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ABSTRACT

Easy Targets and the Timing of Conflict*

Contestants have to choose whether to initiate a contest or war, or whether to remain peaceful for another period. We find that agents wait and initiate the contest once their rival is sufficiently weak to be an easy target.

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1 Introduction

Enemies often live their lives in parallel, waiting for decades for the optimal time to attack one another, and it can take a long time for the actual contest to take place. This is true for individuals within a company who can spend effort on influence activities to try to defeat the opponent, for rival politicians within the same party who compete for candidacy, for owners of rival companies, for medieval rulers of independent states trying to conquer each other's territory, or for nation states, as with the Franco-German, Arab-Israeli, Greek-Turkish, Indo-Pakistani conflicts, and for the US and the Soviet Union in the cold war decades. As Maoz and Mor (2002) point out, over the past centuries, a majority of international conflicts have been enduring rivalries. We consider the factors that determine the timing of the actual contest or war.

A question that is closely related and that precedes this analysis of timing is the question of why war takes place at all. War wastes resources. Rational decision makers should therefore negotiate and find a bargaining solution that avoids this inefficiency. War then plays an important role as an outside option or threat point in bargaining (see, e.g., Powell 1996, 1999 and Werner 1999) even though the actual war may not take place. Actual war may still take place if bargaining fails to reach an outcome that, for both rivals, is superior to going to war. Fearon (1994, 1995) and Filson and Werner (2002) highlight incomplete information as a possible source of war and its role in bargaining. Another reason why bargaining need not solve the conflict is discussed in Fearon (1995). The rivals may face commitment problems and other constraints in bargaining that could make war a rational policy outcome.

We consider a situation with symmetric information but with several plausible constraints on bargaining that make peaceful negotiation outcomes impossible. The type of contract incompleteness that eliminates the scope for peaceful settlement in our set-up is similar to the one in Garfinkel and Skaperdas (2000) and relies on the non-contractibility of future resources or future influence. More precisely, we consider two rulers. Each controls a territory and receives income in each period as long as he stays in charge. They can remain peaceful and live in parallel for ever, but each one can also decide to attack the other ruler in any period, in which case the outcome of a contest decides who rules both territories for all future time. Rulers cannot borrow against future expected income. Accordingly, they can use only their

current period resources for a possible conflict or for consumption. Rivals cannot commit to abstaining from future threats of war, or from attack, unless they are finally defeated. Second, rulers could negotiate and agree on allocating current output, but cannot write binding contracts on property rights to resources or income in future periods or control rights to military power in future periods.¹ Instead, a government of a territory always controls the use of the resources its territory produces in the respective time period, and can use them to consume or to fight. In this set-up, the major channels for conflict resolution by bargaining are blocked. The only ‘contract’ about future property or control rights that is feasible, and can be enforced, is a take-over that eliminates the adversary.²

We take the absence of negotiations as a starting point and consider the timing of the wasteful contest or war in sections 2, 3 and 4. In section 5 we confirm more formally that negotiations could not change the outcome in this framework. We find that war is initiated by the stronger party when it is sufficiently inexpensive for one of the conflicting parties to initiate war and defeat the rival player, which is the case if the weaker player is sufficiently weak. Our result makes a prediction that is the opposite of the “power transition” theory (Organski and Kugler (1980), Morrow (1996)) that suggests that conflict or war is more likely once the weaker rival becomes stronger and particularly when the weaker rival is about to surpass the stronger power. In this theory the time paths of players’ capabilities develop according to some long-term trends. Accordingly, the dominant power that anticipates a further decline in relative strength may initiate war before it loses its dominance. In our framework, absolute and relative capabilities evolve along stochastic paths and they fluctuate according to intertemporally independent random processes. For this reason, players who are strong in one period could be strong or weak in the next period. The only way to establish dominance for the future is to defeat the rival and to acquire his territory. A player may therefore initiate a contest if it is inexpensive to defeat the rival, which is the

¹To give an example: France could not prevent German rearmament after World War II. A country can always simply violate a contract that commits it to abstaining from building weapons or from future military action, and without exercising permanent military control, it is difficult to control the resources of a country ruled by another government.

²A literature on resource allocation if property rights are not costlessly enforced highlights the relevance of this assumption, particularly in an international context. See, e.g., Skaperdas (2003) for an outline and a survey.

case in a period in which the rival is sufficiently weak.³

The research question is also related to questions associated with dynamic optimization and the option value principle. In a situation in which superior information may arrive later, an agent may delay an irreversible investment choice in order to preserve an option value (McDonald and Siegel 1986, and Pindyck 1991 for an overview). In a game theory context, the arrival of information is often endogenous and depends on the co-players' actions. For instance, agents may want to delay their own investment decision and so wait and observe the experience the co-players gain from investing early (e.g., Chamley and Gale 1994, Gale 1996 and Thimann and Thum 1998). What makes the decision to go to war different from the option value considerations in uncertain irreversible investment problems is that a player does not have full control over whether to enter a period of war: each player can start a war, but if one player starts the war, the other player is forced to go to war as well.

In the next section we describe the general framework in which conflict takes place, the technology of conflict, the set of possible actions and timing of actions. Our main result is reported in section 3, showing that war or conflict is delayed until one of the rival players becomes a sufficiently easy target. Section 4 considers a different technology of conflict and shows that relative strength may also play a role for the timing of conflict or war. Section 5 explains why negotiations must fail, and war cannot be avoided given the assumptions about what contracts are feasible and enforceable between rival players, and what contracts are not enforceable. This section justifies why we disregard negotiations in the analysis in the previous sections. Section 6 concludes.

2 A formal approach

We consider two rivals who rule "territories" of equal size A and B , respectively. The meaning of territories is broad here, they are the zones of influence from which rulers can extract some rent. One example in which we frame our

³Delay of open conflict in full information contests has also been considered in a paper by Bester and Konrad (2002). They show that asymmetry between attack and defense can also explain delay. Here we take a different approach and consider a contest that is fully symmetric with respect to attack and defense. Hence, the desire to be the defender does not cause the delay.

analysis would be the kingdoms of two rulers who can try to conquer each other. Some non-storable revenue is generated from each of the territories in each period, and for an infinite sequence of periods. Suppose these revenues are $T_A(t)$ and $T_B(t)$ in period t , and are identically and independently drawn from a distribution $F(T)$ with no mass points and a support $[0, \bar{T}]$ for both territories. The period revenues of a territory accrue to whomever rules the territory in the respective period.

Rulers maximize their expected income over an infinite lifetime. Therefore at any period t a risk-neutral ruler values ownership of a perfectly secure territory as the present value of the infinite sequence of expected revenues, i.e.,

$$\sum_{k=0}^{\infty} \frac{ET}{(1+r)^k} = \frac{ET}{r}, \quad (1)$$

where ET is the expected revenue from owning a territory in any period, and r is the rate of interest which is exogenously given. As the revenue is non-storable, there is no way to shift resources intertemporally. Therefore, r is determined by the rulers' discount rate of future consumption.

Because there are two rulers, their rulership is not absolutely safe and their benefit will be different from (1). One ruler can try to conquer the other ruler's territory, expell the other ruler, and from then on become the ruler of both territories. Such an attempt is called a contest or war and will be described in detail below. If there is a contest in a period, one of the rulers will be eliminated as a result; hence, the outcome of this contest determines who will safely rule both territories for all future periods. Thus, there can be a contest in, at most, one period, and this contest determines the owner of all future rents from both territories.

Suppose no conflict has occurred prior to period t . In period t , both rulers first observe the resources $T_A(t)$ and $T_B(t)$ available to them in this period. Now each ruler decides whether to initiate the contest in this period. If neither starts a contest, they remain peaceful until the beginning of period $t+1$. They observe their resources in $t+1$, and the same consideration about starting the contest recurs in period $t+1$. If at least one of them decides for a contest, the contest will take place in this period. If this happens, the rulers simultaneously choose the resources they want to use in the contest. These resources are denoted $x_A(t)$ and $x_B(t)$.⁴ As borrowing or lending between the rivals and from a third party can be ruled out due to the lack

⁴More formally, this can be seen as a two-stage process in which the contestants have

of commitment, they cannot spend more than their resources in this period; i.e., $x_A(t) \in [0, T_A(t)]$ and $x_B(t) \in [0, T_B(t)]$. The resources available in a given period are like a budget cap on the resources that can be used in the conflict.

Here the rivals first decide whether to declare war or not. War takes place in a period t if at least one rival declares war, and if the decision is for war, they choose how much of the resources available in this period to use in the conflict and how much to consume. This choice of timing may need some comments. Garfinkel and Skaperdas (2000) and Anbarci, Skaperdas and Syropoulos (2002) for instance, assume that contestants first determine their stocks of contest resources (weapons) and, once these stocks are chosen and observed by all contestants, they consider whether to fight or to settle.⁵ Their timing may well adequately describe battles or a *blitzkrieg*.⁶ We consider the reverse timing, in which contest effort is chosen only if a contest takes place, which could be more suitable for describing a war that may go on for a long period. The ‘period’ considered in the theoretical analysis here is an exogenously given time interval that, depending on the context, can be arbitrarily long. In a war that goes on for a considerable period of time, the initial stock of weapons is small compared to the total amount of resources that can be turned into weapons and can be used in the conflict. For instance, during the first four years of World War II, national incomes grew steadily in the major countries involved, and military production grew at even higher rates, because it took time to reorganize the industry and to increase military production both absolutely and as a share of national income.⁷ The productive capacity and the resources that a contestant could

the opportunity to commit. Each contestant can decide whether or not to “declare war” in a first stage. If neither declares war, there is a binding commitment for both of them: neither has the ability to enter a military conflict in this period. However, if one (or both) of them declares war, each of them can use any amount of their own period income in a military conflict against the other.

⁵Anbarci, Skaperdas and Syropoulos (2002) compare different bargaining solutions with respect to the decision to build up stocks of weapons. A key aspect of their analysis is that the possibility of future negotiations and settlement induces the contestants to spend resources on producing weapons, because the stock of weapons affects the rivals’ threat points.

⁶Rotte and Schmidt (2002) find strong evidence that numerical superiority matters for battlefield success. Similarly, Hochheimer (1967, p.83) reports that, at the end of the 16th century, an upcoming battle could have been decided by simply counting the numbers of soldiers on both sides.

⁷McNeill (1982, 353n.) reports that German armaments production in World War II

mobilize over the period of conflict is decisive. The productive capacity of the contestants will be directed towards military production once the conflict has started, and the total productive capacity becomes the relevant measure of military power.

The relationship between the contestants' efforts and the conflict outcome is described by a contest success function. This function maps the resources x_A and x_B that A and B spend in the contest into win probabilities. The probability of A winning is denoted

$$p_A(x_A, x_B). \tag{2}$$

B wins with the remaining probability $1 - p_A(x_A, x_B)$. There are several parametric versions of this function that are micro-founded, axiomatized and used in the literature, and we will consider two particular types of contest success function in the next sections.

In what follows we analyse the timing of the contest in a subgame perfect equilibrium concentrating on the case when the two rivals use stationary and symmetric strategies. Before we analyse this in greater detail for more specific contest success functions, we state that the contest can always occur as a failure to coordinate here:

Proposition 1 *An equilibrium in which there is no delay always exists.*

A proof is as follows. Suppose A expects that B will declare war in the first period. Then A is indifferent to whether to declare war or not to declare war, as the war takes place in any case. A may as well declare war. Hence, A 's choice to declare war on B and B 's choice to declare war on A are optimal responses to each other. \square

While the equilibrium without delay always exists, it is of limited interest. In many cases it constitutes a coordination failure and yields lower payoffs to both contestants than those they could obtain by some equilibrium with delay.

peaked in July 1944, six years after the beginning of the war. According to Harrison (2000, p.21), Germany's military outlays as a percentage of national income rose from 23 percent in 1939 to 70 percent in 1943, while GDP steadily grew in these years as well. The data for other major countries involved in World War II are similar but less extreme. The US needed 3 years to fully reorganize its industry towards armaments production. UK military production also peaked in 1943, in the fifth year of war (see Harrison 2000, p.15).

3 Fully discriminatory contests

To analyse how the decision to initiate a contest depends on period resources, we consider the following benchmark case. Suppose that the contestant who spends the largest amount of effort in the contest wins with certainty. If both contestants spend the same effort then let the contestant win who has more resources available that he could use in the conflict, and let A and B have the same win probability if they are symmetric with respect to their efforts and with respect to their period resources T_A and T_B .⁸ More formally, let the contest success function if the contest takes place in a particular period be given by

$$p_A(x_A, x_B) = \begin{cases} 1 & \text{if } x_A > x_B \\ \alpha(T_A, T_B) & \text{if } x_A = x_B \text{ with } \begin{cases} \alpha = 1 \text{ if } T_A > T_B \\ \alpha = 1/2 \text{ if } T_A = T_B \\ \alpha = 0 \text{ if } T_A < T_B \end{cases} \\ 0 & \text{if } x_A < x_B \end{cases} \quad (3)$$

First consider the equilibrium outcome of a subgame in which the contest takes place. The following lemma describes the equilibrium outcome of a contest with two contestants who choose contest efforts $x_A \in [0, T_A]$ and $x_B \in [0, T_B]$ and face a contest success function (3) if the contest is about an exogenously given prize Z . We will later define what is the prize Z of winning the contest in the multi-period framework here, but for a general characterization of the contest equilibrium $Z > 0$ be some prize of arbitrary size.

Lemma 1 *Suppose contestants A and B compete for a prize of size $Z > 0$. Let the contest success function be given by (3). Then no equilibrium in pure strategies exists.*

The (unique) equilibrium in mixed strategies is described by cumulative density functions of efforts $x_A \geq 0$ and $x_B \geq 0$ for the case $T_A < T_B$. The cumulative density functions are

$$G_R(x_R) = \begin{cases} \frac{x_R}{Z} & \text{for } x_R \in [0, Z] \\ 1 & \text{for } x_R > Z \end{cases} \quad \text{for } R \in \{A, B\} \quad (4)$$

if $T_A \geq Z$, with contest payoff equal to zero for A and B , and the sum of expected contest efforts equal to Z .

⁸This tie-breaking rule about what happens if $x_A = x_B$ is convenient. It simplifies the analysis but does not qualitatively affect the results.

The equilibrium cumulative density functions are

$$G_A(x_A) = \begin{cases} 1 - \frac{T_A}{Z} + \frac{x_A}{Z} & \text{for } x_A \in [0, T_A] \\ 1 & \text{for } x_A \geq T_A \end{cases} \quad (5)$$

and

$$G_B(x_B) = \begin{cases} \frac{x_B}{Z} & \text{for } x_B \in [0, T_A] \\ 1 & \text{for } x_B \geq T_A \end{cases} \quad (6)$$

if $T_A < Z$. The contest payoffs are zero for A and $Z - T_A$ for B and the sum of expected contest efforts is equal to T_A in this case.

For a proof see Hillman and Riley (1989) and Baye, Kovenock and deVries (1996) for the case in which both contestants have resources that exceed Z and Che and Gale (1997) for the case in which at least one contestant is resource constrained and could not spend as much as Z .

Typically no equilibrium in pure strategies exists in a contest if the contestant who spends the highest effort wins with certainty. Instead, contestants choose mixed strategies in the equilibrium and randomize their efforts according to the distribution functions G in the lemma.⁹ The precise shape of these distribution functions does not matter for our analysis. However, equilibrium payoffs are important for what follows. Both contestants have a payoff of zero in the equilibrium if they both could choose effort up to the value of the prize. This is intuitive, given the fierce competition that emerges in this case. If, however, one of the contestants (say, A) is resource constrained in the sense that he cannot choose an amount of effort that equals the value of the prize, the payoff of the contestant with the higher amount of resources in the contest period must have a positive equilibrium payoff: B could always out compete A by an effort that just exceeds the maximum effort that A could choose by spending all his period resources on the contest, and B would then win with certainty and still spend less than the full amount of the prize. This explains why the less resource constrained contestant receives a payoff equal to $Z - \min\{T_A, T_B\}$. The contestant with the lower endowment will have zero payoff also in this case. Intuitively, this contestant can always be out competed by the contestant with the higher endowment.

⁹The non-existence of a pure strategy equilibrium is illustrated by a simple contradiction. Suppose there is a pure strategy equilibrium in which player A chooses x_A . In the equilibrium B anticipates this choice, and B 's optimal reaction is either $x_B = 0$ or some x_B that exceeds x_A by a small amount. For both these choices x_A is not optimal for A . This establishes the contradiction.

Return now to the decision whether to initiate the contest or war in a given period. It will turn out that there is a critical amount of resources denoted T^* such that the contest is initiated in the equilibrium if one of the contestants' resources in this period fall short of T^* . For establishing this result and for finding the critical amount T^* , the following definitions are useful. Let

$$p(T^*) \equiv \text{prob}(\min\{T_A, T_B\} \leq T^*) = 2F(T^*) - [F(T^*)]^2. \quad (7)$$

Here, $p(T^*)$ is the probability that at least one of the rivals' period endowments in period t does not exceed T^* , where T^* is simply some given positive number at this point of the analysis. As the distribution properties of $T_A(t)$ and $T_B(t)$ are time invariant, this probability $p(T^*)$ is also time invariant, and the second equality makes use of stochastic independence. Generally $p(T^*)$ will depend on T^* and on the distribution F of T_A and T_B .

Using this probability, we further define the following discount factor:

$$\Delta(T^*) \equiv \sum_{k=0}^{\infty} \frac{p(T^*)(1-p(T^*))^k}{(1+r)^k} = \frac{(1 - (1 - F(T^*))^2)(1+r)}{r + (1 - (1 - F(T^*))^2)}. \quad (8)$$

This discount factor is the *expected* present value of one unit of effort that is spent in the first period in which $\min\{T_A, T_B\} \leq T^*$. E.g., $\min\{T_A, T_B\} \leq T^*$ occurs for the first time in period k (starting with $k = 0$) with probability $p(T^*)(1-p(T^*))^k = (1 - (1 - F(T^*))^2)(1 - F(T^*))^{2k}$, and the present value of one unit of effort that is spent in period k is $1/(1+r)^k$. Generally, the discount factor $\Delta(T^*)$ is decreasing in T^* . We can now formally state our main result:

Proposition 2 *If*

$$2T^* - \frac{(1 - (1 - F(T^*))^2)(1+r)}{r + (1 - (1 - F(T^*))^2)} \int_{y=0}^{y=T^*} ydF(y) = \frac{2ET}{r} \frac{1}{1+r} \quad (9)$$

has a unique solution for $T^ \in [0, \bar{T}]$, then there is a perfect equilibrium in which the contestants delay the contest to the first period t in which $\min\{T_A(t), T_B(t)\} \leq T^*$ and with equilibrium effort choices in that period given by (5) and (6) and with a prize of winning the contest in this period of $Z = 2ET/(r(1+r))$.*

A proof is as follows. We consider the contestants' decision whether to declare war or to delay. We can restrict consideration to the case $T_B > T_A$ in a given period, because, for the case $T_A > T_B$, the contestants A and B simply switch roles, and because the case $T_A = T_B$ has zero probability.

If $\min\{T_A, T_B\} \geq 2ET/(r(1+r))$ neither A nor B wants to enter a war in this period, because in such a war they would dissipate the present value of all future rents.

If $\min\{T_A, T_B\} = T_A < 2ET/(r(1+r))$, then A would prefer a delay. A 's expected payoff from war in period t is equal to $T_A(t)$ in the contest equilibrium by Lemma 1, as this is A 's total payoff from choosing $x_A = 0$ which is within A 's equilibrium support, whereas A 's payoff from delay is strictly positive (at least higher than $T_A(t)$). This shows that the contestant with the smaller income in a given period will always prefer delay. Accordingly, the contestant with the higher income decides whether there will be war.

Consider B 's payoffs from war and no-war in a given period t if there was no war prior to t and if $\min\{T_A, T_B\} = T_A < 2ET/(r(1+r))$. In the case of war, B receives an equilibrium payoff that is equal to $T_B(t) + 2ET/(r(1+r)) - T_A(t)$. B 's income in period t is $T_B(t)$, and B 's payoff from participating in the contest, given that $T_B(t) > T_A(t)$, is $2ET/(r(1+r)) - T_A(t)$ by Lemma 1, as $2ET/(r(1+r))$ is what B receives if B wins with probability 1, as B wins with probability 1 if B chooses $x_B = T_A(t)$, and as $x_B = T_A(t)$ is in B 's equilibrium support. If war is delayed, B receives his full period income $T_B(t)$ and, by symmetry as regards the uncertain future, half the present value of all future consumption flows minus half of all future contest efforts. The present value of half of all future gross incomes equals $ET/(r(1+r))$. Consider the present value of the sum of expected contest efforts. At most, one contest takes place. Suppose for a moment that the contest takes place if $\min\{T_A(t), T_B(t)\} \leq T^*$ for some given T^* . Then the sum of expected efforts in this contest is equal to

$$E(\min\{T_A, T_B\} | \min\{T_A, T_B\} \leq T^*) = \int_{y=0}^{y=T^*} y dF(y)$$

and contestant B bears half of this cost in expectation. In order to make this cost comparable with the other elements of the payoff, this expected contest effort needs to be discounted, and the discount factor is $\Delta(T^*)$ as defined in

(8). B is indifferent between declaring or delaying war in period t if

$$\begin{aligned} & T_B(t) + \frac{2ET}{r} \frac{1}{1+r} - T^* \\ = & T_B(t) + \frac{ET}{r} \frac{1}{1+r} - \frac{E(\min\{T_A(t), T_B(t)\} | \min\{T_A(t), T_B(t)\} \leq T^*)}{2} \Delta(T^*) \end{aligned} \quad (10)$$

Using (8), this equation simplifies to (9). The right-hand side in (9) is constant. The left-hand side is smaller than this constant for sufficiently small T^* . Accordingly, if the left-hand-side in (9) is continuous and (9) has a unique solution, then it is preferable for B to declare war if $T_A(t) \leq T^*$ and it is optimal to delay war if $T_A(t) > T^*$. \square

Proposition 2 shows that conflict is delayed until a period is reached in which one of the rivals is sufficiently “weak” to make it inexpensive for the stronger contestant to initiate war and defeat the weak rival. The intuition of the result is as follows. The more constrained, or “weaker”, contestant has nothing to gain from a contest in this period. The effort constraint he faces puts him at a serious disadvantage if there is a contest. Accordingly, it is the less constrained, or “stronger”, contestant who possibly initiates the conflict. This stronger contestant compares his costs and benefits of conflict. Whereas the gains (gross of effort) from immediate conflict are independent of the endowments that the contestants have in this period, the cost of initiating conflict is increasing in the weaker rival’s endowment, because this endowment determines the stronger contestant’s effort needed for him to win. If the endowment of the weaker contestant is sufficiently low, the resources needed to defeat him are small enough to make the conflict worthwhile.

It is interesting to contrast this outcome with the results in the “power transition” theory of war. This theory suggests that war takes place when the weaker rival catches up, and is most likely to take place in the range when one of the rivals approaches the strength of the other rival. We find that wars take place if their cost is low, which is the case if one of the contestants is weak and, hence, an easy target.

4 Contest success functions with noise

The contest in which the contestant who spends the highest effort wins with certainty is an interesting benchmark case that highlights the importance of

the weakness of the weaker contestant for the stronger player's decision to initiate war. Additional aspects such as relative strength may also play a role for different contest success functions. To see this, we turn to an example in which the probability of winning equals the ratio between the contestant's own contest effort and the sum of his and his rival's contest effort. This contest success function is frequently used to describe a contest in many areas of economics and political science. In the area of rent seeking it goes back to Tullock (1980). It allows for some noise in the contest outcome, as it implies that the contestant who spends less effort than his rival also has a smaller, but still positive chance to win. Formally, this function is given by

$$p_A(x_A, x_B) \equiv \begin{cases} \frac{x_A}{x_A + x_B} & \text{if } \min\{x_A, x_B\} > 0 \\ 1/2 & \text{if } x_A = x_B = 0 \end{cases}.$$

The function has been axiomatized by Skaperdas (1996) and has been given microeconomic underpinnings, e.g., by Mortensen (1982), Hirshleifer and Riley (1992), Fullerton and McAfee (1999) and Baye and Hoppe (2002). The set of pairs of incomes in which no contest takes place in a given period depends not only on the specific contest success function, but also on the distribution of income pairs. Contestant A prefers not to enter a contest in a given period t , if

$$x_A^* + \frac{V}{1+r} > \frac{x_A^*}{x_A^* + x_B^*} \frac{2E(T)}{r(1+r)}.$$

Here, x_R^* is R 's equilibrium choice of effort if the contest takes place in the respective period, and obeys the constraint $x_R^* \leq T_R$. V is the value of being ruler of a territory at the beginning of a period before the resources in this period are known to the rivals, if no contest had taken place previously, that is, if a rival ruler exists in this period. In order to calculate V , $F(T)$ must be further specified.

Even for simple versions of $F(T)$, the calculations are non-trivial, also because the constraint $0 \leq x_R^* \leq T_R$ is sometimes, but not always, binding. We restrict consideration here to an example in which the constraint is binding for all possible outcomes of T_A and T_B . Suppose $T_A(t)$ and $T_B(t)$ are identically distributed, and pairwise and intertemporally stochastically independent. Let them take values from the set $\{0.8, 1, 1.2\}$ with equal probabilities of $1/3$. Suppose further that $r = 0.12$. In this case there are nine possible combinations of resources in a given period.

We find that the contest takes place if

$$(T_A, T_B) \in \{(0.8, 1), (0.8, 1.2), (1, 0.8), (1.2, 0.8)\},$$

whereas an equilibrium with no contest in this period exists if

$$(T_A, T_B) \in \{(0.8, 0.8), (1, 1), (1, 1.2), (1.2, 1), (1.2, 1.2)\}.$$

The following matrix shows the equilibrium choices of declaring or delaying war for the different combinations of period incomes.

	$T_B = 0.8$	$T_B = 1$	$T_B = 1.2$
$T_A = 0.8$	delay	B declares war	B declares war
$T_A = 1$	A declares war	delay	delay
$T_A = 1.2$	A declares war	delay	delay

To confirm this, consider the value of being a ruler if this matrix adequately describes future contest outcomes at the beginning of some period when the available resources in this period are not yet known. This value can be calculated to be equal to

$$V = \frac{2 + 2.4 + .8}{9} + (5/9)V/(1.12) + (4/9)\frac{8.3333}{1.12}.$$

The first term is the expected period income conditional on the contest being delayed. The second term is the present value of being a ruler at the beginning of the next period, given that the contest has been delayed, times the probability (5/9) with which the contest is delayed. The third term is the expected payoff from the states of conflict times the probability (4/9) with which the contest takes place in this period. This payoff equals the present value of half the income flow of the two territories, from next period on. This is equal to $\frac{2ET}{2} \frac{1}{r} \frac{1}{1+r}$, or, using $ET = 1$ and $r = .12$, it is equal to $\frac{8.3333}{1.12}$. Accordingly, $V = 7.7081$. Now the payoff from fighting needs to be compared with the payoff from not fighting in this period for each contestant to confirm the respective choices. Note that it is enough for the contest to take place if one of the rivals prefers fighting to not fighting in the respective period. For instance, for $(T_A(t), T_B(t)) = (1.2, 0.8)$, A prefers to enter a contest. A 's payoff is equal to $1.2 + \frac{7.7081}{1.12} = 8.0822$ if no contest takes place in this period, and A 's payoff equals $\frac{1.2}{2} \frac{2}{(0.12)(1.12)} = 8.9286$ if a contest takes place in this period.

In the analysis in section 4 the weakness of the weaker contestant was decisive for whether the conflict was delayed. The example in this section shows that, more generally, both the size and the difference between the contestants' endowments can matter for the timing of the contest.

5 Negotiations

Before a war is initiated, the rivals may consider bargaining and finding a cooperative agreement. Much of the recent literature on rational war has considered the question of why wasteful wars occur despite possible negotiations. In the formal analysis we did not allow for negotiations of contestants at the onset of war. This simplified the game structure, but is also justifiable here, because allowing for such negotiations does not change the equilibrium outcome. Negotiations could not be successful here, at least for a wide parameter range. Like in Garfinkel and Skaperdas (2000), there is a parameter range in which negotiations break down as a result of a lack of contractibility, even though there is no asymmetric information between rivals. Contracts that yield an outcome that is Pareto superior to war require commitment about future resources or future decisions, and cannot be enforced.

A few reasonable assumptions lead to this outcome. First, rivals cannot contract on who rules in future periods, on future transfers, or on future decisions to start a war. Whoever rules a given territory has full control over the resources generated in this territory in the relevant period. Hence, the only feasible states are the status quo with two independent rulers who each control one territory, and the state in which one of the rulers has eliminated the other and gained full control of both territories.

To analyse negotiations, consider a particular period t with endowments T_A and T_B in this period. A and B could delay, contest, or negotiate. We already determined the equilibrium of non-cooperative behavior (delay or actual contest). Consider whether negotiations could make both contestants strictly better-off. As a matter of convention let A be the weaker rival in the given period. We concentrate on the fully discriminatory contest and on a pair of period outputs T_A and T_B for which war occurs in this period in the absence of negotiations. Hence, without negotiations, conflict takes place in this period, leading to payoffs

$$(T_B - T_A) + \frac{2ET}{r(1+r)} \tag{11}$$

for B and a payoff of zero for A . Suppose A and B could negotiate about a transfer from A to B and a binding agreement that B does not attack A in this period. The most A could offer to B in exchange for this agreement is T_A , that is, the total amount of resources available to A in this period. If B accepts, this will lead to a two-ruler regime in the next period. The expected payoff for B depends on whether there will be war in the future or not and on future negotiations and hence is not well determined. However, the case in which there is no war in the future (e.g., due to successful periodwise negotiations) gives an upper limit to B 's expected future payoff and, considering A and B as symmetric at the beginning of the next period when their resources are not yet known to them, this upper limit is one half of all future benefits: $ET/(r(1+r))$. Accordingly, in this continuation game, negotiations and abstinence from war give B an expected payoff that cannot exceed

$$T_B + T_A + \frac{ET}{r(1+r)}. \quad (12)$$

As discussed, this maximum is reached if B receives the maximum transfer that is feasible, and if, for whatever reason, the two rulers co-exist in the future. Comparing (11) and (12) reveals that negotiations must fail if

$$\frac{ET}{r(1+r)} > 2T_A. \quad (13)$$

If condition (13) holds, then the stronger rival B 's benefit of destroying and eliminating A as a future rival for all times and receiving the income from A 's territory is larger than the sum of the savings in military effort and of the maximum possible transfer.

This consideration shows that ruling out binding contracts about future periods leads to a situation in which war is the rational outcome if one of the contestants becomes sufficiently weak, even if negotiations and a binding commitment to abstain in exchange for transfers from the weaker ruler are technically feasible. The condition determining whether negotiations could avoid war also reveals that successful negotiations are less likely to be feasible the weaker the weak ruler is. This result is reverse of the predictions made by the "transition theory" of war that suggests that war is unlikely if rivals are very unequal in strength and becomes more likely if the weaker rival catches up with the dominant but declining power. The main reason for the failure to avoid a war by negotiations among rivals who are currently very

unequal is the inability of the weaker ruler to constrain its future resource use and own future power in current negotiations, which seems to be a plausible assumption.

6 Conclusions

In this paper we considered contestants' decision to enter a contest or to delay the contest to a future period. We showed that the contest is sometimes delayed and we characterize the main determinant of delay. Contestants' resource constraints matter. They are more likely to prefer to initiate a contest when their rival is "weaker", and, in particular, if their rival is "sufficiently weak" to be an easy target that does not need many resources to defeat him.

7 References

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