our MB negotiation perceives some net benefit from participating; they may still experience very different welfare costs from the alternative proposals. Hence one unit is added to the intercept of each country's utility function, as shown in Tables 2 and 3.

We estimate four sets of preferences by varying the set of countries with CO_2 emission constraints and the trade regime in emission permits. The first two sets of preference function estimates correspond to the case of abatement by all OECD members assuming No trade and Trade in emission permits, respectively (Table 2). The

[5] Assuming Euclidean preferences, we estimate $\alpha(i)$, $\beta(i)$ and $A(i,j)$ for each i using the welfare of i for all nine scenarios in Table 1. The criteria used in the estimation was to minimize the sum of squared residuals. Given the nonlinear nature of the utility function the estimation entailed simple non-linear optimization algorithms. Details are provided in Pinto (1998).

other two sets refer to the case of abatement by the EU (all 15 countries) and the USA, assuming Trade and No Trade, respectively (Table 3).

Table 2: Ideal points and utility parameters under OECD abatement

Ideal points and utility parameters for OECD members under OECD abatement (No Trade)				
	Policy		Utility parameters	
Country	Breadth	Depth	Coefficient	Intercept (1)
AUS	2006.53	10	0.0287	1.0272
NZL	2006.88	10	0.0469	0.704
JPN	2007.17	10	0.0224	0.826
CAN	2006.95	10	0.0407	0.7852
USA	2006.70	10	0.0415	0.7872
E_U	2006.95	10	0.0301	0.7903
EU3	2007.10	10	0.0210	0.8065
Ideal points and utility parameters for OECD members under OECD abatement (Trade)				
	Policy		Utility parameters	
Country	Breadth	Depth	Coefficient	Intercept (1)
AUS	2006.45	10	0.0255	1
NZL	2006.88	10	0.0469	0.794
JPN	2007.17	10	0.0224	0.826
CAN	2006.95	10	0.0407	0.7852
USA	2006.70	10	0.0415	0.7872
E_U	2006.95	10	0.0301	0.7903
EU3	2007.09	10	0.0210	0.8065

(1) A value of 1 was added to the intercept estimates

Table 2 presents OECD members' ideal points regarding the depth and breadth of the abatement policy under No Trade in emission permits and under Trade. All OECD countries prefer to abate only 10% of carbon emissions, independently of the assumed trade regime. Moreover, the trade regime does not have any influence on the ideal time limit of abatement for each of the seven countries/regions in the OECD. However, there is some variation among countries. The EU3 and JPN prefer later abatement than the other countries (2007.10, and 2007.17, respectively). On the other hand, AUS prefers abatement earlier than any of the other countries (2006.45, approximately). The E_U and CAN prefer to defer abatement slightly until 2006.95. NZL and the USA prefer earlier abatement than the E_U and CAN (see Figure 1).

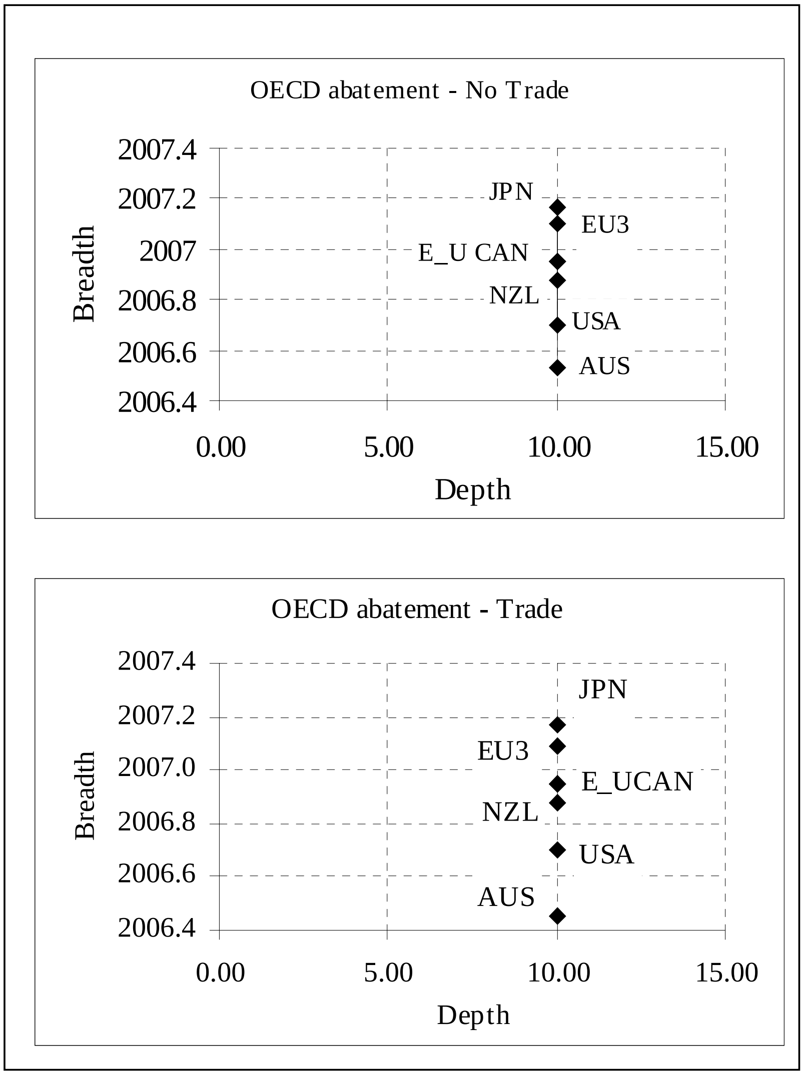

Figure 1: Estimated ideal policy vector under OECD abatement

The estimated parameters of the utility function for each country are invariant to changes in the trade regime, apart from AUS. However, there is some variation across country/region. AUS is the country with highest utility at its optimal policy vector. NZL is the country with lowest utility at the optimal policy vector. Examining the rate of decline of utility as the policy vector moves away from the ideal point of each country, we conclude that NZL is the country most affected by abatement policies, followed by CAN and the USA. AUS is the country with lowest welfare cost of abatement.

Table 3: Ideal points and utility parameters under USA/EU abatement

Ideal points and utility parameters for OECD members under USA/EU abatement (No Trade)				
	Policy		Utility parameters	
Country	Breadth	Depth	Coefficient	Intercept (1)
AUS	2004.0686	18.8725	0.01	1
NZL	2009.9385	12.1176	0.01	1
JPN	2009.3134	14.0207	0.01	1
CAN	2004.4024	13.4656	0.01	1
USA	2006.7188	10.000	0.0416	0.7731
E_U	2006.9716	10.000	0.0304	0.7756
EU3	2007.1225	10.000	0.0212	0.7936
Ideal points and utility parameters for OECD members under USA/EU abatement (Trade)				
	Policy		Utility parameters	
Country	Breadth	Depth	Coefficient	Intercept (1)
AUS	2008.9418	16.0337	0.01	1
NZL	2007.9983	11.3302	0.01	1
JPN	2009.2992	16.6830	0.01	1
CAN	2007.5143	11.4894	0.01	1
USA	2007.1780	10.000	0.0184	0.8433
E_U	2007.3205	10.000	0.0131	0.8533
EU3	2007.3561	10.000	0.0086	0.8994

(1) A value of 1 was added to the intercept estimates

Table 3 presents the estimated ideal points of OECD members in terms of the depth and breadth of the abatement policy when only the USA and the EU are abating or financing CO_2 emissions abatement. As shown in Table 3 and Figure 2, if trade in emission permits is not allowed the USA and the EU prefer to abate less and later than the other countries. Pinto (1998; chapter 5) explains this result as follows, based on a detailed review of the underlying simulations results. As some OECD countries abate, they lose competitiveness relative to other countries, mainly other OECD countries. Thus, the tighter the cut in emissions by the USA and the EU, the higher the welfare of other OECD members and the lower the welfare of the abating countries.

Compared to the estimates obtained if trade in emission permits is allowed, the ideal points of abating countries consist of later cuts under Trade in emission permits than under No Trade in emission permits. However, the ideal depth of abatement is the same.

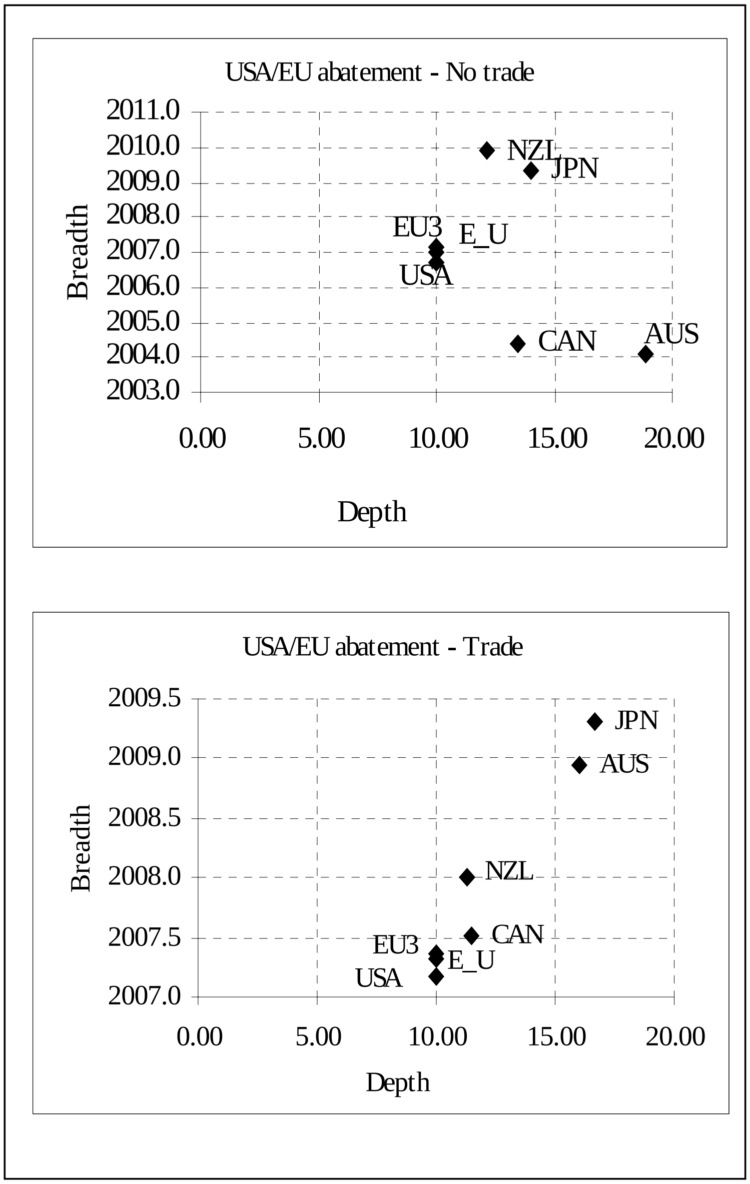

Figure 2: Estimated ideal policy vector under USA/EU abatement

Preferences for non-abating countries at the negotiations do not follow a unique pattern. AUS and CAN prefer later and higher emission abatement, while NZL and JPN prefer earlier abatement under Trade than under No Trade. These differences are primarily attributable to differences in the countries relative abatement costs, and the extent to which these countries benefit from trade in emission permits. As trade in emission permits is allowed, unconstrained countries with lower abatement costs than those of constrained countries tend to realize welfare gains by selling abatement to constrained countries. Both CAN and AUS are expected to have relatively higher welfare gains as the regime moves from No Trade in emission permits to Trade than NZL or JPN. Moreover, the rate at which utility in abating countries declines as the policy vector moves away from the ideal point is higher under No Trade in emission permits. Thus, abating countries stand to lose more under No Trade in emission permits than under Trade in emission permits. On the other hand, abating countries' utility level at their ideal points is lower under No Trade than under Trade.

Having completed the process of preference functions estimation, we can now proceed to analyze the MB institution.

THE MULTILATERAL BARGAINING MODEL

The MB game developed by Rausser and Simon (1991) can be viewed as an extension of Rubinstein's (1982) alternating offer bargaining game. In Rubinstein's model, two players bargain over the division of a pie of size one. In the first round, one of the players, the proposer, offers a division of the pie to the other player. In the second round, this other player either accepts or rejects the proposed division. If he accepts then the game ends with the proposed division being implemented. If he rejects it is his turn to propose an alternative division. In Rubinstein's game the bargaining can go on for an infinite number of periods.

Rausser and Simon's (1991) formulation differs in two critical respects from Rubinstein's formulation: they incorporate multiple players and multidimensional issue spaces. The MB game consists of T rounds. Each round is divided into three subperiods. In the first subperiod nature chooses a player to be a proposer according to a prespecified vector of strictly positive "access probabilities".[6] In the second subperiod the proposer announces a coalition,[7] of which he must be a member, and a policy vector that is feasible[8] for that coalition. In the third subperiod the remaining members of the proposed coalition each choose whether to accept or reject the proposed policy vector. If all accept, the game ends. If at least one member rejects, the next period begins and a new proposer is selected. If the last round of the game is reached without any agreement on a policy vector, a pre-specified disagreement outcome is implemented. Therefore, the purpose of the negotiation is to select a policy vector from a set of possible vectors and a voting coalition from a set of admissible coalitions.

An admissible coalition is a subset of the players that has the authority to impose a policy choice on the whole group. In a majority rule bargaining game, an admissible coalition must contain a majority of the players.[9] In this particular application we assume that an admissible coalition must contain one specific player referred to as the central player.

The central player is distinguished from the other players by three characteristics. First, the central player must be in every coalition. Second, the utility function of the central player must be a function of the utility of the other players with the utility of each player receiving a strictly positive weight. [10] Third, the central player

[6] By access probabilities we mean the probability of a particular player being called to propose a policy vector and a voting coalition.

[7] A coalition is a set of players.

[8] A feasible policy vector is one that involves an abatement policy that all members of the proposed voting coalition would vote for in comparison to the disagreement outcome.

[9] A coalition is admissible if it contains a majority of the players, assuming all players have the same voting power. Alternatively, if players have different voting power such as in the EU, a coalition is admissible if it consists of a subset of players that have a majority of the voting power.

[10] Specifically, we assume a linear utility function for the government. The arguments of this utility function are the utility of each country involved in the game. That is, the utility of each country is a perfect substitute for the utility of other countries.

must have some positive access probability. The existence of a central player guarantees a solution.[11]

The equilibrium concept usually employed in this kind of game is subgame perfection. A subgame perfect equilibrium for a game is a strategy profile with the property that at every sub-period of the game each player's choice is optimal given the strategies specified by the other players. This concept is not sufficiently discriminating since the MB game has many subgame perfect equilibria, some of which have undesirable characteristics. For any game in which at least two players are required for agreement, any policy that is weakly preferred by all players relative to the disagreement outcome can be implemented with certainty as a subgame perfect equilibrium. Several refinements eliminate these equilibria, and Rausser and Simon (1991) specifically employ the properness equilibrium originally developed by Myerson (1987).

APPLYING THE MB MODEL

In our application the players are the seven regions/countries constituting the OECD. These countries are modeled as negotiating over the depth and the breadth of the abatement policy. Therefore, countries in the negotiation choose a policy vector and a coalition of countries willing to vote for the proposal. The policy vector consists of a specific emission cut and a specific year to attain it. The proposed coalition must be an admissible coalition as previously defined. The central player is, in our application, designated by the Intergovernmental Panel of Climate Change (IPCC), which is the organization currently supervising the negotiations. It seems reasonable to assume that

[11] The solution is in general deterministic, and is in the core of the corresponding cooperative game. In the context of the MB institution, a vector x is in the core if it is feasible for some coalition and if, for every coalition C, there is no feasible vector that is weakly preferred to x by each member of C and strictly preferred by one member. Rausser and Simon (1991) present the formal model along with proofs of those results. They also discuss some generalizations of the model not used in this application (e.g.,

the IPCC exerts some influence over climate change negotiations. We analyze the role that the IPCC must exert in the negotiations so that the negotiating parties reach an agreement. This evaluation is undertaken by varying the IPCC's access probability and voting power.

Table 4: Overview of Simulations

Simulations	No trade	OECD abatement	IPCC out
			IPCC in
		USA/EU abatement	IPCC out
			IPCC in and IPCC in with unanimity
	Trade	OECD abatement	IPCC out
			IPCC in
		USA/EU abatement	IPCC out
			IPCC in

Table 4 summarizes the negotiation simulations performed. Two trade regimes, No Trade and Trade, are considered. In each case we consider abatement by either the whole OECD or just the USA and the EU. In other words, there are two possible abating coalitions, one formed by all negotiating parties and one constituted by the USA and the EU. Additionally, we consider two cases regarding the presence or absence of the IPCC in the negotiations.

MB GAME WITH NO TRADE IN EMISSION PERMITS

Assuming trade in emission permits is not allowed, in this section we analyze the outcome of MB under five different settings. In terms of the abating coalition, we analyze the case where all OECD member parties are willing to undertake abatement and the case where only the USA and the EU are committed to abating carbon

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allowing for time discounting during negotiations and risk aversion).

emissions. For each abating coalition we additionally consider the influence of the IPCC on the speed and outcome of the negotiations. We also consider the effect of a unanimity rule when the abating coalition is formed by the USA and the EU. Table 5 shows the outcomes of these simulations using the preferences reported in the first set of Tables 2 and 3.

The first column in Table 5 indicates the number of negotiation rounds necessary to reach an agreement. The second column lists the coalition proposed by each player. Potential members in any coalition are AUS, NZL, JPN, CAN, USA, E_U, EU3, and the IPCC. The defined sequences follow this order where a "1" indicates that the country is in the coalition and a "0" indicates that the country is out of the coalition. For example, the sequence 0 0 1 1 0 1 1 1 indicates that AUS, NZL, and USA are out of the coalition, and that JPN, E_U, EU3, and IPCC are in the coalition.[12] The third column indicates the country proposing the coalition and the abatement policy. The third and fourth columns indicate the proposed policy breadth and depth. The remaining columns list each country's payoff from the proposed abatement policies. The expected payoff for each country is a weighted average of the payoffs earned by the country in each abatement policy, where the weights are the access probabilities of the countries making the proposal.[13]

[12] The voting coalition reported in Tables 5 and 6 for each player may be equivalent to other voting coalitions that generate the same payoff to the proposing player. However, only one of the equivalent voting coalitions is reported. For more detailed information see Pinto (1998, p.253).

[13] The proposed policies and the resulting payoffs reported in Table 5 refer to the last round of negotiations.

Table 5: MB Simulations under No Trade in emission permits

Number Rounds	Coalition members	Proposing country	Breadth	Depth	AUS payoff	NZL payoff	JPN payoff	CAN payoff	USA payoff	E_U payoff	EU3 payoff	IPCC payoff
					OECD abatement/No IPCC							
5	11011101	AUS	2006.918	10.00	1.016	0.792	0.820	0.784	0.778	0.789	0.803	------
	01011101	NZL	2006.918	10.00	1.016	0.792	0.820	0.784	0.778	0.789	0.803	------
	00110111	JPN	2006.954	10.00	1.015	0.790	0.821	0.785	0.777	0.790	0.804	------
	11111101	CAN	2006.946	10.00	1.015	0.791	0.821	0.785	0.777	0.790	0.804	------
	00011111	USA	2006.918	10.00	1.016	0.792	0.820	0.784	0.778	0.789	0.803	------
	11111101	E _U	2006.952	10.00	1.015	0.791	0.821	0.785	0.777	0.790	0.804	------
	00110111	EU3	2006.954	10.00	1.015	0.790	0.821	0.785	0.777	0.790	0.804	------
	Expected payoff				1.016	0.791	0.821	0.785	0.777	0.790	0.803	------
					OECD abatement/IPCC in							
5	11010001	AUS	2006.918	10.00	1.016	0.792	0.820	0.784	0.778	0.789	0.803	5.783
	01011101	NZL	2006.918	10.00	1.016	0.792	0.820	0.784	0.778	0.789	0.803	5.783
	00110111	JPN	2006.951	10.00	1.015	0.791	0.821	0.785	0.777	0.790	0.804	5.783
	11111101	CAN	2006.946	10.00	1.015	0.791	0.821	0.785	0.777	0.790	0.804	5.783
	00011111	USA	2006.918	10.00	1.016	0.792	0.820	0.784	0.778	0.789	0.803	5.783
	00110111	E _U	2006.951	10.00	1.015	0.791	0.821	0.785	0.777	0.790	0.804	5.783
	00110111	EU3	2006.951	10.00	1.015	0.791	0.821	0.785	0.777	0.790	0.804	5.783
	11111101	IPCC	2006.918	10.00	1.016	0.792	0.820	9.784	0.778	0.789	0.803	5.783
	Expected payoff				1.016	0.791	0.821	0.785	0.778	0.790	0.803	5.783
					USA and EU abatement/IPCC out							
16	10111001	AUS	2006.863	10.22	0.909	0.964	0.955	0.959	0.762	0.768	0.786	------
	01100111	NZL	2007.062	10.41	0.908	0.965	0.955	0.957	0.758	0.770	0.790	------
	11110111	JPN	2007.005	10.20	0.908	0.965	0.955	0.958	0.759	0.770	0.789	------
	10111001	CAN	2006.863	10.22	0.909	0.964	0.955	0.959	0.762	0.768	0.786	------
	10011101	USA	2006.803	10.11	0.908	0.963	0.953	0.959	0.768	0.770	0.786	------
	01001111	E _U	2007.016	10.07	0.907	0.964	0.954	0.957	0.760	0.773	0.791	------
	01100111	EU3	2007.091	10.08	0.907	0.965	0.955	0.957	0.757	0.771	0.792	------
	Expected payoff				0.908	0.964	0.955	0.958	0.761	0.770	0.789	------
					USA and EU abatement/IPCC in							
13	10111001	AUS	2006.881	10.17	0.909	0.964	0.954	0.959	0.763	0.770	0.787	6.106
	01100111	NZL	2007.035	10.11	0.908	0.965	0.955	0.957	0.759	0.772	0.791	6.106
	11110011	JPN	2006.989	10.12	0.908	0.965	0.955	0.958	0.760	0.771	0.789	6.106
	10111001	CAN	2006.881	10.17	0.909	0.964	0.954	0.959	0.763	0.770	0.787	6.106
	10011101	USA	2006.844	10.09	0.908	0.963	0.954	0.958	0.767	0.771	0.787	6.108
	01001111	E _U	2006.991	10.08	0.907	0.964	0.954	0.957	0.761	0.773	0.790	6.108
	01100111	EU	2007.055	10.07	0.907	0.965	0.954	0.957	0.759	0.772	0.792	6.106
	10011101	IPCC	2006.890	10.10	0.908	0.963	0.954	0.958	0.765	0.772	0.788	6.108
	Expected payoff				0.908	0.964	0.954	0.958	0.762	0.771	0.789	6.107
					USA and EU abatement/IPCC in with unanimity							
4	11111111	AUS	2006.718	12.29	0.929	0.968	0.969	0.974	0.678	0.706	0.744	5.967
	11111111	NZL	2006.720	12.29	0.929	0.968	0.969	0.974	0.678	0.706	0.744	5.967
	11111111	JPN	2006.720	12.29	0.929	0.968	0.969	0.974	0.678	0.706	0.744	5.967
	11111111	CAN	2006.718	12.29	0.929	0.968	0.969	0.974	0.678	0.706	0.744	5.967
	11111111	USA	2006.719	12.29	0.929	0.968	0.969	0.974	0.678	0.706	0.744	5.967
	11111111	E _U	2006.719	12.29	0.929	0.968	0.969	0.974	0.678	0.706	0.744	5.967
	11111111	EU	2006.719	12.29	0.929	0.968	0.969	0.974	0.678	0.706	0.744	5.967
	11111111	IPCC	2006.719	12.29	0.929	0.968	0.969	0.974	0.678	0.706	0.744	5.967
	Expected payoff				0.929	0.968	0.969	0.974	0.678	0.706	0.744	5.967

The first set of numbers in Table 5 show the results of the MB game assuming that the IPCC takes no role at the negotiations. Specifically, the IPCC has no access to make proposals (its access probability is zero), and it has no voting power. In practical terms, this corresponds to a situation where the IPCC is absent from negotiations.[14] The game reaches equilibrium after 5 rounds of negotiations, characterized by all players proposing an emission cut of 10% by about the year 2006.9. The simulation reported in the second set of results in Table 5 differ from the previous one in terms of the role attributed to the IPCC. Specifically, the IPCC is given the same access probability and voting power as the other parties in the negotiations. Comparison of the two sets of results shows that the presence of the IPCC in this setting has no influence on the policy vector agreed or on the speed of the negotiations. The voting coalition proposed by each country/region is also invariant with the presence/absence of the IPCC.[15]

These results refer to situations in which the negotiating countries/regions have compatible interests, in the sense that their preferences are for abatement policies involving as little abatement as possible, and as late as possible, despite some regional variation. A more interesting case consists in analyzing situations of conflicting interest. An example of such a situation would be imposing carbon restrictions on only some of the negotiating countries/regions (the last three sets of results in Table 5 refer to such situations).

Assuming that only the USA and the EU are undertaking abatement activities, Table 5 shows that inclusion of the IPCC in the negotiations increases the speed of negotiations, but that the number of rounds required to reach an agreement is significantly higher than in the case where all parties were carbon constrained.

[14] Although the IPCC is present in the game, the assumption that it has no access to make proposals and has no voting power renders the IPCC's proposal unimportant.
[15] The reported voting coalition proposed by the E_U and the EU3 varies with the presence/absence of the IPCC, however, these countries are indifferent between the two coalitions reported.

Considering the policy vector proposed by each country/region in the last round, the negotiated breadth is very similar in both situations, but the depth is in general smaller when the IPCC is present in the negotiations. In fact, differences in the depth of the agreed abatement policy are between 0.3 and 0.01 percentage points, which are significant in terms of the implied quantity of carbon emissions. Voting coalitions proposed are similar under the presence and absence of the IPCC, although there is some variation across countries/regions. The E_U proposes a voting coalition with the USA, the EU3, and NZL, while the EU3 and the USA propose a voting coalition excluding each other and including NZL and JPN, while the USA includes AUS and CAN. Expected payoffs are equal or higher for abating countries when the IPCC is present. For non-abating countries, expected payoffs are equal or lower under the presence of the IPCC.

To test the robustness of the MB institution to different decision rules we simulate negotiations under a unanimity rule. The last set of results in Table 5 show that requiring unanimity leads to higher emission abatement than in any of the situations analyzed. Moreover, the agreement is reached after only four rounds of negotiations. Since all players must agree with the policy vector proposed, the range of policy proposals is, in a sense, reduced. Non-abating countries must satisfy abating countries' preferences and abating countries must satisfy non-abating countries' preferences.

MB GAME WITH TRADE IN EMISSION PERMITS

Trade in emission permits allows countries more flexibility to achieve their emission targets. Each country can issue the amount of carbon emission permits according to a given target and then firms or governments can trade these permits in a world market. As stressed in Pinto (1998), if countries are to choose between a regime of non-tradable emission permits and a regime of tradable emission permits across regions, all countries prefer the latter. In this section we evaluate the MB game assuming that countries can trade emission permits in a world market. The preference function estimates used in the simulations performed in this section are the second blocks of Tables 2 and 3.

As can be seen from the negotiation outcomes reported in Table 6, we analyze four different specifications of the MB institution that vary the members of the abating coalition and the presence of the IPCC. The first set of results in Table 6 refer to the situation characterized by the absence of the IPCC and with the presence of all members of the OECD in the abating coalition. The second set refers to a situation with the same abating coalition but with the presence of the IPCC at the negotiations.

By comparing the two situations we conclude that the presence of the IPCC only affects the number of rounds needed to reach an agreement. Specifically, if the IPCC is present at the negotiations only two rounds are necessary to reach an agreement. Although the voting coalition proposed by the E_U and the EU3 reported in Table 6 is different, in fact both countries are indifferent between the voting coalition they propose when the IPCC is present and when it is absent. If the abating coalition is composed of the USA and the EU the presence of the IPCC is significant on the speed of agreement (these results are in the third and fourth set of results in Table 6). Comparing the two sets of results we conclude that the presence of the IPCC significantly decreases the number of negotiation rounds needed to reach an agreement.

If the abating coalition is formed by the USA and the EU, the agreed policy depends on the proposer selected by Nature. If the proposer is in the abating coalition the solution consists of approximately 11% emission abatement by the year 2007.8. On the other hand, if the proposer does not belong to the abating coalition the agreement consists of an 11.4% emission abatement by the year 2007.6/2007.8. Moreover, countries propose only two different voting coalitions. Specifically, they either propose

Table 6 : MB Simulations under Trade in emission permits

Number	Coalition	Proposing	Breadth	Depth	AUS	NZL	JPN	CAN	USA	E_U	EU3	IPCC
OECD abatement/IPCC out												
5	11110001	AUS	2006.914	10.00	0.988	0.792	0.820	0.784	0.778	0.789	0.803	------
	01011101	NZL	2006.914	10.00	0.988	0.792	0.820	0.784	0.778	0.789	0.803	------
	00110111	JPN	2006.956	10.00	0.987	0.790	0.821	0.785	0.777	0.790	0.804	------
	11111101	CAN	2006.946	10.00	0.987	0.791	0.821	0.785	0.777	0.790	0.804	------
	00011111	USA	2006.914	10.00	0.988	0.792	0.820	0.784	0.778	0.789	0.803	------
	10001111	E _U	2006.952	10.00	0.987	0.791	0.821	0.785	0.777	0.790	0.804	------
	00110111	EU3	2006.956	10.00	0.987	0.790	0.821	0.785	0.777	0.790	0.804	------
	Expected payoff				0.988	0.791	0.821	0.784	0.777	0.790	0.803	------
OECD abatement/IPCC in												
2	11110001	AUS	2006.927	10.00	0.988	0.792	0.820	0.784	0.778	0.790	0.803	5.755
	01011101	NZL	2006.927	10.00	0.988	0.792	0.820	0.784	0.778	0.790	0.803	5.755
	00110111	JPN	2006.952	10.00	0.987	0.791	0.821	0.785	0.777	0.790	0.804	5.755
	11111101	CAN	2006.946	10.00	0.987	0.791	0.821	0.785	0.777	0.790	0.804	5.755
	00011111	USA	2006.927	10.00	0.988	0.792	0.820	0.784	0.778	0.790	0.803	5.755
	11111101	E _U	2006.952	10.00	0.987	0.791	0.821	0.785	0.777	0.790	0.804	5.755
	00011111	EU	2006.952	10.00	0.987	0.791	0.821	0.785	0.777	0.790	0.804	5.755
	00011111	IPCC	2006.946	10.00	0.987	0.791	0.821	0.785	0.777	0.790	0.804	5.755
	Expected payoff				0.988	0.791	0.821	0.785	0.777	0.790	0.803	5.755
USA and EU abatement/IPCC out												
6	11110001	AUS	2007.672	11.37	0.952	0.997	0.944	0.998	0.816	0.835	0.887	------
	11110001	NZL	2007.834	11.28	0.951	0.998	0.944	0.996	0.817	0.835	0.888	------
	11110001	JPN	2007.683	11.37	0.952	0.987	0.944	0.998	0.816	0.835	0.887	------
	11110001	CAN	2007.582	11.38	0.952	0.996	0.944	0.999	0.817	0.835	0.887	------
	01001111	USA	2007.778	10.97	0.948	0.996	0.941	0.994	0.822	0.839	0.890	------
	01001111	E _U	2007.808	10.96	0.948	0.996	0.941	0.994	0.822	0.839	0.890	------
	01001111	EU3	2007.816	10.95	0.948	0.996	0.941	0.994	0.822	0.839	0.890	------
	Expected payoff				0.950	0.996	0.943	0.996	0.819	0.837	0.889	------
USA and EU abatement/IPCC in												
2	11110001	AUS	2007.672	11.37	0.952	0.997	0.944	0.998	0.817	0.835	0.887	6.429
	11110001	NZL	2007.851	11.25	0.951	0.998	0.944	0.996	0.817	0.836	0.888	6.429
	11110001	JPN	2007.683	11.37	0.952	0.997	0.944	0.998	0.816	0.835	0.887	6.429
	11110001	CAN	2007.556	11.37	0.951	0.996	0.944	0.999	0.817	0.835	0.887	6.429
	00011111	USA	2007.402	10.99	0.947	0.993	0.940	0.995	0.825	0.840	0.891	6.431
	01001111	E _U	2007.753	10.85	0.947	0.995	0.940	0.993	0.824	0.841	0.891	6.431
	01001111	EU3	2007.763	10.84	0.947	0.995	0.940	0.993	0.824	0.841	0.891	6.431
	01001111	IPCC	2007.601	10.96	0.948	0.995	0.940	0.995	0.824	0.840	0.891	6.432
	Expected payoff				0.949	0.996	0.942	0.996	0.821	0.838	0.889	6.430

a voting coalition excluding the USA, the E_U, and the EU3, or a coalition excluding AUS, JPN, and CAN. Obviously, non-abating countries propose a coalition excluding all abating countries. On the other hand, abating countries propose a coalition excluding all but one non-abating country. In each case these proposals are sufficient to constitute an admissible coalition. The choice of NZL in the coalition proposed by abating countries is explained by the fact that this is the country with preference for smaller emissions abatement amongst non-abating countries.

What do we conclude by comparing the results under No Trade in emission permits with the results of the MB institution with Trade in emission permits? The MB solution obtained under No Trade in emission permits takes more time to reach than under Trade in emission permits, mainly because under Trade in emission permits non-abating countries stand to gain more from an agreement than under No Trade. Consequently, agreement on a proposal is more difficult. On the other hand, countries agree on a lower abatement target and later emission abatement.

If the abating coalition is composed of all OECD member countries the prediction of the MB model is very similar with respect to the abatement policy agreed and the voting coalition. If the abating coalition is defined as the USA and the EU the agreed policy proposal depends on the country proposing the policy and the voting coalition. Specifically, the abatement policy agreed to is more stringent under USA/EU abatement than under abatement by all OECD countries.

The proposed target year for abatement depends on the members of the abating coalition. If all OECD countries are in the abating coalition they agree on 2006.9 or 2007 as the target year. However, if only the USA and the EU are in the abating coalition then the target year depends on the country making the proposal. With respect to the choice of the voting coalition, players' choices are independent of the role attributed to the IPCC under abatement by the USA, the E_U, and the EU3.

CONCLUDING REMARKS

We propose and demonstrate the use of computable general equilibrium models and game theory to model multilateral economic policies.

The process of modeling and evaluating the effects of multilateral policies with economic implications was illustrated in the context of climate change. Specifically, using a CGE model we assessed the welfare effects of alternative carbon abatement policies in order to estimate political preference functions of OECD member countries. We found that if all OECD members are carbon constrained, the trade regime is unimportant and countries have very similar preferences regarding the abatement policy. On the other hand, if only some countries are carbon constrained, preferences regarding abatement policies vary across countries/regions.

Using these estimated preferences, we simulated several negotiating scenarios. The negotiations are over the amount of abatement and the time limit to attain the required reduction in CO_2 emissions and over a voting coalition willing to approve the proposed policy. If all negotiating countries are carbon constrained, the number of rounds necessary to reach an equilibrium is small, and the IPCC has no significant effect on the speed of the agreement or on the policy agreed. However, if only some countries are carbon constrained, then the interests of the negotiating parties are not compatible. In other words, carbon constrained countries prefer lower and later abatements while non-abating countries prefer higher and sooner abatements. Under this specification, negotiations take longer to converge to an equilibrium. In the case of USA/EU abatement with trade in emission permits, the equilibrium policy and voting coalition is not unique. The solution of the MB institution in such situation depends on the country making the proposal being in the abating coalition or not. Under these circumstances, inclusion of the IPCC leads to faster agreements.

One limitation of these analyses results from the assumption that benefits of abatement are constant across the policy scenarios evaluated. One valuable extension would be to modify the IIAM model so as to compare the cost effectiveness across abating coalitions maintaining the same global abatement target, as in Harrison and Rutherford (1998). In particular, countries would be committed to undertake some level of global abatement. That is, instead of being committed to reduce their own emissions by a given percentage they would be committed to reduce global emissions by a given percentage. The main difference between these two types of commitment is that under the latter carbon-constrained countries would have to compensate for any carbon leakage. Under this alternative, abatement benefits would be constant across coalitions subject to the same global emission target since the same environmental target would be met, by assumption. Thus, a direct comparison of welfare costs would be possible.

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