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Structuring International Institutions for the Efficient Provisioning of Global Security

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Structuring international institutions for the efficient provisioning of global security

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Abstract This paper analyzes the issue of security provision by an alliance against the threat of a rogue nation. Proactive security effort by an alliance member is assumed to be non-rival and non-excludable, so the results of the effort jointly accrue to every other member. This effort has both positive and negative effects, as security measures mitigate the threat, but also involve loss of commercial benefits, collateral damages, and infringement on human rights. In this paper I suggest an institutional structure for the alliance which would lead to the achievement of the efficient level of world security through multilateral participation.

Keywords Alliances · Multilateralism · Security

JEL Classification D62 · D71 · D74 · H21 · H23 · H41 · H56

1 Introduction

National security is a major concern facing nations. Sometimes if a group of nations face a common threat to their national security, they form an alliance to jointly counter this threat. The Cold War saw the formation of the North Atlantic Treaty Organization (NATO). The nature of alliances has changed over the years, depending on the kind of threat facing an alliance. During the Cold War, members of NATO faced an overall threat from the Soviet bloc, though there was no open warfare. The United States stationed a significant amount of men and materials in Europe. The American nuclear deterrent was also extended to all NATO allies. At present, nations like Iran and North Korea threaten the stability of the world order not only at the regional, but global level. In the near past, similar challenges to global security have been posed by Libya and Iraq under Saddam Hussein. Such challenges to global security have rekindled general interest in how international institutions (and alliances) like the United Nations and the NATO might be used to counter them. Some questions arise from this context. How can an alliance of countries achieve a level of effort against a "rogue

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nation" that is in some sense optimal for the alliance as a whole? Further, given that these countries are all sovereign and cannot be made to comply with the directives of other alliance members, do we need some institutions within the alliance to achieve this optimal (or efficient) level as a decentralized solution? These questions assume importance in the context where the preferences of the countries in the alliance are not only different from one another, but some nations in the alliance might actually dislike the action against the rogue nation to escalate beyond a point. This dislike for escalation might especially be true if the action against the rogue nation is undertaken unilaterally by a single member of the alliance. If security effort by an alliance member is non-rival and non-excludable, both the positive and negative effects of the effort jointly accrues to every other member. Beyond a certain point, unilateral action by a certain alliance member against the rogue nation might not provide positive externality to some members of the alliance, but might be a negative externality to the latter.[1]

This results of this paper indicate that a certain institutional structure might be required for international organizations or alliances to efficiently combat a global threat, while ensuring multilateral participation by its members. Initially, I characterize the equilibrium of a non-cooperative game of joint effort provision among the nations. In this equilibrium a single nation unilaterally provisions effort for the whole alliance. For specified conditions, this level of effort may be either greater or lesser than the efficient level. Then, I suggest an institutional structure for the alliance which would lead to the achievement of the efficient level of world security through multilateral contribution. Under the institutional arrangement suggested in this paper, a neutral supranational agent (who is part of the institutional structure) can propose a scheme to alliance members. In this scheme transfer payments are made by countries having a low preference for effort (against the rogue nation), to the country having the highest preference, as well as some other countries preferring a high level of effort. In addition to proposing the transfer scheme, the neutral agent has the power to exclude some countries from voting on the scheme (some free-riding deal-breakers, as will be seen later). However, the neutral agent has no further control, and his proposed scheme survives if it is unanimously adopted by the voting countries.[2] If the neutral agent's scheme is adopted, it is possible for the joint effort to occur at the optimal level for the alliance, though even then this effort might be made by a single country. The surprising result is that the set of voters must include countries that have the lowest preference of security effort provision and the one that has the strongest preference. Countries that have preferences close to the country having the strongest security preference must, in fact, be excluded from voting. This result qualifies the conventional wisdom that membership to institutions providing international public goods should be restricted through an exclusion mechanism to a small number of members sharing similar 'tastes' with respect to the problem at hand.[3] It is seen that efficient provisioning of the international effort against rogue nations may still occur with

[1] The reader should note that the negative externality suffered by Germany and France from the US invasion of Iraq did not arise from the fact that they thought that the American action would cause the Iraqi threat level to rise. They also did not fear that the Iraqi threat would be deflected towards them because of the American action. However, President Chirac and Chancellor Schroeder's expressed opposition towards the US actions, due to the negative externalities they posed for their countries. In Sect. 2 of this paper, I will discuss the kind of negative externalities (precisely the ones that I will try to capture in my model) that these leaders might have been concerned about.

[2] See Adams et al. (1996) and Simon et al. (2003), for the role of institutions and intra-institutional rules in arriving at optimal outcomes in settings involving externalities.

[3] See Sandler (1997).

hugely divergent preferences, so long as some countries (having tastes close to the country with the highest preference) are excluded from voting on the agenda.

The institutional structure suggested in this paper to arrive at the optimal solution circumvents not only the problem of deal-breakers, but also avoids another classic problem that sometimes arises in Coasean bargaining, on the side of the payees. This classic problem occurs when certain transfer payees refuse to contribute their share, hoping to free-ride on the other payees. The (institutional) solution to this problem presented in this paper is distinct from the traditional ones seen in the literature on collective action. The traditional solutions commonly suggest ways to exclude participants from the group if they do not contribute payments, or focus on the ability of group leaders to galvanize all members into action.[4]

The contribution of this paper to the economic theory of alliances[5] can best be seen in the post Cold-War context in which the tastes of traditional allies regarding global security issues have diverged to an extent not seen previously. In fact, this divergence is so marked that there seems to be disagreement among these nations whether after a certain level security effort is intrinsically 'good' or 'bad', as seen by the French and German reactions to the Second Gulf War. In contrast, during most of the Cold War, US defence provisions in Europe were mostly supported by all NATO members. This forces us to rethink our earlier conclusions on how best to structure alliances like the NATO or the United Nations. In this process we add to the literature on the economics of alliances that began with Olson and Zeckhauser's seminal contributions (1966 and 1967), and continued with later contributions by Murdoch and Sandler (1982), McGuire (1990), Bruce (1990), and McGuire and Groth (1995). In the context of the current paper, Weber and Wiesmeth's (1991) analysis of a supranational institutional structure for NATO, that leads to quasi-egalitarian cost-sharing among the members, is of special interest.[6] As mentioned, the current paper adds to the literature by assuming that security effort may not only have positive externalities, but also have negative externalities beyond a point. The institutional structure suggested by the paper takes into consideration this important assumption, which is driven by realities currently observed in the international arena. Section 2, below, develops a model of global security provision. Section 3 discusses the implications of the findings of the model. I conclude in Sect. 4.

2 The model

2.1 Environment

There is a finite number of countries (governments) $i = 1, 2, \ldots, I$ forming an alliance, to fight against an exogenous level of global threat $\overline{t} \in [0, \infty)$. The threat level $\overline{t}$ can be considered as a level of effort by the rogue nation.[7]

[4] See Olson (1965) and Sandler (1992) for details of this literature.

[5] For a comprehensive review of this literature see Hartley and Sandler (1995) and Sandler and Hartley (1995). In addition to the alliance literature, there is some literature on terrorism that is interesting, including Lee (1988), Lee and Sandler (1989), Sandler and Lapan (1988), and Sandler et al. (1983) and Sandler (2003). An article which the reader might find particularly interesting is Sandler (2005), which discusses in the context of counterterrorism both positive and negative externalities of security spending.

[6] For cooperative solutions to such problems, see Moulin (1995) and Helm (2001). For discussions of institutional arrangements within a nation for the allocation of defense budgets, see Murdoch et al. (1991) and Jones (1992).

[7] I have restricted the model to exogenous threats here because of expositional simplicity.

The utility of government i is given by:

$$\begin{aligned} U^i(m^i, e; \overline{t}) &= m^i + S^i(e; \overline{t}) - N^i(e) \\ &= m^i + \lambda^i(\overline{t}) S(e) - \varpi^i N(e) \\ &= m^i + \lambda^i(\overline{t}) e - \varpi^i e^2 \end{aligned}$$

Here m^i is a private good (money) consumed by i, $e = \sum_{i=1}^{I} e^i$ is the amount of joint effort expended by the alliance against the rogue nation, e^i is i's contribution to the joint effort.[8] Effort is assumed to be proactive, non-rival, and non-excludable—its results jointly accrue to every member. Note that this effort might include military action, trade embargoes, and other kinds of punitive action. Let $\lambda^i(\overline{t}) \in (0, \infty)$ be different for each nation (we explain below what λ is), or $\lambda^i(.) \neq \lambda^j(.), \forall i, j$. Let $\varpi^i = 1$. I assume that λ is increasing in the level of threat $\overline{t}$, hence $\lambda^i_{\overline{t}} > 0$. The value of $\lambda(.)$ is greatest for country I for any $\overline{t}$, so $\lambda^I(.) > \lambda^i(.)$, $\forall i \neq I$. The other $(I-1)$ alliance members are ranked according to the value of their λs, such that for all $\overline{t}$, $\lambda^{I-1}(.) > \lambda^{I-2}(.) > \cdots > \lambda^1(.)$. For an exogenous level of threat $\overline{t}$, one can think of the λs as being parameters themselves. However, it is seen later that there is an interesting comparative static result associated with a changing level of threat.

The marginal benefit of effort for i is $[\lambda^i(\overline{t}) - 2e]$, which implies $\frac{\partial^2 U}{\partial e \partial \overline{t}} > 0$. The marginal benefit is more for higher $\lambda^i(\overline{t})$. λ^i may be thought of as an index of public support for security effort in a nation.[9] It is assumed that each government takes the preferences of the nation's populace for security effort into account in this manner (in some aggregate fashion). A country having a higher λ has more public support for action against the rogue nation. This might depend on the amount a country gets attacked itself, or the level of solidarity with the other allies that get attacked. For example, the threat perception of the American public from North Korea's nuclear program may be more than the threat felt by people in European countries. Basically, it is assumed that a rogue nation poses a threat to all the alliance members, but the level of threat is not equal for everyone. This leads to the public support for security effort to be different across nations. So the utility of security effort for a government not only depends on the level of overall security provisioned by the alliance, but also on the level of domestic support for the war. λ^i is dependent on the level of threat and for a higher level of $\overline{t}$, its value increases.[10]

Each country decides on an amount of money $m^i \in [0, \infty)$ to consume and an amount of effort $e^i \in [0, \infty)$ to put in, given its budget constraint $m^i + C(e^i) \leq M^i$, where $0 < M^i < \infty$

[8] It may be argued that the effort of various nations might be complementary, not perfectly substitutable, and that at times the alliance might require minimum effort by every member. However, the focus of this paper is on a certain institutional aspect of alliance formation, so I have made this simplifying linearity assumption. The main justification of this assumption is that in the present global context, such complementarity might well be small, given the demonstrable ability of certain nations to 'go-it-alone'. Also, the quasi-linear form of the utility function keeps out the income effects, and helps in giving sharper results.

[9] In this model, I have assumed complete and information regarding λ. If that is not so, there is scope for preference falsification by governments, who will have an incentive to misreport their λ. In support of my assumption, it may be argued that public support in various nations for fighting a war against an external threat may be quite accurately gauged through opinion polls (like the Gallup and PollingReport.com polls). As such opinion polls are usually public, the assumption of complete information is not such a heroic one in this context.

[10] The assumption of single-peaked preferences, with countries having an ideal amount of security effort, lets me avoid unnecessary complications and derive some interesting comparative static results in the paper.

is the initial endowment of the private good of i and $C(e^i)$ is the cost of effort level e^i. It is assumed that cost of effort to be linear, so $C(e^i) = ce^i$, where $c > 0$.[11]

There might be debate whether the governments' utility function assumed in this model really reflects the 'true' utility of the nation, or is it more indicative of the government's popular support?[12] While acknowledging the merit of that debate, I would like to stress that the intention of this paper is to model the problem of global security provision in an environment where national governments are major actors. For a given level of threat in the world, the governments' utility is dependent on the amount of private good consumed and the security effort expended by the alliance. However, such effort does not only have the positive effect of increasing security $S(e) = e$ by eliminating the threat,[13] but also has a negative effect $N(e)$ on utility in case the effort put in by the alliance infringes on human rights, diminishes trade relations, and reduces commercial benefits.[14] Both these elements are captured in the government's utility function by the term $S^i(e;\overline{t}) - N^i(e) = [\lambda^i(\overline{t})e - e^2]$, where $S^i(e;\overline{t}) = \lambda^i(\overline{t})S(.) = \lambda^i(\overline{t})e$ and $N^i(e) = \varpi^i N(e) = \varpi^i e^2 = e^2$ (since ϖ^i is assumed to be 1 for all nations). For a given level of $\overline{t}$, an increase in joint effort e leads to greater utility by providing security, but also has a disutility that is captured by the part e^2. Note that it is assumed that if the level of threat $\overline{t}$ is more, rather than less, the utility of security effort to a government is more for any given level of e, as public support for security effort rises. Thus, in a more dangerous world, utility of any effort level is more than in a less dangerous world.

The main assumption made with regard to the disutility of joint effort is that the marginal disutility of effort rises at an increasing rate (in other words, the disutility of effort is akin to convex costs). This assumption would be satisfied by a functional form e^n where $n > 1$. For the sake of analytical simplicity let us assume in this model that $n = 2$, i.e. the disutility of joint effort is measured by the negative of the term e^2. However, I emphasize that all results of the model would hold for any other value of n greater than one. Let me now justify the grounds for the "convex" disutility assumption. As mentioned before, I assume disutility of joint effort rises as that effort increases. This disutility arises from violation of human rights, collateral damage, disruption of trade contacts and societal interaction with the region where these efforts are undertaken. The convexity assumption is based on the conjecture that as effort increases, the disutility grows at an increasing rate. For example, let us think of two situations. One where effort is raised from the level of electronic surveillance of rogue nations to covert commando operations. The second situation is where the effort level is raised from covert commando operations to full scale strikes with cruise missiles. It might be argued that the disruption of trade contacts and collateral human damage is much more in the second situation than the first. In other words, as effort increases, the escalation of effort brings about a greater change in disutility (comparing the increase in utility to the change in effort between the two cases, respectively). This is the logic behind the convex disutility function.

[11] The results of the paper could be easily modified for effort cost being heterogeneous across nations. There will be no qualitative change in the conclusions as long as the marginal cost of effort is least for I.

[12] I have assumed that governments take into account the opinions of their citizens, which they are able to aggregate in some fashion.

[13] I assume there is a simple linear technology converting effort to a level of security (by destroying the threat). The process how effort eliminates the threat is not modeled.

[14] That punitive actions have negative consequences is undeniable. For example, trade embargoes against Iran by the United Nations, *even without retaliation by Iran*, would affect countries like Russia and France quite negatively.

2.2 The game

The members of the alliance play a simultaneous-move game among themselves. This is a game of complete information, with I players each choosing effort $e^i \in [0, \infty)$ and having payoff V^i. Here,

$$V^i(.) = M^i + \sum_{i=1}^{I} e^i \left[\lambda^i(\bar{t}) - \sum_{i=1}^{I} e^i \right] - ce^i \text{ and } i = 1, 2, .., I.^{15}$$

The game is solved for the *Nash equilibrium* of the game between the governments in the alliance.[16]

Solution to the FOC of country i's problem gives:

$$e^i = \frac{1}{2}\left[\lambda^i(\bar{t}) - c - 2\sum_j e^j \right], \quad \text{for } \lambda^i > c + 2\sum e^j,\ j \neq i \text{ and } 0, \text{ otherwise.}$$

Proposition 1 *In equilibrium, country I with $\lambda^I > \lambda^i$, $\forall\, i \neq I$, makes all of the joint effort against the threat, while all other countries in the alliance make no effort. This equilibrium is unique.*

Proof See Appendix 1. □

It is seen that $e^N = e^I = \frac{1}{2}[\lambda^I(\bar{t}) - c]$ is the equilibrium amount of joint effort provisioned by the alliance.[17] This effort is made only by country I. The intuition behind this result is as follows. If no other countries are making any effort, then country I makes effort at its private level (where the marginal cost of its own effort equals its marginal utility). Also, as I's utility from security effort is the greatest, its private level of provision is greater than the private effort provision of all other alliance members (what each of them would provision, if no one else put in any effort). Now, due to the public nature of I's effort, its benefits (and negative effects) accrue to all other alliance members. Since the other alliance members are able to receive the effect of an effort level greater than their private level, their best recourse is to do nothing if I puts in its own private level of effort. As already mentioned, I would do that for non-action by other alliance members. Thus, in equilibrium we have I putting in all the effort and the other alliance members doing nothing. In what follows, we will term e^N as the unilateral effort level.

[15] Each government (country) i's objective is: Maximize$_{\{m^i, e^i\}}$ $U^i(.) = m^i + e[\lambda^i(\bar{t}) - e]$, s.t. $m^i + ce^i = M^i$; $m^i \in [0, \infty)$; $e^i \in [0, \infty)$, may be written as: Maximize$_{\{e^i\}}$ $V^i(.) = M^i + \sum_{i=1}^{I} e^i[\lambda^i(\bar{t}) - \sum_{i=1}^{I} e^i] - ce^i$; $e^i \in [0, \infty)$; $V^i \geq 0$. In what follows, we consider that the condition $V^i \geq 0$ is met.

[16] There might be contention whether effort provision in some alliances can be sequential. I assume that at times of crises the time available for responses is so small that effort provision must practically be simultaneous.

[17] If there was a partner with the same λ, in equilibrium the total level of joint effort provision would still be at the 'unilateral level' in our paper. The actual amount of effort supplied by either partner would lie in the interval $[0, e^N]$ and taken together would add up to e^N, with any division constituting an equilibrium. In that case, other external factors like the international stature of the country might determine the effort shares. If the countries had different cost functions (assumed to be the same in this paper), then the country with lower costs (but same preference) would provision the effort.

Remark 1 $\frac{\partial e^N}{\partial \bar{t}} > 0$ (since $\lambda^I_{\bar{t}} > 0$): For an increase in the given level of world threat, the equilibrium amount of effort by I would increase.

Some of the alliance partners would benefit if I reduced the amount of effort it puts in. As seen in the lemma below, any alliance partner whose preference index λ^i is sufficiently less than I's index λ^I, would have its utility level go up if the latter reduced its equilibrium effort. The result also implies that there might be countries in the alliance whose utility would decrease if I put in less effort, so a reduction in effort might actually end up hurting them.

Lemma 1 *The utility of an alliance partner $i \neq I$ would rise if country I reduced its effort level from the unilateral level, for $\lambda^i(\bar{t})$ being sufficiently lower than $\lambda^I(\bar{t})$, i.e. $\lambda^i(\bar{t}) < \lambda^I(\bar{t}) - c$.*

Proof See Appendix 2. □

In light of the above result, it is possible to distinguish the alliance members between ones who would prefer some reduction in I's effort, and those who would not. Note that the bliss level of effort for any country i is given by the peak of their utility functions, and is equal to $\frac{\lambda^i(\bar{t})}{2}$. Countries for which the unilateral level of effort is beyond the peak of their utility functions would experience an increase in their utility levels for a decrease in effort up to the respective peaks. In the definition below, a country in this category is called a 'non-supporter' of I. A country which would not want I either to increase or decrease its effort level from the unilateral level (that is, its utility would go down in either case because the collective effort level is at its bliss point) is called a 'marginal supporter' of I. There may also be nations (for whom the condition seen in the above lemma would not hold) whose utility would increase for an increase in effort by I, because even with an increase in effort the collective effort level is still less than their bliss point.

Definition 1 A alliance partner $i \neq I$ is defined as a 'non- supporter' of I's effort level if $\lambda^i(\bar{t}) < \lambda^I(\bar{t}) - c$, and a 'marginal supporter' if $\lambda^i(\bar{t}) = \lambda^I(\bar{t}) - c$.

Interestingly, an increase in the level of threat might actually increase the number of countries within the alliance who want I to reduce its effort level. As $\frac{\partial e^N}{\partial \bar{t}} > 0$, the unilateral level of effort by I increases for an increase in the level of threat. Under these circumstances, a marginal supporter of I whose domestic support index λ does not increase sufficiently more than λ^I would become a non-supporter. This result is interesting since it contradicts the usual intuition that a greater amount of world threat would automatically mean greater support for I's security efforts from its alliance partners. The intuition here is that for an increase in threat would lead to an increase in security effort by I.[18] For a marginal supporter of I to remain so, an increase in its disutility from greater effort must be outweighed by the benefits. This would only happen if the rate of increase of its λ due to the rise in threat was sufficiently greater than the rise in λ^I. Otherwise, the rise in I's security effort would be so much that the negative effect would outweigh the positive for a marginal supporter.

[18] It is assumed that the ranking of λs remains unchanged for an increase in the threat level.

Proposition 2 *If the exogenous level of threat* $\bar{t}$ *increases, then a marginal-supporter* i *becomes* I*'s non-supporter if the rate of increase of* λ^i *for an increase in* $\bar{t}$ *is not greater than the increase of* λ^I*; i.e.* $\lambda^i_{\bar{t}} < \lambda^I_{\bar{t}}$.

Proof See Appendix 3. □

2.3 The efficient outcome

In order to compute the level of effort that is optimal for the alliance as a whole, the sum of net utility of the members is maximized. This is called the efficient level of joint effort for the alliance.[19]

Solving for the efficient level of joint effort:

$$Maximize_{\{\sum m^i, e\}} \sum_{i=1}^{I} U^i(.) = \sum_i m^i + \sum_i e[\lambda^i(\bar{t}) - e],$$

$$s.t. \sum_i m^i + ce = \sum_i M^i; \quad \sum m^i \in [0, \infty); \; e \in [0, \infty)$$

or

$$Maximize_{\{e\}} \sum_{i=1}^{I} V^i(.) = \sum M^i + e\left[\sum \lambda^i(\bar{t}) - Ie\right] - ce; \quad e \in [0, \infty) \text{ and } \sum_{i=1}^{I} V^i \geq 0$$

Solution to the FOC of the above problem gives the efficient solution:

$$e^E = \frac{1}{2I}\left[\sum_{i=1}^{I} \lambda^i(\bar{t}) - c\right]$$

Comparison with the unilateral effort shows that this efficient level may be more or less than the unilateral level, depending on whether λ^I is sufficiently higher compared to the average for the index for all alliance members, then the efficient amount of effort is lower than the unilateral level.[20] This is seen in the following lemma.

Lemma 2 *The efficient level of joint effort is lesser* (*greater*) *than the unilateral outcome if* λ^I *is higher* (*lower*) *than the average value of* λ^i *for all countries plus the amount* $\frac{c(I-1)}{I}$*, i.e.* $\lambda^I(\bar{t}) \gtreqless \frac{\sum_{i=1}^{I} \lambda^i(\bar{t})}{I} + \frac{c(I-1)}{I}$.

Proof $e^E \lesseqgtr e^N$ for $\frac{1}{2I}[\sum_i \lambda^i(\bar{t}) - c] \lesseqgtr \frac{1}{2}[\lambda^I(\bar{t}) - c]$. Rearranging the terms of the inequality, gives the above result. □

This result is to be expected, since if the marginal benefit of effort is much higher for I than the average taken across all alliance members, then the amount of effort it provisions unilaterally would be more than the efficient amount for the whole alliance.

[19] In essence the Benthamite Social Welfare Function is maximized here. This gives the efficient effort level. This is in the sense that for a movement from this effort level, no ally can be made better off without making someone else worse off, even with transfers of the private good.

[20] It is easy to see that e^E is always greater than zero, if e^N is greater than zero, in the case where $e^E < e^N$.

2.4 Using an institution to achieve efficiency

The joint effort level e^E can be achieved in many ways by the alliance. In fact, it may be achieved by any effort vector $(e^1, e^2, \ldots, e^E)$ that divides effort among the allies such that $\sum_{i=1}^{I} e^i = e^E$. I will consider one among all the possible effort vectors, namely $(0, 0, ..0, e^E)$, and analyze under what conditions the alliance will achieve this effort profile. As is evident, in this outcome country I will singly continue to provision effort for the whole alliance, but its effort will be at the efficient level and not at its earlier unilateral level.[21]

As seen below, the alliance will be able to achieve the effort vector $(0, 0, ..0, e^E)$ if a certain subset of the allies make suitable transfer payments to others. However, for these transfers to occur, there is the need of proper institutions (rules) in place. Otherwise these transfers will not occur, even though certain countries might benefit by paying these transfers. In what follows, $(e^i)_{i=1}^{I}$ denotes a vector (profile) of efforts of the alliance partners and $(Z^i)_{i=1}^{I}$ denotes a tax (negative transfer) vector. The amount Z^i is positive for payments (taxes) and negative for receipts (transfers) by country i.

The set of all the I members of the alliance is called S. The transfers will be paid by a set of payees $P \subset S$ to a set of recipients $R \subset S$. In what follows, I will outline a game of perfect and complete information in which all the members belonging to the sets P and R participate,[22] along with a neutral player. There will be certain rules of interaction among the players. From these rules it is possible to identify an institutional structure for the alliance that would lead to the efficient outcome. I call the game described below the 'institutional game'. All players in this game are rational and have complete information. This game exists only if $P \neq \phi$. It is assumed that the following ex-post efficiency condition holds:

Condition 1 *Let* $\sum_{i\in P}(e^E - e^N)[\lambda^i(\bar{t}) - (e^E + e^N)] \geq \sum_{i\in R}(e^{i*} - e^E)[\lambda^i(\bar{t}) - (e^{i*} + e^E) - c]$.[23]

The Institutional Game: There are four stages in this game. In the first stage, the neutral player[24] makes a proposal to the other players. The proposal is a collection of elements $[P, R, (T^i)_{i=1}^{I}, (e^i)_{i=1}^{I}]$, where P is a set of payees, R is a set of recipients, $(T^i)_{i=1}^{I}$ is a vector of transfers paid by payees and received by recipients, and $(e^i)_{i=1}^{I}$ is a particular effort vector. For what follows, let the effort vector proposed by the neutral player be $(e^i)_{i=1}^{I} = (0, 0, ..0, e^E)$. P and R are such that $P \cup R = S$, and $P \cap R = \phi$.

In the second stage, the players in the set P and player I simultaneously vote either *Agree* or *Not Agree* to the proposal. As mentioned, for the payees the proposal contains a total amount that they need to pay and a rule to divide the payment among them. For I, the proposal commits to pay an amount of transfer τ to him, dependent on it making

[21] In this model, it does not matter whether compensation to I is made through effort or money. Multilateral participation through cost-sharing is equivalent to multilateral effort-sharing. In reality, if the marginal cost of effort of one nation is lower than other nations, it would be more efficient for that nation to make all effort on behalf of the alliance. Also note that for non-linear costs whether there is cost-sharing between nations, or effort-sharing, is a matter of contention.

[22] Though it is not formally proved, it is obvious that nation I shall belong to set R.

[23] It is proved in Lemma 3 below that the maximum amount a payee country would be willing to pay for the change from the unilateral to the efficient outcome is: $(e^E - e^N)[\lambda^i(\bar{t}) - (e^E + e^N)]$.

[24] The neutral player can be thought of as an entity within a supranational agency, like the Office of Security within the NATO.

the efficient effort level. For the proposal to be adopted, it must be adopted *unanimously* by all players in the set P and player I. Otherwise the proposal fails, and no transfers are made.[25] Once a player votes for the proposal, it is committed to adhering to it. It is not possible (by membership rules of the alliance) for any member of P to make a private transfer to any other player, other than through the neutral player. If the proposal succeeds, the neutral player takes the amounts given in vector $(T^i)_{i=1}^I$ and holds them.[26] If it does not, no payments are made, that is $(T^i)_{i=1}^I = (0^i)_{i=1}^I$.

In the third stage, the alliance members $i \in R\backslash I$ play a simultaneous-move non-cooperative game of effort choice for adoption of the proposal. For non-adoption of the proposal, there is the status quo effort choice game with all players in S. If the proposal was adopted in the second stage, there is an effort choice game where transfer amounts are committed by the neutral player to recipients according to a scheme outlined in the proposal (which is discussed in detail later). In brief, the neutral player commits to pay players $i \in R\backslash I$ a transfer sum $Z^i \in \Re^-$ from the transfer amounts handed over to it by the payees, if the effort chosen by them is zero. If, however, they make positive effort then they do not receive this transfer. For the proposal being adopted and $R\backslash I = \phi$, there is no third stage, the fourth stage described below follows the second. In what follows we assume the more general case, so $R\backslash I \neq \phi$.

The fourth stage is the payments stage (for the game with transfers). Payments are made to all recipients upon observation of effort or money given back to payees, in full or in part (dependent on the effort choices of the players in set R).

Lastly, it is assumed that the neutral player does not retain any money itself (thus, the amount paid by the payees equals the amount received by the recipients) and conforms to all the rules of the game described above. The timeline of the institutional game is depicted in Fig. 1.

In this game, the strategy of a player $i \in P$ and I consists of voting *Agree* or *Not Agree* in the second stage and making an effort level $e^i \in [0, \infty)$ in the third stage for non-adoption. For adoption, its effort choice is pre-committed.[27] The strategy of a player $i \in R/I$ is to choose an effort level $e^i \in [0, \infty)$ in the third stage, for a second stage occurrence.[28] Dependent on these choices, these players automatically pay or get transfer amounts Z^i, as per rules proposed by the neutral player.

In the next few sections, the payees and recipients are identified, as well as the set of transfer vectors that can lead to the achievement of allocations with the vector $(0, 0, ..0, e^E)$ as the effort outcome.[29]

[25] It is assumed that an *Agree* vote means that the concerned country pays up. Since countries cannot be forced to pay, a sovereign country voting *Not Agree* will never pay. The unanimity requirement needed to pass the proposal is one which takes into account that these countries are completely sovereign in this respect. A majority or supermajority voting rule would mean that countries voting *Not Agree* have to exogenously commit to that voting rule and pay in spite of not wanting to. This is a feature we want to avoid.

[26] See Maggi and Morelli (2006) for the optimality of the unanimity voting rule in achieving outcomes in international organizations.

[27] A player's strategy has to specify what it would do if the second stage proposal is adopted and also if it is not. So for $i \in P$, a strategy might be $\{Agree, e^i = 0$ for non-adoption$\}$. We understand that adoption of the proposal means that all $i \in P$ and I have played *Agree* in the first round, while non-adoption encompasses all possible combinations where one or more of them have played *Not Agree*.

[28] For $i \in R$, a strategy might be $\{e^i = 0$ for both adoption & non-adoption$\}$.

[29] Questions may be raised whether, in fact, it is the unilateral actor who would make side-payments (pay bribes) to other countries to make effort, in order to gain international legitimacy for its actions. That is a

The 1st stage: Proposal stage

- The neutral player makes a proposal

The 2nd stage: Voting stage

- The payees & I vote to adopt the proposal under Unanimity rule

The payees hand over amount T to the neutral player for adoption, otherwise not

The 3rd stage: Effort stage

- *If proposal is adopted*, there is an effort choice game involving transfers to recipients (recipients other than I play this game)
- *For non-adoption*, there is the non-cooperative effort choice game (all players play this game)

The 4th stage: Payments stage *(only for the game with transfers)*

- Payments are made to recipients upon observation of effort or money given back to payees

Fig. 1 Timeline of the institutional stage game

2.5 Gainers and losers

There will be gainers and losers among the alliance members for the movement to the efficient outcome (in which I makes all effort) from the unilateral outcome. There will also be a maximum amount the gainers would be willing to pay to compensate the losers. The results proved in this section will be useful in determining feasible transfer profiles for the players in the institutional game.

For a country to be willing to pay a positive amount (say, z^i) for the movement from the unilateral to the efficient level, it has to be true that its utility from e^E must be greater than from e^N, even after it pays z^i. If i itself makes no effort in either outcome, then it has zero cost of effort in both situations. This can be written as the following individual rationality constraint. At the unilateral outcome, no country would be willing to pay any other country any transfer amount.

Condition 2 *The individual rationality condition for i being willing to pay $z^i > 0$ to achieve the efficient effort outcome over the unilateral outcome is* $[V^i(m^E, e^E; \overline{t}) \mid z^i > 0] \geq [V^i(M^i, e^N; \overline{t}) \mid z^i = 0]$.

The utility of i when the joint effort level is e^E is denoted by $[V^i(m^E, e^E; \overline{t}) \mid z^i > 0]$, given its consumption of the private good is m^E, and it pays amount z^i. For joint effort level e^N its utility is $[V^i(M^i, e^N; \overline{t}) \mid z^i = 0]$, given its consumption of the private good is M^i, and it pays nothing. The exogenous threat level is $\overline{t}$ in either case. Note that if i makes no effort in the efficient outcome, then $m^E = M^i$ also, since it has to bear no cost of effort.

question that is not addressed in this paper. The focus is on designing a mechanism by which efficient effort level for the alliance is achieved.

For a certain country willing to pay for the change, what is the maximum amount that it is willing to pay? The individual rationality constraint is used to answer this. Clearly, a country would pay at most an amount that would make its utility after the payment (with effort provision being at the efficient level) equal to what its utility was at the unilateral outcome (where there were no payments). This is seen in the lemma below.

Lemma 3 *If the utility of a country rises for a change in the joint effort to the efficient level, the maximum amount it might be willing to pay for the change is* $(e^E - e^N)[\lambda^i(\bar{t}) - (e^E + e^N)]$, *given that it makes no effort contribution in the efficient allocation.*

Proof See Appendix 4. □

The next question is, which of the alliance members would be willing to pay for a move from the unilateral to the efficient outcome. As seen in the proposition below, it is possible to categorize countries into those that are willing to pay for the change and those who are not, according to the value of their index λ^i. It is to possible to find a cutoff value for λ^i (for both the cases $e^E > e^N$ and $e^E < e^N$) which separates those countries that are willing to pay for the movement from those which are not. Note that we are continuing to assume that i makes no effort, it has zero effort-cost.

Lemma 4 (i) *For* $e^E > e^N$, *only a country with sufficiently high* λ^i *might be willing to pay a positive amount for a change to the efficient effort level, i.e.* $z^i > 0$ *only if* $\lambda^i > (e^E + e^N)$.

(ii) *For* $e^E < e^N$, *only a country with sufficiently low* λ^i *might be willing to pay a positive amount for the change, i.e.* $z^i > 0$ *only if* $\lambda^i < (e^E + e^N)$.[30]

Proof See Appendix 5. □

It is seen from this proposition that for efficient effort being more than the unilateral level, countries with the λ closer to I (with higher λ values) might be willing to pay it a positive amount to move to the efficient effort level. Similarly, for the efficient outcome being less than the unilateral outcome, countries with λ further from I (with lower λ values) might be willing to do so.

There may also be countries which suffer a loss in their utilities due to a move. For the countries that suffer a loss, let $V^i(M^i, e^N; \bar{t})$ be the utility for the unilateral outcome, and $V^i(M^i, e^E; \bar{t})$ be the utility if the efficient outcome is achieved. As per assumption these countries make no effort in the efficient outcome, so there is no need to include any effort cost while computing their utility even in that outcome. Thus, the loss in utility is:

$$\begin{aligned} l^i &= V^i(M^i, e^N; \bar{t}) - V^i(M^i, e^E; \bar{t}) \\ &= \{M^i + e^N[\lambda^i(\bar{t}) - e^N]\} - \{M^i + e^E[\lambda^i(\bar{t}) - e^E]\} \\ &= (e^N - e^E)[\lambda^i(\bar{t}) - (e^N + e^E)] \end{aligned}$$

These countries need to be compensated by the above amount if they are not to suffer a loss in their utilities due to the change.

Summarizing the results obtained above:

[30] For simplicity we assume there is no country with $\lambda^i = (e^E + e^N)$.

(A) For $e^E < e^N$:
  (i) The countries suffering a loss need to be paid the amount $l^i = (e^N - e^E)[\lambda^i(\bar{t}) - (e^N + e^E)]$ if they are to be compensated fully. These countries have $\lambda^i > (e^N + e^E)$.
  (ii) The countries gaining from the movement might be willing to pay $0 \leq z^i \leq (e^E - e^N)[\lambda^i(\bar{t}) - (e^N + e^E)]$. The last term in this inequality is the value of the gain for these countries due to the shift to the efficient level. These countries have $\lambda^i < (e^N + e^E)$.

(B) For $e^E > e^N$:
  (i) The gainer countries might be willing to pay $0 \leq z^i \leq (e^N - e^E)[\lambda^i(\bar{t}) - (e^N + e^E)]$ for the movement. These countries have $\lambda^i > (e^N + e^E)$.
  (ii) Countries suffering a loss due to this movement need to be paid $l^i = (e^N - e^E)[\lambda^i(\bar{t}) - (e^N + e^E)]$ to be fully compensated. These countries have $\lambda^i < (e^N + e^E)$.

2.6 Characterizing the payments structure

In this section we will characterize the transfer profiles that would lead to respective effort choices by the allies in the institutional game of that correspond to the outcome $(0, 0, ..0, e^E)$. The results derived here will be used while solving for the subgame perfect equilibrium of the institutional game.

For nation I, let the neutral player propose a transfer $\tau = (e^E - e^N)[\lambda^I(\bar{t}) - (e^E + e^N) - c]$, dependent on it making the efficient effort level. For any other effort level, it does not receive any transfer.[31] This transfer make nation I's utility the same under the unilateral and efficient outcomes, given no effort by others.

$$\begin{aligned}\tau &= V^I(M^I, e^N; \bar{t}) - V^I(M^I, e^E; \bar{t}) \\ &= \{M^I + e^N[\lambda^I(\bar{t}) - e^N] - ce^N\} - \{M^I + e^E[\lambda^I(\bar{t}) - e^E] - ce^E\} \\ &= (e^N - e^E)[\lambda^I(\bar{t}) - (e^N + e^E) - c]\end{aligned}$$

In order to figure out the payments structure for other nations, consider the original effort choice game, with the sole modification that I provisions the efficient effort level.[32] Note that given a transfer amount τ, I is indifferent between making the unilateral or the efficient effort level (given no effort by others). We assume that in case of this indifference, nation I will choose the efficient level.[33]

In the case $e^E > e^N$, no country wants to make any effort for I making the efficient effort provision. The intuition behind this is simple. None of the other countries were making effort at the unilateral level. As the efficient level is more than the unilateral level, I increases its effort. Given that they were not making any effort at the lower level, the other countries would not make any effort given this greater increase by I. The proof is as seen below.

[31] This is not the only transfer rule that can be used. However, since I want to concentrate on the institutional nuances of multilateral participation, I restrict the present study only to this particular rule for the sake of brevity. The institutional structure I will develop will be able to accommodate other rules as well.

[32] At this moment let us ignore where the transfer amount comes from.

[33] This assumption can be easily avoided by making the transfer to nation I greater by an infinitesimally small amount.

Lemma 5 *If $e^E > e^N$, then the best response effort of all countries $i \neq I$ in the effort provision game is zero, given $e^I = e^E$. The best response of I is e^E for no effort by $i \neq I$ and transfer $\tau = (e^N - e^E)[\lambda^I(\bar{t}) - (e^N + e^E) - c]$ for $e^I = e^E$, and 0 for $e^I \neq e^E$.*

Proof See Appendix 6. □

The implication of this result is that for the efficient level being greater than the unilateral level, no country other than I needs to be given a transfer to achieve the effort outcome $(0, 0, ..0, e^E)$. Thus, in this case the set R may be a singleton, containing only I.[34] The neutral player can include all the players who would be gain in the set P, to whom it makes its payment proposal in the first stage of the game. As we recall from Proposition 3, these are countries having their public support index $\lambda^i > (e^E + e^N)$.

When $e^E < e^N$, the situation is more complicated. There are countries which would make positive effort, dependent on the effort levels of other alliance members, given I makes only the efficient amount of effort. As is seen below, if any of the alliance partners has λ^i close enough to λ^I, then its best response to the efficient amount of effort by I in the effort choice game would not be zero effort, given that the other alliance members make no effort.

Lemma 6 *If $e^E < e^N$ and if I chooses effort e^E in the effort choice game, then the optimal effort level for country $i \neq I$ which does not receive a transfer compensation would be positive for $\lambda^i > \frac{\sum_{i=1}^{I} \lambda^i}{I} + \frac{c(I-1)}{I}$, given the other countries continue to make no effort and.*

Proof See Appendix 7. □

Of course, the above result also implies that if there are alliance partners for whom $\lambda^i > \frac{\sum_{i=1}^{I} \lambda^i}{I} + \frac{c(I-1)}{I}$, then if I makes the efficient amount of effort, then the best response of the other countries is to make positive effort. So, only if λ^I is sufficiently greater than the λs of its other alliance partners, then their best response to efficient effort by I is to do nothing. Otherwise, if I makes the efficient effort, then other countries with sufficiently high preference for effort would step in and make effort, if they are left uncompensated.

The intuition behind the above result is as follows: If the λ^i of any country is close enough to λ^I, then its private provision level of effort e^{i*} (the amount of effort it would put in, if no one else did so), is close to that of I. This private level is given by $e^{i*} = \frac{1}{2}[\lambda^i(\bar{t}) - c]$. The only reason it does not put in any effort in the original unilateral equilibrium is because I provisions an effort level greater than its own private level, from which it derives publicly available benefits. But, if I provisions the efficient effort level, and this level falls below the private level of provision for i, then i's response would be to make a positive effort level to make up the deficit between the efficient level and its own private level (if no other country other than I and itself make any effort). However, if the efficient effort level remains above the private level for all alliance partners of I, then they continue making no effort, even if the former drops effort from the original unilateral level. Interestingly, the above result shows that even the nations that gain from the cut-back (and not only the losers) might want to start putting in positive amounts of effort after the move to the efficient level. In fact, for any country i the best response effort level is not zero if joint effort of its alliance partners (or

[34] It would be a singleton if the neutral player does not specifically want to compensate the losers. Non-compensation of the losers would not affect the achievement of the desired effort outcome.

$\sum_{j\neq i} e^j$) is less than its private provision level e^{i*}, irrespective of whether it loses or gains from the shift. [35]

The above results give an idea of the countries the neutral player needs to include in the set of recipients R, and those it can place among the set of payees P, and help devise a scheme that would lead to $(0, 0, ..0, e^E)$as the effort outcome of the institutional game.

2.7 Solving the institutional game

I will now formally solve for the subgame perfect equilibrium of the institutional game discussed in Sect. 2.4. The solution will involve backward induction, where I will first solve the effort choice game, and then the first stage voting game among the payee members. In what follows, I assume that $e^E < e^N$. The analysis would be similar for $e^E > e^N$, so I will briefly outline the relevant conclusions for that situation later in our discussion. In the institutional game, a player i belongs to R if its private effort provision level $e^{i*} \geq e^E$. For $e^{i*} < e^E$ it belongs to P.

2.7.1 The effort choice subgame

If the transfer proposal is defeated in the first stage, there are no transfers and we will have the status quo effort choice game among all countries in the alliance in the third stage subgame. This game will lead to the unilateral outcome. However, if the transfer proposal is adopted in the second stage, the players $i \in R\backslash I$ each choose effort $e^i \in [0, \infty)$ and have payoff V^i. The payoffs in this subgame are:

$$V^i(.) = M^i + e[\lambda^i(\bar{t}) - e] - ce^i + Z^i,\ i \in R/I,$$

where $Z^i > 0$ if i receives a payment for $e^i = 0$, and 0 otherwise.

For $i \in R/I$, such that $e^E < e^{i*}$ the neutral player proposes the following payment rule: $Z^i > 0$, only if $e^i = 0$, otherwise $Z^i = 0$. For $i \in R/I$, such that $e^E = e^{i*}$ the neutral player proposes $Z^i = 0$.

More specifically, the neutral player proposes $Z^i = (e^{i*} - e^E)[\lambda^i(\bar{t}) - (e^{i*} + e^E) - c]$, for $i \in R\backslash I$ such that $e^E < e^{i*}$.[36] The role of this proposed compensation scheme in achieving the desired effort outcome will be observed shortly. Let the neutral player include all the nations in the alliance which have index $\lambda^i > \frac{\sum_{i=1}^{I}\lambda^i}{I} + \frac{c(I-1)}{I}$ in the set $R\backslash I$. This means that all players having a private provision level e^{i*} (the level it have provisioned if it were facing the threat single-handedly) greater than e^E belong to the set of recipients, regardless of whether the move from the unilateral level to the efficient level makes them better or worse off.

Note that by choosing transfer amount Z^i, the recipients are compensated to a certain extent for the utility loss they suffer because of the move from the unilateral to the efficient outcome. It turns out that under this transfer scheme the recipient would be paid just enough

[35] None of the gainers from the shift to the efficient outcome to have a positive effort deviation only if $e^E \geq e^N - c$. Otherwise there may be some gainers, who if left uncompensated, would start putting in effort. This is easily seen by recalling that for these countries $\lambda^i < (e^E + e^N)$. Hence, $e^i < \frac{1}{2}[(e^E + e^N) - c - 2e^E] = \frac{1}{2}[e^N - c - e^E]$ for every i. So $e^i = 0$, only if $e^N - e^E \leq c$.

[36] Notice that this compensation amount is one which puts a recipient country at the utility level at which it would be if the joint effort provision of the alliance were at its private provision level, but it had to bear the cost of provision only for the that amount of this effort which was above the efficient level.

to restore the loss of utility it suffers for not making up the difference in effort between the efficient level and its private effort level. For the countries losing from the reduction in effort, this makes their utility level less than what they had at the unilateral outcome, but leaves them with no incentive to undertake any effort themselves.[37] There might also be recipients who gain from the shift to the efficient from the unilateral level (for whom the unilateral level was too much), but for whom the unilateral effort is lower than their private effort level e^{i*}. These countries are left better off under the transfer scheme, compared to their utility in the unilateral outcome. The technical details pertaining to this discussion are included in Appendix 8.

In Lemma 5, it was seen that for the proposed transfer scheme, nation I would optimally choose the efficient level of effort if no other nation made any effort. As the payee nations in set P do not make any effort, combining Lemma 5 and Lemma 6 below, we get the result that the proposed transfer scheme can be used to sustain the effort vector $(0, 0, \ldots, e^E)$ as a mutual best-response outcome of the effort choice subgame.

Lemma 7 *The effort vector* $(0, 0, \ldots, 0)$ *for all players* $i \in R\backslash I$ *is sustainable as a Nash outcome of the effort choice subgame if the proposal has passed in the second round, given*: $Z^i = (e^{i*} - e^E)[\lambda^i(\overline{t}) - (e^{i*} + e^E) - c]$ *for* $e^i = 0$ *and* 0 *otherwise, for* $i \in R\backslash I$ *such that* $e^E < e^{i*}$ *and* $Z^i = 0$ *for* $i \in R\backslash I$ *such that* $e^E = e^{i*}$.

Proof See Appendix 9. □

The transfers paid in the proposed scheme make the recipients as well off as they would be in their private outcome. This means that some countries in the set of recipients could be worse off than they would be at the unilateral outcome (though better off than at the efficient outcome without transfers). Among this group are countries with preferences close to nation I, for whom any reduction of effort from the unilateral level causes a decrease in utility (in addition to the efficient level being below their private effort level). It is observed from the above lemma that even though these nations are paid less than the amount they need to be given to make them as well off as they were in the unilateral outcome, the scheme discussed above makes them stick to zero effort level (for efficient effort by I).[38] There is a second group of countries among the recipient, whose utility level decreases for a reduction in effort to the unilateral level. But after getting compensated for not making effort to cover the difference between their private level and the unilateral effort level, the utility of the countries in this second category of recipient actually surpasses their utility in the unilateral outcome. Note that these countries have effort preferences that are further from nation I, compared to the first category of recipient. Finally, the set of recipients contains a third group of countries as well, for whom a reduction from the unilateral level increases their utility level, but the efficient level is below their private effort level. These countries are

[37] Under this payment scheme, these countries might be worse of compared to the unilateral outcome, but they may still be better of compared to their private outcome, where they would have to tackle the threat from the rouge country single-handedly.

[38] This is easily seen by comparing the amount they would need to be paid to give them their utility at the unilateral outcome, and what they are actually given under the proposed scheme. A payment of $(e^N - e^E)[\lambda^i(\overline{t}) - (e^N + e^E)]$ puts them at the former level, but the proposed scheme gives them $(e^{i*} - e^E)[\lambda^i(\overline{t}) - (e^{i*} + e^E) - c]$. It turns out that a sufficient condition for $(e^{i*} - e^E)[\lambda^i(\overline{t}) - (e^{i*} + e^E) - c] < (e^N - e^E)[\lambda^i(\overline{t}) - (e^N + e^E)]$ is $\lambda^i > \lambda^I - 2c$. But from Lemma 1, we know that for this particular group of recipients $\lambda^i > \lambda^I - c$. So, the sufficiency condition is automatically satisfied for them.

better off compared to the unilateral outcome, under the proposed scheme. This is because the moving to the efficient outcome makes them better off, and they get a transfer over and above that (to stop them from making any effort).

2.7.2 The voting stage

This section analyzes the second stage voting game. In this game, voters decide on the adoption of the proposal made by the neutral player. The proposal involves the adoption of the effort vector $(0, 0, ..0, e^E)$ and the transfer scheme $(T^i)_{i=1}^I$. The transfer scheme $(T^i)_{i=1}^I$ contains payments for the recipients in set R along the lines of what was discussed in the previous section. For the payees, the proposal gives a payment amount Z^i for each of them satisfying the constraints: $0 \leq Z^i \leq (e^E - e^N)[\lambda^i(\bar{t}) - (e^E + e^N)]$, for all $i \in P$, and $\sum_{i\in P} Z^i = \sum_{i\in R}(e^{i*} - e^E)[\lambda^i(\bar{t}) - (e^{i*} + e^E) - c] \equiv T$.

In a natural extension of my model, the neutral player may include in its proposal a sharing rule f, by which the total payment amount T can be shared among the payees. This sharing rule must allocate an amount Z^i to be paid by every payee. Formally, $f : (T, \Theta^i) \rightarrow Z^i$, where $Z^i \in \Re^+$ and Θ^i is a certain characteristic particular to i. The sharing rule f should be such that each Z^i must satisfy the constraints:

$$0 \leq Z^i \leq (e^E - e^N)[\lambda^i(\bar{t}) - (e^E + e^N)], \quad \text{for all } i \in P, \text{ and } \sum_{i\in P} Z^i = T.^{39}$$

For the proposal to be adopted, it must have unanimous support of the set of voters, decided by the neutral player. The set of voters is made up of a particular subset of the alliance members, namely nation I and all the payee nations belonging to set P.

In the voting-stage every player $i \in P$ and I must vote either *Agree* or *Not Agree*. The proposal is passed only if all voters unanimously vote *Agree*. Looking at the game from the viewpoint of any $i \in P$ which votes to *Agree,* the payments proposal is passed (P hereafter) if all the other players $-i \in P$ and I vote *Agree.* However, but if one or more players in $-i \in P$ or I vote *Not Agree* then the proposal is not passed (*NP* hereafter), for all possible combinations of such players (recalling that we must have unanimity for the proposal to pass). Under the first situation the payments to the recipients can be committed by the neutral player in the third stage effort choice subgame. It has been shown in Lemmas 5 and 6 that an effort outcome of that subgame, when suitable transfers are made, is $(e^i)_{i=1}^I = (0, 0, \ldots, e^E)$. However, if the proposal is not passed then no transfers are made, and the status quo effort choice game is played in the next stage. As we know, this game leads to the unilateral effort outcome. For i voting *Not Agree* the proposal is not passed, regardless of the way any of the other players might vote. So in that case the status quo effort choice game would anyway be played in the next stage. For i voting *Agree* the proposal is adopted only if every other player also votes to *Agree.* The second stage voting game is depicted in the diagram below.

[39] For example, there can be a rule f such that $Z^i = f(T, \Theta^i) = f^i(.)T$, where $f^i(.) = \frac{(e^E - e^{i*})}{\sum_{i=1}^j (e^E - e^{i*})}$, for $i = 1, ..j$. We notice that $\sum_{i=1}^j f^i(.)T = T$, since $\sum_{i=1}^j f^i(.) = 1$. Under this rule, each country $i \in P$ pays an $\frac{(e^E - e^{i*})}{\sum_{i=1}^j (e^E - e^{i*})}$th fraction of T. This version of the rule assumes that the willingness-to-pay constraint is met for all countries. A technical appendix discussing a version of this rule, when all such constraints are not met, is available on request.

The payoffs of the players are:
For I:

$$V^I(.) = M^I + e^E[\lambda^I(\bar{t}) - e^E] + Z^I - ce^E, \text{ given } Z^I = \tau \text{ for the proposal passing}$$

and the unilateral payoff otherwise,
For $i \in P$:

$$V^i(.) = M^i + e[\lambda^i(\bar{t}) - e] - ce^i - Z^i, \ i \in P, \text{ for the proposal passing}$$

(where $Z^i > 0$ is a lump sum payment)

and the unilateral payoff otherwise.

Lemma 8 *The neutral player's proposal is unanimously adopted in the voting stage*: (i) *Every player* $i \in P$ *Agree' to pay amount* Z^i *and the effort vector* $(0, 0, ..0, e^E)$ *in the voting stage, where* $0 \leq Z^i \leq (e^E - e^N)[\lambda^i(\bar{t}) - (e^E + e^N)]$ *for every* $i \in P$. (ii) *Player* I *also votes 'Agree' to the proposed effort and transfer vectors.*

Proof '*Agree*' is a weakly dominant strategy for every player $i \in P$ (follows from Lemma 3) and I. Hence, all voters *Agree* to pass the proposal, which is thus unanimously adopted. [40] □

In this game every player in the set of payees votes to pass the proposal, since it does not lose anything compared to the status quo outcome if the proposal does not pass, but might gain if it does pass. This game is depicted in Fig. 2.

2.7.3 The subgame perfect equilibrium of the institutional game

The analyses of the last few sections reveal the subgame perfect equilibrium of the overall institutional game. This equilibrium is outlined in the following proposition. We have assumed that if a country gets the same payoff from making zero effort and a positive effort, then it makes no effort.

	$-i \in P \backslash i$ and I	
i	Agree	Not Agree
Agree	Proposal adopted: Game with Transfers in 2nd stage (Payoff from efficient effort given transfer payments)	Proposal fails: Status Quo Game in 2nd round (Status Quo payoff)
Not Agree	Proposal fails: Status Quo Game in 2nd round (Status Quo payoff)	Proposal fails: Status Quo Game in 2nd round (Status Quo payoff)

Fig. 2 The second stage voting game among the payees and I on adoption of the neutral player's proposal

[40] It has been assumed a player votes *Agree* when it is indifferent between paying and not paying.

Proposition 3 *The profile* $(\{Agree, e^i = 0 \text{ for } NP\}_{i\in P}, \{e^i = 0 \text{ for } P \,\&\, NP\}_{i\in R\setminus I}, \{Agree, e^I = e^N \text{ for } NP\})$ *is a subgame perfect equilibrium of the institutional game, for the elements proposal by the neutral player being such that*:

(i) $0 \le Z^i \le (e^E - e^N)[\lambda^i(\bar{t}) - (e^E + e^N)]$, *for all* $i \in P$, *and* $\sum_{i\in P} Z^i = \sum_{i\in R}(e^{i*} - e^E)[\lambda^i(\bar{t}) - (e^{i*} + e^E) - c] \equiv T$.

(ii) *The neutral player proposing to compensate player* I *an amount* $Z^I = (e^N - e^E)[\lambda^I(\bar{t}) - (e^N + e^E) - c] \equiv \tau$ *for* $e^I = e^E$, *and* 0 *otherwise*.

(iii) *Proposing to compensate players* $i \in R\setminus I$ *an amount* $Z^i = (e^{i*} - e^E)[\lambda^i(\bar{t}) - (e^{i*} + e^E) - c]$, *for choosing* $e^i = 0$ *in the effort choice subgame with transfers, and* 0 *otherwise*.

(iv) *The proposal requiring unanimity support of nation* I *and nations* $i \in P$, *who are the only nations invited to vote on the proposal. All recipient nations* (*other than* I) *are not invited to vote on the proposal*.

This subgame perfect outcome of the institutional game has all players $i \in P$ *and* I *voting to pass the neutral player's proposal in the second round and all alliance members* $i \in S$ *making effort choices in the third round such that the effort outcome is* $(e^i)_{i=1}^I = (0, 0, \ldots, e^E)$. *Hence, the joint effort of the alliance is at the efficient level.*

Proof Given the above payment proposals to $i \in R\setminus I$, $(e^i)_{i=1}^I = (0, 0, ..0, e^E)$ is an outcome of the effort choice stage (see Lemma 7). The payees $i \in P$ and I vote to pass the sharing scheme (which leads to the payments in the effort choice stage) in the voting stage if it satisfies the conditions of the above proposition (see Lemma 8). Hence the proposition is true. □

This proposition gives the central result of this paper.[41] It indicates a particular institutional structure for the alliance that would help it reach its efficient effort level. For such an institutional structure, unilateral action by a single nation would be tempered towards the efficient outcome by multilateral participation by other alliance members.[42]

3 Discussion

3.1 Implications of our results for alliance building

The results of the model show there can be unilateral action by a single nation among those in a alliance fighting an external threat. This nation is the one which has greatest benefit from security effort among all alliance members. While all other alliance partners avail of

[41] It is possible to verify that the neutral player's proposal could have also secured unanimous approval even if a subset of recipients (those with $\lambda^i < \lambda^I - c$) were included among the set of voters in the second stage voting game).

[42] Questions might be raised whether in the absence of transaction costs we could have the same outcome through Coasean bargaining, given all nations have the right to make effort. However, a fundamental problem with Coasean bargaining is that it tends to break down in the presence of a large number of agents who need to pay compensation, since each of them might want to free-ride on the other. The institutional structure discussed in this paper is essential to avoid this problem. Further, enforcement of Coasean bargains may not be possible for sovereign nations, who might renege on payment promises, or promises regarding effort choice. In my model, since payments are handed over to the neutral player, it is possible to ignore the enforceability problem and also not have to make strong assumptions regarding commitment.

the benefits of this nation, some of these partners will benefit from a decrease in its level of activity.

This paper proposes an institutional structure for the alliance under which it is possible for the unilateral agent continues to act singly for the whole alliance, but get a payment (transfer) from other countries (through the intermediation of a neutral supranational agency), and change its activity to the efficient level for the alliance. While it might seem that action by a single nation is occurring under all situations, one realizes that this institutional scheme is indicative of multilateralism, especially since in this model money and effort are perfectly substitutable. A movement to efficiency can occur only through multilateral participation, rather than non-participation of certain nations in the fight against threat. It is seen that when the efficient level is higher than the unilateral level, only countries with high benefits from security activity would be willing to contribute to a tax-transfer scheme to make the unilateral agent raise its effort. For the efficiency level being lower than the unilateral level, only countries with low benefits from security effort would be willing to contribute to the payment fund. However, for payments to be made (even when payees are individually better off by making the payment), payee countries have to overcome a collective choice problem. This problem, often seen in Coase bargaining situations involving multiple agents, arises because payment by a nation has positive externalities for other payees, and might lead to a hold-up of payments. The particular institutional structure for the alliance, suggested in this paper, solves this problem.

It is also seen that in the case where the efficient amount of effort is lower than the unilateral level, some countries other than the unilateral provider also need to be paid off, in order that the efficient amount of effort be achieved. Otherwise, these countries would start making effort levels such that the efficient amount of joint effort would not be sustained. The situation is different in the case where the efficient joint effort level is greater than the unilateral amount. The results of this paper imply that in that case the efficient effort level may be obtained by making payments to the unilateral provider alone. No other country needs to be paid off, since they would make no effort for the unilateral provider making the efficient level of provision (see Lemma 5).

It is interesting that while it may be possible to make some countries better off, and none worse off for the efficient effort outcome (through a suitable redistribution of money), doing so is not essential in implementing it as the joint effort of the alliance.[43] In fact, in the scheme proposed in this paper, such a type of redistribution does not take place. The other interesting result is that in this scheme some of the beneficiaries of the movement from the unilateral to the efficient outcome end up getting paid for not deviating from their zero effort levels, rather than having to pay for their gain. So, in some sense, these 'centrist' countries end up gaining a lot, in the process of movement of the alliance to the efficient outcome. Countries preferring high levels of security activity may be worse-off for the shift, since they derive the greatest free-riding benefits from unilateral action by the nation having the strongest preference. As noted, these countries need not be compensated as much as the amount to their loss to sustain the efficient outcome.

A big hurdle to multilateral action stems from the fact that there is a collective choice problem among countries that must pay for the transfers. Countries cannot be excluded from the benefits of payments made by other countries. We have suggested an institutional solution to the problem, keeping in mind our particular context. Because of the institutional

[43] However, if indeed the scheme suggested by the neutral player was such that no nation was worse off, then all countries in the alliance could have been included in the 2nd stage unanimity voting game, and not just the payees and I. The payment proposal would win with affirmative votes by *all* alliance members in that case.

structure we suggest, it is possible to entirely skip the question of how the payees might decide to share the total payment amount they have to make (or fail do so), if they were left to make this decision entirely by themselves. Our solution has implications for the organization of international institutions. First, as we observe in our model, the presence of a neutral player is important. This role can be played in the real world potentially by a body like the United Nations or an expanded NATO. International organizations need to be organized in such a fashion that such a body has the capability of fulfilling the role of both a proposer and facilitator, along the lines indicated by our findings. Perhaps this role might be assumed within NATO alliance by the NATO Office of Security or by a special directorate within the United Nations. The facilitating role of such an entity would in no way impinge on the sovereignty of any nation, but arise from the decisions of the nations themselves. As we saw in our model, the payee countries decide to pay up of their own free will, by voting on the neutral player's payment proposal. All nations make their effort choices freely as well. The role of the neutral player is only to hold money given to it by certain nations, and then doling out payments to others contingent on their actions. However, the role of the neutral player as a mediator is of particular significance. The alliance is able to reach the efficient outcome in our model due to the neutral player making certain specific proposals to specific countries. In the real world, an independent and neutral agency within an international organization (alliance) can fulfill this role. The next section contains a more detailed discussion on this issue.

The model demonstrates that there needs to be clear institutional rules like unanimity voting involving the nations which have the most extreme preferences regarding the combat of threat.[44] Voting on the issue of security provision should be restricted to a subset of member nations (notably the country preferring the highest level of security provision, and those preferring it to be sufficiently low), as well as the requirement of unanimity among these nations to adopt a resolution. While some of the institutional rules suggested in the paper are routinely followed by many real world organizations, other rules might be harder to achieve, and might need reform of existing institutions.[45] The positive implication of the results seen in this paper is that it might be possible for alliance members who are polarized on their approach to global security threats to reach a multilateral solution, if the organization of the alliance is reformed as suggested. [46]

[44] Also, no private payments should be possible among the alliance members.

[45] For example, the rule that voting on the adoption of the neutral player's agenda be restricted to a subset of alliance members. Also, the creation of an entity with the powers and discretion of the neutral player might require considerable diplomatic effort and the reform of existing institutions. The reform of supranational institutions, in order for them to be more effective, has been advocated time and again. Experts have suggested the need to reform the United Nations through adoption of the recommendations of the report prepared on behalf of the Dag Hammarskjold Foundation by Childers and Urquhart (1994) entitled, "Renewing the United Nations System". This report made extensive suggestions on restructuring the Secretariat and the administrative and financial management of the United Nations. It would be interesting to study if the structure of the UN Secretariat suggested in this report would make it capable of assuming the role of the 'neutral player' seen in our model.

[46] Questions might arise why a country would want to remain in such an organization, especially if it knows it will be designated as a payee country. It might want to stay outside the organization, and hope that it is able to free-ride on others joining the organization and paying up. To preempt this, a certain level of participation should be required to form an alliance. For example, it is hard to conceive of the NATO without the involvement of France or Germany. Given such participation requirements, these countries may prefer to be in the alliance to the case where the alliance does not form and unilateral action takes place.

3.2 The "neutral agent": a few thoughts

In this section I will briefly discuss my ideas regarding the form and powers of the "neutral agent" discussed above. I will also outline some conditions that might ensure the neutrality of that agent and encourage its performance. Finally, I will discuss the circumstances under which the member countries would agree to have such a neutral agent as part of their international organization. This discussion is informal, and provides some thoughts and ideas that might be useful for future research on this topic.

As mentioned before, the role of the neutral agent may be fulfilled by a special independent directorate or department within the international organization. Some of the issues pertaining to the form, structure, and rules that might ensure the neutrality and performance of this directorate, are briefly outlined below.

(i) The rank and file of this directorate might be staffed by suitable experts recruited competitively on basis of their "technical" qualifications. Applicants for these positions might belong to any of the member states, or even outside the member states, if deemed suitable. This directorate might in fact correspond to an international civil service, admittance to which might depend on qualifications, and performance on an entrance examination.

(ii) The actions of those in leadership positions of this directorate would be extremely important in determining its neutrality. No doubt, member states would have influence in determining these leadership positions, and there might be politicking associated with these appointments. So what would ensure that the top managers of this directorate would indeed be neutral, and not either succumb to the influence or actively promote the interests of the nation(s) backing their appointment? In order to answer this question, it might be useful to refer to the literature on Central Bank Independence, which many readers will recognize as addressing certain similar questions, though in a different context.[47] Some of the lessons learnt from that literature, suitably adapted, might be useful to us. Adapting Neumann's (1991) observation on personnel independence in central banks to our situation, we may state that "the conditions of contract and of office would have to be set such that the appointee frees himself or herself from all former nationalistic ties or dependencies and accepts the *neutrality objective* as his or her professional leitmotif. We may call this a Thomas Becket effect". Lifetime appointments (like those of U.S. Supreme Court Justices) might also make the top managers of the directorate less susceptible to outside influences.

(iii) To a great extent, like many bureaucratic entities, the neutrality of the directorate might be dependent on the personalities that lead and work in it. In order to provide checks and balances, which would ensure its neutrality, devolution of power within the directorate might be helpful. A balance of decision-making power between top level leadership (who might sometimes be more susceptible to pressure from particular member states), and the technical experts who make up the rank and file, might ensure neutrality of the directorate. There should be adequate protections for the technical cadre from pressure from the top leadership. On the other hand, the top leadership should be able to provide directional guidance for the directorate. Hence, the power structure and decision-making rules within the directorate should be formally laid out in order to preserve its neutrality.

[47] For excellent surveys on the issue of central bank independence see Eijffinger and Haan (1996), and Romer and Romer (1996).

(iv) There might also be incentive schemes that promote the neutrality of the operatives and leadership of the directorate, and encourage them to work out a proposal (as defined in Sect. 2) that would lead to the optimal outcome. Note that the role of the directorate is important in determining: (a) the efficient level of joint effort, (b) who pays and receives transfers, and (c) the amounts of transfers that are paid and received. In fact, given the perfect information model in the paper (i.e. all λ^is are known), a neutral directorate (which has the requisite technical expertise) should be able to determine items (a), (b), and (c) in a transparent manner. In fact, in a perfect information case, the only way bias could be introduced would be through a non-transparent process for determining these items. Hence transparency in the working of the directorate is of utmost importance. What constitutes a transparent process is a matter of further investigation, and would require specific structural details of the organization under consideration.

(v) Finally, the directorate determines the set of voters who would vote to approve the proposed transfer scheme, which would move the alliance towards the optimal effort level. If the directorate (or rather key operatives employed within the directorate) had vested interests in favor of nations whose welfare are reduced by the scheme, a way to ensure that the scheme does not pass the vote would be by manipulating the set of voters—and include at least one voter whose interest is hurt by the scheme. This would lead to the scheme not surviving the unanimity based voting process outlined in Sect. 2. This behavior can be made unprofitable for those employed in the directorate by making their compensation packages and retention dependent to an extent on whether the proposed transfer scheme is adopted or not. This mechanism for ensuring the neutrality of the functionaries of the directorate is akin to the mechanism suggested for ensuring the independence of the leadership of Central Banks from their political principals by Persson and Tabellini (1993). According to Persson and Tabellini, central bank leadership should be made explicitly accountable for meeting inflation targets.[48] The mechanism I have suggested for keeping the leadership and operatives of the neutral directorate honest, in choosing the group of voters, is an adaptation Persson and Tabellini's idea.

As discussed above, a study of the literature on Central Bank Independence provides us with ideas for conditions which might ensure the neutrality of the independent directorate, which I suggest would fulfill the role of my model's "neutral agent". However, the reader will recognize that the suggestions discussed above are far from complete, and only provide the basis for further research. It is my belief that questions regarding the form and structure of the neutral agent, and the conditions for its efficient functioning, are challenging. Their study might require interdisciplinary collaboration in order to yield practicable answers. These answers might not only require input from economists, but also experts in political science, international relations, international law, and diplomacy, who have knowledge regarding the intricate working of specific international institutions like the United Nations or the NATO.

Finally, let me address a couple of important issues, which might be of interest to the reader. Would the members of the international organization (alliance) at all agree to have a powerful independent directorate within the organization, and more importantly, allow it to continue if their individual interests are not well served? And what would ensure acceptance of the directives of the directorate, when such acceptance reduces the welfare of a nation? Before discussing these issues, I would like to remind the reader that in the transfer scheme

[48] Indeed, this type of system has existed in New Zealand since 1989, where the governor of the central bank can be dismissed if the inflation rate exceeds 2%.

proposed in my model, no nation gets a welfare level lower than their "private" level, i.e. the level they would get if they decided to go alone. Thus, there is no incentive for anyone to leave the organization after the transfer scheme is adopted, even if it is one of the nations whose welfare is reduced compared to the Nash equilibrium level.[49] Thus, the answer to issue of why nations would accept the directives of the directorate is an easy one (as long as the directorate is able to exist and maintain its independence). No one has an incentive to go against the directives of the directorate, especially if going against the directives would lead to expulsion from the organization. This brings us to the first issue—what would lead to the foundation of the neutral directorate and its continuance over time. It is my belief that the foundation of an independent directorate with suitable powers within the international organization would require an opportune historical moment, where the interests of a sufficient number of the alliance members are conducive to such a set up. Not only should the operating rules of the directorate be set up such that it might fulfill its goal, but there should be organizational rules which would ensure its continuance (even at times when its schemes are not popular with many, perhaps a majority, of the alliance members). This might require the alliance members to adopt inflexible rules that have to be adhered to by member nations at all times. As the reader might recognize, the problem here is again similar to one seen in the literature on central bank independence, where the political principals might find it difficult to be dynamically consistent regarding their objectives, and hence their dealings with central bank operatives, over time. As in that case, the existence of inflexible organizational rules might help the neutral directorate to continue its existence and fulfill its obligations. More research is needed to identify situations where member nations of relevant international organizations might be agreeable to setting up of such an independent directorate. From a historical perspective, the suitable structuring of international organizations and alliances depend to a great extent on the alignment of events, objectives, and personalities. Witness the robustness and endurance of the United Nations, compared to what many might call its predecessor—the League of Nations. It is also true that once they come into being, the rules and regulations governing many international organizations survive over time, even when many member nations disagree with those regulations.[50] This historical perspective lends us comfort that the incorporation of a neutral agent within relevant international organizations, whose actions will facilitate in realizing the efficient outcome, may indeed be possible.

4 Conclusion

The model presented in this paper provides a starting point for answering some questions on the issue of providing global security, within the framework of an alliance. The paper developed an institutional framework for the alliance that leads to the efficient and multilateral provisioning of security against the threat by a rogue nation. The suggested institutional

[49] In the scheme suggested in this paper, all countries, except certain extreme free-riders end up better off than in the Nash equilibrium. However, even these extreme free-riders are as well off as they would be in their private outcome. This suggests that no alliance member really has an incentive to break away from the alliance, especially if that break-away causes the demise of the alliance, and destroys all the benefits associated with it.

[50] In fact, it might be fascinating to study which kind of regulations survive disagreement and why, and which do not. In the real world, once an institutional rule is in place, members of that institution might follow the rules because a violation might lead to expulsion. Expulsion might have costs which they do not want to bear. This would be especially true if the alliance was formed to deal with multiple issues, and the cost of expulsion from the alliance on a single issue might hurt a country more than it wants on other issues.

framework overcomes coordination and hold-up problems which are observed in the context of Coasean bargaining. I have discussed the findings of the paper in Sect. 3.

This paper is a first step in dealing with the problem of designing international alliances (and institutions) to efficiently and multilaterally provide security against global threats. My model focuses on the interaction within an international alliance, and hence considers the external threat to be exogenous. A basic extension of my model might make this threat endogenous. Further, there is complete information about the security preferences of the alliance members, for reasons discussed earlier. If there were incomplete information about these preferences, however, the institutional structure might need additional structure. There are some other important questions that also require further attention. I have introduced the concept of a "neutral player" as a proposer and facilitator within the institution of the alliance, with certain discretionary powers. Multidisciplinary research involving economics, political science, law, and diplomacy might be required to study the practical difficulties associated with incorporating such an entity within the existing international organizations. Not only is there the question of reforming the present institutions through agreement among the present member nations, but there is also the matter of the structure and form of the "neutral player". The structure and powers of this entity called the neutral player, as well as the incentive mechanism for it, would go a long way in ensuring its "neutrality" and its ability to steer the international alliance towards an efficient outcome. As mentioned, the answers to these questions would likely require considerable research involving multidisciplinary collaboration.

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Appendix 1: Proof of Proposition 1

Proof By assumption $\lambda^I > \lambda^i, \forall i \neq I$.

It follows from the solution to the FOC for country $i \neq I$ that for $\sum_{j\neq i} e^j = \frac{1}{2}[\lambda^I(\bar{t}) - c]$, $e^i = 0$ is its best response.

But for $e^i = 0$, $e^I = \frac{1}{2}[\lambda^I(\bar{t}) - c]$ is the best response for I (from its FOC & the above assumption).

So the Nash equilibrium is: $(e^1, e^2, \ldots, e^I) = (0, 0, \ldots, \frac{1}{2}[\lambda^I(\bar{t})\bar{t} - c])$.

Thus, $e^N = e^I = \frac{1}{2}[\lambda^I(\bar{t}) - c]$, as $e^i = 0$, for $i \neq I$.

This equilibrium is unique since for any other profile of effort by the players, at least one player has a profitable deviation:

Consider $e^i = \theta^i \geq 0$ for $i \neq I$, with $\theta^i > 0$ for at least one i.

I's best response in this case is: $e^I = \frac{1}{2}[\lambda^I(\bar{t}) - c - 2\sum_{j\neq I} e^j] > 0$ or 0.

But for such a response by I, i's best response is:

$$e^i = \frac{1}{2}\left[\lambda^i(\bar{t}) - c - 2\sum_{j\neq i,I} e^j - 2e^I\right] = \frac{1}{2}\left[\lambda^i(\bar{t}) - c - 2\sum_{j\neq i,I} e^j - \left\{\lambda^I(\bar{t}) - c - 2\sum_{j\neq I} e^j\right\}\right]$$

$$= \frac{1}{2}[\lambda^i(\bar{t}) - \lambda^I(\bar{t}) + 2\theta^i], \quad \text{(putting } e^i = \theta^i > 0\text{)}$$

$$= \theta^i + \frac{1}{2}[\lambda^i(\bar{t}) - \lambda^I(\bar{t})] < \theta^i, \quad \text{since } \lambda^i(\bar{t}) < \lambda^I(\bar{t}).$$

Hence θ^i is not i's best response.

Now, consider $e^I < \frac{1}{2}[\lambda^I(\bar{t}) - c]$. We have seen that for $e^i = 0$ for $i \neq I$, this is not I's best response. The only way it might be a best response is if $e^i > 0$ for some $i \neq I$. But we have already seen than any outcome with $e^i > 0$ for some $i \neq I$ cannot be a Nash equilibrium since $e^i > 0$ is not i's best response. Hence the Nash equilibrium is unique.

Appendix 2: Proof of Lemma 1

Proof In equilibrium, the utility of country $i \neq I$ is given by: $V^i(.) = M^i + e^N\lambda^i(\bar{t}) - (e^N)^2$.

Therefore, for country $i \neq I$, $\frac{\partial V^i}{\partial e^N} < 0$ for $\lambda^i(\bar{t}) - 2e^N < 0$.

Substituting the value of e^N and rearranging the terms, we get the above result.

Appendix 3: Proof of Proposition 2

Proof For a 'marginal supporter' of I:

$$\lambda^i(\bar{t}) = \lambda^I(\bar{t}) - c \tag{1}$$

Let (1) hold for country i for an initial exogenous level of threat $\bar{t}$.

Let $\lambda^i(\bar{t}) \equiv A$ and $\lambda^I(\bar{t}) - c \equiv B$.

For an increase in $\bar{t}$, the LHS of (1) increases by $\frac{\partial A}{\partial \bar{t}} = \frac{\partial \lambda^i}{\partial \bar{t}}$, and the RHS increases by $\frac{\partial B}{\partial \bar{t}} = \frac{\partial \lambda^I}{\partial \bar{t}}$.

However, for increased $\bar{t}$, the initial equality between the LHS and RHS of (1) would no longer hold if $A + \frac{\partial A}{\partial \bar{t}} < B + \frac{\partial B}{\partial \bar{t}}$.

But this would happen if $\frac{\partial \lambda^i}{\partial \bar{t}} < \frac{\partial \lambda^I}{\partial \bar{t}}$.

Hence, the above proposition follows.

Appendix 4: Proof of Lemma 3

Proof From the individual rationality condition, a country i might be willing to pay a positive amount, i.e. $z^i > 0$, only when $[V^i(m^E, e^E; \bar{t}) \mid z^i > 0] \geq [V^i(M^i, e^N; \bar{t}) \mid z^i = 0]$

Or, $[V^i(m^E, e^E; \bar{t}) \mid z^i > 0] - [V^i(M^i, e^N; \bar{t}) \mid z^i = 0] \geq 0$

We note that the utility of $i \neq I$ for the unilateral outcome is $M^i + e^N[\lambda^i(\bar{t}) - e^N]$,

And its utility in the efficient outcome is $M^i + e^E[\lambda^i(\bar{t}) - e^E] - z^i$ (As $m^i + ce^i + z^i = M^i$ is i's budget constraint, and $e^i = 0$)

So, $[V^i(m^E, e^E; \bar{t}) \mid z^i > 0] - [V^i(M^i, e^N; \bar{t}) \mid z^i = 0] \geq 0$

$\Longrightarrow \{M^i + e^E[\lambda^i(\bar{t}) - e^E] - z^i\} - \{M^i + e^N[\lambda^i(\bar{t}) - e^N]\} \geq 0$

$\Longrightarrow z^i \leq (e^E - e^N)[\lambda^i(\bar{t}) - (e^E + e^N)]$.

Appendix 5: Proof of Lemma 4

Proof From Lemma 3 it follows that $z^i > 0$ for $(e^E - e^N)[\lambda^i(\bar{t}) - (e^E + e^N)] > 0$.

Hence, for $e^E > e^N$, $z^i > 0$ for $\lambda^i > (e^E + e^N)$.

Similarly, for $e^E < e^N$, $z^i > 0$ for $\lambda^i < (e^E + e^N)$.

Appendix 6: Proof of Lemma 5

Proof I's payoff from effort $e^I = e^E$ for $\tau = (e^N - e^E)[\lambda^I(\bar{t}) - (e^N + e^E) - c]$ is equal to the payoff from the original game (given $e^i = 0$ by $i \neq I$). As any other effort level forfeits this transfer to I (or $\tau = 0$), I is indifferent between the payoff it was getting in the original game and receiving the transfer and making the efficient effort. So, I chooses $e^I = e^E$ given $e^i = 0$ by $i \neq I$.

For $i \neq I$, recall that the best response function is $e^i = \frac{1}{2}[\lambda^i(\bar{t}) - c - 2\sum_j e^j]$, for $\lambda^i > c + 2\sum e^j$, $j \neq i$ and 0, otherwise. Given $e^I = e^E$ and $e^E > e^N$, it follows that $\lambda^i < c + 2\sum e^j$. So $e^i = 0$ in equilibrium.

Appendix 7: Proof of Lemma 6

Proof For country $i \neq I$, the best response function is: $e^i = \frac{1}{2}[\lambda^i(\bar{t}) - c - 2\sum_j e^j]$, for $\lambda^i > c + 2\sum e^j$, $j \neq i$ and 0, otherwise.

Now, for $e^I = e^E$, and $e^j = 0$, for $j \neq I$, $e^i = \frac{1}{2}[\lambda^i(\bar{t}) - c - \frac{1}{I}\sum_{i=1}^{I}\lambda^i(\bar{t}) + \frac{1}{I}c]$

The expression $[\lambda^i(\bar{t}) - c - \frac{1}{I}\sum_{i=1}^{I}\lambda^i(\bar{t}) + \frac{1}{I}c] > 0$ for $\lambda^i(.) > \frac{\sum_{i=1}^{I}\lambda^i(\bar{t})}{I} + \frac{c(I-1)}{I}$

Hence the assertion is true.

Appendix 8

The transfer amount to $i \in R\backslash I$ is given by $Z^i = (e^{i*} - e^E)[\lambda^i(\bar{t}) - (e^{i*} + e^E) - c]$. This discussion shows that this transfer amount gives the recipients a utility level equal to the level where it would be fighting the global threat single-handedly. Let $V^i(m^{i\prime}, e^{i*} - e^E, Z^{i*} \mid e^{i*})$ be the utility of country i when it makes an effort level that is the difference between its private level of effort and the efficient level, the joint effort for the alliance (alliance) is equal to its private level. The consumption level of the public good is given by $m^{i\prime} = M^i - c(e^{i*} - e^E)$. Note that Z^* cannot be less than 0, since $e^{i*} - e^E > 0$.[51] Note that Z^{i*} is dependent on the effort level of i.[52]

Let $V^i(m^E, 0, Z^{i\prime\prime} \mid e^E)$ be the utility of a country when it makes no effort, gets a payment of the amount Z^i (again, this is dependent on making zero effort), and the joint effort for the alliance is at the efficient level. We have $m^E = M^i$.

Let Z^i be set such that $V^i(m^E, 0, Z^{i*} \mid e^E) = V^i(m^{i*}, e^{i*} - e^E, 0 \mid e^{i*})$ for the countries $i \in R\backslash I$. Hence, Z^i equals:

$$V^i(m^{i\prime}, e^{i*} - e^E, 0 \mid e^{i*}) - V^i(m^E, 0, Z^{i\prime\prime} \mid e^E) = 0$$

or,

$$\{M^i - c(e^{i*} - e^E) + e^{i*}[\lambda^i(\bar{t}) - e^{i*}]\} - \{M^i + e^E[\lambda^i(\bar{t}) - e^E] + Z^{i\prime\prime}\} = 0$$

[51] No country other than I can get a payment if it makes anything other than zero effort.

[52] Note that for $e^I = e^E$ and $e^j = 0$, for $j \neq i, I$, $e^i = \frac{1}{2}[\lambda^i - c - 2e^E] = \frac{1}{2}[\lambda^i - c] - e^E = e^{i*} - e^E$, where e^{i*} is the private provision level of i.

or,

$$Z^{i,\prime\prime} = (e^{i*} - e^E)[\lambda^i(\bar{t}) - (e^{i*} + e^E)] - c(e^{i*} - e^E) = (e^{i*} - e^E)[\lambda^i(\bar{t}) - (e^{i*} + e^E) - c]$$

This value of Z^i makes i's utility of getting payment Z^i and doing nothing when the alliance effort is at the efficient level, equal to its utility when it makes the residual effort provision for the whole alliance over the efficient level (so that alliance effort equals its own private level) and gets no payment. Notice that as $e^E < e^{i*}$ and $[\lambda^i(\bar{t}) - (e^{i*} + e^E) - c] = \frac{1}{2}[\lambda^i(\bar{t}) - c] - e^E = e^{i*} - e^E > 0$, Z^i must be positive.

Appendix 9: Proof of Lemma 7

Proof Note that for countries $i \in R\backslash I$ the best response function in the status quo game is:

$$e^i = \frac{1}{2}\left[\lambda^i(\bar{t}) - c - 2\sum_j e^j\right], \quad \text{for } \lambda^i > c + 2\sum e^j,\ j \neq i \text{ and 0 otherwise.}$$

In the game with transfers, given $Z^i = (e^{i*} - e^E)[\lambda^i(\bar{t}) - (e^{i*} + e^E) - c]$ for $e^i = 0$ and 0 otherwise, the best response effort level is zero, for e^E by I and no effort by others.

This is because from the best response function $e^i = \frac{1}{2}[\lambda^i(\bar{t}) - c - 2\sum_j e^j]$, for $\lambda^i > c + 2\sum e^j$, $j \neq i$ and 0 otherwise, its best response to e^E by I and no effort by others, is to make effort $e^{i*} - e^E$. The payoff from making this effort is $V^i(m^{i\prime}, e^{i*} - e^E, 0 \mid e^{i*})$ if $e^I = e^E$. But payoff from making no effort is $V^i(m^E, 0, Z^{i\,"} \mid e^E)$. Since by construction $V^i(m^E, 0, Z^{i\,"} \mid e^E) = V^i(m^{i\prime}, e^{i*} - e^E, 0 \mid e^{i*})$, i's effort level zero is payoff equivalent to making effort.[53] Note that if a country gets the same payoff from making zero effort and a positive effort, then it makes no effort (by assumption).

Further, for $e^i = \theta \neq 0$, $Z^i = 0$ and $e^I = e^E - \theta$ (for no effort by the other players).

Hence, i's payoff from deviation is $M^i + e^E[\lambda^i(\bar{t}) - e^E] - c\theta < M^i + e^E[\lambda^i(\bar{t}) - e^E] + Z^i$.

Thus, $e^i = 0$ maximizes (weakly) i's payoff, given $e^I = e^E - \theta$ and $e^j = 0$, $j \neq i, I$. Thus, $e^i = 0$ maximizes (weakly) i's payoff, given $e^I = e^E - \theta$ and $e^j = 0$, $j \neq i, I$.

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[53] In this proof $V^i(m^i, e^i, Z^i(e^i) \mid e)$ denotes i's utility from its consumption of the private good m^i, the amount of effort e^i that it puts in, and the transfer $Z^i(e^i)$ it gets (dependent on its effort), given the joint effort level e. Note that an 'effort level e^i is weakly preferred by i to an alternate level $e^{i\prime}$, if $V^i(m^i, e^i, Z^i(e^i) \mid e) \geq V^i(m^{i\prime} e^{i\prime}, Z^{i\prime}(e^{i\prime}) \mid e')$ for given effort levels of all $j \neq i$.

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