INVESTING IN ARMS TO SECURE WATER

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ABSTRACT. The supply of resources critical to a national economy, such as water supplies drawn from a river, can often lie within the borders of another country. When supply is assured in the natural state, e.g. normal river flows, interruptions can increase international tensions and possibly lead to war. Homer-Dixon (1999) argues that resource wars are most likely over water, where there is a high level of dependency by a militarily superior downstream nation, a downstream leader. We develop a two stage game to test whether war is more likely with a downstream leader, or at a leaderless equilibrium. We show that a leaderless model often does not have a pure strategy Nash equilibrium, and that in most situations war is less likely when one nation is a leader. A downstream leader chooses a threat level that diverts upstream resources to less water consuming activities, generating a benefit without going to war. However, the leader is also indifferent between peace and war. Water scarcity can therefore create the conditions for war, while not being the immediate cause.

1. INTRODUCTION

Access to water is expected to be one of the most serious resource issues of the twenty-first century, particularly in the developing world [Rosegrant, 1997]. Some fear that as populations grow and demand expands, these disputes may lead to violent international conflict [Serageldin, 1995], particularly where water is already scarce [Falkenmark, 1990, Gleick, 1993, Sandler, 2000]. Some empirical research suggests that violent conflict between cultural groups is an effort at resource capture, particularly when the risk of natural disasters is high [Ember and Ember, 1992]. There is also evidence suggesting that population pressure is related to involvement in military conflicts [Tir and Diehl, 1998]. Further, modern asymmetries in military technology may increase the attractiveness of using force on the part of the stronger adversary [Orme, 1997]. However, this view is not universally held. Gileditsch [1998] surveys the literature relating the environment and violent armed conflict. He finds little research that effectively tests these relationships. [Homer-Dixon, 1991, 1994, 1999] argues that resource wars between nations are unlikely, except in particular cases. Violence is more likely to occur within nations as interest groups battle for resource access. International wars over water are likely only when a downstream nation is highly dependent on a water source that an upstream nation can substantially disrupt, that there is a history of antagonism between the nations, and that the downstream nation has substantially superior military power. We explore this proposition by modifying a simple anarchy model to reflect the riparian relationship between a pair of river basin nations. Although Homer-Dixon's

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conjecture is not developed in the context of a model with Stackleberg type leadership, for our analysis we intrepret it as such. In contrast to Homer-Dixon, we find that in general, conflict is less likely when there is a clear leader than when there isn't one. We also show that an arms race may benefit a downstream nation, since the upstream defensive response can divert upstream resources away from more water consuming activities. Finally, when there is a downstream leader, its selected point does leave it indifferent between war and peace. Water is not enough to trigger the war, but it does create an outcome where it is more likely.

The Nile River basin has the water conflict characteristics described by Homer-Dixon. Egypt, at the bottom of the Nile, relies on the river for virtually all of its water needs. It also has the largest military and largest economy of any nation in the Nile basin, as well as one of the largest populations [Dinar and Alemu, 2000, Rached et al., 1996]. Ethiopia, one of the poorest nations in the basin, is the source of over 70% of the water reaching Egypt. Having recently experienced severe droughts, Ethiopia is keenly aware of how it could benefit by capturing and using more of the water that falls within its boundaries. It has been very hesitant to participate in any agreements that would commit it to a particular sharing arrangement [Swain, 1997]. However, Egypt is also aware that any increase in water usage by Ethiopia could reduce the amount of water available in the lower Nile. Egypt has not recently gone to war over water, but it has stated that if its water supplies are threatened, it will act [Gleick, 1993, Ndege, 1996, Wiebe, 2001]. It is within this context that the riparian nations of the Nile basin are seeking arrangements to share the Nile waters [Council of Ministers of Water Affairs of the Nile Basin States, 2001]. There are a range of ways in which cooperative development of the Nile could benefit the riparian nations [Wichelns et al., 2003], but these would involve levels of political and economic integration that will be difficult to implement[Dinar and Wolf, 1994, Dinar and Alemu, 2000]. Understanding the strategic issues that will impact on these negotiations is particularly important at this time.

This paper is motivated by the Nile example, where a nation (Egypt) that is in a superior military and economic position is also in the most vulnerable position where access to the resource is concerned. If upstream nations feel that the threat of an Egyptian attack on their water infrastructure is sufficiently credible, then any investment in that infrastructure would have to be accompanied by sufficient investment in the military to protect that infrastructure. In so far as the military and infrastructure investments are mutually exclusive - guns and tanks are not a substitute for irrigation canals in water delivery - increased military investment will reduce infrastructure investment. As a result, downstream investments that increase the threat perceived by upstream nations can increase the water received by the downstream nation. Provided that the marginal increase in economic output resulting from the extra water is greater than the marginal cost of increasing the threat level, there will be an incentive for the downstream nation to increase its threat level. The military investment need not be used to generate a payoff.

Although motivated by the Nile basin example, we believe that our study is relevant in other cases where resources are sequentially shared between nations. Several other river systems, such as the Jordan, the Tigris and Euphrates, the Ganges and Brahmaputra, the Danube and the Rhine, flow from one country to another. In some of these, military conflicts have occurred while in others they have been absent. The model we develop provides an analytic framework to describe what have been here-to-for descriptive explanations for these phenomena. Other sequential resource movements, such as animal migration patterns, may also fit this analytical framework. Further, the role of the upstream and downstream nation may be reversed for resources where active extraction is required, such as for a transboundary aquifer or oil reserve. If one nation is able to pump from a deeper point in the underground reserve, it may be able to draw down the overall reserve in a way that the neighboring nation cannot also do. An arms race may be a means by which the nation with poorer resource access can induce a slower extraction rate by the nation with superior access.

The relationship between military spending and economic growth is complex. Growth retarding effects include resource diversion from more productive activities and the accumulation of national debt, while growth enhancing effects include technical and human capital spillovers and aggregate demand stimulation. [Looney, 1993, Blomberg, 1996]. Empirical studies investigating the relationship between military expenditures and economic growth have generated ambiguous results. LaCivita and Frederiksen [1991] find that for most countries, one cannot attribute causality to either growth or military spending, in relation to each other. Looney [1993] also finds the relationship weak, and concludes that the impact on economic growth of reduced military expenditure (the 'Peace Dividend') is likely minimal for most nations. Kusi [1994] reports results for a sample of 77 countries, finding cases where military expenditure is caused by economic growth, cases where it causes economic growth, cases where they are mutually endogenous, and cases with no relationship. More recently, Dakurah et al. [2001] conduct a cointegration study accounting for stationarity. No substantial difference is found, except that were long run effects can be isolated, they tend to be positive, regardless of the direction of causality. Using panel data methods to estimate a Feder-Ram style model for a set of Latin American and Asian nations, Murdoch et al. [1997] find a positive and strongly significant relationship between military expenditure and economic growth. However, no causality can be attributed to these results, and for Latin America there is evidence that military expenditure crowds out more productive investments.

In an interesting twist on these arguments, Lipow and Antinori [1995] suggest that the level of threat acts to unite a nation, an effect that reduces internal frictions and thereby enhances economic growth. In an elementary cross sectional regression with dummy variables reflecting threat levels, support is found for this interpretation. Landau [1994] makes a similar contention, arguing that military expenditure affects growth through a combination of positive security and efficiency effects together with negative crowding out effects in response to external threats. Again, econometric analysis weakly supports this argument. We concur with the conclusions of these authors that the relationships are more complex than that which a simple relation between military expenditure can capture. We argue that resource linkages such as water may play a part in determining whether military expenditure accelerates or retards economic growth.

At a theoretical level, two relatively distinct approaches have emerged. One parallels the econometric analysis, exploring the impact of military expenditures on aggregate economic output. In some cases, these have been developed with econometric analysis in mind, such as in Blomberg [1996]. Others develop a growth theoretic model with an additional stock, that being military expenditures. Such investigations typically do not include military conflict, but rather focus on a threat level. [Zou, 1995] constructs a model where increases in threat level reduce utility, but have no effect on the production function. If the threat level is increased in the current period, the present value of utility is maximized by shifting resources from capital into the military. In contrast, if the threat level increases in a future period, then it is optimal to shift resources from consumption to capital, allowing increased future military expenditure. However, since military investments have no effect on the production function, the steady state capital stock is identical to that for a model without a military threat. Shieh et al. [2002] also include military stock in the utility function, arguing that it conveys security. Their production function includes a private capital stock, a government provided infrastructure stock, and a military capital stock. They find that the growth maximizing infrastructure to military ratio involves less military spending than the welfare maximizing ratio. This occurs because the military stock generates a utility benefit as well as a productive benefit, an effect not captured when optimizing for growth. Gong and Zou [2003] extend the Zou model by introducing uncertainty. They show that the relationship between domestic capital accumulation and foreign military expenditure is strongly related to the rate of inter-temporal substitution.

The second approach to the economic analysis of military spending identifies Nash equilibria in resource capture games, seeking to identify under what conditions cooperation can be supported. Military expenditures enter a *conflict function*, which determines the likelihood of successful resource capture. Skaperdas [1992] highlights the importance of the relative productivity of military investment in determining whether an equilibrium without engagement can be supported. Hirshleifer [1995] develops a resource capture model to evaluate the relative stability of 'anarchy', defined as a situation "in which contenders struggle to conquer and defend durable resources, without effective regulation by either higher authorities or social pressures [Hirshleifer, 1995, p. 27]." It is shown that changes in the effectiveness of military power or relative strength are important factors in determining whether 'anarchy' is stable. A particularly interesting result is that when one nation can act as a leader, it is able to gain in absolute terms, but in relative terms the follower gains more.

Cothren [2000] integrates these approaches. In his model, the only impact of military accumulation is through the conflict function. Nash equilibria exist where both nations have sufficient military capacity to deter potential attacks by their rival, with both nations indifferent between attacking and not attacking. Our approach is similar to Cothren, in that we consider economic growth and the decision to go to war. However, we focus on a particular asymmetric resource competition, nations along a river.

The paper proceeds as follows. In the next section we describe the model. We begin with a two period two nation example, where nations decide in the first period how much to divide an endowment between a productive activity and military expenditures. A numerical demonstration of the two period model is then presented, with functional forms chosen to reflect conventional assumptions. The penultimate section discusses the model's implications. The paper is ended with a brief conclusion.

2. Model

We introduce a resource connection between two riparian neighbors by making both nations dependent on a common water resource. The nations are spatially ordered, so that the downstream nation cannot use more water than that left by the upstream nation. If w_1 and w_2 are the water volume used in each nation, and V is the total water originating in the upstream nation, then $0 \leq w_1 \leq V$ and $0 \leq w_2 \leq V - w_1$.

The amount of water that each nation is able to capture depends on a capital stock. We define a water capture function $g_i(K_i)$ which measures the share of the river's flow that nation i is able to capture. The capture function is assumed to be continuous and have continuous derivatives to at least the second order satisfying $\partial g_i/\partial K_i > 0$, $\partial^2 g_i/\partial K_i^2 < 0$, $g_i(0) = 0$ and $\lim_{K_i \to \infty} g_i(K_i) = 1$. This last assumption ensures that for finite cost, the upstream nation cannot prevent all water from reaching the downstream nation. With these definitions, $w_1 = V g_1(K_1)$ and $w_2 = V[1 - g_1(K_1)]g_2(K_2)$, which gives us that $\partial w_2/\partial K_1 < 0$.

We assume that water is the only input constraining production, and that the only factor affecting water capture is invested capital. Water enters a production function $f_i(w_i)$, assumed continuous to at least two derivatives, which satisfies the standard assumptions that $\partial f_i/\partial w_i > 0$ and $\partial^2 f_i/\partial w_i^2 < 0$. For simplicity, we write $F(K_1)$ for the upstream nation's production function and $G(K_1, K_2)$ for the downstream nation's production function, thereby incorporating the hydrologic relationship between the nations directly into the production function. For partial derivatives, subscripts on F and G will index the argument with respect to which the derivative is taken. Using the definitions of w_i, it quickly follows that $F_1 > 0$, $F_{11} < 0$, $G_1 < 0$, $G_{11} > 0$, $G_2 > 0$, $G_{22} < 0$ and $G_{12} < 0$. We assume that period welfare is a function of period output, so that investment decisions do not crowd out current welfare enhancing consumption, but contribute to future welfare. We therefore focus exclusively on the relationship between capital and military investment when a downstream riparian neighbor can choose to attack its upstream neighbor's capital stock.

The approach we follow is similar to that used by Cothren [2000]. Like Cothren, military expenditures affect the probability of a successful attack, using resources that could otherwise be invested in production. We also compare an attack always Nash equilibrium with an equilibrium that can be supported without an attack. However, the analysis of Cothren differs from ours in several respects. First, the interaction of our nations rests on a shared resource, rather than the potential to capture the rival's output. Second, the attack option is targeted at capital affecting resource availability, rather than at capturing output. Thirdly, we use a more complicated production function that captures critical features of the resource process integrating the nations of our model. We will also consider three types of solutions, the Nash equilibrium, investment chosen first by the downstream nation, and investment chosen first by the upstream nation.

We seek to compare the likelihood of conflict when there is no clear leader against situations where there is one. Before discussing the implications of leadership, we need to establish the characteristics of equilibria that exist for the model when there is no leader. The analysis proceeds in four steps. First we characterize the equilibria for two degenerate games, one where an attack never occurs in the second period and the second where it always occurs. We then show the reaction functions are affected by allowing a second stage attack choice. The relationships demonstrated allow us to prove that a game of this form cannot have pure strategy equilibria where the downstream nation is indifferent between attacking and not attacking. Finally, we argue that in most situations of this type, an attack would be less likely with a downstream leader than with no leader.

If the only choice facing each nation is the investment level, then each nation would invest its endowment, with the downstream nation enduring lower returns as a consequence of the water captured by the upstream nation. The welfare function for the two nations as $W_1 = F(K_1)$ and $W_2 = G(K_1, K_2)$ if there is no attack. The assumptions on the water capture and production functions together ensure that W_1 and W_2 satisfy strict quasi-concavity over the range of available K_1 and K_2 values, allowing us to make the following proposition:

Proposition 2.1. *For the ranges $0 \leq K_1 \leq \omega_1$ and $0 \leq K_2 \leq \omega_2$, where ω_i is the endowment available to nation i, and assuming each nation seeks to maximize its welfare, the best response functions for the two nations are $K_1(K_2) = \omega_1$ and $K_2(K_1) = \omega_2$.*

Proof. The proof is straightforward. For the upstream nation $W_1 = F(K_1)$. Since $F_1 > 0$ for all values of K_1, it immediately follows that $\partial W_1 > 0$, so that to maximize welfare, the upstream nation will choose $K_1 = \omega_1$. Similarly, for each value of $K_1 \in [0, \omega_1]$, we have that $G_2 > 0$ ensuring that $\partial W_2 / \partial K_2 > 0$. Therefore, downstream welfare is maximized by choosing $K_2 = \omega_2$. □

The result which follows from this proposition is that the Nash, upstream leader and downstream leader equilibria all coincide at $K_1 = \omega_1$ and $K_2 = \omega_2$. For completeness then,

Corollary 2.2. *For two nations engaged in a noncooperative simultaneous move, upstream leader, or downstream leader game, with strategies and payoffs as in Proposition 2.1, all three games have the same solution, $K_1 = \omega_1$ and $K_2 = \omega_2$.*

Proof. Since $K_1(K_2) = \omega_1$ and $K_2(K_1) = \omega_2$, where $K_i(K_j)$ denotes the best response of nation i to strategy K_j, the result immediately follows. □

This game is rather uninteresting, as the downstream nation cannot influence the decision of the upstream nation. We therefore extend the game by allowing a second stage decision for the downstream nation, to attack the upstream nation's capital stock.

For the extended game, we focus exclusively on the use of military expenditure to influence probability of a successful attack. A successful downstream attack reduces the capital stock in the upstream nation to a level $\underline{K}_1$. Conceptually, K_1 is considered to be a structure such as a dam, and an attack either levels the dam or does not. Let the probability of a successful attack be $\phi(M_1, M_2)$, where M_i is the military stock held by country i. $\phi(M_1, M_2)$ is assumed continuous to at least two derivatives. We expect $\partial\phi/\partial M_2 > 0$ and $\partial^2\phi/\partial M_2^2 < 0$, capturing the fact that increased military expenditure by the downstream nation increases the probability that an attack will be successful, but that this effect experiences diminishing returns. Likewise, we expect that $\partial\phi/\partial M_1 < 0$ and $\partial^2\phi/\partial M_1^2 > 0$, reflecting the fact that military expenditure by the upstream nation reduces the probability of an attack, but also at a decreasing rate. We also assume that $\phi(M_1, 0) = 0$, which implies that even when the upstream nation has no military, the downstream nation must have one to attack. Finally, we assume that $\phi(0,\epsilon) = 1$ for all positive ϵ. Effectively, if the upstream nation does not have any defense, the downstream nation can successfully destroy the upstream dam for a very small cost. If an endowment is split such that $K_i + M_i = \omega_i$, then we can also write $\pi(K_1, K_2) = \phi(\omega_1 - K_1, \omega_2 - K_2)$, which will satisfy $\pi_1 > 0$, $\pi_{11} < 0$, $\pi_2 < 0$ and $\pi_{22} > 0$.

Before considering the two stage game, we describe the features of the game when an attack always occurs. In this case the welfare functions are

$$W_1^A(K_1, K_2) = \pi(K_1, K_2)F(\underline{K}_1) + [1 - \pi(K_1, K_2)]F(K_1) \tag{2.1}$$
$$W_2^A(K_1, K_2) = \pi(K_1, K_2)G(\underline{K}_1, K_2) + [1 - \pi(K_1, K_2)]G(K_1, K_2) - C_2 \tag{2.2}$$

where $\underline{K}_1$ is the level to which a successful downstream attack reduces upstream capital, and C_2 is the cost of that attack to the downstream nation. We assume that $\partial W_1^A/\partial K_1\big|_{K_1=\underline{K}_1} > 0$, which ensures that $K_1(K_2) > \underline{K}_1$. We also assume that for $K_1 \leq \underline{K}_1$, $F(\underline{K}_1) = F(K_1)$ and $G(\underline{K}_1, K_2) = G(K_1, K_2)$, so that if $K_1 < \underline{K}_1$, an attack has no effect. We will also make the notation more concise by defining $\underline{F} = F(\underline{K}_1)$, $\overline{F} = F(K_1)$, $\underline{G} = G(K_1, K_2)$ and $\overline{G} = G(\underline{K}_1, K_2)$ and using subscripted numbers to indicate partial derivatives. Using the assumptions outlined above, it is relatively easy to show that 2.1 is strictly concave with respect to K_1 and that 2.2 is strictly concave with respect to K_2. The convexity of the welfare functions when an attack always occurs ensures that the best response function is single valued. The derivative conditions and boundary conditions also ensure that it will be interior. We state this as a proposition.

Proposition 2.3. *For all values of $K_2 \in [0, \omega_2)$, the best response function $K_1(K_2)$ satisfies $0 < K_1(K_2) < \omega_1$, and for all values of $K_1 \in (\underline{K}_1, \omega_1]$, the best response function $K_2(K_1)$ satisfies $0 < K_2(K_1) < \omega_2$, provided that $\underline{G}_2 + \pi_2^K(\overline{G} - \underline{G}) < 0$. Also, $K_1(\omega_2) = \omega_1$ and for $K_1 \in [0, \underline{K}_1]$, $K_2(K_1) = \omega_2$.*

Proof. Since both welfare functions are concave, by virtue of the assumptions on the component functions, we only need show that over the indicated ranges, the welfare functions are increasing on the lower boundary and decreasing on the upper boundary. For the upstream nation, $\partial W_1^A/\partial K_1\big|_{K_1=0} = (1-\pi)F_1 > 0$ and $\partial W_1^A/\partial K_1\big|_{K_1=\omega_1} = \pi_1(\underline{F} - \overline{F}) < 0$, which establishes the result. For the downstream nation, $\partial W_2^A/\partial K_2\big|_{K_2=0} = \pi\overline{G}_2 + (1-\pi)\underline{G}_2 > 0$ and $\partial W_2^A/\partial K_2\big|_{K_2=\omega_2} = \pi_2^K(\overline{G} - \underline{G}) + \underline{G}_2$ when $K_1 \in (\underline{K}_1, \omega_1]$. Thus, if $\pi_2^K(\overline{G} - \underline{G}) + \underline{G}_2 < 0$, an interior maximum exists. When $K_2 = \omega_2$, $\pi(K_1, \omega_2) = 0$, so that $K_1(\omega_2) = \omega_1$. Finally, when $K_1 \in [0, \underline{K}_1]$, $\partial W_2^A/\partial K_2 = G_2 > 0$ for all K_1, so that $K_2(K_1) = \omega_2$. □

The additional condition $\underline{G}_2 + \pi_2^K(\overline{G} - \underline{G}) < 0$ means that the change in expected gain resulting from a reduction in K_2 (increase in military expenditure), $\pi_2^K(\overline{G} - \underline{G})$, must be greater than the loss in output, $\underline{G}_2$, when $K_2 = \omega_2$. If this were not the case, then it would never be worthwhile investing in the military, reducing the exercise to the solution for proposition 2.1.

Corollary 2.4. *A game with payoff functions as in equations 2.1 and 2.2, with $\pi_2^K(\overline{G} - \underline{G}) + \underline{G}_2 < 0$, must have an interior pure strategy Nash equilibrium.*

Proof. Proposition 2.3 establishes that the best responses are interior, relative to their arguments, over the range $K_1 \in (\underline{K}_1, \omega_1]$ and $K_2 \in [0, \omega_2)$. Continuity assumptions on the components of the welfare functions result in the best response functions being continuous in both arguments in this region. The assumption that $\partial W_1^A/\partial K_1\big|_{K_1=\underline{K}_1} > 0$, which implies that $K_1(K_2) > \underline{K}_1$ everywhere, ensures that the upstream best response does not pass through the discontinuity in the downstream best response at $\underline{K}_1$. All the requirements of Kakutani's fixed point theorem are therefore strictly satisfied on the restricted range $(\underline{K}_1, \omega_1] \times [0, \omega_2]$, which confirms the result. □

When the second stage attack decision is part of the game, and the downstream nation is assumed to attack whenever this is return maximizing, then the investment choice space can be partitioned into those investment pairs that will result in an attack and those that will not. Let the attack set be called Q^A, which is defined as

$$Q^A = \{(K_1, K_2) \in [0, \omega_1] \times [0, \omega_2] | \pi\overline{G} + (1-\pi)\underline{G} - C_2 > \underline{G}\}$$

Also let $Q^A(K_1)$ be the subset of Q^A where the value of K_1 is fixed. Further let $\overline{Q}^A$ be the complement of Q^A, the set of strategy combinations where an attack will not occur. The fact that Q^A is open on the interior of the strategy space means that $\overline{Q}^A$ is closed on the interior. Both sets are closed along the boundary of the strategy space.

Notice that so long as $C_2 > 0$, it follows immediately that Q^A will not contain the boundaries $K_1 = 0$, $K_2 = 0$ and $K_2 = \omega_2$. To see this, consider each case in turn. First, when $K_1 = 0$, $\pi\overline{G} + (1-\pi)\underline{G} - C_2 = \underline{G} - C_2$, because $\underline{G} = \overline{G}$ when $K_1 = 0$. Since $\underline{G} - C < \underline{G}$ for all $C > 0$, we have the first result. When $K_2 = 0$, $\underline{G} = \overline{G} = 0$, so that $\pi\overline{G} + (1-\pi)\underline{G} - C = -C < 0$, establishing the second result. Finally, when $K_2 = \omega_2$, then $\pi = 0$, which leads to $\pi\overline{G} + (1-\pi)\underline{G} - C = \underline{G} - C < \underline{G}$ for all $C > 0$, completing the set. Using these facts, we can conclude that the downstream best response curve must have a discontinuity in the two stage game, and that the upstream best response cannot include points in the interior of $\overline{Q}^A$. We state these results as two propositions.

Proposition 2.5. *For the two stage game, the downstream best response function in the first stage, applying sub-game perfection to the second stage, has at least one discontinuous break.*

Proof. Let $K_2^A(K_1)$ be the best response conditional on an attack always occurring. Proposition 2.1 establishes that the best response functions when there is no attack are $K_1 = \omega_1$ and $K_2 = \omega_2$. Thus, when the sub-game does not result in an attack, which occurs for all K_1 where $Q^A(K_1)$ is empty or where $W_2^A(K_1, K_2^A(K_1)) \leq W_2(K_1, \omega_2)$, then the best response is $K_2 = \omega_2$. When $W_2^A(K_1, K_2^A(K_1)) > W_2(K_1, \omega_2)$, proposition 2.3 shows that $K_2(K_1)$ is interior. At values of K_1 when $W_2^A(K_1, K_2^A(K_1)) = W_2(K_1, \omega_2)$, the best response consists of two K_2 values, $K_2 = \omega_2$ and a K_2 value in the interior of $Q^A(K_1)$. This latter point must be true because with $G_2 > 0$, which leads to $\partial W_2/\partial K_2 > 0$, there must be a region between $K_2^A(K_1)$ and ω_2 where $\partial W_2^A/\partial K_2 < 0$ or we could not have that $W_2^A(K_1, K_2^A(K_1)) \geq W_2(K_1, \omega_2)$. Since one best response is interior to $Q^A(K_1)$ and the boundary is not in $Q^A(K_1)$, there must be a discontinuous break. □

Proposition 2.6. *For the two stage game, the upstream best response function in the first stage, applying sub-game perfection to the second stage, is either on the boundary of* $\overline{Q}^A$ *or contains strategy combinations in the interior of* Q^A.

Proof. Assume that $C > 0$, so that $\overline{Q}^A$ has an interior. For all strategy combinations in $\overline{Q}^A$, $W_1 = F(K_1)$. Since $F_1 > 0$ for all K_2, for any points not on the boundary of $\overline{Q}^A$, W_1 can be increased by increasing K_1. Notice that the $K_1 = 0$ cannot be in a best response. The best response will be $\{K_1 \in \overline{Q}^A(K_2) | K_1 = \max[\overline{Q}^A(K_2)]\}$, the boundary of $\overline{Q}^A$, except where $F(\max[\overline{Q}^A(K_2)]) < \max_{K_1 \in Q^A(K_2)} W_1^A(K_1, K_2)$. In this latter case, the best response is interior to Q^A. □

Propositions 2.5 and 2.6 establish the conditions sufficient to show that there cannot be a pure strategy Nash equilibrium for games of this form where the downstream nation is indifferent between attacking and not attacking. If attacking is ever a best response, any pure strategy Nash equilibrium without an attack must be on this boundary. By establishing that such equilibria do not exist, we can then conclude that if there is a Nash equilibrium, it must be a mixed strategy equilibrium, and our function definitions ensure that this mixed strategy equilibria cannot put zero weight on realizations not in Q^A. Using this result we can then argue that in many such situations, leadership will not lead to attack while not having a leader has a nonzero attack probability. This contradicts Homer-Dixon's conjecture.

Let Γ be a two stage game where payoffs are either $F(K_1)$ and $G(K_1, K_2)$ or as in equations 2.1 and 2.2, with properties as outlined earlier. Player two chooses which payoff functions will apply in the second stage of the game, after both players have chosen values for K_1 and K_2. We state the non-existence result as a theorem.

Theorem 2.7. *For any two stage, two player game with the form of* Γ, *a pure strategy Nash equilibrium where the payoff choosing player is indifferent between second stage choices does not exist.*

Proof. Proposition 2.6 establishes that the upstream best response is either on the boundary outside Q^A, inside Q^A, or equal to ω_1. Along the boundary of $\overline{Q}^A$, adjacent to Q^A, $W_2(K_1, K_2) = W_2^A(K_1, K_2)$. Proposition 2.1 shows that when $(K_1, K_2(K_1)) \in \overline{Q}^A$, $K_2(K_1) = \omega_2$. When $C > 0$, so that $\overline{Q}^A$ has an interior, ω_2 cannot be in the set of points that define the boundary of $\overline{Q}^A$ adjacent to Q^A. Therefore, since the gap(s) in the downstream best response occur where $G(K_1, K_2(K_1)) = G(K_1, \omega_2)$ (proposition 2.5), these gaps must span the boundary. Since pure strategy Nash equilibria with the downstream nation indifferent about attacking must lie on the boundary, no such Nash equilibria can exist. □

The only Nash equilibria possible for this game are therefore mixed strategy equilibria. Further, since the structure introduces a non-concavity into the payoff functions of the overall game, there is no guarantee that there will be a mixed strategy equilibria either (see Osborne and Rubenstein 1994 for existence conditions for Nash equilibria). It can be shown that the upstream nation's payoff functions both with and without an attack are strictly quasi-concave for the arguments K_1 and K_2. Strict quasi-concavity means that for any set of K_2 values and probability distribution over those values, there will be a single K_1 value that maximizes the expected payoff. Therefore, the upstream nation will only have a pure strategy best response to any mixed strategy played by the downstream nation if the realizations are either all in Q^A or all in $\overline{Q}^A$. Since $K_2(K_1)$ is also single valued in these regions, no mixed strategy equilibria can exists which does not generate realizations in both Q^A and $\overline{Q}^A$. This means that if we observed a large number of independent replications of this game, when a mixed strategy Nash equilibrium exists, we would expect to see the attack option being exercised in some realizations.

With reference to Homer-Dixon's proposal that water wars are more likely when there is a downstream leader, to support it we must show that a downstream leader would play a strategy that is more likely to lead to an attack. A downstream leader chooses K_2, incorporating the upstream best response $K_1(K_2)$. Clearly, when the $K_1(K_2)$ is entirely in $\overline{Q}^A$, all downstream leader outcomes will involve $(K_1, K_2) \in \overline{Q}^A$, which will never result in an attack. When a pure strategy Nash equilibrium exists, it will always involve an attack in the second stage. Therefore, a downstream leader cannot increase the likelihood of an attack. The only cases where a downstream leader may be more likely to attack than at a solution without leadership is when the upstream best response includes a segment inside Q^A but this segment does not intersect $K_2(K_1)$ inside Q^A. In this situation, the downstream leader may prefer a point on $K_1(K_2)$ where an attack will occur, while the solution without a leader may sometimes not generate an attack. In our numerical analysis we find no such situations. For downstream leadership to increase the likelihood of war over water in an international river basin, very specific circumstances must apply. In most cases, downstream leadership probably reduces the likelihood of war, relative to the case where there is no clear leader.

3. Numerical Example

To illustrate the analytical results, we use a numerical example. The assumptions on the water capture functions are satisfied by implementing them as

$$w_i = (P - w_{i-1})(1 - e^{-g_i K_i})$$

where P is the precipitation in the upstream nation, g_i is the effectiveness of investment at water capture, and $w_0 = 0$. This water enters a production function

$$F_i(K_1, K_2) = [w_i(K_1, K_2)]^{\alpha_i}$$

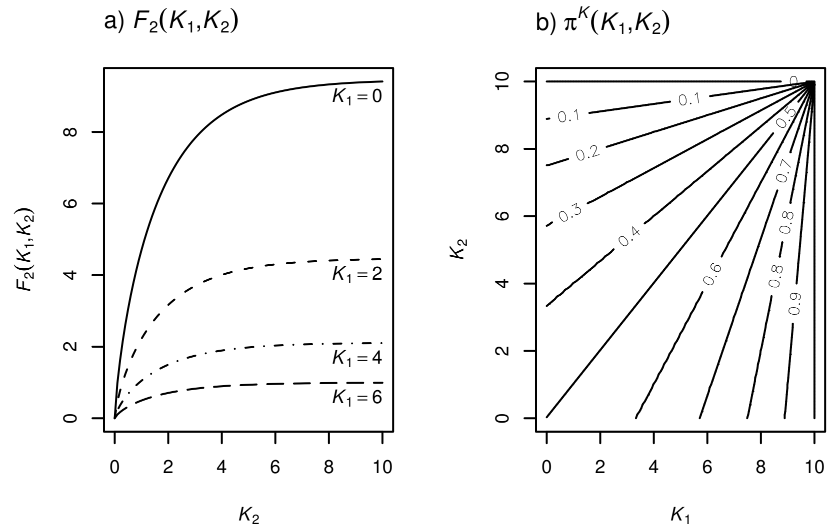
where $0 < \alpha_i < 1$ ensures diminishing marginal productivity. The attack success probability function, identical to that used by Cothren [2000], is

$$\pi^K(K_1, K_2) = \frac{\omega_2 - K_2}{(\omega_1 - K_1) + (\omega_2 - K_2)}$$

with $\pi(\omega_1, \omega_2) = 0$. Figure 3.1 shows the production function and the attack succession function, both defined in terms of upstream and downstream investment levels, with parameters $\omega_1 = \omega_2 = 10$, $P = 10$, $g_1 = g_2 = 0.5$, and $\alpha_1 = \alpha_2 = 0.75$. Notice that with symmetric parameter values, $F_1(K_1) = F_2(0, K_1)$, so that the upstream production function can also be seen in figure 3.1, where $K_1 = 0$. All results and graphics were generated using in R [Ihaka and Gentleman, 1996].

Figure 3.2 shows the best response functions for the two nations, for four different attack costs. In all four cases, a portion of the upstream nation's best response curve follows the boundary between the region where an attack will occur in the second stage and that were it will not. When the attack cost is low ($C_2 = 0.5$), there is a large segment of the upstream nation's best response curve that lies inside the attack region. A pure strategy Nash equilibrium exists at the intersection of the best response curves inside the attack region. The equilibria with the upstream or downstream nation as leaders lie close to the Nash equilibria. These are both pure strategy equilibria, and being in the attack region, both result in an attack

FIGURE 3.1. Production and attack success probabilities as functions of K_1 and K_2, with parameters $\omega_1 = \omega_2 = 10$, $P = 10$, $g_1 = g_2 = 0.5$, and $\alpha_1 = \alpha_2 = 0.75$.

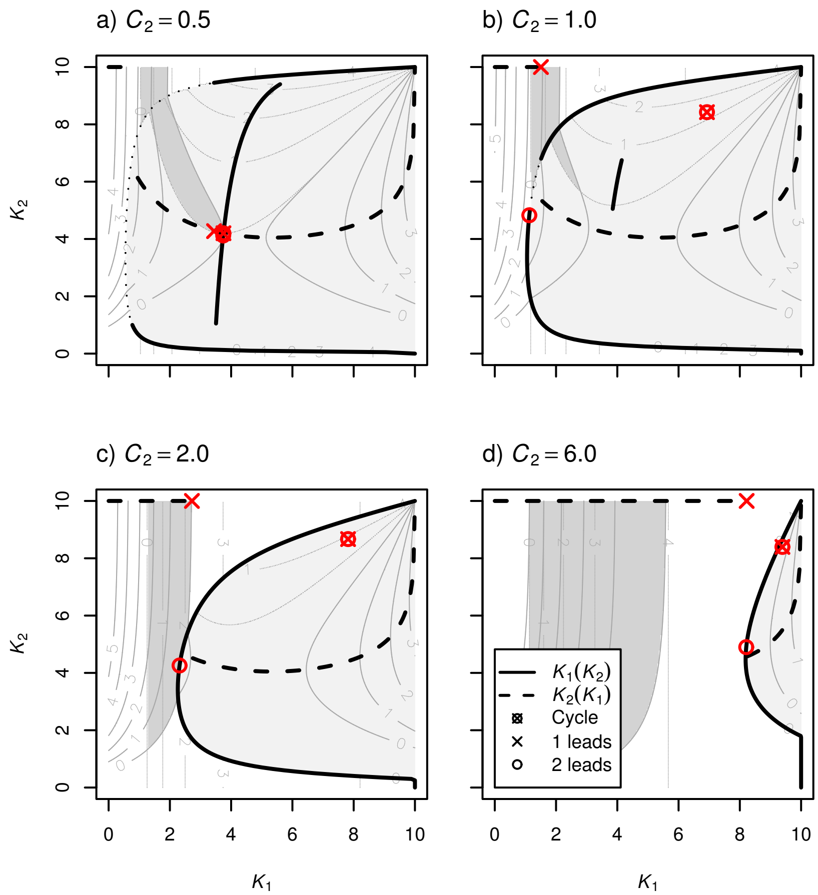


in independent play of the game. The investment levels and expected payoffs are given in table 1.

Increasing costs to $C_2 = 1.0$, the share of the upstream nation's best response function that lies along the boundary of the attack region increases. There is no longer a pure strategy Nash equilibrium in the attack region. Although not an equilibria in a one shot game, the average of a best response cycle is indicated in the figure. For this cycle, war occurs approximately 63% of the time. Both leader situations now do not result in war. When the upstream nation is the leader, it selects an investment level just small enough that the downstream nation always chooses $K_2 = \omega_2$ and then $A_2 = 0$. When the downstream nation is the leader, it chooses that point on the upstream best response which maximizes its return, which is now on the attack region boundary. Therefore, no attack occurs. Notice that in comparison to the cycle average, the downstream leader has reduced its investment (increased its military) which leads to a lower upstream investment (larger upstream military), and a higher return to the downstream nation. Thus, increased military spending by the downstream nation has increased national output, while increased military spending by the upstream nation, when it is the follower, has reduced it.

Further increasing the cost of an attack to $C_2 = 2.0$ closes the discontinuity in the upstream nation best response. The upstream nation's best response now coincides with the boundary of the attack region. There is now no strategy that could be chosen by the downstream nation to which the upstream nation would respond with an investment level leading to an attack. However, the discontinuity in the downstream nation's best response curve is such that no pure strategy Nash equilibrium exists. If the upstream nation leads, it chooses an investment level just below that at the cycle average, which leads to $K_2 = 10$ and no possibility of

FIGURE 3.2. Best response functions, Nash equilibria, and equilibria with upstream or downstream nation as leader. Lightly shaded region marks investment combinations where the downstream nation will attack, while darkly shaded regions are investment combinations that leave both nations better off than they are at the Nash equilibrium or cycle average.



attack. If the downstream nation leads, it chooses the point along the boundary of the attack region where its return is maximized. Its investment in its military is again larger than at the cycle average, which again leads to an increase in upstream defensive spending and an increase in the downstream return.

The final case, panel (d), shows the situation for $C_2 = 6.0$. At this high cost level, there is only a small set of strategy pairs where it is optimal to attack. The cycle average continues to have a relatively high attack rate at 60%. If the upstream nation chooses its investment first, it is able to increase its return by keeping $K_2 = 10$. However, when the downstream nation leads, it is unable to

TABLE 1. Equilibrium strategies and payoffs for various attack costs. When a Nash equilibrium does not exist, the average for a best response cycle passing through (ω_1, ω_2) is reported. For '1 leads' and '2 leads' results, the leading nation chooses its investment level, using the pure strategy best response of the other nation in place of taking the other nation's strategy as fixed.

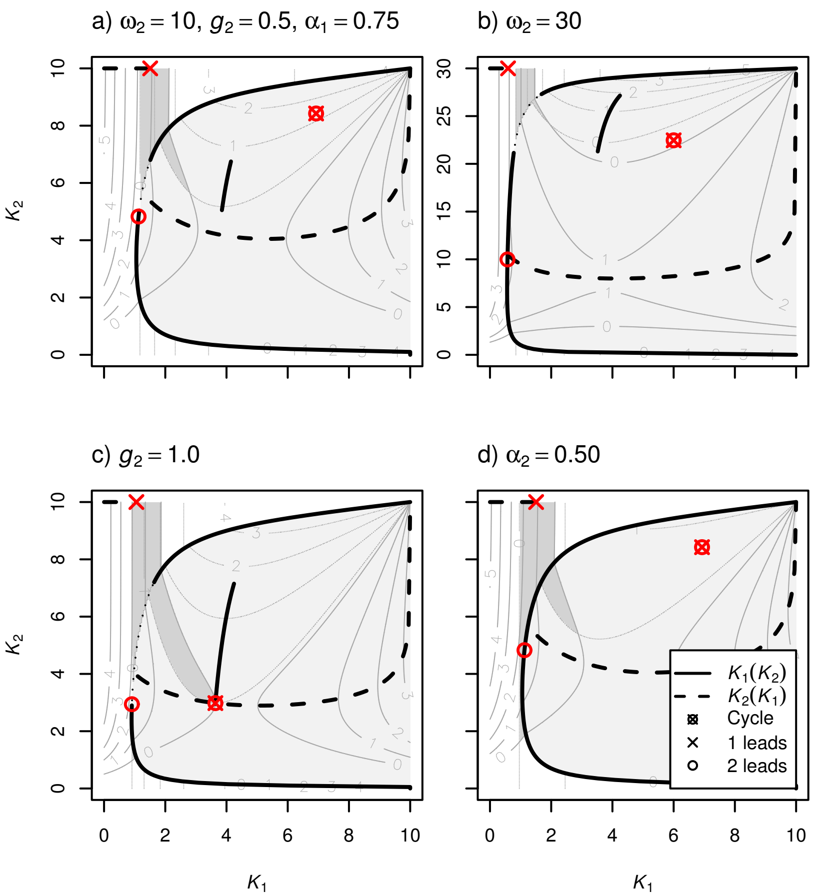
	Upstream		Downstream			Cycle	
	K_1	W_1	K_2	W_2	Length	St. Dev	Attack
$C_2 = 0.5$							
Nash	3.75	4.80	4.20	4.56	1	0.00, 0.00	1.00
1 leads	3.44	4.81	4.27	4.63	-	-	1.00
2 leads	3.74	4.78	4.12	4.57	-	-	1.00
$C_2 = 1.0$							
Cycle	6.93	5.14	8.42	4.24	8	3.90, 2.64	0.63
1 leads	1.51	5.87	10.0	5.35	-	-	0.00
2 leads	1.13	5.03	4.83	5.78	-	-	0.00
$C_2 = 2.0$							
Cycle	7.82	5.34	8.67	3.42	8	3.36, 2.27	0.63
1 leads	2.72	7.57	10.0	3.40	-	-	0.00
2 leads	2.32	7.13	4.26	3.61	-	-	0.00
$C_2 = 6.0$							
Cycle	9.39	5.04	8.40	1.16	10	0.78, 2.14	0.60
1 leads	8.22	9.34	10.0	0.43	-	-	0.00
2 leads	8.21	9.34	4.90	0.41	-	-	0.00

increase its welfare relative to the cycle average. Downstream leadership now has no advantage.

Since leadership by either nation is questionable when both nations are identical, we also consider three cases where downstream leadership is more credible. These are shown in figure 3.3, with numerical values in table 2. Panel (a) reproduces the results of panel (b) in figure 3.2. In panel (b), the endowment of the downstream nation has been increased to $\omega_2 = 30$. As a share of endowment, the upstream best response has shifted down, indicating that with a larger endowment, a larger share of the endowment is devoted to the military whenever $K_2(K_1) < \omega_2$. With a larger endowment, the relative marginal productivity of the military, used to 'liberate' upstream water, increases. The richer country can 'afford' to attack the poorer country. With the downstream leader, the solution does not involve an attack. Further, relative to the cycle average, a 56% reduction in productive investment results in a 43% increase in earnings. This compares to a 43% reduction in investment generating a 26% increase in return for the $\omega_2 = 10$ case. With a larger endowment, a downstream leader is again better off not attacking, and gains more in relative terms than when endowments are equal.

Panel (c) increases the effectiveness of the downstream water capture investment. As for the endowment increase, the downstream best response shifts down. Now it does so because with the more effective capture investment, a greater share of water released by an attack is captured. With this parameterization, there is

FIGURE 3.3. Best response and attack regions for cases where the downstream nation has a larger endowment, has better capture technology, and is more productive in its use of water. Parameter values are $C_2 = 1$, $\omega_1 = \omega_2 = 10$, $g_1 = g_2 = 0.5$ and $\alpha_1 = \alpha_2 = 0.75$ unless otherwise indicated.



an interior Nash equilibrium. However, the downstream leader is still better off choosing a strategy that does not lead to an attack as compared to one that results in an attack. In this case, a 1.3% reduction in investment is sufficient to shift the upstream nation from a best response in the attack region to one in the boundary. This shift increases the downstream return by 37%.

Panel (d) gives the downstream nation a technological advantage over the downstream nation by setting $\alpha_1 = 0.5$ and keeping $\alpha_2 = 0.75$. The upstream best response curve is now entirely outside the attack region, so that the downstream leader can only choose points that will not result in an attack. In this case, a 43% reduction in investment relative to the cycle average results in a 28% increase in

TABLE 2. Equilibrium strategies and payoffs when endowment, capture success and output elasticity are varied. When a Nash equilibrium does not exist, the average for a best response cycle passing through (ω_1, ω_2) is reported. For '1 leads' and '2 leads' results, the leading nation chooses its investment level, using the pure strategy best response of the other nation in place of taking the other nation's strategy as fixed.

	Upstream		Downstream			Cycle	
	K_1	W_1	K_2	W_2	Length	St. Dev	Attack
$C_2 = 1.0$							
Cycle	6.93	5.14	8.42	4.24	8	3.90, 2.64	0.63
1 leads	1.51	5.87	10.0	5.35	-	-	0.00
2 leads	1.13	5.03	4.83	5.78	-	-	0.00
$\omega_2 = 30$							
Cycle	6.26	4.40	22.7	5.29	8	4.39, 9.60	0.49
1 leads	0.59	3.40	30.0	7.58	-	-	0.00
2 leads	0.57	3.33	9.99	7.59	-	-	0.00
$g_2 = 1.0$							
Nash	3.64	4.45	2.98	4.70	1	0.00, 0.00	1.00
1 leads	1.06	4.85	10.0	6.36	-	-	0.00
2 leads	0.91	4.44	2.94	6.46	-	-	0.00
$\alpha_1 = 0.5$							
Cycle	7.14	2.79	8.51	4.15	8	3.90, 2.64	0.63
1 leads	1.51	3.25	10.0	5.34	-	-	0.00
2 leads	1.13	2.94	4.83	5.78	-	-	0.00

return. This is the smallest increase in return, but still larger than the 26% increase in return when both technology parameters are equal. In all four panels, if the upstream nation is the leader, it will choose a strategy that results in $K_2 = \omega_2$ and no attack.

In both figure 3.2 and figure 3.3, a set of strategy combinations that generates a higher expected welfare than the Nash equilibrium or cycle average is also identified. The existence of such an area in all four panels shows that this game has aspects of a prisoner's dilemma. Not only do there exists strategy combinations which generate greater aggregate welfare than cycle average, there are combinations that leave both nations better off without requiring a means of redistributing welfare. There is therefore scope in all four cases considered for a Folk theorem result where, if the game is repeated, cooperation allows a Pareto improvement to be realized. The size of the strategy combinations which support such cooperation increases as costs increase, from the point where the upstream best response function becomes continuous. All combinations here involve no attack. For costs where the upstream best response is not continuous, the set of mutually advantageous strategies increases as costs fall. However, some lie in the attack region. With cheap attack costs, strategies can be coordinated to increase mutual gain while, somewhat perversely, the downstream nation continues to attack the upstream nation's infrastructure.

Beyond pure and mixed strategy Nash equilibria, there are other solution concepts. Best response cycles with various belief structures may generate equilibria. Naive expectations, adaptive expectations and moving average expectations were tried in this numerical example, always resulting in periodic attacks. A version of this model, focusing only on the simultaneous move form, was implemented as an experiment [Janmaat, 2004]. Subjects playing repeated rounds were unable to coordinate on no attack solutions, although average behavior tended to lie between the attack always Nash equilibrium and a no attack point consistent with the Folk Theorem. Further experiments will explore the impact of leadership, and seek to identify relevant solution concepts.

4. Discussion

In this paper we have constructed a model where two countries are connected by a natural resource, water, and are able to invest in military hardware. The downstream nation's military investment creates a threat to the upstream nation, while the upstream nations military investment provides protection against that threat. In both cases, the military investment provides no utility or productivity impact beyond this. Thus investment in military expenditure is costly in terms of foregone production, and provides no benefit beyond its impact on attack success probabilities.

One general result of our analysis is that for a one shot two stage game where a downstream nation can try to destroy upstream capital, there are very few situations where a downstream leader is more likely to use its military than when there is no leader. This is in contrast to the results of Homer-Dixon [1999], who argues that a militarily and economically superior nation, such as Egypt in its relationship with its upstream neighbors, is more likely to resort to force than when there is no clearly superior power. Egypt is well known for its insistence that it will use force to protect is water security. However, perhaps it is this credible threat that provides Egypt with water security, relative to a situation where the superiority of one nation is not so apparent. The ongoing dispute between India and Pakistan over the Kashmir region, an important headwater area for the Indus, may be a situation where leadership - in particular military leadership - is not so obvious. Both nations have atomic weapons, and neither seems to have a clear strategic advantage in the Kashmir region.

A one shot game is clearly a gross simplification of the complex relationship between nations. Further, military investments are made for more reasons than the one we include in our model. If this game was repeated, we would expect the probability of war fall. From the Folk Theorem, we would expect the nations to be able to coordinate on a strategy pair that increases both of their returns. The points with the highest return lie in the no attack region, so that any Folk Theorem supported equilibria will likely not involve an attack. If there is a downstream leader, its punishment strategy is to choose the leader equilibrium strategy, a point where no attack occurs.

A richer dynamic model could also have each nation investing to accumulate military and productive capital stocks. This added dimension of realism is also likely to reduce the probability of war. When productive capital takes time to accumulate, the cost of military expenditure - especially if it is not productive - is greater. Likewise, the present value of the lost production is also greater, should that capital be destroyed. Therefore, the upstream nation is likely to increase its military expenditure to protect its capital, while the downstream nation is likely to invest less. Taken together, these moves would reduce the likelihood of war. We leave the details of this dynamic analysis to future work.

Although our results contradict Homer-Dixon's suggestion about the conditions that would make water wars more likely, they do suggest that these conditions may bring nations to the brink of war. In our model, when there is a downstream leader, the equilibrium has both nations arming and the downstream nation indifferent between war and peace. This situation is stable in our deterministic model. Cothren [2000] found a similar result, in that both nations in his model were indifferent between attacking and not attacking at the Nash equilibrium. When Hauge and Ellingsen [1998] explored the relationship between domestic conflict and environmental scarcity, they found a positive relationship. However, they also found that military expenditure was the best predictor of the severity of conflict. "The sources of civil conflict are not necessarily closely related to the severity of the conflict. Although environmental scarcity is a cause of conflict, it is not necessarily also a catalyst [Hauge and Ellingsen, 1998, p. 314]". In the model presented here, water is the source of the conflict, but nations need not go to war. In a stochastic setting, this delicate balance is likely to be upset. As such, we may expect to see more international military conflicts where states are resource dependent, even though it is difficult to directly link the start of the conflict to a resource issue. The results of Tir and Diehl [1998], who find that there is a strong interaction between military capacity and population growth as a predictor of involvement in military conflict is consistent with this result.

Our results also point out the critical role played by the cost of the attack to the attacking nation. If the cost of attack is low relative to the expected gains, then an attack is rational, while if the cost is high, then an attack would not be expected, and military investment to prepare for an attack would not occur. These costs may play a key part in determining what triggers can transform an arms race into a war. In particular, the prospect of sanctions or other economic censure from the international community may serve to increase the costs. Such changes would reduce the need for the upstream nation to invest in its own military, allowing it to increase its investment in more productive capital.

In a dynamic setting, nations invest in both productive and military capital. Productive capital accumulation is an important source of economic growth, while the role of military accumulation is less clear. Our results suggest that the relationship between military expenditure and economic growth can depend on where nations sit in a riparian system. For an upstream nation, increasing military expenditure is likely to reduce economic growth by crowding out productive investment. In contrast, downstream military expenditure may increase the threat level in a way that leads to more water reaching the downstream nation. Thus, for the upstream nation, one would expect to see a negative correlation between military expenditure and economic growth, while for the downstream nation the correlation would be positive. This result adds a new element to the literature linking economic growth and military expenditure. This literature is generally inconclusive. In some cases the data is consistent with military expenditures causing economic growth. In other cases, the data is consistent with military growth acting as a drag on economic growth. Explanations for these effects point to offsetting impacts of military expenditures. The growth enhancing effects of military expenditures include building human capital, stimulation of aggregate demand, and enhanced political stability. The growth retarding effects include the diversion of resources from productive capital to military accumulation and a substitution of imports for domestic production. The balance between these effects will differ from nation to nation, and thereby generate differing impacts. Our results suggest that an underlying resource relationship between rival nations may be an additional factor.

There are at least three empirical implications of this model that can be explored. First, where resources are scarce and shared, the level of militarization is likely to be high. Second, international conflicts are also likely to be more frequent where resources are scarce, even though it may be difficult to directly attribute their cause to the underlying resource scarcity. Third, the correlation between economic growth and military expenditure will depend on the type of resource relationships that a nation has with its neighbors. If it is a resource supplier to its neighbors, then the relationship between military expenditure and growth is likely to be negative, while if it is dependent for resources on its neighbors, then it is likely to have a positive relationship between military expenditure and growth. Anecdotally these propositions appear to be supported. We leave detailed empirical analyses to the future.

Finally, this work also suggests that efforts to isolate international agreements to single issues, in this case water access or arms control, may be inappropriate. The level of military preparedness is directly related to concerns about water access. The downstream nation is unlikely to agree to or abide by any arms control agreement that it feels will lead to a reduction in its access to water. In a similar fashion, the upstream nation will not agree to reduce its own military preparedness if it feels that will increase the likelihood it will be attacked. Any agreement to share the water will also be subject to the state of the arms race. The accumulation of arms provides extra bargaining power for the downstream nation, as it enhances the credibility of an attack. Likewise, increased defensive readiness enhances the bargaining power of the downstream nation, as it can better protect itself from an attack. Without an outside authority that can enforce the agreement, it will be subject to the military posturing of the nations involved.

The results of this analysis are developed in the context of a shared river, as that is seen as the most likely situation for a resource war. However, other international resource relationships also exhibit some of these features. One other water example is international aquifers. A nation that pumps from a deeper part of the shared aquifer is in a position analogous to the upstream nation, in that it can extract all the water in the aquifer, while the maximum extraction by the nation in the shallower portion is in part limited by the amount that the other nation leaves behind. Larger investments in pumping by the nation with access to the deep portion of the aquifer therefore have an adverse effect on the other nation, in a manner similar to that of a river.

We have used a one shot game, and discussed repetition of this game. Implicitly, we assume that the size of the resource stock - the precipitation - does not change over time. For a non-renewable resource, this is not appropriate. Oil fields are analogous to an aquifer, with no natural recharge. A key variable for analyzing these situations is the size of the resource pool, which declines over time. For results not presented in numerical example, increasing the size of the resource supply that the nations are accessing increases the likelihood of war. When the resource is more abundant, provided that this abundance does not generate costs (see Janmaat and Ruijs, 2004 for impact of flooding risk on cooperation), investments in capture have a larger potential gain. Fighting over resources is more important when there are more resources to fight over. Wars over finite resources are most likely to occur when scarcity has increased prices sufficiently to make it valuable, but while stocks are large enough that there is something worth fighting over. Rather than mayhem and anarchy when oil supplies approach exhaustion, as some popular pundits suggest, it will occur much sooner, when supplies are relatively abundant but of high value.

5. Conclusion

In this paper we show that when nations are linked by a natural resource such as water, the more dependent nation may invest in its military as a means of encouraging its less dependent neighbor to divert resources away from using the resource and towards its defense. This strategy benefits the downstream nation by increasing its access to the resource, even though no military action need ever occur. In general, when there is a downstream leader, the likelihood of war is reduced relative to the situation when there is no clear leader. However, we would expect that the increased military preparedness would lead to conditions where conflict is more likely, even though its trigger may not be the disputed resource.

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