INVESTING IN CONFLICT MANAGEMENT*

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ABSTRACT

Achieving peace and building the institutions that will make it last require much time and effort on the part of adversaries. While making this effort, the likelihood of peace is uncertain and preparations for conflict are on-going. We examine a setting that takes such considerations into account.

Adversaries divide their resources between "guns," "butter," and investments in conflict management. Even when all adversaries undertake sizable investments in conflict management, peace is uncertain. We find that larger initial wealth increases the likelihood of peace, whereas the number of adversaries can have widely different effects. A larger number of adversaries in cases of international conflict tends to increase the likelihood of peace, but it has the opposite effect in cases of domestic conflict.

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1 Introduction

Arming and war can be thought to occur in the absence of commitment devices that could prevent the parties involved from arming or engaging in war if they were to find it in their short-run interest to do so. Otherwise, if potential adversaries were able to commit not to arm or not to engage in war, they would all be able to find a way to do better since those activities divert resources from production or destroy production. Then, the question of why there is conflict can be reconceptualized as that of why parties are unable to commit not to arm and not to engage in war.

Much thought on this problem in economics, rational-choice political science, and game theory over the past two decades or so has focused on the effects of long-term relationships in developing a measure of commitment between the different parties in avoiding conflict. With more orthodox game-theoretic tools (see, e.g., Fudenberg and Tirole, 1991, Ch. 6) cooperation could be achieved between completely self-interested and rational parties if they all were to value the future highly enough. A similar outcome can occur within an evolutionary framework where adversaries are not rational but follow strategies that are successful on average (see, e.g., Axelrod, 1984). However, cooperation in these settings is not necessary – typically it is not a unique equilibrium – and in many ways the cooperative equilibria can be thought of as being more fragile than those that induce conflict.[1] Moreover, this approach skirts the issue of commitment as it abstracts away from the many institutions that often manage conflicts. In practice, constitutions, laws, diplomatic procedures, domestic and international organizations provide some guidance and measure of commitment that other parties will not resort to the barrel of the gun but to their lawyers, diplomats, the negotiating table, and the courts to solve their disputes. And, using and building these institutions and organizations, is costly.

In this paper we take a first look at a setting in which conflict management is indeed costly and the potential adversaries can take actions to increase the chance of peace while simultaneously preparing for war. Our modelling takes account of two characteristics of institutions of conflict management.

First, they take time to build. For example, the federal structure of the US took more than a century to crystallize and a bloody civil war along the way. The building of EU institutions (which, in its beginnings can be considered a conflict-avoidance device) is more than forty years old and still very much in its infancy in many respects. Almost a decade after the fall of the Soviet Union, basic laws about property in land, which would minimize conflict and allow a more efficient usage, are still non-existent in almost all of the successor republics. And, all post-war international institutions and organizations have taken much time and effort to build.

The second characteristic that our modelling takes into account is that there is no guarantee that institutions of conflict management bring success in avoiding the worst. That is, the effect of these institutions is up to a point uncertain about their effect on peace. The interwar League of Nations that was meant to prevent a recurrence of the Great War did not prevent World War II, although the experience that had accumulated along the way undoubtedly was utilized in creating the UN. The US Constitution and subsequent legislation and understandings that were carefully put together to balance the interests of Northern and Southern states did not prevent a civil war (see, for example, Weingast, 1998). And, of course, the various international institutions that exist today have not eliminated war.

We take account of these two characteristics of institutions of conflict management by treating conflict management as (i) the outcome of the "investments" that the potential adversaries may undertake in a dynamic setting that, in turn, (ii) yields a probability of peace and a probability of conflict, with greater levels of investment increasing the probability of peace. According to our approach the adversaries would make such investments for the same reason that they would arm: to maximize their expected income.[2]

We seek to understand likely implications for the time path of conflict and conflict management. Our most robust, and perhaps in retrospect most obvious, finding is that how rich the adversaries are has a large effect on the probability of peace. The poorer are the adversaries, in the sense of the real resources they possess, the lower is their investment in conflict management and the lower is the probability of peace. In addition, poorer adversaries will devote proportionately a greater percentage of their resources into guns and less into butter than richer adversaries would, thus compounding the effects of initial resource poverty. Although this finding appears consistent with some evidence – wars tend to be concentrated in poorer countries in terms of income per capita – we need to be careful in distinguishing resource poverty from actual poverty in terms of income.

Furthermore, we consider the effect of the number of adversaries on the chance of peace. In models of conflict (see, e.g., Hirshleifer, 1995), a greater number of adversaries intensifies conflict by increasing the resources devoted to guns and by reducing the resources devoted to butter.

This property implies, however, that the returns to investments in conflict management could be higher when there are more rather than fewer adversaries.

This indeed occurs, and a greater number of adversaries increases the probability of peace, when adversaries start with their own resources - like when a new country enters an existing conflict. When, however, a greater number of adversaries is the result of the fragmentation of existing adversaries, like it can occur in civil wars, the effect of a greater number of adversaries is to reduce investments in conflict management and the probability of peace.

2 The Basic Ingredients: Guns, Butter, and Conflict Management

Suppose there are n potential adversaries indexed by $i \in \{1, 2...n\}$. In each period of interaction there is useful production - "butter" - that is contested by the adversaries. Each party possesses a resource of size R that can be used to produce butter (b_i), can be allocated to guns (g_i) or be spent on investments in conflict management (m_i).

Specifically, we have

$$b_i = R - g_i - m_i \tag{1}$$

Guns are used to determine the distribution of butter in a way that we will describe later. Although the classic trade-off between guns and butter is easy to understand, we need to explain the ways in which conflict management can be a costly alternative to these two other choices. Let us note first that we would be hard-pressed to find cases of conflict in which there has been absolutely no communication or diplomatic activity between adversaries.

In the case of states, there is formal diplomatic communication up to the point of declaration of war and often back-channel diplomacy after that. In the case of civil wars and other types of conflict, leaders of competing groups engage in intermittent diplomacy and communication either directly or through third parties. When there is a truce or peace, adversaries prepare for war and when there is war the adversaries have to keep an eye for the possibility of peace, whose time, one way or another, will eventually come.

Such communication and diplomatic activity between rivals can occupy much of the time of the leaders and their staff, time that could be devoted to a more effective prosecution of war, and is therefore costly.

However, these are not the sole costs of conflict management by any means. Ultimately, peace depends on the development of lasting institutions. Within countries, the development of constitutions, legislation, administrative procedures, and courts that divert contention from the battlefield and the streets to ordinary politics and the courts require much debate, time, and effort. Sovereign states also have developed institutions and organizations to mediate disputes among them - from the World Court to the WTO, as well as the UN. Moreover, states strive to develop relationships with potential adversaries, not only for economic reasons but for purely security purposes as well. The original members of the European Community came together at least partly as a way of building more permanent economic ties so that the likelihood of a repetition of the previous two wars was reduced. Sometimes, costly investments in conflict management can take very interesting, perhaps ingenious, forms, as in the case of the "podesta" in twelfth century Genoa (Greif, 1998).[3] Furthermore, norms and voluntary associations that have been lately discussed under the name of "social capital" (Putnam, 1993) can be considered forms of capital that reduce conflict and which require investments over long periods of time.

To make the presentation as simple as possible, we suppose two periods. In the first period the adversaries make the choice between guns, butter, and investment in conflict management but war always occurs. Investment in conflict management can bear fruit only in the second period by increasing the chance that peace will occur then.

When war occurs in either period, the division of output, of butter, is determined by guns through a "contest success function" $p_i(\mathbf{g}_t)$ where $\mathbf{g}_t \equiv (g_{1t}, ...g_{nt})$ is the amount of guns chosen by all sides in period $t = 1, 2$. Letting G_t denote the total number of guns in a period, $G_t = \sum_{j=1}^{n} g_{jt}$, we use the following functional form for the contest success function:[4]

$$p_i(\mathbf{g}_t) = \frac{g_{it}}{G_t}. \tag{2}$$

In the first period, since investments in conflict management can have an effect only in the second period, conflict is unavoidable. Thus, a party i 's share of the net output in the first period is a function of its relative armament and its first-period payoff, and is given by

$$U_{i1} = \frac{g_{i1}}{G_1}(nR - M - G_1) = \frac{g_{i1}}{G_1}(nR - M) - g_{i1} \tag{3}$$

where $M = \sum_i m_i$ is the total investment in conflict management. Please note that we do not make a distinction here between the probability of winning in the case of conflict and the share of total output received by an adversary. Under risk neutrality and our other assumptions the two interpretations of the contest success function in (2) - as a probability or as a share - coincide. There are of course many reasons that would make the probability of winning different from the share, including the destruction that conflict induces, risk preference, and complementarities in production or consumption. However, since we don't see a reason for our qualitative results to be affected by complicating the model so as to allow between a hot war and a cold war, we chose to go with the simpler formulation. This is of course not to say that no additional insight could be gained by allowing for a richer environment.

In the second period, the same choices regarding the disposition of resources are available but obviously, because there is no future beyond that, there is no reason to invest in conflict management. The first period's investments in conflict management, however, have an effect on how the available surplus is divided. In particular, the more the two sides have invested in conflict management the higher is the probability that they will cooperate and will not need to resort to guns to divide the total surplus.

Let $\mathbf{m} = (m_1, m_2, ...m_n)$ describe the investment in conflict management the n parties engage in. The probability of cooperation is a function $q(\mathbf{m})$ that takes values between 0 and 1 and has the following properties. One would expect $q(\mathbf{m})$ to be symmetric, non-decreasing and concave in each of its arguments. Because peace cannot be achieved with just a subset of the adversaries and, moreover, it requires the active participation of all parties, we should expect an increase in the investment of one party to increase the marginal return to the other parties. In other words, we should expect to have complementarities among the levels of investment of the participants. Finally, one would expect that if all parties are investing the same amount m in conflict management and one additional contender investing m is added, the probability of cooperation does not increase. In fact, under such circumstances we assume that the probability of cooperation remains unchanged when a player is added. A functional form that we will use later and which satisfies all the above properties is:

$$q(\mathbf{m}) = \begin{array}{c} \mu \left(m_1 m_2 ... m_n\right)^{\frac{\alpha}{n}} \; if \; m_1 m_2 ... m_n \leq \left(\frac{1}{\mu}\right)^{\frac{n}{\alpha}} \\ 1 \; otherwise \end{array} \quad where \; \alpha \leq 1 \; and \; \mu \in (0, 1] \tag{4}$$

The parameter α is a measure of returns to scale (or, of the degree of homogeneity) of the investment function. When $\alpha = 1$ a simultaneous doubling of all parties's investments in conflict management would also double the probability of peace. When $\alpha < 1$ a doubling of all investments would less than double the probability of peace. This functional form will allow us to illustrate more precisely the effect of cooperative investment in conflict management.[5]

Given their investments in conflict management in the first period, in the second period the adversaries face a probability of peace, $q(\mathbf{m})$, and a probability of war, $1 - q(\mathbf{m})$. Based on these probabilities and without knowing the outcome, the adversaries make their choice between guns (g_{i2}) and butter ($R - g_{i2}$). In the event of peace they hold on to the butter they have produced, whereas under war all the butter that is available is divided in accordance with the relative amount of guns each adversary possesses. The amount spent on guns is lost in either case.

Therefore, the second-period payoffs are the following:

$$U_{i2} = q(\mathbf{m})R + (1 - q(\mathbf{m}))\frac{g_{i2}}{G_2}nR - g_{i2} \tag{5}$$

A *strategy* for an agent i, s_i, is a triplet $s_i \equiv (m_i, g_{i1}, g_{i2})$. Let $S_i \subset \Re^3_+$ be the set of feasible strategies for agent i, $S_i \equiv \{g_{i1}, m_i, g_{i2} \geq 0 \; g_{i1} + m \leq R$ and $g_{i2} \leq R\}$, and $S = S_1 \times S_2 ... \times S_n$. A *strategy profile* is $\mathbf{s} = (s_1, s_2 ... s_n) \in S$.

The payoff function over the two periods is simply the sum of the two single-period payoffs.

$$U_i(\mathbf{s}) = \frac{g_{i1}}{G_1}(nR - M) - g_{i1} + q(\mathbf{m})R + (1 - q(\mathbf{m}))\frac{g_{i2}}{G_2}nR - g_{i2} \tag{6}$$

3 How Many Guns and what Is the Chance of Peace?

In the first period, the adversaries make decisions about guns (g_{i1}), investments in conflict management (m_i) and, implicitly, by (1) on butter for the first period. However, in doing so they both affect what can be expected to occur in the second period and, in turn, the predictable consequences of first period actions should be taken into account in determining those actions. Therefore, in accordance with the concept of subgame-perfect equilibrium, we begin in reverse order, by considering what would occur in the second period given the actions of the first period. The equilibrium concept used is the subgame perfect Nash Equilibrium:

Definition 1 *A Nash Equilibrium of this game is a strategy profile is* $\mathbf{s}^* = (s_1^*, s_2^*, .., s_n*)$ *such that*

$$U_i(\mathbf{s}^*) \geq U_i(s_i, s_{-i}^*) \forall s_i \in S_i \, and \forall i \tag{7}$$

and $\mathbf{s}^*$ *is subgame perfect if no party has interest to deviate from it in the second period.*

3.1 Second-Period Outcome

Consider the second period first. At the beginning of the second period, given all investment in conflict management has already been undertaken, the probabilities of peace and conflict are already given.

Party i chooses his level of guns taking the amount of guns acquired by the other parties as given. The first order condition for an interior choice of guns is given by

$$\frac{G_2 - g_{i2}}{(G_2)^2}(1 - q(\mathbf{m}))nR - 1 = 0 \qquad \text{for } g_{i2} \in (0, R) \tag{8}$$

Clearly, if $q(\mathbf{m}) = 1$ there won't be any conflict in the second period and therefore there would not be any reason to choose a positive level of guns. In this case g_{i2} has to be 0 in equilibrium. Consider now a situation in which conflict occurs with a positive probability, $q(\mathbf{m}) < 1$. Notice then that, if he were not to invest in any guns, the first term, i.e. the marginal benefit of guns, would become $\frac{1}{G_2}(1-q)nR$. Hence, if the other parties were to invest hardly anything and G_2 were to be very close to 0, i's marginal utility from some guns would tend to infinity. In other words, if there a chance of conflict, no matter how small, there has to be some guns in equilibrium. Agent i would acquire an amount of guns that would equate his marginal benefit to his marginal cost, so that (8) is 0. By having all parties going through the same calculus, it can be shown that that there is a unique equilibrium outcome in the second period in which $g_{i2}^* = g_2^*$ for all $i = 1, ...n$ with [6]

$$g_2^* = \frac{n-1}{n}(1 - q(\mathbf{m}))R \tag{9}$$

Hence, the total amount of guns as a measure of the total level of conflict in the second period is

$$G_2^* = (n-1)(1 - q(\mathbf{m}))R$$

Clearly, the equilibrium level of armaments depends on the investment in conflict management via the probabilities with which peace and conflict arise. If $q(\mathbf{m}) = 1$ then no gun investments will be made in the second period. Moreover, for a given probability of conflict, the higher the level of resources R is and the more adversaries n there are, the higher is the level of conflict.

Using the equilibrium level of guns (9) in (5), the second-period utility in equilibrium is

$$U_{i2} = R\left[1 - \frac{n-1}{n}(1 - q(\mathbf{m}))\right] = R[\frac{1}{n} + q(\mathbf{m})\frac{n-1}{n}] \tag{10}$$

3.2 First Period and Investments in Conflict Management

Consider now the decisions to be made in the first period. Given the second period outcomes that can be induced by any choices made in the first period, contender i tries to maximize (6)

$$U_i(\mathbf{s}) = \frac{g_{i1}}{G_1}(nR - M) - g_i^1 + R\left[\frac{1}{n} + q(\mathbf{m})\frac{n-1}{n}\right]$$

In this first period, each adversary makes choices on first-period guns (g_i^1) and on investments in conflict management (m_i). An interior solution for i's investment in conflict management would satisfy

$$-\frac{g_{i1}}{G_1} + \frac{n-1}{n}q_i(\mathbf{m})R = 0 \tag{11}$$

where $q_i(\mathbf{m}) = \frac{\partial q(\mathbf{m})}{\partial m_i}$ is the marginal impact of i's investment in conflict management on the probability of peace. The first, negative term represents the marginal cost of investing in conflict management. Note that this marginal cost is just a fraction of its actual resource cost, the share of guns he has. Other things being equal, the larger is the number of contenders, the lower is this marginal cost. The second term represents the marginal benefit of investing in conflict management and comes from the second period payoff. Other things being equal an increase in the number of adversaries n increases this marginal benefit. That marginal benefit is also increasing in the amount of resources, R, that each party possesses.

The first order condition tells us that an interior solution for party i's gun acquisition is given by

$$\frac{G_1 - g_{i1}}{(G_1)^2}(nR - M) = 1 \tag{12}$$

Consider this expression. By the same argument made earlier, if no one were to invest in guns i's marginal utility from investing in some guns would be infinite, and therefore there is a strictly positive level of armaments in equilibrium in the first period. For the same reasons outlined in our second period analysis there is a unique equilibrium level of guns acquisition in the first period where $g_{i1}^* = g_1^*$ for all $i = 1, 2...n$ and

$$g_1^* = \frac{n-1}{n}(R - \frac{M}{n}) \tag{13}$$

Let us next consider the specific function mapping the investment in conflict management into the likelihood of avoiding conflict introduced in (4) and study the different equilibria that could prevail.

3.3 Equilibria

We now show that typically there are two equilibria: One in which no party makes any investments in conflict management and another in which there are positive investments. We shall examine and discuss this second type of equilibrium more than the first as it is Pareto-superior and also richer in its implications.

With a probability of cooperation given by (4) the first-order condition for m_i (11) implies

$$\frac{n-1}{n}\frac{\alpha\mu}{n}\frac{\Pi_j m_j^{\alpha/n}}{m_i}R = \frac{g_{i1}}{G_1} \quad m_i > 0 \tag{14}$$

First, note that if a single agent were not to invest in conflict management, $m_j = 0$ for any $j \neq i$, then the other agents have no incentive to invest in conflict management. We would have $q_i(\mathbf{m}) = 0$ and $m_i = 0$ for all i. There is no investment that i could undertake that could affect the probability of peace. Hence, there is always a Nash Equilibrium at

$$s_i^* = (0, \frac{n-1}{n}R, \frac{n-1}{n}R)\forall i = 1, 2...n \tag{15}$$

yielding to each contender a total utility over the two periods of $U_i(\mathbf{s}^*) = \frac{2}{n}R$. In such case the total amount of guns is $G = \frac{n-1}{n}2R$. We call this equilibrium the *pure conflict* equilibrium. Such an equilibrium is plausible since to achieve peace all parties would have to acquiesce to it by investing at least something in managing conflict. It therefore follows that if none of one's adversaries were to invest in conflict management, he or she would not invest either.

Next consider positive investments in conflict management. Assume that $m_j \neq 0$ for all $j \neq i$. Using the fact that in equilibrium $g_1 = ... = g_n$ (and therefore $\frac{g_{i1}}{G_1} = \frac{1}{n}$) in equation (14), it is easy to see that i's choice of investment is given by the following expression

$$m_i = \begin{array}{c} \left[\frac{n-1}{n}\alpha\mu\left(\Pi_{j\neq i}m_j^{\alpha/n}\right)R\right]^{\frac{n}{n-\alpha}} \; if\, m_i \leq \frac{(1/\mu)^{n/\alpha}}{\Pi_{j\neq i}m_j} \\ \frac{(1/\mu)^{n/\alpha}}{\Pi_{j\neq i}m_j}\; otherwise \end{array} \tag{16}$$

Clearly the amounts invested in conflict management by the different agents are strategic complements as long as peace is uncertain ($m_i < \frac{(1/\mu)^{n/\alpha}}{\Pi_{j\neq i}m_j}$). The more the others invest the more one is willing to spent to reduce conflict. Once the investments are such that the likelihood of conflict is reduced to zero ($m_i \geq \frac{(1/\mu)^{n/\alpha}}{\Pi_{j\neq i}m_j}$), then naturally i would be happy to reduce his investment as long as it does affect the probability of peace. This is that strategic substituability that appears in the second line of (16).

Since all agents are identical and given the symmetry and complementarity of $q(m)$, the equilibrium has to be symmetric. In the equilibrium, each agent chooses the same investment in conflict management, $m_1 = m_2 = ...m_n = m^*$, and therefore

$$m^* = \min\{\left(\frac{n-1}{n}\alpha\mu R\right)^{1/(1-\alpha)}, (1/\mu)^{1/\alpha}\} \tag{17}$$

It is helpful to consider the cases of decreasing returns to scale ($\alpha < 1$) and constant returns ($\alpha = 1$) separately.[7]

3.3.1 Decreasing returns to scale in conflict management($\alpha < 1$)

When $\left(\frac{n-1}{n}\alpha\mu R\right)^{1/(1-\alpha)} < (1/\mu)^{1/\alpha}$, or $\frac{n-1}{n}\alpha R < (1/\mu)^{(1-\alpha)/\alpha}$, each party invests an amount $m^* = \left(\frac{n-1}{n}\alpha\mu R\right)^{1/(1-\alpha)}$ in conflict management.

The total of these investments generates a probability $q(\mathbf{m}^*) = \mu\left(\frac{n-1}{n}\alpha\mu R\right)^{\alpha/(1-\alpha)}$ of peace that is strictly lower than 1. We can call this equilibrium *partial cooperation*. The amount of guns a contender acquires in the second period is $g_2^* = \frac{n-1}{n}(R - [\mu R(\frac{n-1}{n})^\alpha \alpha^\alpha]^{1/(1-\alpha)})$ and in the first period is $g_1^* = \frac{n-1}{n}(R - \left(\frac{n-1}{n}\alpha\mu R\right)^{1/(1-\alpha)})$ (which is actually less than in the second period if $\left(\frac{n-1}{n}\alpha\right)^{1-\alpha} > 1$) such that the overall level of arming is $G^* = \frac{n-1}{n}2R$. The equilibrium payoff of each adversary can be shown to be strictly higher than that under pure conflict, and therefore this equilibrium which always exists is Pareto-superior.

When $\left(\frac{n-1}{n}\alpha\mu R\right)^{1/(1-\alpha)} \geq (1/\mu)^{1/\alpha}$, or when $\frac{n-1}{n}\alpha R \geq (1/\mu)^{(1-\alpha)/\alpha}$, each party invests in conflict management the maximum amount possible $m^* = (1/\mu)^{1/\alpha}$. The probability of peace is 1 and therefore no guns are acquired in the second period ($g_2^* = 0$). In addition, the investment in conflict management made in the first period reduces the amount of guns each party accumulates in that period, $g_1^* = \frac{n-1}{n}(R - (1/\mu)^{1/\alpha})$. Hence, the total amount spent on guns over the two periods is greatly reduced, $G^* = (n-1)\left(R-(1/\mu)^{1/\alpha}\right)$. We call such an equilibrium pure cooperation. Again, the equilibrium payoffs are higher than that under pure conflict and are Pareto dominant.

3.3.2 Constant returns to scale in conflict management ($\alpha = 1$)

When $\frac{n-1}{n}\mu R < 1$, it can be shown that no equilibrium other than pure conflict exists. The marginal payoffs to investing in conflict management are too low for any adversaries to put anything in such an investment. When, however, $\frac{n-1}{n}\mu R \geq 1$ the marginal benefit of investing in conflict management is equal or higher to its marginal cost, and all parties put the maximum amount possible to conflict management, $m^* = 1/\mu$.[8] In such a case, peace obtains with probability one, we have pure cooperation.

Thus, under decreasing returns to scale in conflict management there is always an equilibrium, either with partial cooperation or with pure cooperation, that Pareto-dominates pure conflict, whereas under the limiting case of constant returns there is no possibility of obtaining partial cooperation as an equilibrium; at low levels of resources R, "productivity" of conflict management as indicated by the parameter μ , and numbers of adversaries n, pure conflict obtains uniquely, whereas at sufficiently high levels of the same parameters, pure cooperation becomes an equilibrium.

In this section we have identified the conditions under which multiple equilibria occur and described the different equilibria. It is worth realizing that when multiple equilibria prevails in this game a simple refinement would select the equilibrium with the least conflict. Introducing a commonly held belief under which all players have a strictly positive (even if very small) probability to invest a positive amount in conflict management. Then there is strictly positive probability of peace if an agent invests a positive amount, and it is indeed in his interest to do so when an equilibrium other than pure conflict exists. Hence, it this sense we would expect the Pareto dominant equilibrium to be selected. Note, however, that any form of discounting would lower the benefit from conflict management, thereby increasing the range of parameter values under which the conflict equilibrium is unique.[9] We now turn to other factors that influence investment in conflict management.

4 Number of Contenders, Resources, and Peace

How is the probability of peace affected by an increase in the number of parties involved? And how does the amount of resources influence the likelihood of peace? In the case of pure conflict, both per capita and the total amount of guns in this equilibrium $G = (n-1)\,2R$ are increasing in the number of contenders, and the utility of each of them decreases. To answer such questions for the other, more interesting equilibria, it is useful to distinguish between a situation in which additional adversaries have their own resources R, and a situation in which the amount of total resource is constant at a level $\overline{R}$ and is divided up among the adversaries $R = \frac{\overline{R}}{n}$. The former situation can be considered one of *replication* of the adversaries and is perhaps more fitting to cases of international conflict. The latter situation with a fixed amount of total resources is one of *fragmentation* and would be more appropriate for cases of internal, domestic conflict.

4.1 Replication Or International Conflict

Each party's investment in conflict management is given by (17) whose first term is increasing in n while the second term is unchanged. As the number of parties involved increases, the total amount of guns that would be acquired in the absence of conflict management increases. Hence, the cost of conflict increases and the benefits from investing in conflict management increase. This implies that for $\alpha < 1$ the more parties gets involved in the potential conflict the higher the probability of peace in a partial cooperation equilibrium and the more likely this probability will be 1 and we will have a pure cooperation equilibrium.

In the case constant returns to scale ($\alpha = 1$), we saw that if $\frac{n-1}{n}\mu R > 1$ a pure cooperation equilibrium exists in addition to the pure conflict one. Clearly the greater the number of contenders is the more likely it is that this pure cooperation equilibrium will exist.

Figure 1 about here

Figure 1 illustrates the relationship between the probability of cooperation and the number of parties involved for both $\alpha = 1$ and $\alpha < 1$.[10]

Finally, the richer are the parties, the greater is the probability of peace. Beyond a certain threshold level of resources ($R^* = \frac{n}{(n-1)\alpha\mu^{1/\alpha}}$), the probability of peace is one.

4.2 Fragmentation or Domestic Conflict

In this case, with the total amount of resources fixed, an increase in the number of adversaries implies a reduction in the amount that each contender has; that is, $R = \frac{\overline{R}}{n}$.

Under the pure conflict equilibrium, although per capita armaments decreases as fragmentation increases ($g = \frac{n-1}{n^2}2\overline{R}$) the total amount of guns in this equilibrium $G = \frac{n-1}{n}2\overline{R}$ increases in n. For the other types of equilibrium investment in conflict management (17) we have

$$m^* = \min\{\left[\frac{n-1}{n^2}\alpha\mu\overline{R}\right]^{\frac{1}{1-\alpha}}, (1/\mu)^{1/\alpha}\}$$

The first term of this expression is for the case of partial cooperation and is clearly decreasing in n. The second term, reflecting the pure cooperation case, is independent of n but to reach that equilibrium with a larger n a higher level of total resources $\overline{R}$ would be needed.

For values of α lower than 1, partial cooperation becomes less as fragmentation increases, and in this case the amount invested in conflict management decreases.

For $\alpha = 1$ we saw that either there exists another equilibrium in which pure cooperation is achieved or pure conflict is the unique equilibrium.

Hence, as the degree of fragmentation increases, at some point the pure cooperation equilibrium will disappear; that is, the range of parameters values such that a pure cooperation equilibrium exists is smaller as n becomes larger. The effects of fragmentation on the probability of peace are illustrated in Figure 2 for $\alpha = 1$ and $\alpha < 1$.

Figure 2 about here

Note, however, than increasing the amount of resources at stake has the same effect on both international and domestic conflict. Higher levels of resources make conflict relatively costly and they also simply leave more room in the "budget" allocation for investments in conflict management. With more resource, the range of parameters under which a pure cooperation equilibrium exists and the probability of peace increases in a partial cooperation equilibrium. That is, we have a rather robust finding: more wealth increases the chance of peace.

5 Concluding Remarks

Peace does not come without negotiation, without the development of a measure of trust, and ultimately without the presence of institutions that will maintain it into the future. All these require effort and expense that has to be undertaken by all interested parties. Making peace is an endeavor that entails much uncertainty and the chance of success should depend on the degree of effort, the size of the investments in conflict management. The model we have developed in this paper is the first to take these considerations into account. Naturally, there might be other interesting ways of formulating the problem but there is no reason for our main findings to change. What would be interesting for future research is to consider substantive issues that we have not examined here. Among the most promising would be to consider the possibility of the formation of alliances among the participants. Often conflict is bipolar, not multipolar. Is there a natural dynamic that makes a large number of participants to divide themselves into two sides, by having peace made first amongst the members of each side? We intend to examine questions like this one in the future.

Endnotes

[1] In many cases, cooperative equilibria are not "renegotiation-proof" while conflictual equilibria are. Hirshleifer and Martinez-Coll (1988) provide evidence on the fragility of the tit-for-tat strategy, the winning strategy in Axelrod's (1984) tournament. In addition, a "long shadow of the future" can be shown to intensify conflict (Skaperdas and Syropoulos, 1996) or lead to conflict (Garfinkel and Skaperdas, 2000) in non-stationary environments.

[2] That is, in the language of Collier and Hoeffler (2002) the actions that are undertaken are out of "greed" rather than "grievance."

[3] Genoa was ravaged by Civil War between rival clans during the second half of the twelfth century and the institution of podesta was introduced as a way of reducing that conflict towards the end of that time. The podesta was typically a foreign noble who was hired for a term of one year and was expected to perform police, judicial, and administrative functions. He was very well paid and he had some enforcement power through his armed retinue, but not enough to upset the balance of power between the rival clans. See Greif (1998) for details. Based on cross-country regressions, Elbadawi and Sambanis (2002) estimate risk factors that influence the incidence of civil wars that are broadly consistent with our findings, although there is no explicit variable in the empirical framework to stand for investments in conflict management.

[4] Tullock (1980) first employed this functional form in his study of rent-seeking contests. For a discussion of this and another class of functional forms see Hirshleifer (1989). For an axiomatic derivation of general functional forms as well as of this particular one, see Skaperdas (1996).

[5] The economists among the readers will notice that this is an offshoot of the Cobb-Douglas production function. The same analysis holds for all functional forms belonging to the CES class of functions: $q(\mathbf{m}) = \left[\beta \sum_{i=1}^{n} m_i^{\lambda\rho}\right]^{1/\rho}$, where $\beta > 0, \rho \leq 1$ and $\lambda \leq 1$, which encompass among many other functional forms the Cobb-Douglas functional form presented here.

[6] This solution is unique since along i's best response (BR_i)

$$\frac{dg_{i2}}{dg_{j2}}|_{BR_i} = \frac{g_{i2} - g_{j2}}{2g_{j2}} \forall i, j \in \{1, ...n\}$$

which is positive whenever $g_{i2} > g_{j2}$ and negative whenever $g_{i2} < g_{j2}$. At $g_{j2} = g_{i2}$, $\frac{dg_{i2}}{dg_{j2}}|_{BR_i} = 0$.

[7] We do not examine the case of increasing returns to scale ($\alpha > 1$) because if an equilibrium other than pure conflict were to exist, it would be unstable.

[8] Note that for $\alpha = 1$ in the special case in which $\frac{n-1}{n}\mu R = 1$, all levels of conflict management m could be chosen, there is a continuum of equilibria with a probability of cooperation ranging from 0 to 1. However, any small perturbation of the parameters makes the equilibrium shift in one or the two extreme cases, pure conflict or pure cooperation (when the latter case exists).

[9] The opposite would occur of course, if we allowed for conflict to be destructive and thus yield a lower payoff than a negotiated settlement under the threat of conflict. We have avoided making the distinction between actual (and destructive) conflict versus a negotiated settlement for ease of exposition. For a framework that allows for this distinction and which examines the circumstances that lead to either conflict or settlement (but with arming), see Garfinkel and Skaperdas (2000).

[10] For convenience, the number of parties n is treated as continuous.

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