CHAPTER 2

MULTILATERAL ARMS RACES

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ABSTRACT

In this work, the author explores the specific structural conditions that render multilateral arms control agreements problematic by situating their dynamic in a three-person Prisoner's Dilemma game. The addition of even a third state to an arms race compounds many times over the structural difficulties that face two racing states. Nevertheless, even in multilateral arms races, conditions exist that make it rational for all participating states to pause. The most salient of these conditions is the existence of a coalition that is collectively rational for a subset of the racing states. It was suggested that if such a coalition exists naturally, or if one forms as a result of a exogenous shock to the system, then it is possible for it to offer incentives to all states not in the coalition to join it and, at the same time, increase the payoffs to the original members of the coalition. Thus, if such a coalition exists, then the possibility also exists that all the participating states could be induced to stop arming. Nonetheless, the major lesson that should be drawn from this chapter is the realisation that the conditions under which multilateral arms races might rationally be terminated are generally quite restrictive.

Keywords: Multilateral arms race; Prisoner's Dilemma; coalition; termination of multilateral arms race; exogenous shocks; payoffs to the original members

1. INTRODUCTION

On 2 August 2019, the United States unilaterally terminated the 1987 Intermediate Nuclear Force Agreement that banned both American and Soviet ground-launched ballistic and cruise missiles with ranges of between 500 and 5,500 kilometres.

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US officials justified the decision by pointing to Russian violations of the terms of the treaty, but the principle strategic target was, in fact, China. The restrictions of the agreement made it impossible for the United States to deploy intermediate range missiles in Asia to offset a build-up of tactical Chinese missiles. Giving credence to this explanation was the push by the Trump administration shortly after it announced its intention to withdraw from the treaty for a trilateral arms control agreement that included both Russia and China (Sanger & Wong, 2019). While some critics of the administration saw this policy initiative as disingenuous and designed to undercut the New Start Treaty negotiated by the Obama administration in 2010, others saw it as unrealistic. But even neutral observers recognised that 'a trilateral nuclear arms-control agreement among the United States, Russia and China would be a watershed diplomatic achievement' (Sonne & Hudson, 2019).

Are trilateral arms control agreements possible? Huntington (1971, p. 366) argues that they are not even necessary since there never has been a trilateral arms race. In Huntington's opinion, what has historically appeared to be an arms competition among three or more states has, in fact, been a collection of dyadic races. The empirical validity of this claim, however, is dubious. History offers several examples of multilateral arms competitions, including 'that between Britain, the United States and Japan to which the 1922 Washington Conference and Treaty put an end' (Watt, 1962, p. 375). And, as Gray (1971, p. 45) has pointed out:

> the evidence of Britain's naval relations with France and Russia, and the naval relations of France with Italy and Germany in the early 1890s, suggests a complexity of naval building standards that defies an exclusively bilateral interpretation.

Assuming, then, that the empirical evidence is dispositive, I next explore the theoretical conditions that stand in the way of multilateral arms control agreements and the circumstances under which those conditions might be mitigated. More specifically, I ask:

(1) Does the addition of a third or fourth or *n*th nation to an arms competition change the strategic problems faced by the states and what effect does this have on the possibility of mutual cooperation and/or arms control agreements?
(2) Are there any factors other than size affecting the likelihood of cooperation in a multilateral arms race?

2. A TRILATERAL ARMS RACE GAME

To address these and related questions, consider a game composed of three players, States A, B and C (see Fig. 1) and assume that each state views the other two as potential adversaries. Thus, any advance in the military position of any one state necessarily threatens both remaining states. In this game each state has two strategies: either to cooperate (C) by not arming or to defect (D) from cooperation by arming.

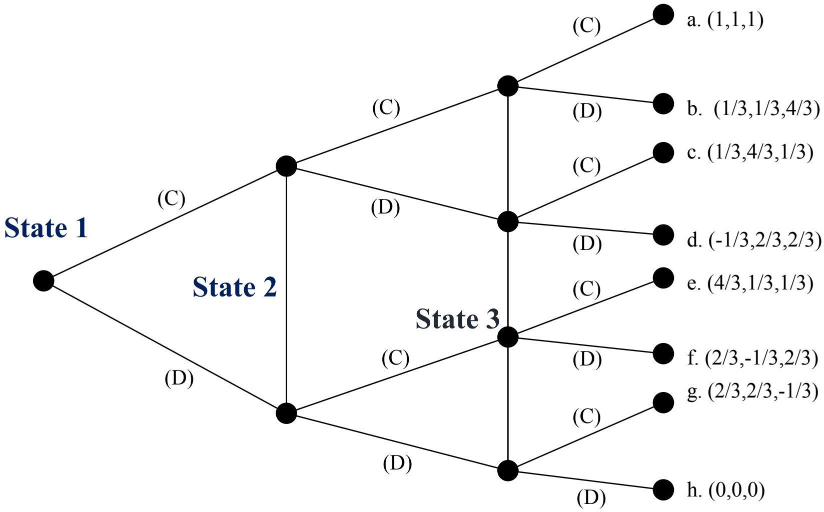

Fig. 1. A Three-Player Arms Race.

The outcomes of this game are listed at the endpoints of each branch of the game tree. To facilitate the subsequent analysis, the eight outcomes are labelled a through h. By convention, the first entry in each payoff vector represents the payoff to State A, the second to State B and the last to State C. For example, the outcome (4/3, 1/3, 1/3) represents a payoff of (4/3) to State A and a payoff of (1/3) to the other two states. Finally, assume that each nation:[1]

(1) Most-prefers to be the sole defector and gain a strategic advantage over the other two states. The sole defector receives a payoff of (4/3).
(2) Second most-prefers that all three states cooperate and not arm. In this case, no state gains a military advantage, each state gains the benefits of a smaller defence budget and receives a payoff of (1).
(3) Third most-prefers being one of two defectors, thus gaining an edge over the state that cooperates but not over the other defector. In this case, each defector receives a payoff of (2/3).
(4) Fourth most-prefers being one of two cooperators. Here the two cooperators reap the benefits of an arms control agreement with each other but these benefits are nearly offset by the strategic advantage gained by the defector. Hence, each cooperator receives a payoff of only (1/3).
(5) Fifth most-prefers the status quo and a payoff of (0) where each state increases defence spending yet gains no strategic advantage over the other two states.
(6) Least-prefers to be the sole cooperator and lose a strategic advantage to the two defectors. The sole cooperator receives a payoff of (–1/3).

An examination of the strategies of the players and the outcome assigned to each endpoint of the game tree reveals this game to be a three-person Prisoner's

Table 1. Outcomes, and Payoffs and Preferred Strategy of State A, Given Strategies of States B and C.

Strategy Choices of States B and C:	Outcomes	Payoff if (C)	Payoff if (D)	Optimal Strategy
Both (C)	a, e	(1)	(4/3)	(D)
State B (C) State C (D)	b, f	(1/3)	(2/3)	(D)
State B (D) State C (C)	c, g	(1/3)	(2/3)	(D)
Both (D)	d, h	−(1/3)	(0)	(D)

Dilemma game. To demonstrate this, consider for a moment the consequences for State A of choosing either of its two strategies (see Table 1). From State A's point of view, the other two states could both choose (C), or one could choose (C) and the other (D), or both could choose (D).

If both choose (C), (outcomes a and e), then State A receives a payoff of (1) by also choosing (C) and a payoff of (4/3) by choosing (D). Obviously, Nation A prefers the outcome associated with a choice of (D) since it receives a higher payoff.

If Nation D and Nation C are split in their choice of strategies (one chooses (C) and the other (D)), then Nation A receives a payoff of (1/3) if it chooses (C) and (2/3) if it chooses (D) (outcomes b, c, f and g). Again, the choice of (D) provides a higher payoff for Nation A.

Finally, if both states choose (D) (outcomes d and h), State A receives a payoff of (–1/3) if it chooses (C) and (0) if it chooses (D). As before, the choice of (D) provides State A with a higher payoff.

State A, then, always does better by choosing (D) regardless of the choice of the other two players. It can be shown, in a similar way, that States B and C also always do better by choosing (D) regardless of the choices of the other players. In other words, (D) strictly dominates (C) for each player. Yet, each player receives a worse payoff (0) if they all choose (D) than the payoff they would receive (1) if they all choose (C). Hence, since each player has a dominant strategy that results in deficient (or non-Pareto-optimal) outcome, this game is an *n*-person Prisoner's Dilemma.[2]

It is easy to demonstrate that this three-person variant of Prisoner's Dilemma is more intractable than the two-person version. Assume for a moment that the players in this game are permitted to form coalitions and coordinate their strategies. Also assume that State A unilaterally announces that it intends to step up military spending in the immediate future, that is, that it intends to choose (D). The problem for States B and C, then, is to choose a joint strategy that maximises their collective payoff. From Fig. 1, it can be seen that of those outcomes possible when State A chooses (D) (outcomes e, f, g and h), States B and C do best when they both cooperate. If they both cooperate (outcome e), their joint outcome is (1/3) + (1/3) = (2/3), while it is (2/3) + (–1/3) = (1/3) if one cooperates and the other does not (outcomes f and e), and is (0) + (0) = (0) if both do not cooperate (outcome h). Thus, the coalition between States B and C maximises its payoff by not arming.

The increased intractability of the three-person variant of Prisoner's Dilemma lies in the unfortunate fact that the joint strategy maximising the return to this coalition, while collectively rational, is not individually rational. Either State B or State C could increase its individual payoff from (1/3) to (2/3) by reneging on the agreement and defecting (D). But if each player defects, both receive a lower payoff (0) than if both had cooperated (1/3). Therefore, the principle of individual rationality renders this coalition – and because this game is symmetric, the coalitions between A and B, and A and C – unstable. A similar analysis would reveal the grand coalition of all three nations to be collectively rational but individually irrational as well.

Put another way, embedded in each three-person Prisoner's Dilemma game are three two-person variants. Not only is each individual player faced with a dilemma in the three-person version, then, but so is each two-player and three-player coalition. As a result, the three-person version of Prisoner' Dilemma compounds many times over the perversity of the two-player version, and neatly 'encapsulates the paradox of individual and collective rationality' (Schofield, 1975, p. 451).

Given this increased structural complexity, it should not be surprising that experimental research has found a significantly lower proportion of cooperation in three-person Prisoner's Dilemma games than in their two-person counterpart (Kahan, 1973, pp. 124–122), 'suggesting a qualitative difference in behavior as one proceeds from two to more than two players' (Goehrins & Kahan, 1976, p. 117), and also decreasing levels of cooperation as the number of players in these games increases (Fox & Guyer, 1978, pp. 469–481; Hamburger, Guyer, & Fox, 1975, pp. 503–531). How, then, can one explain the rash of multilateral arms control agreements, like the Non-Proliferation Treaty (1968) or the Partial Test Ban Treaty (1963), negotiated in the middle part of the twentieth century? Are there any factors, other than size, affecting the likelihood of cooperation in these games, and are there any other important differences between two-person and *n*-person Prisoner's Dilemma games that might make multilateral arms control agreements easier to negotiate than bilateral agreements?

One interesting difference is noted by Hardin who shows that in an *n*-person Prisoner's Dilemma, but not in a two-person version, the cooperative outcome is preferred by a majority of the players to any other outcome.[3] Or in Hardin's (1971, p. 472) words, 'the cooperative outcome in such a game would prevail in election against all other outcomes'.

Hardin's result can be interpreted as one theoretical justification for a strong supranational organisation, and highlights an important weakness of international institutions like the League of Nations or the United Nations. Supranational organisations with the means of enforcing its collective will could provide one mechanism for reaching solutions to otherwise intractable international conflicts, but in the absence of enforcement powers, the fact that the cooperative outcome is unstable may render it unattainable (Okada, 1993).

A strong supranational organisation, however, is neither a necessary nor a sufficient condition for multilateral cooperation in arms control matters. Fortunately, there are other, albeit highly restricted, conditions under which a multilateral agreement might be both individually and collectively rational.[4] Among these conditions is the existence of what Schofield calls a *cooperative coalition*, that is, some coalition other than the grand coalition for which the cooperation of its members is collectively though not individually rational.

The existence of a cooperative coalition, in turn, depends directly on another parameter, namely the ratio, r, of the benefits accruing to the system from the cooperation of all the players to each player's cost of cooperation. More formally,

$$r = \frac{\text{Benefits to the system of cooperation}}{\text{Costs to each player of cooperation}}$$

Hence, to understand the conditions under which a multilateral agreement is *both* individually and collectively rational, an examination must first be made of the role of r in determining the structure of game and its relationship to the existence of a cooperative coalition.

To this end, assume, for a moment, that the benefits of cooperation in the previous example were mainly systemic in nature, that is, shared by each nation regardless of whether or not it cooperated. Such might be the case in a game in which each cooperator had no intention of deploying a new weapon or of deploying old weapons in a new way or place, or where each cooperator merely diverted the funds scheduled for the acquisition of strategic weapons to other non-strategic military programs. Also assume that these systemic benefits, such as a reduction in international tension, a reduced probability of war, or in a spillover effect, increased cooperation in other non-military affairs, equal 2 units. Finally, assume that unlike these benefits, the costs of cooperation – be they domestic political or economic costs, a reduced sense of security, or whatever – are born solely by each cooperator and that they equal 1 unit. Thus, the ratio of benefits to costs, $r = 2/1 = 2$. Obviously, under these conditions, the payoff to each nation depends on the number of nations cooperating:

(1) If all three players cooperate, $2 \times 2 \times 2 = 6$ units of benefits accrue to the system. Each player's share of these benefits, 6/3 or 2 units, reduced by its costs of 1 unit, results in a net payoff to each player of 1 unit.
(2) If two players cooperate, $2 \times 2 = 4$ units of benefits accrue to the system. Each cooperator thus receives a payoff of $4/3 - 1 = 1/3$ while the lone defector, who does not bear any costs, receives a payoff of 4/3.
(3) If only one player cooperates, the cooperator's share of the benefits minus its costs is $2/3 - 1 = -1/3$ while each defector receives a payoff of 2/3.
(4) Finally, if no player cooperates, there are no benefits to be divided and no costs to be born. Hence, the net payoff to each player is 0.

The alert reader will notice that these payoffs are the same as those given in Fig. 1. In other words, for the game depicted in Fig. 1, $r = 2$. Hence, the role of

r in determining both the payoffs to the players and the structure of the game is not insignificant.

More importantly, though, at least for the purposes of this discussion, is the impact of the magnitude of r on the existence of a cooperative coalition. Specifically, it can be shown that a coalition of size m in a game of n players will be a cooperative coalition if and only if $m > n/r$. For instance, in our example, where $n = 3$, $r = 2$ and $n/r = 3/2$, a single cooperator ($m = 1$) does not have an incentive to cooperate since $1 < 3/2$. This can be verified by referring to Fig. 1 where the payoff to a single cooperator is (–1/3).

By contrast, two players can gain by cooperating even if the third does not since $m = 2 > 3/2$. If two cooperators jointly bear the costs of cooperation and share the benefits with the lone defector, they each gain a payoff of 1/3, as can be seen in Fig. 1. Nevertheless, although a two-nation coalition is collectively rational for its members, since this game is a variant of Prisoner's Dilemma, it is not individually rational. Either player could benefit and receive a higher payoff (2/3) by defecting. As before, then, one must conclude that the principle of individual rationality would preclude the formation of a cooperative coalition.

Under certain real-life circumstances, however, one might expect a cooperative coalition to form despite the fact that it is not individually rational for its members to cooperate. For instance, a severe shock to the international system might drive two states together, at least temporarily, in order to counter a shared threat or problem. The sudden cooperation between the American- and Chinese-backed factions in Angola in response to the imminent victory of the Soviet sponsored rebels in Angola in 1975, or the increased solidarity of some Western and Middle Eastern states following the Soviet invasion of Afghanistan in 1979, could conceivably be explained in these terms. More recently, the closer ties between the governments of Vietnam and the United States could be explained, at least in part, by the spectre of looming Chinese economic dominance in the Pacific region.

Alternatively, in a game composed of players with different weights (or sizes), a large state might stand to gain such a disproportionate share of the benefits of cooperation that it will be individually rational for it to bear a disproportionate share of the costs of cooperation. One could interpret a state of such weight as a natural coalition of the size $m > n/r$.[5] It has been suggested that the United States spends a larger proportion of its GNP supporting international organisations like NATO or the United Nations precisely for this reason (Olson & Zeckhauser, 1966). If so, the Trump administration's attempt to prod its European allies to increase their defence budgets may fail, even if it is successful in the short run.

Are cooperative coalitions that form because of an exogenous shock doomed to eventually disintegrate because continued cooperation is not individually rational for their members? Are large states that constitute a natural cooperative coalition doomed to provide benefits to smaller, some might say parasitical,[6] states that refuse to cooperate?

An intriguing answer to these questions is provided by Schofield who shows that in n-person Prisoner's Dilemma games, *if* a cooperative coalition should form, and *if* it is able to redistribute its payoffs,[7] then it will be in a position to offer each player outside the coalition a larger payoff if it joins the coalition than it could receive if it remained outside the coalition. Furthermore, it is possible that the cooperative coalition could make these offers in such a way that the payoff to each original member of the coalition is increased. Thus, Schofield (1975, p. 441) concludes, if a cooperative coalition should form, then, it must, through a series of bargaining moves, 'unanimously and rationally grow until it becomes the grand coalition'.

This growth process is easily illustrated by referring to the game depicted in Fig. 1. If one of the three possible two-player cooperative coalitions should form in this game, each member of the coalition would receive a payoff of (1/3) while the lone defector receives (4/3). However, the defector could be induced to join the coalition with an offer of say (5/3), and thereby increase the total payoffs to the players in the game from $(1/3) + (1/3) + (4/3) = 2$ to $1 + 1 + 1 = 3$. This is just one of several rational offers that the cooperative coalition could make since a payoff of (5/3) to the defector would leave a payoff of (2/3) rather than (1/3) for each original member of the coalition.

The bargaining process envisioned by Schofield is reminiscent of great power behaviour in a series of naval disarmament conferences during the 1920s and 1930s. At the Washington Naval Conference of 1921, for instance, a United States–Great Britain coalition quickly formed around a proposal offered by Charles Evans Hughes, the American Secretary of State. Hughes's proposal called for a 10-year moratorium on the construction of capital ships and the scrapping of certain American, British and Japanese battleships to bring the tonnage of their fleets into a 5:5:3 ratio, respectively.[8] The Japanese resisted this proposal, at first, holding out for a more favourable 10:10:7 ratio, but eventually accepted it when the United States and Great Britain agreed to the scrapping of an older and smaller Japanese battleship, the Settsu, in place of the newer and larger Mutsu, as Hughes had originally proposed, and promised not to fortify their naval bases in parts of the pacific.

In 1927, however, at the Three-Power Naval Conference held in Geneva, these same naval powers were unable to extend the agreements reached at Washington to auxiliary vessels, that is, to cruisers, destroyers and submarines. At this conference, a cooperative coalition never formed as the United States and Great Britain, who had concurred that such a treaty should be based on Anglo-American parity, could not agree on what constituted parity. As a result, 'the Japanese, although present, played a minor role. They stood quietly by observing and profiting from the dissension between the two parties who should have been in agreement on their naval "requirements"' (Tate, 1948, p. 151). But in 1929, after a number of bilateral discussions, the United States and Great Britain found a formula for equating large and small cruisers. Consequently, concessions were made to the Japanese at the London Naval Conference in 1930 and limitations on these vessels were set similar to those agreed on at Washington in 1921.[9]

What will be the exact offer made by the cooperative coalition to induce other players to cooperate? Unfortunately, Schofield's model is unable to forecast the particular structure of the payoffs to the players since 'the distribution of payoffs within a cooperative coalition very much depends on the process by which it has formed.' Hence, one could find an equal distribution or 'great inequality in terms of payoffs within the coalition' (Schofield, 1975, p. 444). Nevertheless, even without being able to predict these payoffs, Schofield's results are important because they specify the conditions under which the cooperative outcome is both individually and collectively rational in n-person Prisoner's Dilemma games.

As noted above, however, this result depends on the magnitude of r. If r is small enough, there may be no cooperative coalition, and hence no opportunity for it to grow. Specifically, in a three-person game, the critical value for r is 1.5. It is easy to demonstrate that if $r < 1.5$, there will be no cooperative coalition in a game among three players. By contrast, if $r > 1.5$, say 1.6, then a two-player coalition will have a collective incentive to cooperate since $m = 2 > n/r = 3/1.6$. Incidentally, it can also be shown that for large values of r, that is, when $r > n$, a game ceases to be Prisoner's Dilemma and each player's dominant strategy is to cooperate (Olson, 1971, p. 49).

Because r is defined as the ratio of the benefits to the costs of cooperation, r can be raised by either increasing the benefits or decreasing the costs of cooperation. This suggests that multilateral arms control agreements are most likely to be reached when there is either a considerable common interest in agreement, as in the Washington Naval Treaty of 1922 or in the non-Proliferation Treaty (1968), or when the costs of cooperation are negligible, as in the Antarctica Treaty (1959) or the Seabed Treaty (1971).

Interestingly, there is some experimental evidence to support this conclusion. In a study designed to examine the relationship between the size of a group and its propensity to cooperate, Bonacich, Shure, Kahan, and Meeker (1976, p. 704) found:

> no simple relation between group size and cooperation. The relation may be positive or negative depending on the way in which individual group payoffs are affected by variations in the size of the group.

Specifically, this study found that cooperation was more frequent in expanded groups if 'gain'[10] increased faster than the size of the group. Thus, Bonacich et al. (1976, p. 699) concluded there are 'reward conditions under which large group size has a facilitating effect on cooperation'.

3. CONCLUDING COMMENTS

In this chapter, I explore the structural conditions that render multilateral arms control agreements problematic by situating their dynamic in a three-person Prisoner's Dilemma game. It is shown that the addition of even a third state to an arms race compounds many times over the structural difficulties that face two racing states. Nevertheless, even in multilateral arms races, conditions exist that make it rational for states to pause. The most salient of these conditions is the existence of a cooperative coalition, that is, a coalition that is collectively rational for a subset of the participating states. It was suggested that if a cooperative coalition exists naturally, or if one forms as a result of an exogenous shock to the system, then it is possible for this coalition to offer incentives to all states not in the coalition to join it and, at the same time, increase the payoffs to the original members of the coalition. Thus, if a cooperative coalition exists in a multilateral arms race, then the possibility exists that all the participating states could be induced to stop racing.

Perhaps the major lesson that should be drawn from this chapter is the realisation that the conditions under which multilateral arms races might rationally be terminated are generally quite restrictive. Thus, although a potential arms race among the United States, Russia, and China might theoretically be ended, it will not be easily achieved. An appreciation of this fact should enable decision-makers and theoreticians alike to avoid the Scylla of seeking 'quick fixes' to terminating it, and the Charybdis of assuming that it can only be ended by accelerating the pace of the race. In other words, should an agreement be reached, it would indeed be 'a watershed diplomatic achievement' (Sonne & Hudson, 2019).

NOTES

1. These assumptions present the problems of multilateral arms races in their most extreme form. There are, of course, other possibilities that might be called on to explain empirical manifestations of a multilateral arms control agreement.
2. Hamburger (1973, pp. 27–48) offers several criteria, other than a dominant strategy resulting in a deficient equilibrium, necessary to define an n-person Prisoner's Dilemma. Since more than one game satisfies these requirements, an n-person Prisoner's Dilemma game is not a single game but rather a class of games. As will be demonstrated, some of the differences among the games of this class have important strategic consequences.
3. Except in a few degenerate cases. For a discussion of this result, and the exceptions to it, see Hardin (1971, pp. 472–481.)
4. See, for example, Nishihara (1997).
5. Such a game would technically not be Prisoner's Dilemma since (D) would no longer be a dominant strategy for the large state. Nevertheless, the cooperative outcome would remain unstable.
6. Or, in the jargon of the public choice literature, free riders.
7. Technically, Schofield assumes that utility is transferable. Luce & Raiffa (1957, p. 168) assert that 'to make any sense of the elliptic concept of unrestricted transferability and of the mathematics employed, one must suppose that there exists an infinitely divisible, real, and desirable commodity (which for all the world behaves like money) such that any reapportionment of it among the players results in increments and decrements of individual utilities which sum to zero according to some specific set of utility scales for the players'.
8. The ratio for both France and Italy, an issue of secondary importance at this conference, was set at 1.75.
9. In 1934, Japan gave notice that it was withdrawing from these treaties. Two years later, the Washington Treaty and the London Treaty expired.
10. 'Gain' is defined as the difference in payoffs between universal cooperation and universal defection.

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