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Issue linkage and issue tie-in in multilateral negotiations[☆]

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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. © 2002 Published by Elsevier Science B.V.

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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

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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,¹ 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.² Simply extending the concept of coalition structure to a multi-dimensional framework in order to characterize the viability of multilateral cooperation arrangements, however, 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 interaction, 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 non-cooperative 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 certain counter-objections 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 binding agreements are formed in the first stage and policies are selected in the second stage —

¹The point was first stressed by Raiffa (1982) and Sebenius (1983). For a recent application to North–South trade and environmental policy cooperation, see Abrego et al. (2001). Exchange of concessions under cooperative bargaining is only one of the issue-linkage mechanisms that have been analyzed in the literature. Several papers have focused on cross-issue negotiation linkage in non-cooperative frameworks, such as non-cooperative bargaining (Horstmann et al., 2000) and infinitely-repeated interaction (Spagnolo, 1996; Limão, 2000; Ederington, 2001).

²For an extensive survey of this literature, see Bloch (1997).

cooperatively among countries participating in an agreement and non-cooperatively 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.

It is often argued that, in the absence of a supranational authority with autonomous powers of enforcement, all international agreements must be self-enforcing. While this view of cooperation has been incorporated in several recent models of bilateral cooperation (e.g., Bagwell and Staiger, 1997), analyses of multilateral cooperation have typically adopted a cooperative framework, abstracting from the problem of enforcement as we do here.³ It should nevertheless be stressed that the structure of incentives that makes cooperation sustainable by threat of punishment under infinitely-repeated interaction is consistent with the agreement structures that survive the chain of possible objections and counter-objections brought by individual players or by coalitions of players in the cooperative solution concept we describe.⁴

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

³A notable exception is Maggi (1999).

⁴Self-enforcing agreements are only sustainable if the structure of cooperation incentives associated with the underlying non-cooperative game permits it; for example, infinitely-repeated trade policy interaction between a large economy and a small open economy under conditions of constant-returns-to-scale production and perfect competition can never support free trade if this does not Pareto dominate tariff retaliation, unless side-payments are used. In a scenario with three symmetric countries, if free trade does not Pareto dominate a preferential trade agreement between two countries for the two countries concerned, it may not be sustainable if we apply a static solution concept such as the Core, but it may be sustainable under repeated interaction; in the latter case, however, there may still exist Pareto-undominated subgame-perfect equilibria in which two countries adopt discriminatory strategies. There are no clear theoretical guidelines for selecting a particular equilibrium over another in such cases, but the incentives to form a preferential agreement remain; and, just as Pareto dominance is used as an equilibrium selection mechanism for two-player repeated games, one could employ a cooperative solution concept as an equilibrium selection mechanism in multi-player situations.

the policy debate on trade and environment, that the WTO should act as an international policing organ, forcing countries to cooperate over issues that do not strictly pertain to trade policy narrowly defined.⁵ 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),⁶ without directly extending its reach to cover environmental issues, thus rejecting conditionality as a means of promoting compliance.⁷

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.

⁵On this point, see Whalley and Hamilton (1996).

⁶For 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 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, 15–16 March 1999, which are available on the WTO web site.

⁷On 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 on "Policing the Global Economy", on 23 March 1998.

2. Multi-dimensional agreement formation

This section formalizes cooperation choices in an environment where agents can enter into separate agreements with different partners on different policy dimensions. In analyses of coalition formation, coalitions are described as a subset of players who make coordinated choices over their strategies. To model selective cooperation, we simply relax the restriction, implicit in the notion of coalition, that players must pool *all* of their strategies when they choose to cooperate with each other, and allow instead for the formation of issue-specific agreements.

In order to characterize the resulting equilibrium cooperative arrangements, we describe a Core-like equilibrium concept, which we call *Stable Agreement Structure*, whereby subsets of players can put forward objections to a certain proposed configuration of agreements. This is a natural extension of similar constructs that have been proposed for games of coalition formation, such 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 “blocking” *coalitions* of players who can make coordinated objections to a proposed agreement structure. The two concepts are logically distinct: agreement structures determine payoffs after cooperation choices are made; 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.⁸ Objections are themselves required to be immune from further objections by subsets of players within the objecting coalitions.⁹

The remainder of this section provides a full formalization of the game and the equilibrium concept.

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 $i \in I$, Σ_i , be an $N(i)$ -dimensional vector space, with $N(i) \in N$, $i \in I$, representing the number of dimensions in each player's strategy. Strategies for player i are denoted by $\sigma_i \in \Sigma_i$.

⁸In situations where agreements strategically interact with each other (*partition-function* games, often also described as “games with externalities”), it may be 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. 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).

⁹This consistency requirement, ruling out coalitional deviations that are not themselves immune from further deviations, also characterizes equilibrium concepts such as the Coalition-Proof Nash Equilibrium of Bernheim et al. (1987) and the Equilibrium Binding Agreements of Ray and Vohra (1997).

Assumption 1. $\Sigma_i = \times_{j \in \{1, \dots, N(i)\}} \Sigma_{i,j}$, $i \in I$, where the $\Sigma_{i,j}$, $i \in I$, $j \in N(i)$, 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.¹⁰

Definition 1. The sets $\Sigma_{i,j}$, $i \in I$, $j \in N(i)$, are *elementary strategy sets* and their elements, $\sigma_{i,j}$, elementary strategies.

The space of strategy profiles is $\Sigma \equiv \times_{i \in I} \Sigma_i = \times_{i \in I} \times_{j \in \{1, \dots, N(i)\}} \Sigma_{i,j}$, and strategy profiles are $\sigma \in \Sigma$. Players' payoffs are represented by real-valued mappings $\pi_i : \Sigma \rightarrow R$, $i \in I$.

Let $S(i) \equiv \{s \equiv (i,j) \mid j \in \{1, \dots, N(i)\}\}$, $i \in I$ — 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 (s corresponds to a valid index pair (i,j) for elementary strategies σ_{ij}) — and $S \equiv \cup_{i \in I} S(i)$ — 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. Here 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 $\sigma^g \equiv (\sigma_s \mid s \in g)$, and the set of such sub-profiles — the strategy set of agreement g — will be denoted as Σ^g .

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

¹⁰The 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.

Note that Assumption 1 ensures that if a player assigns elementary strategies to different agreements, the strategy sets of the different agreements are independent sets.¹¹

Definition 3. A participant to agreement g , $\tilde{i}^g \in \{i \in I \mid (i, j) \in g \text{ for some } j\}$, 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 .

The vector of payoffs for the participants to agreement g , in the non-cooperative game that ensues agreement formation, will be denoted by $\pi^g(\sigma) \equiv (\pi_i(\sigma) \mid i \in I^g)$.

The behaviour of agreements in the non-cooperative stage is described as follows:

Assumption 2. (agreements' behaviour) Each agreement $g \in G$ chooses $\sigma^g \in \Sigma^g$ so as to attain a maximal element of $\Pi^g(\sigma^g, \sigma^{-g}) \equiv \{\pi^g(\sigma^g, \sigma^{-g}) \mid (\sigma^g, \sigma^{-g}) \in \Sigma\}$ (where $-g$ stands for $G - g$). The best-reply correspondence of agreement g , $\hat{\sigma}^g : \Sigma^{-g} \rightarrow \Sigma^g$, is thus defined as $\hat{\sigma}^g(\sigma^{-g}) = \arg \sup_{\sigma^g} \Pi^g(\sigma^g, \sigma^{-g})$.

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

Definition 4. A non-cooperative outcome for the agreement structure G is a strategy profile $\tilde{\sigma}$ such that $\tilde{\sigma}^g \in \hat{\sigma}^g(\tilde{\sigma}^{-g})$, $g \in G$. The set of non-cooperative outcomes for the agreement structure G is denoted by $\tilde{\Sigma}(G)$.

2.2. Stable agreement structures

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 $(s = (i, j) \in S, \pi_i)$, i.e. an element of S

¹¹Cross-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.

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 π_s .¹²

We shall also need the following definitions:

Definition 6. A *restricted agreement structure* $\tilde{G}(S')$, $S' \subseteq S$, is a partition of S' .

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

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

Our equilibrium concept can be described recursively: an equilibrium agreement structure must be immune from objections, and blocking objections must not only be profitable, but also immune from further external or internal deviations, i.e. they must involve arrangements that are stable (in a restricted sense) according to the very definition of stability so obtained. 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.¹³ This can be formalized in terms of the following two definitions:

Definition 8. A restricted agreement structure $\tilde{G}(S')$, $S' \subseteq S$, can be *blocked*, within an agreement structure $G' \equiv \tilde{G}(S') \cup \tilde{G}(S - S')$, by a coalition $S'' \subseteq S'$ of elementary players if there exists a restricted agreement structure $\tilde{G}(S'')$ — involving only elementary players in the blocking coalition — such that, for each of the restricted structures $\tilde{G}(S' - S'')$ — involving the remaining elementary players in S' — that cannot be blocked within the combined structure $G'' \equiv \tilde{G}(S'') \cup \tilde{G}(S' - S'') \cup \tilde{G}(S - S') \in \mathcal{G}$, we have that (i) $\forall \tilde{\alpha}(G'') \in \tilde{\Sigma}(G'')$, $\forall \tilde{\alpha}(G') \in$

¹²No problem of interpretation arises with respect to the second stage of the game: under Assumption 2, the set of non-cooperative 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.

¹³This construct 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 re-form 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. Under Ray and Vohra's (1997) Equilibrium Binding Agreement rule, existing agreement structures are only allowed to break up into smaller agreements.

$\tilde{\Sigma}(G')$, it is the case that $\pi_s(\tilde{\sigma}(G'')) \geq \pi_s(\tilde{\sigma}(G'))$, $s \in S''$, with the inequality being strict for at least one $s \in S''$; and (ii) $\tilde{G}(S'')$ cannot be blocked within G'' .¹⁴ If $\tilde{G}(S'')$ satisfies the above conditions, we say that it is a *stable objection* to $\tilde{G}(S')$ by S'' .

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

As is the case for analogous solution concepts, an equilibrium is not generally guaranteed to exist. The concept of Stable Agreement Structure may also be difficult to operationalize owing to the large number of potential objections and counter-objections involved. In our application, however, we shall focus on a scenario with only three players and two dimensions of choice, where the solution concept is manageable.

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, which implies that there will typically exist a continuum of non-cooperative equilibria for any agreement structure. In the rest of our analysis, we shall narrow down the set of possible non-cooperative outcomes by assuming a fixed payoff distribution rule within an agreement g , arising as the solution to a bargaining problem amongst 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 payoffs of participants, π_i^{Dg} , $i \in I^g$. Given these, optimal policy choices by an agreement can be characterized as the policy combination (or set of combinations) which maximizes $B(\pi_i - \pi_i^{Dg}, i \in I^g)$, where B is a symmetric, concave function.¹⁵

Consistently with our characterization of stability, the disagreement point D

¹⁴According to this definition, an objection is viable for a coalition only if it yields a Pareto superior outcome for its members under *all* stable counter-objections that the other players can put forward. This idea is analogous to Greenberg's (1990) concept of "pessimistic standard of behaviour".

¹⁵It 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.

should be based on the stable outcomes that prevail if a certain agreement were not to form. One can interpret this specification as implying an initial “pre-agreement” stage where players can unilaterally commit not to enter into certain agreements with certain partners.¹⁶ In the application of Section 4, we shall focus on a scenario where, in this pre-agreement 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.

The agreement formation game as we have described it above does not rule out the possibility of side-payments, if feasible. Side-payments can be formally treated just like additional dimensions of the players’ strategies, which serve to augment bargaining possibilities within agreements.¹⁷

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 player 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, eliminates the possibility of partially overlapping agreement structures, which affects both the set of feasible proposals as well as the set of 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*

¹⁶Since 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 the equilibrium payoff distribution that would arise within the resulting restricted space of agreement structures. Such payoff distribution, in turn, depends on the payoff distribution in alternative agreements, which implies that the characterization of the disagreement payoffs for the various agreements is linked, recursively, to the characterization of stability of the restricted structures that are involved in the various objections and counter-objections. This is consistent with the extensions of the Shapley Value for coalition-form games proposed by Aumann and Myerson (1988).

¹⁷There is nothing in the formal description of the game that would rule out side-payments between agreements in the non-cooperative stage of the game; but, since side-payments, if present, would be chosen concurrently with other actions, no agreement would ever choose to make a unilateral transfer to another agreement. Conditional side-payments from one agreement to another, on the other hand, could be used as a bribe; in our solution concept this would be described as a configuration where the participants in the two agreements choose to form a common agreement that includes transfers as an elementary strategy, either in isolation — in which case side-payments would always be zero under a symmetric bargaining rule — or in conjunction with other elementary strategies.

Global Agreement (JGA), $J \equiv \{\{S\}\}$ — the agreement structure where all players jointly cooperate over all strategic dimensions?

Formally, let $\hat{\mathcal{G}}$ be 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 $\hat{\mathcal{G}}$. A *partially overlapping* agreement structure is an element of $\mathcal{G} - \hat{\mathcal{G}}$.

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

Suppose that, without a tie-in restriction, the set of feasible agreement structures is simply $\tilde{\mathcal{G}} = \mathcal{G}$, and let the sets of Stable Agreement Structures with and without a tie-in restriction be respectively denoted as \mathcal{G}^R and \mathcal{G}^U . Then, theoretically, four possibilities arise: (i) $J \in \mathcal{G}^R \cap \mathcal{G}^U$; (ii) $J \in \mathcal{G}^R - (\mathcal{G}^R \cap \mathcal{G}^U)$; (iii) $J \in \mathcal{G}^U - (\mathcal{G}^R \cap \mathcal{G}^U)$; (iv) $J \notin \mathcal{G}^R \cap \mathcal{G}^U$. In cases (i) and (iv), a tie-in restriction is irrelevant for the stability of the JGA: 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.¹⁸ 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 JGA stable — by eliminating a partially overlapping agreement structure that would otherwise constitute a stable objection to it as in case (ii) above — make the JGA 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. Whether a tie-in restriction will help or hinder multilateral cooperation therefore depends on the payoff structure of the underlying non-cooperative game.

¹⁸For 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.

How should such a tie-in rule be interpreted? It could be thought of as a negotiation rule to which all parties agree at a pre-negotiation stage, a rule that is binding just as agreements are.¹⁹ Alternatively, we may think of a tie-in rule as a purely analytical device for exploring how applying the usual notion of issue-inclusive coalitions to multi-issue situations, rather than allowing for selective cooperation, can bias conclusions as to the viability of multilateral cooperation.

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 multilateral 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.

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

¹⁹This interpretation is consistent with our modelling framework but would be difficult to reconcile with the idea that international agreements must be self-enforcing. Moreover, if a negotiation tie-in rule is enforceable, why should it not be possible to enforce even stricter negotiation rules (e.g., an outright ban on preferential agreements)?

competition. Environmental emissions are “global”, i.e. countries are equally affected by foreign and domestic emissions. Each country $i \in I \equiv \{1,2,3\}$ is endowed with an amount \bar{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 non-traded 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 $k \in I$ are described by a quasilinear, isoelastic utility function:

$$u_k(M_k, Q_k) \equiv M_k + \frac{\beta}{1 + 1/\eta} Q_k^{1+1/\eta} - \frac{\delta}{1 + 1/\theta} D^{1+1/\theta}, \quad k \in I, \tag{1}$$

where M_k is consumption of the non-traded good, Q_k is composite consumption of the traded goods — an isoelastic aggregation of the quantities q_{ik} produced in country i (origin) and consumed by country k (destination), i.e.

$$Q_k = \left[(1 - \mu)^{1/\gamma} q_{kk}^{(\gamma-1)/\gamma} + (\mu/2)^{1/\gamma} \sum_{i \neq k} q_{ik}^{(\gamma-1)/\gamma} \right]^{\gamma/(\gamma-1)}, \tag{2}$$

with γ representing the elasticity of substitution in consumption between traded goods from different sources, and μ representing the share of imports in total tradeables demand $\eta < 0$ is the (constant) elasticity of demand; for the tradeables aggregate; β is a positive scalar; D are global emissions; $\theta > 0$ is the (constant) inverse elasticity of marginal damage valuation with respect to global emissions, and δ is a positive scalar.

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

$$Q_k = [p_k / (\beta m_k)]^\eta, \quad k \in I, \tag{3}$$

where

$$p_k = \left[(1 - \mu) w_{kk}^{1-\gamma} + (\mu/2) \sum_{i \neq k} w_{ik}^{1-\gamma} \right]^{1/(1-\gamma)}, \quad k \in I, \tag{4}$$

m_k is the price of the non-traded 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

$$q_{ik} = \left(\frac{p_k}{\beta m_k} \right)^\eta \alpha_{ik} \left(\frac{p_k}{w_{ik}} \right)^\gamma, \quad i \in I, k \in I, \tag{5}$$

where $\alpha_{ik} = \mu/2$, $i = k$, and $\alpha_{kk} = 1 - \mu$, $i \neq k$.

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 emission are then simply

$$D \equiv \sum_{ik} q_{ik}, \quad k \in I. \tag{6}$$

We restrict the government in country k to using 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 the non-traded good is

$$M_i = \frac{m_i \bar{M}_i + \sum_k [e_i m_i q_{ik} + t_{ki} m_k (1 + e_k) q_{ki}] - p_i Q_i}{m_i}, \quad i \in I. \tag{7}$$

Market clearing then requires

$$M_i + \sum_k q_{ik} - \bar{M}_i = 0, \quad i \in I. \tag{8}$$

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

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

For the purpose of our analysis, a country’s payoff is defined as the sum of consumer surplus and real tariff and tax revenues, minus environmental damage; it is equal to the difference between utility and the endowment \bar{M}_i :

$$\pi_i = u_i(M_i, Q_i) - \bar{M}_i, \quad i \in I. \tag{10}$$

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

4.2. Feasible agreement structures

As discussed in Section 2, it is useful to redefine 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 exists 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,²⁰ this combination being a solution for the first-order conditions $\partial \pi_i / \partial t_{ik} = 0$, $k \in I$, and $\partial \pi_i / \partial e_i = 0$. In turn these conditions are equivalent to best-response conditions obtained by maximizing π_i separately by choice of t_{ik} , $k \in I$, 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

²⁰The payoff π_i is concave in e_i and t_{ik} .

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.²¹ In other words, two separate agreements over trade and environmental policies respectively between two players are here the same as a joint (perfectly overlapping) 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-five possible agreement structures, which, given the symmetry assumption, can be restricted to the following ten:

1. Joint Global Agreement (JGA):

$$\{\{T_1, T_2, T_3\}, \{E_1, E_2, E_3\}\};$$

2. No agreement on either issue:

$$\{\{T_1\}, \{T_2\}, \{T_3\}, \{E_1\}, \{E_2\}, \{E_3\}\};$$

3. Global trade agreement, no environmental agreement:

$$\{\{T_1, T_2, T_3\}, \{E_1\}, \{E_2\}, \{E_3\}\};$$

4. Global environmental agreement, no trade agreement:

$$\{\{T_1\}, \{T_2\}, \{T_3\}, \{E_1, E_2, E_3\}\};$$

²¹If, 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.

5. Partial environmental agreement, no trade agreement:

$$\{\{T_1\}, \{T_2\}, \{T_3\}, \{E_1\}, \{E_2, E_3\}\};$$

6. Partial trade agreement, no environmental agreement:

$$\{\{T_1\}, \{T_2, T_3\}, \{E_1\}, \{E_2\}, \{E_3\}\};$$

7. Partial perfectly overlapping agreements on trade and environment:

$$\{\{T_1\}, \{T_2, T_3\}, \{E_1\}, \{E_2, E_3\}\};$$

8. Partial agreements on trade and environment:

$$\{\{T_1\}, \{T_2, T_3\}, \{E_1, E_2\}, \{E_3\}\};$$

9. Global trade agreement and partial environmental agreement:

$$\{\{T_1, T_2, T_3\}, \{E_1\}, \{E_2, E_3\}\};$$

10. Global environmental agreement and partial trade agreement:

$$\{\{T_1\}, \{T_2, T_3\}, \{E_1, E_2, E_3\}\}.$$

The presence of a cross-issue 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

Note that in this symmetric setup an even stronger tie-in rule forcing conditionality not just across issues but also across agreements (i.e. a rule which constrains countries to negotiating multilateral, multi-issue agreements) would result in the JGA always forming. Thus, what we address here is really a “second-best” question: if full conditionality cannot be imposed, would imposing *partial* conditionality facilitate multilateral cooperation?

If we apply the equilibrium concept described in Section 2 to examine this question, 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) $\pi_i^1 > \pi_i^2$ and $\pi_i^1 > \pi_i^{7*} \forall i$, 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' for which: (i) $\pi_j^{G'} > \pi_j^1$; and (ii) within the set of agreement structures that the other two countries k and h can put forward as counter-objections to G' , there is no structure G'' such that $\pi_k^{G''} \geq \pi_k^{G'}$ and $\pi_h^{G''} \geq \pi_h^{G'}$ (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' for which: (i) $\pi_k^{G'} \geq \pi_k^1$ and $\pi_h^{G'} \geq \pi_h^1$ (with at least one inequality being strict); and (ii) within the set of agreement structures that a third country j can put forward as counter-objections to G' , there is no structure G'' such that $\pi_j^{G''} > \pi_j^{G'}$.

Proposition 2. *A tie-in negotiation rule makes an otherwise stable JGA unstable if and 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) $\pi_j^{7*} > \pi_j^1$ and $\pi_k^{7*} = \pi_h^{7*} > \pi_k^2 = \pi_h^2$, 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 counter-objections to 7^* (including agreement structures 5 and 6 and their mirror images), consider the agreement structure, G' , that yields the highest payoff for countries k and h . Then it must be true that (i) $\pi_k^{G'} = \pi_h^{G'} > \pi_k^{7*} = \pi_h^{7*}$; and (ii) $\pi_j^{G'} < \pi_j^1$; and
- (b.2) no partially overlapping agreement structure (including agreement structures 3, 4, 5, 6, 8, 9 and 10 and their mirror images) is a stable objection to the JGA.

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 $\delta = 0$), 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 gains 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 a move to the excluded country, increase with the importance of trade as reflected in the magnitude of μ .

On the environmental policy side, leaving trade aside (i.e. setting $\mu = 0$), 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 decrease with the elasticity of environmental policy responses to changes in marginal damage valuation, which in turn depends primarily on θ (the lower θ 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 non-cooperation preferable for the remaining two. This is a well-known result and a theme that runs through the literature on environmental agreement formation.²²

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 clear-cut a manner as the above discussion suggests. In particular, as μ approaches unity, import tariffs and emission taxes become progressively closer substitutes.

To illustrate the potential effects of a negotiation tie-in restriction, below we present four different examples, involving alternative parameterizations of the model. Note that, 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; the symmetric bargaining rule we specify to identify coordinated best responses in these asymmetric structures is Utilitarian bargaining ($B(\pi_i - \pi_i^D, i \in I^g) = \sum_{i \in I^g} (\pi_i - \pi_i^D)$) with no side-pay-

²²See, for example, Barrett (1994).

Table 1
 Agreement structures and countries' payoffs; $\mu = 63/100$, $\theta = 3/2$, $\gamma = 2$, $\eta = -3/2$, $\beta = 2/3$, $\delta = 4/3$

Agreement structure	Countries' payoffs (π_1, π_2, π_3)
1: $\{\{T_1, T_2, T_3\}, \{E_1, E_2, E_3\}\}$	(0.722, 0.722, 0.722)
2: $\{\{T_1\}, \{T_2\}, \{T_3\}, \{E_1\}, \{E_2\}, \{E_3\}\}$	(0.656, 0.656, 0.656)
3: $\{\{T_1, T_2, T_3\}, \{E_1\}, \{E_2\}, \{E_3\}\}$	(0.696, 0.696, 0.696)
4: $\{\{T_1\}, \{T_2\}, \{T_3\}, \{E_1, E_2, E_3\}\}$	(0.700, 0.700, 0.700)
5: $\{\{T_1\}, \{T_2\}, \{T_3\}, \{E_1\}, \{E_2, E_3\}\}$	(0.703, 0.667, 0.667)
6: $\{\{T_1\}, \{T_2, T_3\}, \{E_1\}, \{E_2\}, \{E_3\}\}$	(0.607, 0.692, 0.692)
7: $\{\{T_1\}, \{T_2, T_3\}, \{E_1\}, \{E_2, E_3\}\}$	(0.642, 0.695, 0.695)
8: $\{\{T_1\}, \{T_2, T_3\}, \{E_1, E_2\}, \{E_3\}\}$	(0.656, 0.668, 0.704)
9: $\{\{T_1, T_2, T_3\}, \{E_1\}, \{E_2, E_3\}\}$	(0.742, 0.697, 0.697)
10: $\{\{T_1\}, \{T_2, T_3\}, \{E_1, E_2, E_3\}\}$	(0.656, 0.716, 0.716)

ments (see Thomson, 1995), and with the disagreement point for bargaining being given by the payoffs under structure 2 (no cooperation).²³

Tables 1–4 report non-cooperative equilibrium payoffs under each of the ten agreement structures described in the previous subsection, for different

Table 2
 Agreement structures and countries' payoffs; $\mu = 63/100$, $\theta = 3/4$, $\gamma = 2$, $\eta = -3/2$, $\beta = 2/3$, $\delta = 4/3$

Agreement structure	Countries' payoffs (π_1, π_2, π_3)
1: $\{\{T_1, T_2, T_3\}, \{E_1, E_2, E_3\}\}$	(0.824, 0.824, 0.824)
2: $\{\{T_1\}, \{T_2\}, \{T_3\}, \{E_1\}, \{E_2\}, \{E_3\}\}$	(0.764, 0.764, 0.764)
3: $\{\{T_1, T_2, T_3\}, \{E_1\}, \{E_2\}, \{E_3\}\}$	(0.812, 0.812, 0.812)
4: $\{\{T_1\}, \{T_2\}, \{T_3\}, \{E_1, E_2, E_3\}\}$	(0.793, 0.793, 0.793)
5: $\{\{T_1\}, \{T_2\}, \{T_3\}, \{E_1\}, \{E_2, E_3\}\}$	(0.794, 0.771, 0.771)
6: $\{\{T_1\}, \{T_2, T_3\}, \{E_1\}, \{E_2\}, \{E_3\}\}$	(0.717, 0.803, 0.803)
7: $\{\{T_1\}, \{T_2, T_3\}, \{E_1\}, \{E_2, E_3\}\}$	(0.735, 0.803, 0.803)
8: $\{\{T_1\}, \{T_2, T_3\}, \{E_1, E_2\}, \{E_3\}\}$	(0.764, 0.793, 0.793)
9: $\{\{T_1, T_2, T_3\}, \{E_1\}, \{E_2, E_3\}\}$	(0.838, 0.810, 0.810)
10: $\{\{T_1\}, \{T_2, T_3\}, \{E_1, E_2, E_3\}\}$	(0.764, 0.805, 0.805)

²³Since the game we examine is not superadditive, the “surplus” achieved by a partial agreement can be negative. In such cases, we take the disagreement point as an upper bound rather than a lower bound for bargaining (in other words, if there are no feasible joint strategies that can make both players weakly better off in comparison with the disagreement point, then we require that both players be made worse off).

Table 3
 Agreement structures and countries' payoffs; $\mu = 1/10$, $\theta = 2/5$, $\gamma = 2$, $\eta = -3/2$, $\beta = 2/3$, $\delta = 4/3$

Agreement structure	Countries' payoffs (π_1, π_2, π_3)
1: $\{T_1, T_2, T_3\}, \{E_1, E_2, E_3\}$	(0.907, 0.907, 0.907)
2: $\{T_1\}, \{T_2\}, \{T_3\}, \{E_1\}, \{E_2\}, \{E_3\}$	(0.863, 0.863, 0.863)
3: $\{T_1, T_2, T_3\}, \{E_1\}, \{E_2\}, \{E_3\}$	(0.870, 0.870, 0.870)
4: $\{T_1\}, \{T_2\}, \{T_3\}, \{E_1, E_2, E_3\}$	(0.902, 0.902, 0.902)
5: $\{T_1\}, \{T_2\}, \{T_3\}, \{E_1\}, \{E_2, E_3\}$	(0.928, 0.862, 0.862)
6: $\{T_1\}, \{T_2, T_3\}, \{E_1\}, \{E_2\}, \{E_3\}$	(0.859, 0.868, 0.868)
7: $\{T_1\}, \{T_2, T_3\}, \{E_1\}, \{E_2, E_3\}$	(0.923, 0.866, 0.866)
8: $\{T_1\}, \{T_2, T_3\}, \{E_1, E_2\}, \{E_3\}$	(0.862, 0.863, 0.933)
9: $\{T_1, T_2, T_3\}, \{E_1\}, \{E_2, E_3\}$	(0.936, 0.867, 0.867)
10: $\{T_1\}, \{T_2, T_3\}, \{E_1, E_2, E_3\}$	(0.897, 0.905, 0.905)

parameterizations.²⁴ In all cases we set $\beta = 2/3$, $\delta = 4/3$, $\eta = -3/2$, and $\gamma = 2$, and vary only the values of μ and θ . 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 ($\mu = 63/100$) and the inverse marginal damage valuation elasticity is large ($\theta = 3/2$). 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 counter-objections by 2 and 3 (structures 2, 3, 5, 6, 7 and the mirror image of structure 8²⁵) yield a lower payoff for them.

Table 4
 Agreement structures and countries' payoffs; $\mu = 1/10$, $\theta = 4/5$, $\gamma = 2$, $\eta = -3/2$, $\beta = 2/3$, $\delta = 4/3$

Agreement structure	Countries' payoffs (π_1, π_2, π_3)
1: $\{T_1, T_2, T_3\}, \{E_1, E_2, E_3\}$	(0.815, 0.815, 0.815)
2: $\{T_1\}, \{T_2\}, \{T_3\}, \{E_1\}, \{E_2\}, \{E_3\}$	(0.749, 0.749, 0.749)
3: $\{T_1, T_2, T_3\}, \{E_1\}, \{E_2\}, \{E_3\}$	(0.754, 0.754, 0.754)
4: $\{T_1\}, \{T_2\}, \{T_3\}, \{E_1, E_2, E_3\}$	(0.811, 0.811, 0.811)
5: $\{T_1\}, \{T_2\}, \{T_3\}, \{E_1\}, \{E_2, E_3\}$	(0.840, 0.756, 0.756)
6: $\{T_1\}, \{T_2, T_3\}, \{E_1\}, \{E_2\}, \{E_3\}$	(0.744, 0.753, 0.753)
7: $\{T_1\}, \{T_2, T_3\}, \{E_1\}, \{E_2, E_3\}$	(0.834, 0.759, 0.759)
8: $\{T_1\}, \{T_2, T_3\}, \{E_1, E_2\}, \{E_3\}$	(0.751, 0.759, 0.845)
9: $\{T_1, T_2, T_3\}, \{E_1\}, \{E_2, E_3\}$	(0.847, 0.760, 0.760)
10: $\{T_1\}, \{T_2, T_3\}, \{E_1, E_2, E_3\}$	(0.806, 0.814, 0.814)

²⁴Since no closed-form solutions for payoffs as a function of policies are available, we have used numerical methods to obtain the non-cooperative payoff values.

²⁵The 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 $\pi_1 = 0.704$, $\pi_2 = 0.668$, and $\pi_3 = 0.656$.

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 θ large, two countries prefer partial environmental policy cooperation between themselves to full non-cooperation. This implies that, if a country attempts to free ride in 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 (μ 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 country 1, this deviation would not be stable whether or not a tie-in restriction is present, because countries 2 and 3 would counter-object 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 ($\mu = 1/10$, $\theta = 2/5$). 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 counter-object, since their payoff under structure 2 is lower than under structure 7; hence structure 7 constitutes a stable objection to the JGA. If, on the other hand, there is no tie-in restriction, structure 6 is a stable counter-objection 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 JGA. 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 makes it more difficult for two countries to counter single-country objections effectively. With θ 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 JGA unstable.

In the case presented in Table 4, all the parameters are as in Table 3, except for the inverse marginal damage elasticity θ , 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 JGA. 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 θ implies positive net benefits from partial environmental cooperation compared with the non-cooperative outcome.²⁶ In this scenario tie-in is irrelevant, because even without it the JGA would be unstable (case (iv) of Section 3).²⁷

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

²⁶Note, however, that a higher θ also implies a smaller difference in the net benefits between partial environmental cooperation and no cooperation. This is in line with the results of Barrett (1994), who shows that international environmental agreements can be self-enforcing only when they can marginally improve upon the non-cooperative outcome.

²⁷To get some idea of how likely negotiation tie-in is to affect JGA stability in our model, we have also performed a systematic grid search varying θ from 0.1 to 1.0 by increments of 0.1, and μ from 0.05 to 0.95 by increments of 0.05 — a total of 190 points — leaving all other parameters unchanged. In 37% of these cases, negotiation tie-in has an effect on stability of the JGA; in 10% of the cases where it makes a difference, tie-in makes an otherwise stable JGA unstable, while in the remaining cases it has the opposite effect. We have also performed sensitivity analysis with respect to alternative bargaining rules, namely Nash bargaining without side-payments and symmetric bargaining with side-payments being possible within trade and/or environmental agreements (because of quasilinearity, side-payments imply transferable utility, which in turn makes the bargaining outcome invariant with respect to changes in the form of B). Results remain the same in some scenarios but change in others. For example, under both Nash bargaining and bargaining with side-payments, tie-in becomes irrelevant with the parameterization of Table 1. For the parameter configuration of Table 3, a tie-in restriction still makes the JGA unstable under bargaining with side-payments, but has no effect under Nash bargaining.

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.²⁸ To do so, countries should 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 JGA. But in some cases negotiation tie-in could actually become a hurdle to multilateral cooperation, by making an otherwise stable JGA unstable. If this is the more likely scenario, the policy implication would be that conditionality should be rejected in favour of a flexible 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 facilitating role in the case of “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.²⁹

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²⁸This notion is implicit in the proposal for an International Agreement on Trade and Environment (International Institute for Sustainable Development, 1996).

²⁹The 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, 15 March 1999.

References

- Abrego, L.E., Perroni, C., Whalley, J., Wigle, R.M., 2001. Trade and environment: bargaining outcomes from linked negotiations. *Review of International Economics* 9, 414–428.
- Aumann, R.J., Myerson, R.B., 1988. Endogenous formation of links between players and of coalitions: an application of the Shapley Value. In: Roth, A.E. (Ed.), *The Shapley Value*. Cambridge University Press, Cambridge, pp. 175–191.
- Bagwell, K., Staiger, R.W., 1997. Multilateral tariff cooperation during the formation of regional Free Trade Areas. *International Economic Review* 38, 291–319.
- Barrett, S., 1994. Self-enforcing international environmental agreements. *Oxford Economic Papers* 46, 878–894.
- Bernheim, B.D., Peleg, B., Whinston, M.D., 1987. Coalition-proof Nash equilibria: 1. Concepts. *Journal of Economic Theory* 42, 1–12.
- Bloch, F., 1997. Non-cooperative models of coalition formation in games with spillovers. In: Carraro, C., Siniscalco, D. (Eds.), *New Directions in the Economic Theory of the Environment*. Cambridge University Press, Cambridge.
- Bond, E., Syropoulos, C., 1993. Optimality and stability of regional trading blocs. University of Birmingham Department of Economics Discussion Paper No. 93-11.
- Brack, D., 1997. *Trade and Environment: Conflict or Compatibility*. The Royal Institute of International Affairs, London.
- Burbidge, J.B., DePater, J.A., Myers, G.M., Sengupta, A., 1997. A coalition-formation approach to equilibrium federations and trading blocs. *American Economic Review* 87, 940–956.
- Carraro, C., Siniscalco, D., 1993. Strategies for the protection of the environment. *Journal of Public Economics* 52, 309–328.
- Carraro, C., Siniscalco, D., 1994. Policy coordination for sustainability: commitments, transfers, and linked negotiations. In: Goldin, I., Winters, A. (Eds.), *The Economics of Sustainable Development*. Cambridge University Press, Cambridge, pp. 264–282.
- Chander, P., Tulkens, H., 1992. Theoretical foundations of negotiations and cost sharing in transfrontier pollution problems. *European Economic Review* 36, 388–398.
- Ederington, J., 2001. International coordination of trade and domestic policies. *American Economic Review* (forthcoming).
- Esty, D.C., 1994. *Greening the GATT: Trade, Environment, and the Future*. Institute for International Economics, Washington, DC.
- Greenberg, J., 1990. *The Theory of Social Situations: An Alternative Game-theoretic Approach*. Cambridge University Press, Cambridge.
- Horstmann, I.J., Markusen, J.R., Robles, J., 2000. Multi-issue bargaining and linked games: issues and agenda setting for international negotiations. Mimeo, University of Western Ontario and University of Colorado.
- Kennan, J., Riezman, R., 1990. Optimal tariff equilibria with Customs Unions. *Canadian Journal of Economics* 90, 70–83.
- Krugman, P., 1991. Is regionalism bad? In: Helpman, E., Razin, A. (Eds.), *International Trade and Trade Policy*. MIT Press, Cambridge, MA, pp. 9–24.
- Limão, N., 2000. Trade policy, cross-border externalities, and lobbies: do linked agreements enforce more cooperative outcomes? Mimeo, Columbia University.
- Maggi, G., 1999. The role of multilateral institutions in international trade cooperation. *American Economic Review* 89, 190–214.
- Raiffa, H., 1982. *The Art and Science of Negotiation*. Harvard University Press, Cambridge, MA.
- Ray, D., Vohra, R., 1997. Equilibrium binding agreements. *Journal of Economic Theory* 73, 30–78.
- Riezman, R., 1985. Customs Unions and the Core. *Journal of International Economics* 19, 355–365.
- Sebenius, J.K., 1983. Negotiation arithmetic: adding and subtracting issues and parties. *International Organization* 37, 281–316.

- Spagnolo, G., 1996. Issue linkage, delegation, and international policy cooperation. Fondazione Eni Enrico Mattei Working Paper No. 49.96.
- Thomson, W., 1995. Cooperative models of bargaining. In: Aumann, R., Hart, S. (Eds.). *Handbook of Game Theory*, Vol. II. North-Holland, Amsterdam, pp. 1238–1284.
- Whalley, J., Hamilton, C., 1996. *The Trading System After the Uruguay Round*. Institute for International Economics, Washington, DC.
- Yi, S.-S., 1996. Endogenous formation of Customs Unions under imperfect competition: open regionalism is good. *Journal of International Economics* 41, 151–175.