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# Issue Linkage and Issue Tie-in in Multilateral Negotiations<sup>\*</sup>

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## Abstract

We describe a model of international, multidimensional policy coordination where countries can enter into selective and separate agreements with different partners along different policy dimensions. The model is used to examine the implications of negotiation tie-in| the requirement that agreements must span multiple dimensions of interaction| for the viability of multilateral cooperation when countries are linked by international trade flows and transboundary pollution. We show that, while in some cases negotiation tie-in has either no effect or can make multilateral cooperation more viable, in others a formal tie-in constraint can make an otherwise viable joint multilateral agreement unstable.

KEYWORDS: International Cooperation, Trade and Environmental Policy Negotiations.

JEL Classification: F0, F1, Q3, C7.

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# 1 Introduction

International relations involve multiple dimensions of interaction. Even when these dimensions are not directly interdependent| in the sense of the effects of choices along one dimension being dependent on choices along the others| there can still be cross-issue negotiation linkage: by exchanging concessions across different policy dimensions, two countries may be able to achieve cooperation in situations where there would otherwise be no scope for mutual gains to be attained. Although this idea is not new,<sup>1</sup> its implications have so far only been examined in the context of bilateral negotiations, not multilateral negotiations.

The literature on multilateral international agreements has primarily been concerned with whether single-issue multilateral agreements are immune from the possibility of deviations by a subset of countries. Consistently with the single-issue nature of the problem it studies, this literature has built upon theories of coalition formation whereby members of a coalition coordinate all of their actions with other members.<sup>2</sup> Simply extending the concept of coalition structure to a multi-dimensional framework in order to characterize the viability of multilateral cooperation arrangements can be misleading, because it does not account for the fact that countries can (and often do) form selective arrangements with different partners over different issues.

Here we draw a distinction between the idea of issue linkage| which refers to the possibility of forming agreements over multiple issues| and that of issue tie-in| the requirement that agreements must span multiple dimensions of interactions, ruling out single-issue agreements. Multilateral cooperation across different issues (issue linkage) is an equilibrium phenomenon, whereas negotiation tie-in is an exogenous constraint on the set of possible cooperation arrangements. Whether such a tie-in restriction helps or hinders multilateral cooperation depends on the payoff structure of the underlying noncooperative game. In some cases negotiation tie-in can facilitate multilateral cooperation by limiting the set of the feasible objections to joint cooperation arrangements. However, in other cases, rather than inducing parties to trade across issues, a tie-in restriction can actually constitute an obstacle to multilateral cooperation, as it removes

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<sup>1</sup>The point was first stressed by Rai (1982) and Sebenius (1983). For a recent application to North-South trade and environmental policy cooperation, see Abrego et al. (1997).

<sup>2</sup>For an extensive survey of this literature, see Bloch (1997).

certain counterobjections that could be put forward, out of equilibrium, in order to support issue trading in equilibrium.

We build our argument by presenting a model of international policy coordination choices where countries can enter into selective and separate binding agreements with different partners along different policy dimensions. International relations are described as a two-stage game, in which agreements are formed in the first stage and policies are selected in the second stage| cooperatively among countries participating in an agreement and noncooperatively between countries belonging to separate agreements. To accommodate for the possibility of individual countries belonging to multiple agreements, we define an equilibrium concept built on a formal distinction between agreements, as arrangements that determine the payoff structure in the last stage of the game, and blocking coalitions, as subsets of players that can make objections to a proposed configuration of agreements in the first stage. Using this construct, we examine how the stability of the joint global agreement (the agreement structure where all players jointly cooperate over all strategic dimensions) is affected by the imposition of a tie-in rule, a constraint limiting the set of feasible objections to those featuring a simultaneous deviation across all issues for each player involved| which in turn amounts to only considering coalitions of players, rather than general agreement structures.

We then focus on a more specific model where countries are linked by international trade and transboundary pollution. In this context, the presence of a tie-in rule would imply that trade cooperation is conditional on environmental cooperation and vice-versa. This would be in line with the idea, often discussed in the policy debate on trade and environment, that the WTO should act as an international policing organism, forcing countries to cooperate over issues that do not strictly pertain to trade policy narrowly defined.<sup>3</sup> It should be stressed, however, that the prevalent position in policy circles seems to be that the WTO should just accommodate the aims of the parties to multilateral environmental agreements (MEAs),<sup>4</sup> without directly extending its reach

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<sup>3</sup>On this point, see Whalley and Hamilton (1996).

<sup>4</sup>For a discussion of issues related to the integration of multilateral environmental agreements within the GATT/WTO see Esty (1994) and Brack (1997). Such integration would require a new interpretation of WTO rules, or possibly even textual amendments to them, so as to legitimize the use of trade restrictions in accordance with multilateral environmental agreements such as the Basle

to cover environmental issues, thus rejecting conditionality as a means of promoting compliance.<sup>5</sup>

In this model, we show that, while in some cases the stability of a joint multilateral agreement is unaffected or enhanced by tie-in, in others a formal tie-in constraint can make an otherwise stable joint multilateral agreement unstable. The possibility of each scenario occurring is illustrated by means of parameterized examples, for which we derive players' payoffs under alternative agreement structures and bargaining rules. Negotiation tie-in is more likely to facilitate multilateral cooperation in situations where the environmental policy stakes are small relative to the welfare effects of trade policies and when partial environmental coordination is preferred to no cooperation by all countries involved, implying that outsiders can free-ride effectively on partial environmental agreements. On the other hand, when the costs of environmental compliance are high but the ability to free-ride on partial environmental agreements is limited, a negotiation tie-in restriction can hinder multilateral cooperation by making it both attractive and viable for a single country to remain outside of any agreement.

The remainder of the paper is organized as follows. Section 2 describes a cooperative game of multi-dimensional agreement formation and defines the notion of Stable Agreement Structure. Section 3 contrasts issue linkage and issue tie-in, discussing their respective implications for the stability of a joint multilateral agreement. Section 4 applies these ideas to a simple three-country example in which countries can form trade and environmental agreements. Finally, Section 5 offers some concluding remarks.

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Convention on flows of toxic wastes, the Montreal Protocol on ozone layer depletion or the Kyoto Protocol on greenhouse gas emissions. This latter approach is reflected in several speeches made at the WTO High Symposium on Trade and Environment held in Geneva from 15-16 March 1999, which is available on the WTO web site.

<sup>5</sup>On several occasions the WTO has strongly rejected the prospect of "becoming an international body with unilateral powers [...], a world policeman that can force compliance upon unwilling governments"; see, for example, the address given by WTO Director General Renato Ruggiero to the Bellerive/Globe international conference in "Policing the Global Economy", on 23 March 1998.

## 2 Multi-dimensional Agreement Formation

In this section we formalize cooperation choices in an environment where players enter into separate agreements with different partners on different policy dimensions.

### 2.1 Strategies, Agreements and Behaviour

Consider the following strategic-form game. Let  $I$  be the set of players and let the strategy space for each player  $i \in I$ ,  $S_i$ , be an  $N(i)$ -dimensional vector space, with  $N(i) \in \mathbb{N}; i \in I$ , representing the number of dimensions in each player's strategy. Strategies for player  $i$  are denoted by  $s_i \in S_i$ .

Assumption 1  $S_i = \prod_{j \in \{1, \dots, N(i)\}} S_{i,j}; i \in I$ , where the  $S_{i,j}; i \in I; j \in \{1, \dots, N(i)\}$  are one-dimensional sets.

Assumption 1 means that the pure strategy space for each player can be represented as the Cartesian product of one-dimensional sets. This ensures that choices along individual dimensions of the strategy vector can be made independently of each other, i.e. individual dimensions of strategic choice are not directly linked.<sup>6</sup>

Definition 1 The sets  $S_{i,j}; i \in I; j \in \{1, \dots, N(i)\}$  are elementary strategy sets and their elements  $s_{i,j}$  elementary strategies.

The space of strategy profiles is  $S = \prod_{i \in I} S_i = \prod_{i \in I} \prod_{j \in \{1, \dots, N(i)\}} S_{i,j}$ , and strategy profiles are  $s \in S$ . Players' payoffs are represented by real-valued mappings  $u_i : S \rightarrow \mathbb{R}; i \in I$ .

In analyses of coalition formation, coalitions are described as non-empty subsets of  $I$ , and this is then interpreted as meaning that the players in each subset pool all of their elementary strategies and make coordinated choices over them. If we are to separately represent different dimensions of choice, then coalitions can be defined as follows. Let  $S(i) = \{s = (s_{i,j})_{j \in \{1, \dots, N(i)\}}; i \in I\}$  i.e.  $S(i)$  is the set of pairs  $s = (i; j)$  such that  $j$  is a valid dimension of player  $i$ 's strategy vector (i.e.  $s$  corresponds

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<sup>6</sup>The reason for this assumption will be made clear later. Nevertheless, note that it involves no loss of generality. Starting from any given game, it is always possible to augment the strategy set by redefining it as having rectangular support as required by Assumption 1, and then assign an infinite negative payoff for all players to any strategy profile involving the added strategies.

to a valid index pair  $(i; j)$  for elementary strategies  $s_{ij}$  and  $S = \bigcup_{i \in I} S(i)$  i.e. each element of  $S$  corresponds to a different elementary strategy. Finally, let  $P$  be a partition of  $S$  whose elements are the sets  $S(i)$ ,  $i \in I$ . Then, a coalition structure  $C$  consists of a partition of  $S$  which is coarser than  $P$ , i.e. such that all of a player's elementary strategies belong to a single element of the partition. For the purpose of our analysis, we wish to examine situations where a subset of players coordinate their actions with each other only with respect to certain strategy dimensions and not others, and where the same player can enter into different coordinating arrangements with different players for different strategy dimensions. To allow for this, one can simply drop the requirement that the partition of the set of elementary strategies be coarser than  $P$ , and allow instead for arbitrary partitions of  $S$ . The resulting partitions  $G$  will be called agreement structures and their elements  $g$  will be called agreements. The sub-profile of elementary strategies in the agreement will be denoted by  $s_g = \{s_{ij} \mid j \in g\}$ , and the set of such sub-profiles – the strategy set of agreement  $g$  – will be denoted as  $\Sigma_g$ .

**Definition 2** An agreement  $g \in G$  is a subset of strategy dimensions for a subset of players.

Note that Assumption 1 ensures that a player assigns elementary strategies to different agreements, the strategy sets of the different agreements are independent sets.<sup>7</sup>

**Definition 3** A participant to agreement  $g$ ,  $i_g \in I \cap g$  ( $(i; j) \in g$  for some  $j \in g$ ), is a player who contributes at least one elementary strategy to the agreement. The set of participants to agreement  $g$  is denoted by  $I_g$ .

We shall focus on subgame-perfect equilibria of a two-stage game where players first enter into binding cooperative agreements and then the resulting agreements interact noncooperatively. Starting from the last stage, let the vector of payoffs for the participants to agreement  $g$  be denoted by  $v_g(s_g) = (v_{ij}(s_g) \mid i \in I_g)$ .

**Assumption 2 (Agreements' behaviour)** Each agreement  $g \in G$  chooses  $s_g \in \Sigma_g$  so as to attain a maximal element of  $\{v_g(s_g; s_{-g}) \mid s_g \in \Sigma_g\}$  (where

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<sup>7</sup>Cross-linkage between strategy sets is a complication that is typically assumed away in the analysis of strategic-form games and that does not arise when players, having independent strategy sets but possibly not independent choices along different dimensions, form coalitions in the more restrictive sense of the term.

if  $g$  stands for  $G \setminus g$ ). The best-reply correspondence of agreement  $g$ ,  $\beta_g : S \rightarrow S$ , is thus defined as  $\beta_g(s) = \arg \sup_{s_i} u_i(s_i, s_{-i}^g)$ .

This assumption simply generalizes best-response behaviour by individual players in a noncooperative setting to a decision-making unit involving multiple players: no agreement  $g \in G$  can do (Pareto) better than play  $s^g$ , given the behaviour of all other agreements  $(s_{-i}^g)$ .

**Definition 4** A noncooperative outcome for the agreement structure  $G$  is a strategy profile  $s^g$  such that  $s^g \in \beta_g(s^g)$ ;  $g \in G$ . The set of noncooperative outcomes for the agreement structure  $G$  is denoted by  $\Omega(G)$ .

## 2.2 Stable Agreement Structures

Agreement formation in the first stage of the game is formalized using ideas from cooperative game theory. We define a Core-like equilibrium concept whereby subsets of players can put forward objections to a certain proposed arrangement, as in Ray and Vohra (1997). Here, however, we make a formal distinction between agreements among players to coordinate the use of (one or more) strategies, and coalitions of players who can make coordinated objections to a proposed agreement structure. The two concepts are logically distinct: agreement structures determine payoffs in the second stage of the game; coalitions of players can object to a proposed arrangement by rearranging the strategies they control, but such objections do not necessarily imply the formation of agreements between the objecting players.<sup>8</sup>

In order to describe our equilibrium concept, it is convenient to redefine the game by "breaking up" the individual players into smaller units each corresponding to a different elementary strategy:

**Definition 5** An elementary player is a pair  $(s = (i, j) \in S; \frac{1}{4})$ , i.e. an element of  $S$  paired with the payoff mapping of the player to which the elementary strategy  $s$  belongs. The payoff mapping for elementary player  $s$  is denoted by  $\frac{1}{4}$ .

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<sup>8</sup>In partition function games (games "with externalities"), it is possible for two players to obtain a higher payoff by acting individually than by coordinating their actions, because of the effect of a third player's response on the noncooperative outcome. Achieving such an outcome, however, may require abiding by a common, coordinated coalitional choice (i.e. both players must together choose to act in this way).



No problem of interpretation arises with respect to the second stage of the game under Assumption 2, the set of noncooperative outcomes will be the same whether we describe the game in terms of players  $i \in I$  or in terms of elementary players  $s \in S$ . With respect to the formulation of objections to a certain agreement, although we do not require that individual elementary players who share the same payoff coordinate their objections, such coordination will not be ruled out by our equilibrium concept. In other words, elementary players who share the same payoff may still choose to act as a single player.

We shall also need the following definitions:

**Definition 6** A restricted agreement structure  $G(S^0)$ ;  $S^0 \subseteq S$  is a partition of  $S^0$ .

**Definition 7** An unrestricted agreement structure is an agreement structure restricted to  $S$ .

Also let  $G$  denote the set of all possible partitions of  $S$ , and  $\bar{G} \subseteq G$  the set of the feasible agreement structures, where feasibility is a function of institutional or other constraints.

Our equilibrium concept can then be described in terms of the two following definitions:

**Definition 8** A restricted agreement structure  $G(S^0)$ ;  $S^0 \subseteq S$  can be blocked, within an agreement structure  $G^0 \in \bar{G}(S^0) \subseteq \bar{G}(S \setminus S^0)$ , by a coalition  $S^0 \subseteq S^0$  of elementary players if there exists a restricted agreement structure  $G(S^0)$  involving only elementary players in the blocking coalition such that, for each of the restricted structures  $G(S^0 \setminus S^0)$  involving the remaining elementary players in  $S^0$  that cannot be blocked under the combined structure  $G^0 \in \bar{G}(S^0) \subseteq \bar{G}(S^0 \setminus S^0) \subseteq \bar{G}(S \setminus S^0) \subseteq \bar{G}$ , we have that (i)  $\frac{1}{2}G^0 \in \hat{G}(G^0)$ ;  $\frac{1}{2}G^0 \in \hat{G}(G^0)$ , it is the case that  $\frac{1}{2}(G^0) \in \frac{1}{2}(G^0)$ ;  $s \in S^0$ , with the inequality being strict for at least one  $s \in S^0$ , and (ii)  $G(S^0 \setminus S^0)$  can be blocked within  $G^0$ .<sup>9</sup> If  $G(S^0)$  satisfies the above conditions, we say that it is a stable objection to  $G(S^0)$  by  $S^0$ .

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<sup>9</sup>According to this definition, an objection is viable for a coalition only if it yields a Pareto superior outcome for its members under all stable counterobjections that the other players can put forward. This idea is analogous to Greenberg's (1990) concept of "pessimistic standard of behaviour".

**Definition 9** A Stable Agreement Structure  $G^s$  is an unrestricted structure which cannot be blocked.

Note the recursive nature of the above definition: what is required for an objection by a coalition of players to constitute a blocking objection is that it must be not only profitable (condition (i)) but also immune from further external or internal deviations, i.e. it must involve an arrangement that is stable (in the restricted sense) according to the very definition of stability so obtained.<sup>10</sup> In this construct, objections are made by subsets of elementary players| coalitions in the standard sense of cooperative game theory| who make alternative arrangements among themselves without involving the other players. Although such objections are coordinated, they do not necessarily involve pooling all the corresponding elementary strategies into a single agreement.

This specification does away with the need for exogenous rules describing the fate of agreements under an objection involving a subset of its participants (as discussed by Burbidge et al., 1997): in this definition, stable arrangements can reform for any restricted set of players, once an objection is made. Also, although objections are made by successively finer coalitions| as in Ray and Vohra (1997)| the objections themselves can consist of agreement structures that are coarser than the one to which a coalition objects to.<sup>11</sup>

The concept of Stable Agreement Structure appears to be a natural extension of similar equilibrium concepts that have been described for games of coalition formation; as is the case for these analogous solution concepts, existence of an equilibrium may in general be problematic. In practice, the concept of Stable Agreement Structure may also be difficult to operationalize owing to the large number of potential objections and counterobjections that are involved. In our application, however, we shall focus on a scenario with only three players and two dimensions of choice, where the solution concept becomes manageable.

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<sup>10</sup>This consistency requirement, ruling out coalitional deviation which are not themselves immune from further deviations, also characterizes equilibrium concepts such as the Coalition-Proof Nash Equilibrium of Bernheim, Peleg and Whinston (1987) and the Equilibrium Binding Agreements of Ray and Vohra (1997).

<sup>11</sup>Under the Equilibrium Binding Agreement rule of Ray and Vohra (1997), existing agreement structures are allowed to break only into smaller agreements.

## 2.3 Within-agreements Bargaining

Without additional restrictions, Assumption 2 does not tie down behaviour to a specific distributional objective, and does not rule out asymmetric payoff outcomes within an agreement where all participants are identical. This flexibility implies that there will typically exist a continuum of noncooperative equilibria for any agreement structure. In the rest of our analysis, we shall narrow down the set of possible noncooperative outcomes by assuming a fixed payoff distribution rule within an agreement  $g$ , arising as the solution to a bargaining problem among the participants to  $g$ . As elsewhere in this literature (e.g. Burbidge et al., 1997) we shall assume the bargaining rule to be anonymous (i.e. symmetric), implying that identical players in identical situations must obtain the same payoff.

A symmetric bargaining rule involves two ingredients: the set of efficient (within the agreement) payoff combinations that can be attained if players form  $g$ , and the "disagreement" payoff of participants,  $\{v_i^D; i \in I^g\}$ . Given these, optimal policy choices by an agreement can be characterized as the policy combination (or set of combinations) which maximizes  $B(\{v_i; i \in I^g\})$ , where  $B$  is a symmetric, concave function.<sup>12</sup>

Consistently with our characterization of stability, the disagreement point  $D$  should be based on the stable outcomes that prevail if a certain agreement were not to form. In turn, stability of the disagreement point depends on the payoff distribution in alternative agreements, which implies that the characterization of the disagreement payoff for the various agreements is linked, recursively, to the characterization of stability of the restricted structures that are involved in the various objections and counterobjections.<sup>13</sup> One can interpret this specification as implying an initial pre-agreement

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<sup>12</sup>It is natural here to rely on a simple extension of two-player bargaining ideas to multi-player bargaining, rather than resort to the multi-player bargaining solution concepts that have been proposed for superadditive coalition-form games (games without "externalities"), such as the Shapley value. Such solution concepts define a division rule for the gains from multilateral cooperation based on the distribution of payoffs under alternative coalitional outcomes. Our definition of a stable outcome already calls upon a comparison of payoff outcomes under agreements structures; furthermore, in our construct the bargaining rule is relied upon to determine a payoff division within agreements for any agreement structure, not just the grand coalition.

<sup>13</sup>This approach is consistent with the extensions of the Shapley Value for coalitional form games proposed by Aumann and Myerson (1988).

stage where players can unilaterally commit not to enter into certain agreements with certain partners. Since such a commitment by any single player would automatically result in the removal of the corresponding agreement structures from the set of feasible structures, the disagreement point is naturally defined as that payoff distribution that would result within the resulting restricted space of agreement structures. In the application of Section 4, we shall focus on a scenario where, in the "pre-game" stage, players can unilaterally veto the possibility that any agreement will form, in which case the disagreement point  $D$  is taken from the payoff combinations that prevail when all agreements are singletons (i.e. no agreements form).<sup>14</sup>

There is a further complication, arising from the non-superadditive structure of the game: when a subset of players form an agreement, it is possible that the payoffs they can obtain are less than the payoffs that are feasible in the absence of the agreement; thus, the fallback position may involve higher payoffs than are possible in the presence of the agreement itself. It is true that, if this is the case, then the corresponding agreement structure could never be stable according to our definition. Nevertheless, in order to apply our definition of blocking and stability, a payoff distribution must be defined for all agreement structures, even those that are not stable. To deal with such cases, we can apply the bargaining function  $B$  "in reverse" by taking the counter-agreement scenario as defining the (endogenously determined) disagreement point and

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<sup>14</sup>The more general case can be formally described as follows. Let  $Z = \{g, \mu, S, g, X\}$  be a partition of  $Z$  with  $A \subseteq X$  representing an element of this partition; define  $A(g) = \{g \in G \mid g \subseteq A; A \cap G \neq \emptyset; g, \text{ and } G(g) = G \setminus A(g)\}$ . Also, let  $G^s(G)$  denote the set of stable agreement structures given  $G$  as the (possibly restricted) set of feasible agreement structures, and  $G^s : \{G \mid G \subseteq G\} \rightarrow G$  be a mapping which selects one specific structure from a set (with  $\{G \mid G \subseteq G\}$  representing a collection of sets). Then, under a symmetric bargaining rule, behaviour can be defined in the following way: for a given restricted set of agreement structures  $G$ , each agreement  $g \in G \subseteq G$ , chooses  $\pi_g \in \mathbb{R}^g$  so as to maximize  $B(\frac{1}{\#} \{ \pi_g^D(g); g \in I^g \})$ , where  $\pi_g^D(g) = \frac{1}{\#} \{ \pi_g^s(G \setminus G(g)) \}$ . Note that such a definition recursively invokes the definition of stability for a structure within a certain restricted set of structures, and is therefore intertwined with Definitions 8 and 9: in order to determine the payoff distribution within an agreement in a certain structure, it is necessary to determine which structure would be stable if the structures in  $A(g)$  were eliminated; in turn this determination may require knowledge of the payoff distribution within a certain agreement  $g^0$  in alternative structures, which then may require identifying a further stable outcome in a game where further both the structures in  $A(g)$  and in  $A(g)^0$  are ruled out; and so on. The simple version of this construct we use in Section 4 assumes  $X$  to consist of the single element  $Z$ .

the stable no-agreement scenario as defining the (exogenously determined) bargaining outcome.<sup>15</sup>

Some remarks are in order at this point with respect to the feasibility of side payments. The agreement formation game as we have formalized it above does not rule out the possibility of side payments, if feasible. Side payments can be formally treated just like additional dimensions of players' strategies, which become active only within agreements in which the corresponding elementary players participate. In the game so augmented, all of the previous definitions would still apply, both in the general case and in the case of a bargaining-based payoff-distribution rule within agreements.

### 3 Issue Linkage vs. Issue Tie-in

The multi-dimensional agreement formation game described in the previous section naturally involves issue linkage, i.e. players can cooperate over multiple dimensions and bargain across different issues. Such cooperation and exchange may involve the formation of perfectly overlapping agreement structures (i.e. coalitions of players in the standard sense) or only partially overlapping structures (with subsets of players cooperating over certain issues but not others). A negotiation tie-in rule, requiring that countries must form joint agreements over multiple issues<sup>16</sup> coalitions in the usual sense of the term<sup>17</sup> eliminates the possibility of partially overlapping agreement structures, which affects both the feasible proposals as well as the feasible objections to a given proposal. The question we want to address here is the following: what are the implications of a tie-in rule for the stability of the Joint Global Agreement (JGA), i.e. the agreement structure where all players jointly cooperate over all strategic dimensions?

Formally, let  $\hat{G}$  the set of partitions of  $S$  which are coarser than  $P$  (where  $P$  is the partition of  $S$  whose elements are the sets  $S(i)$ ,  $i \in I$ ).

**Definition 10** A perfectly overlapping agreement structure is an element of  $\hat{G}$ . A

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<sup>15</sup>In a scenario with symmetric players, it is possible to abstract from this problem by simply assigning equal payoffs to identical players, which may nevertheless result in lower payoffs when a certain agreement is present than without it. Even in this case, however, the use of an equal-payoff rule would imply the application of a symmetric bargaining rule, where the disagreement point is defined as the payoff-distribution which results in a structure where the agreement in question does take place.

partially overlapping agreement structure is an element of  $G \cap \hat{G}$ .

A negotiation tie-in rule restricts agreements to lie in  $\hat{G}$ . Note that since the J GA belongs to  $\hat{G}$ , it is not ruled out by a tie-in restriction. Nevertheless, such a tie-in restriction may affect the stability of the J GA as it affects the set of feasible objections and counterobjections.

Suppose that, without a tie-in restriction, the set of feasible agreement structures is simply  $\hat{G} = G$ , and let the sets of Stable Agreement Structures with and without a tie-in restriction be respectively denoted as  $G^R$  and  $G^U$ . Then, theoretically four possibilities arise: (i)  $J \in G^R \cap G^U$ ; (ii)  $J \in G^R \setminus G^U$ ; (iii)  $J \in G^U \setminus G^R$ ; (iv)  $J \notin G^R \cup G^U$ . In cases (i) and (iv), a tie-in restriction is irrelevant for the stability of the J GA: in case (i) it is stable with or without a tie-in restriction, whereas in (iv) it is unstable under both scenarios. In case (ii), a tie-in restriction makes J stable when it would not be otherwise; in case (iii) it makes J unstable.

The implicit, informal presumption in the policy debate seems to be that tie-in could "help" cooperation, by forcing asymmetric countries to trade concessions across different issues and by offsetting free-riding incentives.<sup>16</sup> The broad idea behind our counter argument is that what matters for countries to be persuaded to cooperate across all issues is that cross-trading be possible out of equilibrium, not that it be required. In other words, the idea of cross-issue trade focuses on within-coalitions bargains, but the formation of an agreement (and the associated bargaining that takes place within it) is an equilibrium phenomenon, which may or may not occur depending on whether other arrangements can be opposed as objections. From this point of view, the effect of a tie-in rule is, in principle, ambiguous: it could either make the J GA stable by eliminating a partially overlapping agreement structures that would otherwise constitute a stable objection to it as in case (ii) above, make the J GA unstable by eliminating a partially overlapping agreement structure that would otherwise make a certain perfectly overlapping structure unstable as an objection as in case (iii) above, or, finally, have no effect.

To illustrate these ideas, consider the following stylized example. There are three players 1, 2, and 3. Player 1 has two elementary strategies, denoted as  $A_1$  and  $B_1$ ,

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<sup>16</sup>For example, Carraro and Siniscalco (1994) point out that free-riding incentives could be offset by making the signing of agreements entailing positive excludable externalities restricted to signatory countries (e.g. trade or R&D agreements) conditional on environmental cooperation.

while players 2 and 3 have only one elementary strategy each, denoted respectively as  $A_2$  and  $A_3$ . Suppose that to each agreement structure corresponds only one non-cooperative equilibrium, and that payoffs under the  $J$  GA,  $J = \{A_1; B_1; A_2; A_3\}$  are  $\frac{1}{4} = 3; i \in \{1; 2; 3\}$ .

Consider first a scenario where  $\frac{1}{4} = 3; i \in \{1; 2; 3\}$  in the  $J$  GA,  $\frac{1}{4} = \frac{1}{2} = 4, \frac{1}{3} = 0$  under  $G^1 = \{A_1; A_2; B_1; A_3\}$ , and  $\frac{1}{4} = 1; i \in \{1; 2; 3\}$  in all other agreement structures. Then if, under a tie-in restriction,  $G^1$  is ruled out,  $J$  is stable, whereas if it is feasible, players 1 and 2 can block  $J$  by putting forward  $G^1$ , which in turn cannot be blocked by any agreement structure. Here, negotiation tie-in helps support multilateral cooperation.

Consider next a scenario where the agreement structure  $G^2 = \{A_1; B_1; A_2; A_3\}$  [the structure where players 1 and 2 form a coalition] yields payoffs  $\frac{1}{4} = \frac{1}{2} = 4; \frac{1}{3} = 0$ , and all perfectly overlapping structures other than  $J$  and  $G^2$  yield  $\frac{1}{4} = 1; i \in \{1; 2; 3\}$ . Since both players 1 and 2 are better off under  $G^2$  than under  $J$ , the configuration  $G^2$  could in principle constitute a blocking objection to  $J$  for them. It remains to be seen whether  $G^2$  itself is stable with respect to restricted counterobjections (objections made by inner blocking coalitions). The only candidate counterobjections by subsets of the objecting coalition  $\{1; 2\}$  are  $G^3 = \{A_1; B_1; A_2; A_3\}$ ,  $G^4 = \{A_1; A_2; B_1; A_3\}$ , and  $G^5 = \{A_1; B_1; A_2; A_3\}$ . Under a tie-in restriction, however,  $G^4$  and  $G^5$  are infeasible. Suppose that, under  $G^3$  and  $G^5$ , we have  $\frac{1}{4} = 1$ , while under  $G^4$  we have  $\frac{1}{4} = 5, \frac{1}{2} = 1, \frac{1}{3} = 0$ . Then, if  $G^3$  is the only possible counterobjection to  $G^2$ , the latter will be a stable objection to  $J$ , and therefore  $J$  will not be stable. If, on the other hand, there is no tie-in restriction,  $G^4$  and  $G^5$  are feasible counterobjections, and player 1 can block  $G^2$  by putting forward  $G^4$  [which is itself stable, since  $G^5$ , the only possible counterobjection to  $G^4$ , yields a lower payoff for player 2 than  $G^4$  does, and player 2 obtains a lower payoff under  $G^4$  than under  $J$ ]. Thus, without a tie-in restriction,  $G^2$  is not a stable objection to  $J$ , and  $J$  is therefore stable. In this scenario, a tie-in restriction hinders multilateral cooperation.

Notice that issue linkage can still be at work in the same scenario. Suppose, for example, that countries were forced to coordinate over different issues separately [which would rule out both  $G^2$  and  $J$  (as well as all the agreement structures involving the elementary player  $B_1$  and any other player)] and that  $G^6 = \{A_1; A_2; A_3; B_1\}$  (a multilateral agreement over a single dimension) yields payoffs  $\frac{1}{4} = 0; i \in \{1; 2; 3\}$ . Then multilateral cooperation over the first policy dimension would not be possible

unless the other dimension is also brought in.

Whether a tie-in restriction will help or hinder multilateral cooperation therefore depends on the payoff structure of the underlying noncooperative game. In the next section, we describe a policy game involving both trade and environmental policies based on a competitive model of international trade with internationally differentiated goods and transboundary pollution which we then use to examine the implications of negotiation tie-in across trade and environmental policies for the stability of multilateral, joint trade-and-environment policy agreements.

## 4 An Application to Trade and Environmental Policy Negotiations

Much of the literature on international policy cooperation has separately examined cooperation over trade policies and over environmental policies. Riezman (1985), Krugman (1991), Bond and Syropoulos (1993), and Yi (1996), among others, have focused on the creation of Customs Unions, while Carraro and Siniscalco (1993), Barrett (1994) and Chander and Tulkens (1992), among others, have focused on International Environmental Agreements. The broad theme emerging from this literature is that the presence of spillovers between coalitions (positive in the case of environmental coalitions, negative in the case of trade coalitions) makes global cooperation difficult to sustain, and that partial cooperation, restricted to subsets of countries, is more likely to emerge.

In this context, it has been suggested that multilateral cooperation could be enhanced by formally combining different issues with the aim of joint settlement. In the following, the ideas developed in the preceding sections will be used to examine formally the question of whether negotiation tie-in across trade and environmental policy issues would help or hinder multilateral cooperation. For this purpose, we describe a three-country model of international trade with transboundary pollution.<sup>17</sup>

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<sup>17</sup>It can be argued that, in the absence of a supranational authority with autonomous powers of effective enforcement, it is not legitimate to assume international commitments to be binding, and that therefore all international agreements must be self-enforcing. This type of approach to the analysis of international trade agreements, using an infinitely repeated game paradigm, has been pursued, among others, by Bagwell and Staiger (1997). Note, however, that the structure of incentives that



## 4.1 International Trade with Transboundary Pollution

Three ex-ante symmetric countries, 1, 2 and 3, are linked by transboundary pollution and trade, with markets for traded goods being characterized by perfect competition. Environmental emissions are "global", i.e. countries are equally affected by foreign and domestic emissions. Each country  $i \in \{1, 2, 3\}$  is endowed with an amount  $M_i$  of a non-traded good. In each country, firms in the tradeable goods sector produce a single good at a constant marginal cost  $c = 1$  in terms of the nontraded good. Markets are assumed to be segmented, in the sense that consumers in each country view goods produced in different countries as being imperfect substitutes.

Consumers are identical, and the preferences of the representative consumer in country  $k \in \{1, 2, 3\}$  are described by a quasilinear, isoelastic utility function:

$$u_k(M_k; Q_k) = M_k + \frac{\alpha}{1+\alpha} Q_k^{1+\alpha} - \frac{\beta}{1+\beta} D^{1+\beta}, \quad k \in \{1, 2, 3\}; \quad (1)$$

where  $M_k$  is consumption of the nontraded good,  $Q_k$  is composite consumption of the traded goods| an isoelastic aggregation of the quantities  $q_k$  produced in country  $i$  (origin) and consumed by country  $k$  (destination), i.e.

$$Q_k = 4(1 - \alpha)^{\frac{1}{1+\alpha}} q_{kk}^{\frac{1}{1+\alpha}} + (1 - \alpha)^{\frac{1}{1+\alpha}} \sum_{i \in k} q_k^{\frac{1}{1+\alpha}}; \quad (2)$$

with  $\alpha$  representing the elasticity of substitution in consumption between traded goods from different sources, and  $\alpha$  representing the share of imports in total tradeables demand|  $\alpha < 0$  is the (constant) elasticity of demand for the tradeables aggregate,  $\beta$  is a positive scalar,  $D$  are global emissions,  $\mu > 0$  is the (constant) inverse elasticity of marginal damage valuation with respect to global emissions, and  $\pm$  is a positive scalar.

Demand for the traded aggregate in country  $k$  is then given by

$$Q_k = [p_k - \alpha m_k]^{\frac{1}{1+\alpha}}; \quad k \in \{1, 2, 3\}; \quad (3)$$

where

$$p_k = 4(1 - \alpha)^{\frac{1}{1+\alpha}} w_{kk}^{\frac{1}{1+\alpha}} + (1 - \alpha)^{\frac{1}{1+\alpha}} \sum_{i \in k} w_{ik}^{\frac{1}{1+\alpha}}; \quad k \in \{1, 2, 3\}; \quad (4)$$

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makes cooperation sustainable by threat of punishment in a repeated game finds a counterpart in the sequence of objections and counterobjections in our static solution concept. On the other hand, since punishment strategies in a repeated game can be arbitrarily selective, such correspondence would be weakened if only multi-issue agreements were included.

$m_k$  is the price of the nontraded good in country  $k$ , and  $w_{ik}$  is the consumer price in country  $k$  of goods imported from country  $i$ . Using Shephard's Lemma, we can write uncompensated demands for imports and domestic demand for domestically produced tradeables as

$$q_k = \frac{p_k}{m_k} \theta_{ik} \frac{p_k}{w_{ik}}; \quad i \in I; k \in I; \quad (5)$$

where  $\theta_{ik} = 1$  if  $i = k$ , and  $\theta_{ik} = 1$  if  $i \neq k$ .

Production of the traded good in country  $i$  generates environmental emissions that are proportional to output by a certain fixed factor, the same for all countries, which, without loss of generality can be assumed to be equal to unity. Global emissions are then simply

$$D = \sum_{ik} q_k; \quad k \in I; \quad (6)$$

We restrict the government in country  $k$  to the use of only two policy instruments: ad valorem output taxes ( $e_k$ ) which, since emissions are proportional to output, are equivalent to emission taxes and discriminatory, ad valorem imports tariffs ( $t_{ik}$ ). Tax and tariff revenues are returned to consumers in a lump-sum fashion.

Domestic demand for nontradeables is

$$M_i = \frac{m_i \bar{M}_i + \sum_k [e_k m_i q_k + t_{ki} m_k (1 + e_k) q_{ki}] + p Q_i}{m_i}; \quad i \in I; \quad (7)$$

Market clearing then requires

$$M_i + \sum_k q_k - \bar{M}_i = 0; \quad i \in I; \quad (8)$$

Zero-profits for the tradeable goods sector in country  $i$  require that the gross-of-tariff gross-of-tax, consumer price of imports from  $i$  by  $k$  must be

$$w_{ik} = m_i (1 + e_i) (1 + t_{ik}); \quad i, k \in I; \quad (9)$$

For the purpose of our analysis, countries' payoffs are defined as the sum of consumer surplus, and tariff and tax revenues, minus environmental damage, which is in turn equal to the difference between utility and the endowment  $\bar{M}_i$ :

$$V_i = u_i(M_i; Q_i) - \bar{M}_i; \quad i \in I; \quad (10)$$

This is simply a re-normalization of utility, which involves no loss of generality.

## 4.2 Feasible Agreement Structures

As discussed in Section 2, it is useful to redefi ne the game in terms of six elementary players, by breaking up each country  $i$  into two smaller players| its trade and environment \ministers"| denoted respectively as  $T_i$  and  $E_i$ , who share the same payoff function, but control each trade and environmental policy for country  $i$ , respectively.

Note that in this setting there exist a unique welfare-maximizing combination of trade and environmental taxes in each country  $i \in I$ , for any given combination of taxes in the other countries,<sup>18</sup> this combination being a solution for the first-order conditions  $\partial \pi_i / \partial t_{ik} = 0; k \in I, k \neq i$ , and  $\partial \pi_i / \partial e_i = 0$ . In turn these conditions are equivalent to best-response conditions obtained by maximizing  $\pi_i$  separately by choice of  $t_{ik}; k \in I, k \neq i$ , and  $e_i$ , i.e. the conditions that characterize behaviour for two separate elementary players. In other words, in this setting, there is no direct gain for an individual player from coordinating choices across different policy dimensions. Thus, for example, agreement structures involving the single element  $\{T_1; E_1\}$  and structures involving the separate elements  $\{T_1\}; \{E_1\}$  will yield the same payoffs for all players.

For the purpose of our analysis| and consistently with observed practice| we shall restrict feasible agreement structures to those which involve only one policy dimension or both, i.e. trade-only agreements, environment-only agreements and combined agreements, thus ruling out mixed agreements where a country coordinates its trade policy with another country's environmental policies. Note, however, that the same equivalence of single-player optimal choice and elementary players' best responses applies here with respect to single-issue and two-issue agreements involving the same players, implying that we need not separately consider structures featuring joint agreements.<sup>19</sup> In other words, two separate agreements over trade and environmental policies respectively between two players are here the same as a joint (perfectly overlapping)

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<sup>18</sup>The payoff  $\pi_i$  is concave in  $e_i$  and  $t_{ik}$ .

<sup>19</sup>If, for example, two countries sign a trade agreement, their trade ministers will set trade taxes in a cooperative manner, taking as given the environmental taxes chosen by their respective environmental ministers. If the two countries sign an environmental agreement, their environmental ministers will set environmental taxes taking as given the trade taxes chosen by their respective trade ministers. If they sign both, all ministers will behave just as they would under each separate agreement, and this will entail no coordination failure.

agreement between the same two players.

With six elementary players and two strategy dimensions| and given the restriction imposed on the set of feasible agreement structures and the equivalence property discussed above| we need to consider twenty-ve possible agreement structures, which, given the symmetry assumption, can be restricted to the following ten:

1. Joint Global Agreement (J GA):  
ffT<sub>1</sub>; T<sub>2</sub>; T<sub>3</sub>g; fE<sub>1</sub>; E<sub>2</sub>; E<sub>3</sub>gg;
2. No agreement on either issue:  
ffT<sub>1</sub>g; fT<sub>2</sub>g; fT<sub>3</sub>g; fE<sub>1</sub>g; fE<sub>2</sub>g; fE<sub>3</sub>gg;
3. Global trade agreement, no environmental agreement:  
ffT<sub>1</sub>; T<sub>2</sub>; T<sub>3</sub>g; fE<sub>1</sub>g; fE<sub>2</sub>g; fE<sub>3</sub>gg;
4. Global environmental agreement, no trade agreement:  
ffT<sub>1</sub>g; fT<sub>2</sub>g; fT<sub>3</sub>g; fE<sub>1</sub>; E<sub>2</sub>; E<sub>3</sub>gg;
5. Partial environmental agreement, no trade agreement:  
ffT<sub>1</sub>g; fT<sub>2</sub>g; fT<sub>3</sub>g; fE<sub>1</sub>g; fE<sub>2</sub>; E<sub>3</sub>gg;
6. Partial trade agreement, no environmental agreement:  
ffT<sub>1</sub>g; fT<sub>2</sub>; T<sub>3</sub>g; fE<sub>1</sub>g; fE<sub>2</sub>g; fE<sub>3</sub>gg;
7. Partial perfectly overlapping agreements on trade and environment:  
ffT<sub>1</sub>g; fT<sub>2</sub>; T<sub>3</sub>g; fE<sub>1</sub>g; fE<sub>2</sub>; E<sub>3</sub>gg;
8. Partial agreements on trade and environment:  
ffT<sub>1</sub>g; fT<sub>2</sub>; T<sub>3</sub>g; fE<sub>1</sub>; E<sub>2</sub>g; fE<sub>3</sub>gg;
9. Global trade agreement and partial environmental agreement:  
ffT<sub>1</sub>; T<sub>2</sub>; T<sub>3</sub>g; fE<sub>1</sub>g; fE<sub>2</sub>; E<sub>3</sub>gg;
10. Global environmental agreement and partial trade agreement:  
ffT<sub>1</sub>g; fT<sub>2</sub>; T<sub>3</sub>g; fE<sub>1</sub>; E<sub>2</sub>; E<sub>3</sub>gg.

The presence of a tie-in restriction only leaves the perfectly overlapping agreement structures 1, 2 and 7| and all symmetrically corresponding configurations| as feasible agreement structures.

### 4.3 Negotiation Tie-in and the Stability of the Joint Global Agreement

If we apply the equilibrium concept described in Section 2 to this environment, we can state the following:

**Proposition 1** A tie-in negotiation rule makes an otherwise unstable JGA stable if and only if: (a) under a tie-in restriction, no perfectly overlapping structure put forward by a coalition of one or more countries can block the JGA; and (b) when all agreement structures are feasible, a partially overlapping agreement structure is a stable objection to the JGA.

In our three-country example, the conditions of Proposition 1 become:

(a)  $\frac{1}{4} > \frac{1}{8}$  and  $\frac{1}{4} > \frac{1}{8}$ , where 7 indicates agreement structure 7 and its mirror images;

(b.1) Within the set of partially overlapping agreement structures that a single country  $j$  could put forward as objections to the JGA (including agreement structures 5, 6, 9 and 10 and their mirror images), there is at least one structure  $G^0$  for which: (i)  $\frac{1}{8} > \frac{1}{4}$ ; and (ii) within the set of agreement structures that the other two countries  $k$  and  $h$  can put forward as counterobjections to  $G^0$ , there is no structure  $G^0$  such that  $\frac{1}{8}, \frac{1}{8}$  and  $\frac{1}{8}, \frac{1}{8}$  (with at least one inequality being strict); and/or

(b.2) Within the set of partially overlapping agreement structures that two countries  $k$  and  $h$  can put forward as objections to the JGA (including agreement structures 3, 4, 5, 6 and 8 and their mirror images), there is at least one structure  $G^0$  for which: (i)  $\frac{1}{8}, \frac{1}{4}$  and  $\frac{1}{8}, \frac{1}{4}$  (with at least one inequality being strict); and (ii) within the set of agreement structures that a third country  $j$  can put forward as counterobjections to  $G^0$ , there is no structure  $G^0$  such that  $\frac{1}{8} > \frac{1}{8}$ .

**Proposition 2** A tie-in negotiation rule makes an otherwise stable JGA unstable if only if: (a) under a tie-in restriction, a perfectly overlapping agreement structure is a stable objection to the JGA by a coalition of one or more players; and (b) when all agreement structures are feasible, there is no stable objection to the JGA.

In our three-country example, the conditions of Proposition 2 are:

(a)  $\frac{1}{8} > \frac{1}{4}$  and  $\frac{1}{8} = \frac{1}{8} > \frac{1}{8} = \frac{1}{8}$ , where 7 indicates structure 7 and its mirror images;

(b.1) Within the set of partially overlapping agreement structures that two countries  $k$  and  $h$  could put forward as counterobjections to  $7^a$  (including agreement structures 5 and 6 and their mirror images), consider the agreement structure,  $G^0$ , that yields the highest payoff for countries  $k$  and  $h$ . Then it must be true that (i)  $\frac{1}{k}G^0 = \frac{1}{h}G^0 > \frac{1}{k}7^a = \frac{1}{h}7^a$ ; and (ii)  $\frac{1}{k}G^0 < \frac{1}{k}7^a$ ; and

(b.2) No partially overlapping agreement structures (including agreement structures 3, 4, 5, 6, 8, 9 and 10 and their mirror images) is a stable objection to the J GA.

Which of the above scenarios will apply (if any) depends on several factors. If we take the trade policy side in isolation (i.e. set  $\pm = 0$ ), with three symmetric countries, two countries always gain when forming a trade bloc with coordinated tariff setting (a Customs Union) in comparison with a no-coordination scenario (see, for example, Kennan and Riezman, 1990); furthermore the excluded country always gain from a move to free trade from a two-country bloc situation. In such a setting, the gains from forming a two-country bloc to the participating countries, and the cost of such move to the excluded country, increase with the importance of trade as reflected in the magnitude of  $\tau^1$ .

On the environmental policy side, leaving trade aside (i.e. setting  $\tau^1 = 0$ ), the incentives for one country to leave the global environmental agreement and free ride on a partial coordination agreement between the other two, other things equal, increase with the size of the damage and decreases with the elasticity of environmental policy responses to changes in marginal damage valuation, which in turn depends primarily on  $\mu$  (the lower  $\mu$  the easier it is to free ride), but also on the parameters directly affecting tradeables demand. The value of the inverse elasticity of marginal damage valuation (corresponding to the elasticity of abatement demand with respect to marginal damage) also determines whether two countries have an incentive to engage in partial cooperation over environmental policy if the other country does not participate: as environmental policy responses become more inelastic, free-riding by the non-participating country can become so severe as to make noncooperation preferable for the remaining two. This is a well-known result and a theme that runs through the literature on environmental agreement formation.<sup>20</sup>

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<sup>20</sup>See, for example, Barrett (1994).

Note, however, that in this model emissions abatement can only take place through a reduction in the production of tradeables; this means that emission taxes coincide with output taxes, which are a relatively close substitute for export taxes (and, equivalently, import tariffs), and that in turn import tariffs are a substitute for emission taxes with respect to environmental policy goals. Consequently, the effects of trade and environmental policy instruments on payoffs are not additive, and thus trade policy and environmental policy incentives cannot be separated in as clearcut a manner as the above discussion suggests. In particular, as  $\tau$  approaches unity, import tariffs and emission taxes become progressively more equivalent.

To illustrate the potential effects of a negotiation tie-in restriction, below we present four different examples, involving alternative parameterizations of the model. We focus on a scenario with a symmetric bargaining-based distribution rule within agreements. In the present model, even if countries are ex-ante identical, asymmetric payoff distributions could still arise between two participants to an agreement if they do not also participate in the same agreements outside the given one (as in agreement structures 8-10) – a complication that is absent in one-dimensional agreement formation games. We consider alternative bargaining rules: Utilitarian bargaining ( $B(\frac{1}{2}i, \frac{1}{2}j; i, j) = P_{i,j}(\frac{1}{2}i, \frac{1}{2}j)$ ) and Nash bargaining ( $B(\frac{1}{2}i, \frac{1}{2}j; i, j) = Q_{i,j}(\frac{1}{2}i, \frac{1}{2}j)$ ) without side payments,<sup>21</sup> and the case with side payments under a symmetric, strictly concave B.<sup>22</sup> In all cases the disagreement point for bargaining is given by the payoffs under structure 2.

Tables 1 to 4 report noncooperative equilibrium payoffs under utilitarian bargaining under each of the ten agreement structures described in the previous subsection, for different parameterizations.<sup>23</sup> In all cases we set  $\tau = 2/3$ ,  $\alpha = 4/3$ ,  $\beta = 1/3$ , and

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<sup>21</sup>Note that, with quasilinear preferences, lump-sum transfers and utility transfers are equivalent. Transferable utility, however, does not imply that transfers need be feasible. Side payments are hardly observed in the practice of international agreements, perhaps because it is difficult or, in view of future commitments, undesirable to arrive at a precise determination of willingness to pay.

<sup>22</sup>With side payments and a symmetric disagreement point, any symmetric, strictly concave B will always yield an egalitarian outcome, i.e. identical payoffs for all players. With a utilitarian B and side payments, on the other hand, the payoff distribution is indeterminate.

<sup>23</sup>Since no closed-form solutions for payoffs as a function of policies are available, we have used numerical methods to obtain the noncooperative payoff values.

$\alpha = 2$ , and vary only the values of  $\beta^1$  and  $\mu$ . Equilibrium policy levels (not reported) range from zero to 2 for import tariffs and from 0.4 to 2 for emission taxes.

Consider first the scenario in Table 1, in which a large share of tradeable goods is imported ( $\beta^1 = 63=100$ ) and the inverse marginal damage valuation elasticity is large ( $\mu = 3=2$ ). It is easy to verify that the JGA is stable if a tie-in rule is imposed: no subset of players is better off at 2 or 7 than at 1. In contrast, without tie-in the JGA can be blocked by country 1 putting forward structure 9: this is a stable objection, since all the possible counterobjections by 2 and 3 (structures 2, 3, 5, 6, 7 and the mirror image of structure 8<sup>24</sup>) yield a lower payoff for them.

In this scenario, the imposition of a tie-in negotiation rule facilitates multilateral cooperation over trade and environmental policies (case (ii) of Section 3), by removing the possibility of profitable single-issue deviations by a single country with respect to environmental policy, and by a partial alliance of two countries with respect to trade policy. With  $\mu$  large, two countries prefer partial environmental policy cooperation between themselves to full noncooperation. This implies that, if a country attempts to free ride on environmental policy, the other two countries cannot credibly counter the move by resolving not to cooperate among themselves. At the same time, the gains from forming a trade bloc against a third country, for the two countries involved, and the cost of being excluded from a trade bloc, are sizeable ( $\beta^1$  is large). This implies that, with a tie-in restriction, a single country would not find it profitable to exit from a multilateral cooperation agreement.

Consider next a scenario where all parameters are the same as in Table 1 but the inverse elasticity of marginal damage valuation is lower (Table 2). Although the incentive to move to structure 9 still exists for countries 1, this deviation would not be stable whether or not a tie-in restriction is present, because countries 2 and 3 would counterobject to it by moving to structure 3 where they obtain a higher payoff by not coordinating on environmental policy and where country 1 obtains a lower payoff in comparison with structure 1. Thus, in this scenario tie-in is irrelevant, because even without it the JGA would be stable (case (i) of Section 3).

Let us now consider the scenario depicted in Table 3, in which both the import share parameter and the inverse elasticity of marginal damage valuation are small ( $\beta^1 = 1=10$ ,

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<sup>24</sup>The relevant mirror image of structure 8 is one in which countries 1 and 2 cooperate over trade and countries 2 and 3 over environment, yielding  $\frac{1}{4} = 0.704$ ,  $\frac{1}{2} = 0.668$  and  $\frac{1}{3} = 0.656$ .



Table 1: Agreement Structures and Countries' Payoffs  
 $\alpha = 63=100, \mu = 3=2, \sigma = 2, \gamma = 1/3=2, \tau = 2=3, \pm = 4=3$

Agreement Structure	Countries' Payoffs ( $\frac{1}{4}, \frac{1}{2}, \frac{1}{3}$ )
1: ffT <sub>1</sub> ;T <sub>2</sub> ;T <sub>3</sub> g;fE <sub>1</sub> ;E <sub>2</sub> ;E <sub>3</sub> gg	(0.722, 0.722, 0.722)
2: ffT <sub>1</sub> g;fT <sub>2</sub> g;fT <sub>3</sub> g;fE <sub>1</sub> g;fE <sub>2</sub> g;fE <sub>3</sub> gg	(0.656, 0.656, 0.656)
3: ffT <sub>1</sub> ;T <sub>2</sub> ;T <sub>3</sub> g;fE <sub>1</sub> g;fE <sub>2</sub> g;fE <sub>3</sub> gg	(0.696, 0.696, 0.696)
4: ffT <sub>1</sub> g;fT <sub>2</sub> g;fT <sub>3</sub> g;fE <sub>1</sub> ;E <sub>2</sub> ;E <sub>3</sub> gg	(0.700, 0.700, 0.700)
5: ffT <sub>1</sub> g;fT <sub>2</sub> g;fT <sub>3</sub> g;fE <sub>1</sub> g;fE <sub>2</sub> ;E <sub>3</sub> gg	(0.703, 0.667, 0.667)
6: ffT <sub>1</sub> g;fT <sub>2</sub> ;T <sub>3</sub> g;fE <sub>1</sub> g;fE <sub>2</sub> g;fE <sub>3</sub> gg	(0.607, 0.692, 0.692)
7: ffT <sub>1</sub> g;fT <sub>2</sub> ;T <sub>3</sub> g;fE <sub>1</sub> g;fE <sub>2</sub> ;E <sub>3</sub> gg	(0.642, 0.695, 0.695)
8: ffT <sub>1</sub> g;fT <sub>2</sub> ;T <sub>3</sub> g;fE <sub>1</sub> ;E <sub>2</sub> g;fE <sub>3</sub> gg	(0.656, 0.668, 0.704)
9: ffT <sub>1</sub> ;T <sub>2</sub> ;T <sub>3</sub> g;fE <sub>1</sub> g;fE <sub>2</sub> ;E <sub>3</sub> gg	(0.742, 0.697, 0.697)
10: ffT <sub>1</sub> g;fT <sub>2</sub> ;T <sub>3</sub> g;fE <sub>1</sub> ;E <sub>2</sub> ;E <sub>3</sub> gg	(0.656, 0.716, 0.716)

Table 2: Agreement Structures and Countries' Payoffs  
 $\alpha = 63=100, \mu = 3=4, \sigma = 2, \gamma = 1/3=2, \tau = 2=3, \pm = 4=3$

Agreement Structure	Countries' Payoffs ( $\frac{1}{4}, \frac{1}{2}, \frac{1}{3}$ )
1: ffT <sub>1</sub> ;T <sub>2</sub> ;T <sub>3</sub> g;fE <sub>1</sub> ;E <sub>2</sub> ;E <sub>3</sub> gg	(0.824, 0.824, 0.824)
2: ffT <sub>1</sub> g;fT <sub>2</sub> g;fT <sub>3</sub> g;fE <sub>1</sub> g;fE <sub>2</sub> g;fE <sub>3</sub> gg	(0.764, 0.764, 0.764)
3: ffT <sub>1</sub> ;T <sub>2</sub> ;T <sub>3</sub> g;fE <sub>1</sub> g;fE <sub>2</sub> g;fE <sub>3</sub> gg	(0.812, 0.812, 0.812)
4: ffT <sub>1</sub> g;fT <sub>2</sub> g;fT <sub>3</sub> g;fE <sub>1</sub> ;E <sub>2</sub> ;E <sub>3</sub> gg	(0.793, 0.793, 0.793)
5: ffT <sub>1</sub> g;fT <sub>2</sub> g;fT <sub>3</sub> g;fE <sub>1</sub> g;fE <sub>2</sub> ;E <sub>3</sub> gg	(0.794, 0.771, 0.771)
6: ffT <sub>1</sub> g;fT <sub>2</sub> ;T <sub>3</sub> g;fE <sub>1</sub> g;fE <sub>2</sub> g;fE <sub>3</sub> gg	(0.717, 0.803, 0.803)
7: ffT <sub>1</sub> g;fT <sub>2</sub> ;T <sub>3</sub> g;fE <sub>1</sub> g;fE <sub>2</sub> ;E <sub>3</sub> gg	(0.735, 0.803, 0.803)
8: ffT <sub>1</sub> g;fT <sub>2</sub> ;T <sub>3</sub> g;fE <sub>1</sub> ;E <sub>2</sub> g;fE <sub>3</sub> gg	(0.764, 0.793, 0.793)
9: ffT <sub>1</sub> ;T <sub>2</sub> ;T <sub>3</sub> g;fE <sub>1</sub> g;fE <sub>2</sub> ;E <sub>3</sub> gg	(0.838, 0.810, 0.810)
10: ffT <sub>1</sub> g;fT <sub>2</sub> ;T <sub>3</sub> g;fE <sub>1</sub> ;E <sub>2</sub> ;E <sub>3</sub> gg	(0.764, 0.805, 0.805)

Table 3: Agreement Structures and Countries' Payoffs

<sup>1</sup> = 1=10,  $\mu$  = 2=5,  $\circ$  = 2,  $\prime$  = i 3=2,  $\bar{\prime}$  = 2=3,  $\pm$  = 4=3

Agreement Structure	Countries' Payoffs ( $\frac{1}{4}$ , $\frac{1}{2}$ , $\frac{1}{3}$ )
1: ffT <sub>1</sub> ; T <sub>2</sub> ; T <sub>3</sub> g; fE <sub>1</sub> ; E <sub>2</sub> ; E <sub>3</sub> gg	(0.907, 0.907, 0.907)
2: ffT <sub>1</sub> g; fT <sub>2</sub> g; fT <sub>3</sub> g; fE <sub>1</sub> g; fE <sub>2</sub> g; fE <sub>3</sub> gg	(0.863, 0.863, 0.863)
3: ffT <sub>1</sub> ; T <sub>2</sub> ; T <sub>3</sub> g; fE <sub>1</sub> g; fE <sub>2</sub> g; fE <sub>3</sub> gg	(0.870, 0.870, 0.870)
4: ffT <sub>1</sub> g; fT <sub>2</sub> g; fT <sub>3</sub> g; fE <sub>1</sub> ; E <sub>2</sub> ; E <sub>3</sub> gg	(0.902, 0.902, 0.902)
5: ffT <sub>1</sub> g; fT <sub>2</sub> g; fT <sub>3</sub> g; fE <sub>1</sub> g; fE <sub>2</sub> ; E <sub>3</sub> gg	(0.928, 0.862, 0.862)
6: ffT <sub>1</sub> g; fT <sub>2</sub> ; T <sub>3</sub> g; fE <sub>1</sub> g; fE <sub>2</sub> g; fE <sub>3</sub> gg	(0.859, 0.868, 0.868)
7: ffT <sub>1</sub> g; fT <sub>2</sub> ; T <sub>3</sub> g; fE <sub>1</sub> g; fE <sub>2</sub> ; E <sub>3</sub> gg	(0.923, 0.866, 0.866)
8: ffT <sub>1</sub> g; fT <sub>2</sub> ; T <sub>3</sub> g; fE <sub>1</sub> ; E <sub>2</sub> g; fE <sub>3</sub> gg	(0.862, 0.863, 0.933)
9: ffT <sub>1</sub> ; T <sub>2</sub> ; T <sub>3</sub> g; fE <sub>1</sub> g; fE <sub>2</sub> ; E <sub>3</sub> gg	(0.936, 0.867, 0.867)
10: ffT <sub>1</sub> g; fT <sub>2</sub> ; T <sub>3</sub> g; fE <sub>1</sub> ; E <sub>2</sub> ; E <sub>3</sub> gg	(0.897, 0.905, 0.905)

Table 4: Agreement Structures and Countries' Payoffs

<sup>1</sup> = 1=10,  $\mu$  = 4=5,  $\circ$  = 2,  $\prime$  = i 3=2,  $\bar{\prime}$  = 2=3,  $\pm$  = 4=3

Agreement Structure	Countries' Payoffs ( $\frac{1}{4}$ , $\frac{1}{2}$ , $\frac{1}{3}$ )
1: ffT <sub>1</sub> ; T <sub>2</sub> ; T <sub>3</sub> g; fE <sub>1</sub> ; E <sub>2</sub> ; E <sub>3</sub> gg	(0.815, 0.815, 0.815)
2: ffT <sub>1</sub> g; fT <sub>2</sub> g; fT <sub>3</sub> g; fE <sub>1</sub> g; fE <sub>2</sub> g; fE <sub>3</sub> gg	(0.749, 0.749, 0.749)
3: ffT <sub>1</sub> ; T <sub>2</sub> ; T <sub>3</sub> g; fE <sub>1</sub> g; fE <sub>2</sub> g; fE <sub>3</sub> gg	(0.754, 0.754, 0.754)
4: ffT <sub>1</sub> g; fT <sub>2</sub> g; fT <sub>3</sub> g; fE <sub>1</sub> ; E <sub>2</sub> ; E <sub>3</sub> gg	(0.811, 0.811, 0.811)
5: ffT <sub>1</sub> g; fT <sub>2</sub> g; fT <sub>3</sub> g; fE <sub>1</sub> g; fE <sub>2</sub> ; E <sub>3</sub> gg	(0.840, 0.756, 0.756)
6: ffT <sub>1</sub> g; fT <sub>2</sub> ; T <sub>3</sub> g; fE <sub>1</sub> g; fE <sub>2</sub> g; fE <sub>3</sub> gg	(0.744, 0.753, 0.753)
7: ffT <sub>1</sub> g; fT <sub>2</sub> ; T <sub>3</sub> g; fE <sub>1</sub> g; fE <sub>2</sub> ; E <sub>3</sub> gg	(0.834, 0.759, 0.759)
8: ffT <sub>1</sub> g; fT <sub>2</sub> ; T <sub>3</sub> g; fE <sub>1</sub> ; E <sub>2</sub> g; fE <sub>3</sub> gg	(0.751, 0.759, 0.845)
9: ffT <sub>1</sub> ; T <sub>2</sub> ; T <sub>3</sub> g; fE <sub>1</sub> g; fE <sub>2</sub> ; E <sub>3</sub> gg	(0.847, 0.760, 0.760)
10: ffT <sub>1</sub> g; fT <sub>2</sub> ; T <sub>3</sub> g; fE <sub>1</sub> ; E <sub>2</sub> ; E <sub>3</sub> gg	(0.806, 0.814, 0.814)

$\mu = 2=5$ ). Recall that under a tie-in restriction only agreement structures 1, 2 and 7 (and its mirror images) are feasible. Country 1 now benefits from moving from 1 to 7, because the costs of forgoing trade cooperation are low and more than offset by the gains from free-riding on environmental cooperation. Under a tie-in constraint, countries 2 and 3 are unable to counterobject, since their payoff under structure 2 is lower than under structure 7; hence structure 7 constitutes a stable objection to the J GA. If, on the other hand, there is no tie-in restriction, structure 6 is a stable counterobjection to 7 (under 6 players 2 and 3 obtain a higher payoff than under 7, and player 1 obtains a lower payoff than under 1). Thus, without a tie-in restriction, structure 7 is not a stable objection by player 1 to the J GA. Removing a tie-in restriction introduces structure 9 as a possible objection, but this also is unstable.

In this scenario, a tie-in negotiation rule hinders multilateral cooperation over trade and environmental policies (case (iii) of Section 3), because it removes the ability for two countries to effectively counter single-country objections. With  $\mu$  small, if a country chooses not to participate in a multilateral environmental agreement, the two remaining countries are better off if they cease environmental cooperation among themselves. This means that free-riding attempts by a single country could be credibly countered by a move to trade policy-only cooperation between the remaining two. With a tie-in restriction, however, the incentives for two countries to keep cooperating along the trade policy dimension override their incentives to split along the environmental policy dimension, making single-country objections stable and the J GA unstable.

In the case represented in Table 4, all the parameters are as in Table 3, except for the inverse marginal damage elasticity  $\mu$ , which is now higher. Under a tie-in restriction, country 1 still benefits from moving from 1 to 7, which remains a stable deviation from the J GA. Now, however, even without a tie-in restriction, this objection cannot be countered by structure 6, since countries 2 and 3 no longer benefit from splitting a partial environmental agreement. This is because a higher  $\mu$  implies positive net benefits from partial environmental cooperation compared with the noncooperative outcome.<sup>25</sup> In this scenario tie-in is irrelevant, because even without it the J GA would

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<sup>25</sup>Note, however, that a higher  $\mu$  also implies a smaller difference in the net benefits between partial environmental cooperation and no cooperation. This is in the line with the results of Barrett (1994), who shows that international environmental agreements can be self-enforcing only when they can

be unstable (case (iv) of Section 3).

Table 5 shows payoffs for the asymmetric structures 8, 9 and 10, and their mirror images, under alternative bargaining rules| Utilitarian and Nash bargaining without side payments and symmetric bargaining with side payments| in each of the four parameterizations. Payoffs in structures 1-7 are unaffected. Results remain the same in some scenarios but change in others. Under Nash bargaining and bargaining with side payments, tie-in becomes irrelevant in the first parameterization (as in Table 1), since structure 9 is no longer attractive for player 1 in comparison to the J GA. Under the third parameter configuration (as in Table 3), a tie-in restriction makes the J GA unstable in both the Utilitarian case without side payments and the case with side payments; with Nash bargaining without any restrictions structure 7 is not a stable objection as in the other two cases, but structure 9 becomes a stable objection to the J GA. Changing bargaining rules makes no difference in the second and fourth parameterizations.

## 5 Concluding Remarks

In this paper we have described an analytical framework for investigating policy coordination choices when players can enter into selective and separate agreements with different partners along different policy dimensions. We have then applied our model of multi-dimensional agreement formation to the study of trade and environmental negotiations between three symmetric countries, focusing on the effects of a tie-in negotiation rule for the stability of multilateral cooperation over trade and environmental policies.

Multilateral cooperation over environmental policy is hindered by an individual country's incentive to free ride on a partial environmental agreement formed by the other two, while trade cooperation is undermined by the incentive for two countries to form a trade bloc against a third country. It has been suggested that one way to offset free-riding incentives and help sustain more cooperation would be to make trade cooperation conditional on environmental cooperation.<sup>26</sup> To do so, countries should

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marginally improve upon the noncooperative outcome.

<sup>26</sup>This idea is implicit in the proposal for an International Agreement on Trade and Environment

Table 5: Countries' Payoffs under Alternative Bargaining Rules

$\alpha = 2, \beta = 1/3, \gamma = 2/3, \delta = 4/3$

Structure	Countries' Payoffs ( $\frac{1}{4}, \frac{1}{2}, \frac{1}{3}$ )		
	Utilitarian	Nash	Side Payments
$\alpha = 2, \beta = 1/3, \gamma = 2/3, \delta = 4/3$			
8	(0.656, 0.668, 0.704)	(0.656, 0.656, 0.656)	(0.685, 0.685, 0.685)
9	(0.742, 0.697, 0.697)	(0.716, 0.712, 0.712)	(0.712, 0.712, 0.712)
10	(0.656, 0.716, 0.716)	(0.677, 0.702, 0.702)	(0.697, 0.697, 0.697)
$\alpha = 2, \beta = 1/3, \gamma = 2/3, \delta = 4/3$			
8	(0.764, 0.793, 0.793)	(0.760, 0.766, 0.769)	(0.786, 0.786, 0.786)
9	(0.838, 0.810, 0.810)	(0.822, 0.819, 0.819)	(0.820, 0.820, 0.820)
10	(0.764, 0.805, 0.805)	(0.773, 0.798, 0.798)	(0.793, 0.793, 0.793)
$\alpha = 2, \beta = 1/3, \gamma = 2/3, \delta = 4/3$			
8	(0.862, 0.863, 0.933)	(0.864, 0.864, 0.918)	(0.886, 0.886, 0.886)
9	(0.936, 0.867, 0.867)	(0.917, 0.875, 0.875)	(0.890, 0.890, 0.890)
10	(0.897, 0.905, 0.905)	(0.901, 0.903, 0.903)	(0.902, 0.902, 0.902)
$\alpha = 2, \beta = 1/3, \gamma = 2/3, \delta = 4/3$			
8	(0.751, 0.759, 0.845)	(0.758, 0.759, 0.832)	(0.785, 0.785, 0.785)
9	(0.847, 0.760, 0.760)	(0.828, 0.768, 0.768)	(0.789, 0.789, 0.789)
10	(0.806, 0.814, 0.814)	(0.810, 0.812, 0.812)	(0.811, 0.811, 0.811)

commit to a tie-in restriction on international negotiations, which would rule out the possibility of signing single-issue agreements. Formally, such a restriction could be thought of as emerging in an initial constitutional stage in which countries can credibly commit to a certain negotiation process.

Our analysis shows that conditionality could indeed play a positive role, by eliminating stable objections to the J GA. But in some cases negotiation tie-in could actually become a hurdle to multilateral cooperation, by making an otherwise stable J GA unstable. If this is the more likely scenario, the policy implication would be that conditionality should be rejected in favour of a °exible system where countries remain free to decide whether to negotiate multiple-issue agreements or single-issue agreements containing clauses that make them compatible with other agreements (e.g. trade rules allowing countries to use trade remedies against countries that are in violation of a formally separate environmental agreement).

Our results also suggest that conditionality can only play a positive role with respect to "small" environmental problems (small in terms of the associated welfare costs and benefits in comparison with the costs and benefits of trade policies), but is more likely to be an impediment to cooperation for broader issues such as climate change. This provides a rationale for what seems to be the prevailing position in policy circles with respect to global climate treaties.<sup>27</sup>

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<sup>27</sup>The need for a separate "World Environment Organization (...), an institutional and legal counterpart to the World Trade Organization", has been stressed by Renato Ruggiero, Director-General of the WTO, in his opening speech at the High Symposium on Trade and Environment, 15th March 1999.

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