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Applying a Game Theory Model to Conflict and Cooperation on the Columbia River

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Game Theory represents a powerful analytical model with which we can examine the strategies that different states make when negotiating international watercourses. Although economists have applied game theory to a wide variety of conflict models, international water law scholars like Steven McCaffrey have largely limited themselves to applying traditional international law principles to the law governing international watercourses. Other scholars have applied game theory to international law, but few have connected international water law with game theory.[1] Those few that have made the connection have focused on the recurring disputes in the Middle East. By contrast, I will attempt to apply game theoretic principles to the Columbia River and the disputes that have emerged from sovereign struggles over the River.

Game theory began as mathematical inquiry into classes of economic problems in the field of "rational choice" theory. Dr. Don Ross, a game theory scholar at the University of Cape Town, defines game theory as "the study of the ways in which strategic interactions among rational players produce outcomes with respect to the preferences or utilities of those players none of which might have been intended by any of them."[2] Rational does not mean logical; rather it means that actors try to achieve specific goals and that and that they have preferences among their goals. It also means that other players are similarly rational.[3]

To proceed further, two important concepts will require definition: dominant strategy and Nash equilibrium. A strategy is dominant if the strategy is the best choice for a player when considering every possible choice by the other player.[4] A strategy "strictly dominates" another strategy when it leads to a better outcome regardless of the action of the other player. Though this concept is useful in game theory, Douglas Baird, one of the first legal scholars to apply game theory to legal problems, prefers analyzing game theory and legal problems not in terms of dominance but in terms of the Nash equilibrium. A set of strategies forms a Nash equilibrium when no player could improve her payoff, given the strategies of all other players in the game, by changing her strategy.

According to Baird, "[t]he strategy of each player must be a 'best response' to the strategy of the other."[5] Given this definition of a Nash equilibrium, we can see that pursuing a Nash equilibrium is at odds with pursuing a dominant strategy; no strategy could be a Nash equilibrium strategy if it is strictly dominated. When a game is played iteratively, it tends to eliminate strictly dominant strategies. When played enough, the unique outcome results in the Nash equilibrium.

Two benefits emerge from considering a problem in terms of legal game theory that otherwise might not be apparent from typical law and economics approaches. The first is that proposed legal reform can be easily tested by considering whether the reform will create a Nash equilibrium. Useful legal reform should inquire into whether the affected parties will make the best, preferred response given the preferences of the other parties.

The second positive consequence of using game theory and Nash equilibria in particular is the simplicity of the model. By considering fewer important interactions, we

can compare, more easily, the differences between various legal rules and how they work. Even with Nash equilibria, however, finding the best incentives for legal reform may not be simple. We must look at the consequences of a given game, which in the legal context might be whether a statute may lead to more litigation, may inadvertently encourage errors of enforcement, or in the case of international water law, whether a treaty may encourage cooperation or disagreement.

Perhaps the most important conflict model to arise out of game theory is the prisoners' dilemma. Researchers from the Rand Corporation first posited a thought problem in which the police have arrested two suspects, call them Bonnie and Clyde, and are interrogating them separately.[6] Each prisoner can confess or remain silent. If Bonnie remains silent and Clyde confesses, Bonnie will receive a harsh sentence and Clyde will receive a suspended sentence. Thus Clyde prefers to confess in this situation. If Bonnie confesses and Clyde remains silent, Bonnie will receive a suspended sentence and Clyde will get a harsh sentence, inducing Bonnie to confess. If both Bonnie and Clyde confess they each receive a moderate sentence. However, if neither Bonnie nor Clyde confesses, they will each receive a light sentence. The dominant strategy is to confess. The prospect of the other confessing, pushes each to confess and avoid the worst outcome. But when they both confess, the outcome is worse than if both remain silent. This is the basic structure of a prisoners' dilemma.

Interestingly, if the game is played only once each player is more likely to confess and attempt to gain the best outcome for themselves. However, if the game is played repeatedly the benefits of defecting diminish and the benefit of cooperation improves. As Barry Nalebuff, a game theory scholar at Yale, states "[i]f the value of the future

cooperation exceeds what can be gained today by defecting, then the long-run individual interests become aligned with the group interest..."[7] However cooperation is not a necessary consequence of repeated game interactions. Both Baird and Nalebuff warn against assuming that cooperation will follow simply because players will play multiple games. Nalebuff notes that game interactions depend on the relative importance of the present benefits weighed against the future ones. Thus crises may force players to abandon cooperative strategies. Cooperation arising out of a repeatedly played prisoners' dilemma, may be abandoned between desperate corporations: "When times are bad, management focuses on immediate earnings and may not care about the long-term cost of cheating."[8] Analogously for international water disputes, if one state severely needs water, it may ignore future benefits of cooperation in light of the state's immediate needs. This is a useful and probably realistic caveat to remember. However, even Baird who is most wary of putting too much faith in utopian ideals of cooperation notes, "that some empirical data suggest that, in such interactions between neighbors in small communities, a variety of pressures push parties towards acting cooperatively independent of the legal regimes that are in place."[9] Thus pressures outside of the game may encourage cooperation. International analogues of communal pressure, and other diplomatic trade-offs, may similarly reinforce cooperation in a tenuous international water regime.

By itself, we can apply the prisoners' dilemma to a wide range of activities, but when the payoffs for individual strategies change strategists sometimes discover prisoners' dilemma problems that produce more than one Nash equilibrium. Recall that with Nash equilibria, we focus on the solution set that predicts the best response from each player rather than the dominant strategy. When a prisoners' dilemma problem

produces more than one Nash equilibrium, we are looking at a sub-set of prisoners' dilemma problems known as assurance games. An assurance game has two equilibria meaning that two strategies are equally good responses to the strategy of the other player. The problem then becomes choosing the right equilibrium from the two that exist.

In the Bonnie and Clyde scenario we can imagine a situation in which the confessor is "punished" by third parties for turning in their accomplice. This prisoners' dilemma turns into an assurance game when each player agrees to cooperate because that player is assured that the other player will cooperate.

We can just as easily illustrate these game theory principles in a water sharing hypothetical as we can in the criminal context. Consider, Alpha City, which has first rights to use water in the Gamma River. Beta City has junior rights to Alpha. Unfortunately for Alpha, Beta is upstream from them. Pollution originating from either Alpha or Beta creates negative payoffs for both parties. Repeated contamination of the river would harm both cities' use of the river. We assume that each city has two strategies, cooperating in preventing pollution, or non-cooperation, which ignores preventative measures. If one of the cities ignores pollution, significant contamination occurs. There will be negligible contamination if both parties cooperate, and terrible contamination follows if both parties ignore pollutants. We can represent the strategies as follows:

			Beta City
Alpha City		Prevent	Ignore
	Prevent	1,1	2,4
	Ignore	4,2	8,8

In this game, a value of 1 represents *de minimus* pollution and 8 represents long-term contamination. By convention, the player on the left is the first entry and the player on top is the second entry. We can see that this game has two Nash equilibria, (1,1) and (8,8) but one of them is superior to the other; both cities benefit from choosing the cooperative strategy in this assurance game. In the language of game theory the cooperative strategy is Pareto optimal.[10]

In contrast to the neat hypothetical between Alpha and Beta City, disputes between Canada and the United States over the Columbia River have produced at least two different strategies at different times. The strategic positions that the States have asserted over the Columbia River reflect the geographic importance of the River. In recognition of the importance of the Columbia River and related boundary waters, the United States and Canada entered into the Boundary Waters Treaty of 1909.[11]

McCaffrey notes that the 1909 Treaty defined boundary waters narrowly; it did not include tributary waters or the waters of rivers flowing across the boundary.[12] The Treaty also established the International Joint Commission of the United States and Canada, a body that would purportedly deal with boundary water disputes over the Columbia River.

The Columbia rises in British Columbia and flows across the border into Washington State and empties into the Pacific Ocean between Washington and Oregon. In Canada, the Kootenay River is a tributary of the Columbia. The Kootenay rises in Canada, enters Montana, and flows back into Canada to the Columbia.

The crisis over the Columbia began in 1951 when the U.S. proposed to build the Libby Dam on the Kootenay River in Montana. The reservoir behind the dam would have flooded 42 miles of Canadian territory.[13] The U.S. offered to compensate Canada for the flooded land, but offered none of the hydro-electrical benefits of the dam. In response Canada stated that it would and could divert up to 15 million acre/feet per year from the Columbia into the Fraser River Basin on the Canadian side, if the U.S. would not share the power benefits.

The U.S. thus found itself in the uncomfortable position of being a downstream user to Canada a half-century after it had articulated an infamous absolutist position with respect to the downstream state of Mexico over the Colorado River. The U.S. had asserted Absolute Territorial Sovereignty over the Colorado River, in the so-called Harmon Doctrine, which stated that a state had an absolute right to use waters flowing through borders without regard to any other state. Ultimately, the Columbia River dispute may have helped thaw the U.S. position with respect to the Colorado River. At the time, however, Canada argued that the 1909 treaty provided Canada with Harmon-like rights to the river. The plain language of the treaty supports this interpretation: "the High Contracting Parties reserves to itself... the exclusive jurisdiction and control over the use and diversion, whether temporary or permanent, of all waters on its own side..."[14]

To frame the dispute in terms of game theory let us assume that each country can share the water and water power or each country can hoard the water and its uses. If both countries share the water and its power both countries can make moderate, positive gains. If Canada shares the water and the U.S. hoards it and its uses for itself (the U.S.'s original plan with Libby Dam) Canada gains less utility while the U.S. enjoys great use and

spends little to compensate Canada for the flooding. On the other hand if Canada hoards the water upstream it gains significant utility from the water at some State expense. If both countries try to hoard the water, Canada still maintains its advantage over the U.S. with each country paying for their own public works. The table representation looks like this:

			U.S.
Canada		Share	Hoard
	Share	5,5	2,8
	Hoard	8,2	9,1

In this game, the value of ten represents the total economic benefit from using water and water-power. The different strategies of hoarding or sharing distribute the total value of the water differently between the States.

From this perspective Canada has little incentive to consent to anything less than an agreement that permits the U.S. to use the water from the Kootenay, on condition that the U.S. shares the power benefits of the Libby Dam. As the upstream State, Canada does nearly as well by hoarding when the U.S. hoards or hoarding when the U.S. shares. In other words, hoarding water for Canada strictly dominates its strategy. Thus the U.S. should be very interested in a cooperative strategy, if it wants to share the benefits of the Columbia River. The U.S., with some temerity, argued that international law should obligate Canada allow the U.S. to unilaterally divert on its side without the U.S. having to share the water power, in clear reversal of its own policy with Mexico as a downstream State on the Colorado.

After the U.S. repudiated the Harmon Doctrine by declaring it not a part of international law, and after ten years of discord, the United States and Canada resolved the dispute with the 1961 Columbia River Basin Treaty.[15] According to McCaffrey, the agreement establishes a "comprehensive and integrated plan for the development of the resources of the Columbia River Basin."[16] Canada builds storage dams for flood protection and a consistent flow of water for U.S. hydro-power. In return the U.S. provides Canada with half of the power that comes from Canadian projects and flood control benefits. The equitable apportionment is a more logical position for the U.S. to take in this situation and probably for Canada to take when considering its more global relations with the U.S. The U.S. and Canada have chosen the Nash equilibrium of the simplified possible strategies.

By using game theory to model future strategic choices, two or more States can have a clear and coherent way of expressing the benefits and detriments of negotiating a shared watercourse. Since water is a future need as well as a present one, States should look carefully for Nash equilibrium solutions that will allow each State to make the best response to the other States, which will sustain group action for the foreseeable future. From the Columbia River we can appreciate that upstream States like Canada may be willing to choose the non-dominant strategy in favor of a strategy that may help them with situations outside of the single dispute for overall better relations with a neighboring State.

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[1] Two useful exceptions come from Eyal Benvenisti, *Collective Action in the Utilization of Shared Freshwater: The Challenges of International Water Resources Law*, 90 A.J.I.L. 384 (1996), hereinafter referred to as Benvenisti, and Moshe Hirsch, *Game Theory, International Law, and Future Environmental Cooperation in the Middle East*, 27 Denv. J. Int'L. & Pol'y 75 (1998), hereinafter referred to as Hirsch.

[2] Don Ross, *Game Theory*, *The Stanford Encyclopedia of Philosophy*, <http://plato.stanford.edu/archives/sum2003/entries/game-theory/>. (last updated Summer 2003).
[3] Hirsch at 79.
[4] Douglas G. Baird, *Game Theory and the Law*, *The New Palgrave Dictionary of Economics and the Law*, 192-197, (Stockton Press, 1998). Baird, Gertner, and Picker also authored the seminal text, *Game Theory and the Law*. Harvard University Press, 1994.
[5] *Id.* at 192.
[6] Barry Nalebuff, *Prisoners' Dilemma*, *The New Palgrave Dictionary of Economics and the Law*, 89-94, (Stockton Press, 1998).
[7] *Id.* at 91.
[8] *Id.*
[9] Baird at 195.
[10] Benvenisti at 389.
[11] Steven C. McCaffrey, *The Law of International Watercourses*, 293 (Oxford, 2001).
[12] *Id.*
[13] *Id.* at 294.
[14] *Id.*
[15] *Id.* at 295.
[16] *Id.* at 296.