A NON-ZERO SUM GAME: HOW GAME THEORY CAN INFORM BETTER TRANSBOUNDARY WATER RIGHTS TREATY DRAFTING

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Abstract

Despite its fundamental role as to the very existence of humans and their economies, the provision of clean water to their citizens remains a challenge to governments across the globe. This challenge presents itself as a classic interdisciplinary opportunity to blend science, law, and economics into an adaptive management solution ensuring the availability of this critical resource to all of the earth's inhabitants, regardless of location or socioeconomic status. This paper will explore how countries manage transboundary water resources, and how cooperative strategies may emerge that benefit each country that shares an international river or lake. In particular, this research explores how game theory and international treaties integrate the natural geospatial and temporal variability of hydrologic cycles into malleable instruments that ensure water supply and quality even in times of drought. Drawing on the long-term feedback available from the United States' and Mexico's International Boundary and Water Commission treaty for the Rio Grande River (and several smaller transboundary rivers), this paper asserts that even narrowly self-interested states can reach agreements in managing scarce water resources that lead to non-zero sum outcomes and the availability of clean water at all times for their citizenry.

Keywords: Water rights,treaty,game theory

Introduction

The potential for conflict over shared, scarce water resources should not surprise even the greatest of optimists. A finite (albeit naturally cyclic) resource like water is subject to significant impacts as global human population continues to rise. With increases in population come growing threats from climate change, pollution, and general overexploitation of the earth's freshwater. Novel approaches to allocation of international water resources will require the creativity to meet an ever-increasing demand, in a manner that is sustainable to the planet's environment and to future generations. With estimates ranging from 215 to 268 international watersheds, covering nearly half of the world's surface, opportunities abound for both cooperation and conflict alike.[150] In seeking cooperative outcomes, a wide variety of international agreements, such as treaties, commissions, and conferences, have been pursued throughout recent world history. The present research draws from one such of these major instruments: the United States' (U.S.) and Mexico's International Boundary and Water Commission (IBWC).

A brief overview of the unique challenges that exist with respect to international water rights is first necessary. At its core, the allocation of water, before it is ever in dispute among

[150] Clare Shine and Cyrille de Klemm, *Wetlands, Water and the Law: Using law to advance wetland conservation and wise use*(1999), at 271; Stephen E. Draper, *Model Water Sharing Agreements for the Twenty-First Century* (2002), at iv.

humans, is first subject to the laws of nature. Some regions are naturally water-rich, while others are bone-dry. Hydroclimatological conditions are more of a burden for some countries than others, with the poorest countries left most vulnerable.[151] Additionally, the hydrologic cycle is prone to inter-annual variation, resulting in prolonged droughts in many regions of the world, conditions that are expected to be exacerbated by climate change in the coming years. This inherent natural variability, both geospatially and temporally, ultimately dictates the ground rules for water resource allocation. Predictive tools, such as surface water and groundwater models that integrate water supply variability, are the lynchpin of an emerging interdisciplinary body of science, international law, and economics that is the focus of this study. The IBWC is one attempt to merge these bodies of thought into a malleable and adaptive management tool.

The IBWC, comprised of the U.S. and Mexico, "relate[s] to the utilization of the waters of the Colorado and Tijuana Rivers, and of the Rio Grande," which are a series of large, transboundary rivers (Figure 1).[152] The Rio Grande in particular is one of the most water-stressed watersheds in the world.[153] The IBWC is best described as a *series* of treaties that govern the allocation of water resources shared between the two nations. Originating in 1884 and evolving since, the agreement between the two nations has consistently served as a starting point for conflict resolution and cooperation regarding freshwater supply.Although many of the substantive allocation issues were drafted in the IBWC's primary 1944 treaty, it remains a dynamic document reflecting changes in the hydrologic and diplomatic environment shared by the U.S. and Mexico.[154] Among the oldest of such agreements in the world, the IBWC provides the opportunity for long-term assessment of the instrument's efficacy, and it has been previously identified as a model for international water dispute resolution.[155] While leaving some things to be desired, including equal bargaining power between the parties, the IBWC is a binding international treaty that can function as a model for cooperative water allocation in other water-scarce, transboundary regions.

Figure 1. The U.S. - Mexico Border (including transnational waterways in red).[156]

[151]See generally, Leif Ohlsson, *Hydropolitics*(1995).
[152]*Treaty Between the United States of America and Mexico Respecting Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande* (1944).
[153]Rebecca LTeasley and Daene C. McKinney, *Water Resources Management in the Rio Grande/Bravo River Basin Using Cooperative Game Theory* (2011).
[154]*Id.*
[155]See Heather L. Beach, Jesse Hammer, J. Joseph Hewitt, Edy Kaufman, Anja Kurki, Joe A. Oppenheimer, and Aaron T. Wolf, *Transboundary Freshwater Dispute Resolution* (2000), at 119.
[156]Adapted from: http://www.ibwc.gov/Files/US-Mx_Boundary_Map.pdf

Operating under the assumption that water is a public economic good, and that water treaties are essentially contracts for the allocation of this commodity, the goal of this research is to assess, *post facto*, the successes and lessons learned from the IBWC and attempt to use this knowledge to aid the drafting of future water rights treaties. The method to be used for this analysis is a body of economics known as game theory. Game theory provides a useful framework for analyzing the strategic decision-making of riparian states, but is still in its nascent stages as a *pre*-drafting tool.[157] Ultimately, this assessment seeks to turn hindsight into foresight in the creation of equitable and sustainable instruments of international water resource development rights, evidenced by the recommendations made in Section IV, *infra*.

Background

Primer in International Water Law

Generally, international rivers are those fluvial waters which flow within drainage basins that span at least two countries.[158] This definition has expanded over the years to include international catchments, as international water law has embraced the watershed approach to water resource management.[159] Central to the study of international water law is the notion of a *riparian state*, which refers to a country where an international river is located.[160] Of further importance are the distinctions between upstream riparian states and downstream ones and the changing roles states play as water tumbles toward the sea.[161] A major theme of the present analysis will thus focus on the equitable and sustainable distribution of the waters from international rivers among multiple riparian states. This theme, of course, raises new questions: What is equitable and what is sustainable?

Equitability is a concept that has manifest itself as the principle of *equitable utilization* over the past forty-plus years of water law development.[162] In 1970, Finland recommended to the United Nations (U.N.) that non-navigability use agreements for international watercourses should strive for “an equitable apportionment of shared water resources.”[163] Somewhat unsurprisingly, this call for new rules was met with belligerence by many of the world’s upstream riparian states.[164] Not until 1997 did accord occur, when the U.N. adopted the seminal “Convention on the Law of Non-Navigable Uses of International Watercourses” (Convention) and notions of equitability, sustainability, cooperation, and conflict resolution were forever etched into the stone of far-reaching international agreements.[165]

The Convention calls on riparian states to use and develop international watercourses with consideration of other riparian states’ interests and an eye towards protection of the waterbody.[166]These rights and duties are framed at a rote level in terms of morality, that “people should be guaranteed this vital water as part of their human rights.”[167]The Convention also sets the stage for cooperative arrangements in the allocation of international water resources. While recognizing the right to utilize a watercourse, the Convention also

[157]See, e.g., Teasley and McKinney (2011) and K. Madani,*Game Theory and Water Resources*,381 J. Hydrology 225-238 (2010).
[158]Ariel Dinar, Shlomi Dinar, Stephen McCaffrey, and Daene McKinney, *Bridges over Water: Understanding Transboundary Water Conflict, Negotiation and Cooperation* (2007), at 54.
[159]*Id.*
[160]*Id.*, at 55.
[161]*Id.*, at 179.
[162]Ashok Swain,*Managing Water Conflict: Asia, Africa, and the Middle East* (2004), at 164.
[163]*Id.*
[164]*Id.*
[165]*Conventionon the Law of Non-Navigable Uses of International Watercourses* (1997).
[166]*Convention on the Law of Non-Navigable Uses of International Watercourses* (1997), Art. 5, §1.
[167]LeifOhlsson, *Hydropolitics*(1995), at 181.

creates a duty to cooperate among riparian states.[168] This duty to cooperate theoretically necessitates negotiating fair distribution of the limited and shared waters among riparian states.[169]

If equitability refers to the present fairness in resource allocation, then sustainability encompasses notions of futurity as well. To wit, s*ustainable development* is, without hyperbole, the grand unified theory of the international environmental movement. Hailed as a cure-all to the seeming mutual exclusivity of economic growth and environmental protection, sustainable development now thematically links every major international meeting and accord, since the famous 1987 Brundtland Commission report, *Our Common Future*.[170] Nothing short of ground-breaking, *Our Common Future* simultaneously espoused the merits of sustainable development and multilateralism among states in pursuing shared (i.e., global) environmental goals.[171] The progeny of the Brundtland Commission report include 1992's U.N. Earth Summit and Agenda 21 in Rio de Janeiro, which placed environmental issues, including water allocation, at the forefront of the global consciousness.[172] The afterglow of this revolution was short-lived, however, as the prickly issues of who gets what (and when do they get it) persisted.[173]

The problem is that equitability and sustainability are not designed to prioritizeeconomic efficiency, yet states still seek to maximize the latter. The aspirational tone of the Convention, Brundtland, and Rio is noble in theory but difficult to apply in practice. Nonetheless, water rights law presents a serious and unique obstacle in its own right. The commoditization of water, a substance implicit in the very survival of a human being, has added an economic component to a fundamental right. The nightmarish scenario of already-impoverished (in terms of both wealth *and* water resources) nations not being able to afford to provide their citizens with adequate drinking water supplies is already occurring.[174] Despite the rather unholy alliance of fundamental rights and economics, the nature of the issue requires creative solutions that rise above the aspirations of documents like the Convention, and embrace the dismal science. With an uneasy acknowledgement of the intertwined destinies of water rights and economics, an introduction to the governing principles of game theory ensues.

A. Game Theory and Resource Allocation Strategies

Because so much of international law is customary and not binding, *per se*, additional methods should be incorporated when implementing a transnational instrument governing water allocation.[175] One such method is derived from economics, known as game theory, and can potentially be leveraged as a way to make water treaties more efficient in their design. The idea is based on the notion that having an understanding of the potential outcomes of a treaty, both desired and not desired, is advantageous in drafting an instrument that gears its signatories towards the optimum outcome for all states.[176]

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[168]*Convention on the Law of Non-Navigable Uses of International Watercourses*(1997), Art. 5, §2.
[169]Leif Ohlsson, *Hydropolitics* (1995), at 182.
[170]Ken Conca, *Environmental Governance after Johannesburg: From Stalled Legalization to Environmental Human Rights?*(Winter, 2004/Spring, 2005), at 124.
[171]*Id.*
[172]*Id.*, at 125.
[173]*Id.*
[174]See, e.g., Leif Ohlsson, *Hydropolitics* (1995) and Dik Roth, Rutger Boelens, and Margreet Zwarteveen, Eds., *Liquid Relations: Contested Water Rights and Legal Complexity* (2005) for in-depth explorations of the riparian states struggling to provide for their population's basic water demand, including states as diverse as Israel, India, Chile, Ecuador, and South Africa.
[175]Ariel Dinar, Shlomi Dinar, Stephen McCaffrey, and Daene McKinney, *Bridges over Water: Understanding Transboundary Water Conflict, Negotiation and Cooperation* (2007), at 55.
[176]*Id.*, at 81.

Game theory is the use of mathematical models to predict the behavior of two or more "players" in resource allocation scenarios where multiple outcomes are possible.[177] Generally, game theory refers to an analytical framework for assessing the likelihood of a particular social outcome.[178] It comes with its own unique jargon, which will be introduced here. The *players* (e.g., individuals, corporations, or, pertinent to the present research, riparian states) are the rational decision makers taking action.[179]*Strategies* refer to the alternatives each player has to choose from.[180]*Information*, either private (not known to all players) or public (known to all players), is the data upon which decisions are made.[181] The players, strategies, and information are governed by the *rules of the game*, which include laws, regulations, treaties, and natural processes (e.g., hydrologic periodicity).[182] Finally, there are *social outcomes* and *payoffs*. Social outcomes refer to the end result of a particular scenario playing out, whereas payoffs relate to the individual player's valuation (i.e., gain or loss) of a given outcome.[183]

The strategies in the "universe" of possible game theory approaches can be explained by use of a continuum (Figure 2). On one extreme is the "narrow self-interest" strategy where a player simply wants to maximize their own benefits, with zero consideration of the other players.[184]Any benefits accruing to the other players are solely the result of happenstance. At the other extreme is "pure altruism," a strategy that is far less likely to be found in any real-world scenario.[185] The altruistic player puts the benefit of the other players ahead of their own, even if it is to their detriment. Neither of these strategies leads to a player's long-term success; the former is a recipe for conflict creation, while the latter lacks self-preservation.Generally, strategies fall somewhere in the middle; a primary goal of this research is to promote strategies that embrace cooperation in the allocation of scarce, transboundary freshwater resources.

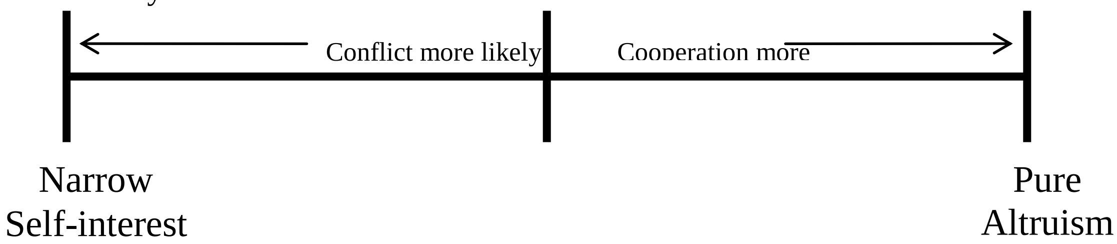

Figure 2. A simplistic continuum depicting the range of game theory strategies.

Water allocation, in a game theory sense, is a non-zero sum game. A *non-zero sum game* refers to a situation where player strategies *may* result in social outcomes where each player receives a net gain, commonly referred to as a "win-win" scenario.[186]In this emerging field of alternative dispute resolution (ADR) in international law, zero sum games are revised as non-zero sum games, where fair division outcomes are the only acceptable solutions.

[177]Talbot Page,*Environmental Economics and Policy: A Modeling Approach* (2002), at 2-8.
[178]*Id.*
[179]*Id.*
[180]*Id.*
[181]*Id.*
[182]*Id.*, at 2-9.
[183]*Id.*
[184]*Id.*, at 2-10.
[185]*Id.*
[186]See generally, Madani, K. *Game Theory and Water Resources,*381 J. Hydrology 225-238 (2010). This outcome contrasts with the classic "cake cutting" problem, where a finite resource (the "cake") must be divvied up among the players. In this zero sum game, as one player takes more cake, there is necessarily less cake for the other players. The other players become envious and conflict is more likely to ensue as each player seeks to maximize their own benefits.

Although clean water is considered to be a finite resource, advancements in technology, environmental awareness, and cooperative strategies can optimize human ability to sustainably use this resource.[187]In the parlance of a famous American expression, it may thus be possible to have one's cake and eat it too.

Optimal resource utilization is the best case endgame scenario, from an economic perspective, in non-zero sum games.[188]*Optimal* refers to the players in the game each receiving their maximum possible shareover all possible scenarios. However, strategies (unsurprisingly) tend toward narrow self-interest as a default starting position in negotiations. When the moral imperative to provide water to your *own* people trumps the moral imperative to provide water to *all* people, the narrow self-interest strategy wins every time. Optimal and economic efficient outcomes need cooperation by the players sharing the water resources to break logjams.[189]

Luckily, as this paper strives to demonstrate, narrow self-interest and cooperation are not mutually exclusive strategies. Indeed, it is possible to imagine a scenario where one riparian state cooperates with their neighbor solely for preservation of their own interests. This type of cooperative behavior is exemplified in Egypt's dealings with the Nile River's upstream riparian states.[190] The Nile River situation is best described as adversarial, with the tenuous Nile Water Agreement of 1929 and the 1959 Agreement for the Full Utilization of the Nile dictating the terms of water allocation.[191] There has been historically little love lost between Egypt and its upstream riparian states, with Egyptian President Anwar Sadat famously stating in 1979 that, "The only matter that could take Egypt to war again is water."[192] The 1929 and 1959 treaties do not reflect a *spirit* of cooperation; they are strictly utilitarian from a self-preservation standpoint.[193]The agreements are effective, however, as conflict has largely been avoided in the volatile Nile River basin, and a tragic outcome has not befallen what is indisputably a world treasure.[194]

B. The Tragedy of the Commons

The tragedy of the commons, the classic scenario envisaged by Hardin (1968), is an apt descriptor of the failings of the pure narrow self-interest strategy in the absence of cooperation.[195] The reader is asked to imagine a communal pasture (the commons) where herdsmen allow their cattle to graze.[196] Initially, there is plenty of pasture to share among the cattle, whose population remains well below the carrying capacity of the commons.[197] Indeed, it is this ampleness that spurs the tragedy, as each herdsman asks, "What is the utility *to me* of adding one more animal to my herd?"[198] Because the herdsman receives all of the benefits of having one more animal, while the increased strain of this animal on the commons is shared by all the herdsman, there is very little downside, at first.[199] The rational herdsman decides to add another; however, in the absence of cooperation, so does every other herdsman, such that the commons collapses under the cumulative impacts of overgrazing[200].

[187]*Id.*
[188]*Id.* Also referred to as Pareto efficiency, this optimal outcome in game theory is often *only* attainable through coalition-building.
[189]Sandra Postel, *Last Oasis: Facing Water Scarcity* (1997), at 80.
[190]Ashok Swain, *Managing Water Conflict: Asia, Africa, and the Middle East* (2004), at 94-105.
[191]*Id.*, at 94.
[192]*Id.*, at 98.
[193]*Id.*
[194]*Id.*, at 105.
[195]Garrett Hardin, *The Tragedy of the Commons* (December 13, 1968), at 1243-48.
[196]*Id.*
[197]*Id.*
[198]*Id.*
[199]*Id.*
[200]*Id.*

The commons can no longer support one animal or herdsman.[201] This tragedy exemplifies the unfettered narrow self-interest strategy: casting a blind eye to the environment's limited carrying capacityleads to catastrophe.

The default position of self-maximization has real-world application in the water context. The Aral Sea, in Central Asia, is a familiar example of a tragedy of the commons. A victim of indiscriminate over-pumping for decades, the Aral Sea has become the poster child for environmental collapse. The once-vast inland "sea" (it is really a freshwater lake), has been steadily shrinking due to pumping stresses from the five countries that share its historic drainage basin.[202] In a region that is prone to ethnic conflicts and has lacked stability since the dissolution of the Soviet Union in 1991, the Aral Sea is precisely what can happen when cooperative strategies are lacking.[203] The resulting collapse is clearly seen in Figure 3. Remarkably, despite a shared history that is less than conducive for cooperation, the five countries have recently recognized the regional importance of the Aral Sea and have begunworkshops to shape their shared future.[204] Long-term security in the region depends, in large part, on an ability to cooperate with respect to the region's most significant freshwater resource.[205] A tragedy of the commons has lead to a *post facto* cooperative outcome. Although an *a priori* solution is most desirable, progress is welcome in any form.

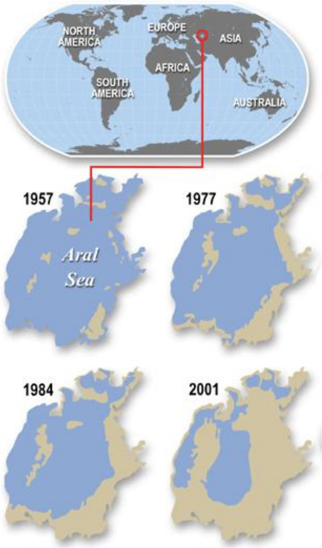

Figure 3. A real-life tragedy of the commons: the shrinking Aral Sea.[206]

C. The Role of Science

In this effort to change hindsight into foresight regarding the drafting of international water allocation instruments, special attention must also be paid to the unique scientific "law" that ultimately governs these issues.[207] Before being bound by any contract, treaty, or

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[201] *Id.*

[202] See generally, John E. Moerlins, Mikhail K. Khankhasayev, Steven F. Leitman, and Ernazar J. Makhmudov, *Transboudary Water Resources: A Foundation for Regional Stability in Central Asia* (2008). The five countries are: Kazakhstan, Uzbekistan, Turkmenistan, Tajikistan, and Kyrgyzstan. The Aral Sea proper is an international waterbody that spans the border between Kazakhstan and Uzbekistan. See also, *United Nations Aral Sea Development Programme* (2012), http://www.undp.org/content/uzbekistan/en/home/operations/projects/poverty_reduction/un-aral-sea-programme/ (accessed February 21, 2014).

[203] *Id.*

[204] *Id.*

[205] *Id.*, at 4-7.

[206] Adapted from: http://www.bracsystemsontario.com/environment.html

[207] Author's aside: This section contains a generalized discussion of the role of hydrology in water rights law based on the author's experiences and does not reflect the views of other contributors.

agreement, players in the international water "game" are bound by the rules of nature. Hydrology is the first, and most significant, arbiter of water rights. This fact does not, of course, render humans powerless to nature's whims, as mankind has routinely developed models based on long-term hydrological observations such that the floods and droughts that characterize our waterbodies are not surprising, even when not expected. There exists a natural periodicity (and regular peaks and valleys) in the earth's water cycle that science has sought to understand for time immemorial. The development of water storage facilities such as reservoirs is a testament to this fact.

With greater awareness comes greater predictability, which is the point of the present research. Predictability is a grand goal when speaking of access to water, a fundamental need which is indisputable.Just as hydrologic modeling attempts to better understand our rivers, flexible agreements between states should recognize the inherent variability of surface water flows.[208]Embracing the same approaches taken in hydrologic studies to minimize unexpectedness in the drafting of water allocation instruments will arguably lead to more cooperation and a better diplomatic environment for dispute resolution. Predictability equals *terra firma* in international dealings.

Analysis

A. Economic Asymmetries

That disparities exist among the earth's states is self-evident: Asymmetries color the relationships between riparian states and they must be understood at the outset in treaty drafting. For example, one very important (and fascinating) consideration is cultural differences and how they can help predict a state's behavior entering international water rights negotiations.[209] A riparian state's level of risk aversion or environmental awareness can be an integral aspect of their cultural identity. Additionally, a state may, as a matter of principle, give NGOs greater sway in intergovernmental negotiations. A more open (democratic) regime may, for instance, *culturally* embrace bringing stakeholders to the proverbial table in negotiation and deal-making.[210] This is a constructivist approach to international relations, which becomes validated over time as customary international law via the formation of treaties and agreements and through the interactions between groups and communities.[211] Another example is economic asymmetries, which form the basis of the analysis portion of this study going forward.[212]

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[208]Frank A. Ward, *Forging Sustainable Transboundary Water-sharing Agreements: Barriers and Opportunities.* 15:3 Water Policy 386 (2013).

[209]See, Marco Verweij, *Transboundary Environmental Problems and Cultural Theory: The Protection of the Rhine and the Great Lakes* (2000), at 15-18 and 45-47. An emerging field within international relations seeks to humanize the differences between states and to consider such differences when negotiating transboundary agreements. Known alternatively as *cultural theory* or *grid-group theory*, this perspective recognizes that norms, mores, and institutions shape each state's strategic approach to negotiating, bargaining, and risk allocation. While self-evident on its face, such an approach is only now gaining traction in international law studies. Although it is not the focus of the research at hand, the author strongly advocates such positive steps in the pre-drafting of water rights agreements.

[210]*Id.*, at 47.

[211]See generally, Susan Park, *The World Bank, Dams and the Meaning of Sustainable Development in Use* (Winter, 2009).

[212]See, Ariel Dinar, Shlomi Dinar, Stephen McCaffrey, and Daene McKinney, *Bridges over Water: Understanding Transboundary Water Conflict, Negotiation and Cooperation* (2007), at 179. A third type of asymmetry pertinent to this topic concerns geographical asymmetries. International rivers either flow through country borders (*through-border* rivers) or form borders (*border-creator* rivers). The dynamic among riparian states is heavily dependent on the type of international river at issue. A downstream riparian state is more disadvantaged in through-border scenarios because of the unimpeded access the upstream riparian state has to the water before it enters the downstream riparian. Theoretically, when two riparian states share a border

Economic asymmetries are best described as incongruities between two states in key indicators of economic development such as income or gross domestic product (GDP).[213] The interactions between two riparian states can be dictated by their relative economic circumstances.[214] Disparity between two riparian states is not necessarily a formula for abuse of negotiating power; rather, a pattern of negotiated outcomes is observed, typically resulting in tradeoffs.[215] The theory behind this phenomenon is explained by differential *willingness to pay* for a clean water supply among economically asymmetric riparian states.[216]Stated differently, riparian states may value differently the same level of access to water resources based on their economic circumstances.

More affluent riparian states generally have more stringent standards for water quality, and have a higher willingness to pay for its public water supply.[217] Conversely, less affluent riparian states may be inclined to accept lower quality water standards to meet its public demand.[218] As a result, wealthier riparian states may make up the differencein the water quality of shared resources by incentivizing the poorer upstream riparian state to meet its higher downstream standards.[219] The method most often employed to achieve this outcome is the *side payment*.[220]

Side payments are an efficient method to align incongruent self-interests into a "win-win" outcome for two or more states. While side payments are certainly an incentive to motivate a particular desired action out of an upstream riparian state (e.g., pollution abatement, reduced demand, or flood control), they also reflect the reality that some benefits enjoyed by the downstream state are created farther upstream.[221]Side payments are a type of tradeoff where cash is traded for an outcome that has a payoff *at least* in line with each riparian state's desired end game. Therefore, effective side payments can be considered "win-win" outcomes: The upstream state gets cash, while the downstream state realizes gains in terms of water quality and/or supply.

Sensitivity to another riparian state's economic situation can pay dividends to a state at a later date.[222] This type of payoff, known as *goodwill value*, is a collateral (and deferred) payoff to the "sensitive" state.[223] Goodwill value accrues when a more affluent state takes on some or all of the costs of a shared water project or a negative externality (e.g., pollution) originating in the less affluent state, or when the richer riparian is disproportionately generous with a specific water allocation. In this social outcome, the richer riparian state may choose to flout customary international law, such as the "polluter pays principle," or simply be generous, in an effort to cultivate a cooperative diplomatic milieu.[224] Although a perverse

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created by a river, the states are geographically symmetrical. In these cases, such as the U.S.-Mexico border, the role of economic asymmetries is magnified, and thus is the focus of the present research.

[213]*Id.*, at 182.

[214]*Id.*, at 183-87.

[215]*Id.*

[216]*Id.*

[217]*Id.*

[218]*Id.*

[219]*Id.*

[220]*Id.*

[221]*Id.*

[222]*Id.*, at 188-89.

[223]*Id.*

[224]*Id.* The "polluter pays principle" is a core tenet in environmental studies. It is an elegant approach to *post facto* environmental problem-solving: The creator of a negative externality such as pollution is also responsible for its clean-up and repaying the costs to those it impacted. It is closely aligned with the legal principle of damages and is pragmatic. As a common-sense approach, it is considered customary international law. The creativity of the game theoretic approach is thus starkly evident when a "victim pays" regime may be an acceptable outcome for the victim.

outcome, insofar as the victim of pollution or over-pumping also has to pay for the abatement of negative impacts, goodwill payoffs may yet result in a "win" for the more affluent victim. The benefits may manifest as future compliance of the less affluent state with a shared water project that is beneficial to the wealthier riparian, or the benefits may be more general (e.g., less contentious diplomacy).[225] The goodwill is essentially "banked"in trust for future use by the more affluent riparian.[226]

B. The Environmental Kuznets Curve

A generalized model for the relationship between affluence and environmental degradation is useful as a backdrop for a discussion about economic asymmetries between two riparian states. The Environmental Kuznets Curve (EKC) (Figure 4) demonstrates the rudimentary inverted U-shaped curve characteristic of this relationship. It was originally developed in 1955 by Simon Kuznets to describe the relationship between affluence and income inequality over time and later adapted in the environmental context.[227] Typically, it is hypothesized on an EKC that key indicators of environmental degradation such as pollution and resource depletion initially increase as a function of increasing economic development.[228] Adherents to the EKC phenomenon hypothesize that environmental protection is a low priority for developing countries that are focused more on establishing political, economic, and civic stability within its populace and with its trade partners and neighbors.[229] However, as per capita income increases over time, environmental degradation slowly begins to occur at a decreasing rate, as priorities shift to meet a growing need for resource protection and pollution abatement.[230] Examples of this phenomenon in the U.S. are the National Parks Service, the EPA (and a host of other agencies), and complex regulatory schemes such as the Clean Water Act, the Clean Air Act, and the Endangered Species Act. It is argued that more affluent states pursue cleaner, more "information-intensive industries and services" while better enforcing their environmental regulations and spending more money on conservation initiatives.[231]

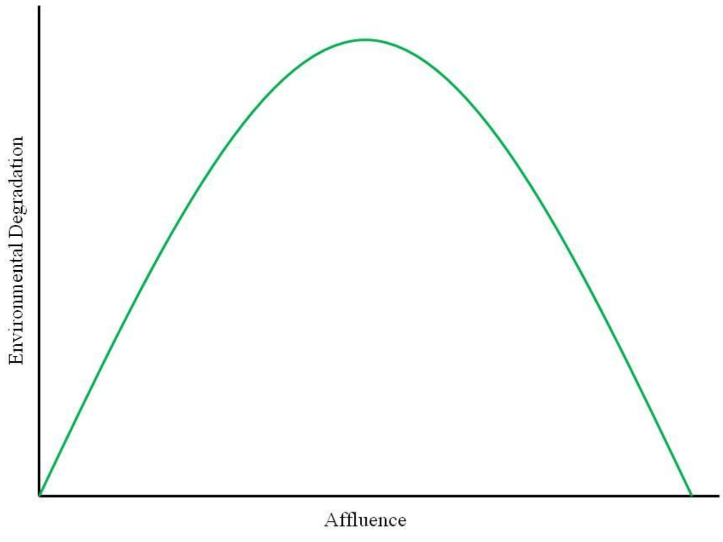

Figure 4. The environmental Kuznets curve.

[225] *Id.*, at 163-65.
[226] K. Madani, *Game Theory and Water Resources*,381 J. Hydrology 225-238 (2010).
[227] David I. Stern, *The Environmental Kuznets Curve* (June, 2003).
[228] *Id.*
[229] *Id.*
[230] *Id.*
[231] *Id.*

Rather than debate the merits of the EKC theory, this research instead chooses to apply it in the limited context of the priorities of two riparian states where economic asymmetries exist between the players. Reaping the benefits of this approach in the development of strategies in water allocation agreements starts with embracing its core tenets; that is, countries' environmental strategies (which include water allocation strategies) change as a function of their overall wealth. This notion fits well the reality of economic asymmetries between neighboring riparian states. It is thus understandable to see how narrow self-interest, as a default strategy, is reinforced by economic asymmetries, especially as poorer states attempt to protect those resources that are *already* under their control. However, this knowledge can also be used to aid strategy-making, *a priori*, in water allocation agreements. Returning to the IBWC, the very acceptance of this reality with respect to the U.S.-Mexico relationship has colored their agreements in the Rio Grande Basin for decades and resulted in social outcomes that differ markedly from customary international law and default strategies.

Turning now to the real-world implications of this model, the IBWC will be analyzed for examples of negotiated tradeoffs that represent "win-win" scenarios for the U.S. and Mexico.[232] (It is assumed for the purposes of this research that the EKC's predictions apply to the two riparian states and that the U.S. occupies a position farther along the X-axis than Mexico.[233]) Specific examples exist in the IBWC's history that demonstrate the aforementioned strategies of side payments (also known as cost-sharing) and goodwill value. Wastewater treatment and treaty amendment are two of the IBWC settings which illustrate the cooperative principles predicted by game theory.

A key consideration of the IBWC, above basic supply, is water quality.[234] As such, three international wastewater treatment facilities have been built in U.S.-Mexico border metropolitan areas as a result of the IBWC: San Diego-Tijuana, Calexico-Mexicali, and Laredo-Nuevo Laredo.[235] These joint construction projects are cost-intensive; but instead of apportioning costs based on population served or the amount of influent coming into the facility from each riparian state, the costs were distributed based on benefits received.[236] The facilities were designed to meet the U.S.' higher water quality mandate.[237] Coupled with the higher willingness to pay of the U.S., a solution was negotiated where the U.S. assumed a higher portion of the construction costs, even though Mexico was receiving the benefit of cleaner water as well.[238] Further, as U.S. standards continue to rise, the U.S. makes side payments to the Mexico for the increased cost of operations in meeting these effluent benchmarks.[239] A "win-win" outcome has occurred, with U.S. sanitation standards being met and Mexico receiving just compensation.

Amendments to the IBWC, such as cost-apportioning and side payment agreements, occur often and with little dispute between the two riparian parties to the agreement.[240] Using "Minutes" to amend the IBWC, the treaty is built on a foundation of trust and good faith. Whena change is desired to the IBWC, one of the parties simply makes the alteration, referred

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[232]The model referred to is the synthesis of the study of economic asymmetries and the EKC.
[233]According to International Monetary Fund estimates (2009), the per capita GDP in the U.S. is approximately $46,000 whereas the per capita GDP in Mexico is approximately $14,000.
[234]George B. Frisvold and Margriet F. Caswell, *Transboundary water management: Game-theoretic lessons for projects on the U.S.-Mexico border* (2000), at 101-02.
[235]*Id.*
[236]*Id.*, at 105.
[237]*Id.*
[238]*Id.*
[239]*Id.*, at 107.
[240]See, Ariel Dinar, Shlomi Dinar, Stephen McCaffrey, and Daene McKinney, *Bridges over Water: Understanding Transboundary Water Conflict, Negotiation and Cooperation* (2007), at 164.

to as a Minute, and the other party has 30 days to *dis*approve it.[241] This general goodwill which surrounds the IBWC has specific instances of being parlayed into real-world payoffs. An example of this concerns the original drafting of the 1944 treaty. The U.S. initially allotted a generous amount of water from the Colorado River to Mexico.[242] As the southwest U.S. boomed, so did its water demands. Subsequent Minutes to the IBWC, which conveyed new diversions from the Colorado River to the All-American Canal in California, as well as extractions from the lower Rio Grande, all of which solely benefitted the U.S., were approved by Mexico due, in part, to the goodwill accrued from the initial generous drafting of the 1944 treaty.[243] These amendments were not beneficial to Mexico, but the U.S. was essentially able to cash in its "banked"goodwill.

C. Hypothetical *Through-Border* Situations

In order to further illustrate the lessons from the IBWC, two instructive hypothetical scenarios have been developed for *through-border* rivers:

1) Imagine a hypothetical two-state international river. The downstream riparian state is at a point much farther along the EKC's X-axis than the upstream riparian state. How can the downstream riparian state ensure that the quantity and quality of water in the river meets its higher demand and standards?

Because the richer downstream riparian state is in the disadvantageous position in this scenario, their strategy must reflect this reality. With lower levels of environmental protections in place, the upstream riparian state is in the default position where its self-interest is served before meeting the more rigorous water quality standards of the more affluent nation. Thus, in order to reach a negotiated outcome that is compatible with the richer state's higher standards, side payments for the higher level of upstream pollution abatement will have to be made. The richer state can pay for (or share in the costs of) wastewater treatment at the source in the upstream portion of the international waterbody. The more affluent riparian state would have to meet its internal water quality standards eventually; doing it at this upstream point also preserves the ecological integrity over a greater length of the river.

2) Imagine once more a hypothetical two-state international river, except in this scenario, the situations are reversed and the upstream riparian state is at a point much farther along the EKC's X-axis than the downstream riparian state. What does game theory predict as to the upstream riparian's strategy?

Goodwill value can be an example of a payoff to the richer upstream riparian state. Their higher willingness to pay for water resource preservation and water pollution abatement may pay dividends later (e.g., cooperation of the downstream riparian in joint projects such as hydropower generation or even non-water allocation issues). This tradeoff outcome is mutually beneficial in that the downstream riparian received more and/or higher quality water while the upstream riparian has done a favor for its neighbor, which can reinforce further cooperation in the future. The idea is that cooperation begets cooperation. A word of caution: There is, however, the danger of paternalism, where the more affluent upstream neighbor dictates the terms of the agreement.[244]

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[241] George B. Frisvold and Margriet F. Caswell, *Transboundary water management: Game-theoretic lessons for projects on the U.S.-Mexico border* (2000), at 105.
[242] *Id.*, at 109.
[243] *Id.*
[244] See, e.g., Shlomi Dinar, *International Water Treaties: Negotiation and cooperation along transboundary rivers* (2008), at 27. The argument is made, however, that hegemony is almost a "necessary evil" as to the inducement of cooperation of a less wealthy riparian state by the richer riparian state. The scope of this research does not include an inquiry into this topic.

D. Drafting Better International Water Allocation Agreements

With both real-world and hypothetical examples of conflict avoidance and cooperation to draw upon, a final legal question materializes: Is it possible to create a model agreement for the governance of shared international water resources? Or, in other words, are there certain universal lessons learned that can be accepted as fundamental to the coordinated allocation of water rights? The American Society of Civil Engineers (ASCE) believes so and has produced "model" language for the drafting of water sharing agreements. Rather audacious in its scope, the ASCE project, known as the Model Code for the Shared Use of Transboundary Water Resources (SUTWR), is the culmination of a decade-long response to the challenges set forth in the aforementioned questions.[245] Ultimately, the SUTWR seeks *pre*-drafting efficiency, embracing many of the predictions made by game theoretic approaches to water allocation, including differential willingness to pay and tradeoffs, while still maintaining integrity with the broad international goals of equitability and sustainability.[246]

The SUTWR recognizes the inherent difficulty in the economic valuation of water resources and that different values create controversy and the potential for conflict.[247] In particular, two of the lessons learned from the IBWC with respect to economic asymmetries are reflected in the model code's provisions. First, the model code recognizes that riparian states enter into negotiations in the default state of narrow self-interest.[248] It does not, however, endorse maintaining such strategies in the code language, preferring instead to use language mirroring that of game theory. The SUTWR creates a duty to coordinate, cooperate, and even share information among the stakeholder states in negotiating tenable outcomes for all.

Second, the model code is cognizant of the differential willingness to pay of riparian states.[249] The SUTWR mandates economic considerations in the creation of international allocation agreements.[250] It states that tradeoffs, such as side payments, are useful tools for achieving balance in equitable and sustainable water use.[251] Understanding that cooperation is oftentimes only bought and sold, there is a seamless integration of economic principles into the model code, despite its stated goal to put environmental conservation and human rights at the forefront.[252] The SUTWR's thematic acceptance of the principles of equitable utilization and sustainability demonstrate that the economic predictions made by game theory, especially the tradeoffs derived from economic asymmetries, are compatible with the moral considerations made by the global community.[253]This interdisciplinary effort suggests that economic efficiency and the moral concerns of a fundamental right to water are by no means mutually exclusive goals.

[245]See generally, Stephen E. Draper, *Model Water Sharing Agreements for the Twenty-First Century* (2002). The SUTWR is a unique interdisciplinary approach designed to promote *a priori* dispute resolution using perspectives from science, economic, policy, and law. The brainchild of Professor Ray Jay Davis of the Brigham Young University School of Law, the SUTWR was originally designed to deal with U.S. interstate water allocation regimes. It evolved into the development of a model code for utilization of waters in *through-border* and *border-creator* scenarios involving sovereign governments.

[246]*Id.*

[247]*Id.*, at 149.

[248]*Id.*, at 92.

[249]*Id.*, at 148-49.

[250]*Id.*

[251]*Id.*

[252]*Id.*, at 5.

[253]*Id.*

Conclusion

The field of international water law is one that appears to be at a crossroads; stuck between the feel-good sentiment of its major conventions and meetings and the reality of enacting these tenets in reality, problems obtaining results persist. The importance of the field cannot be understated, yet there exist serious short-comings in the equitable and sustainable distribution of scarce international water resources.Rather than pretend that a one-stop-shop for curing these ills exists, incremental change may be the best interim strategy on the global path to fulfilling the fundamental human right to water. The magnanimous goals of the international community (equitability and sustainability) should continue to be pursued, while the less attractive goal of economic efficiency may in fact be the best project-specific approach to international water treaty drafting. Game theoretic approaches, while limited in their scope of applicability, foster unifying themes of cooperation and collaboration, such that the dismal science may not be so out of touch with humanity after all.

A. Limitations

A notable omission from this study is the role of multinational corporations in the commoditization and distribution of water. There is no dispute that major corporations control access to copious amounts of the world's freshwater, such as the ongoing dispute between Nestlé and Bolivia.[254] And there is similarly no doubt that these entities should be considered key stakeholders in the context of cooperation and conflict resolution. Nonetheless, significant discussion of their role in international water law was left out of this study due to their (ostensible) exclusion from the instrument drafting process. The partnership process, discussed *infra*., may change this dynamic in the future.

It should also be noted that this research is not designed to be a blind devotional to the role of game theory in international treaty-making. There is a danger in reducing all treaties to mere contractual agreements between states, especially when considering the international public interest that treaties are supposed to uphold.[255] If treaties are nothing more than contracts between rational actors seeking to maximize their own benefits, then how can the global good ever be advanced?[256] However, in many situations, such as the simplified two-state scenarios discussed in this study, the illustrative qualities of game theory are evident. Game theory may or may not be capable of handling the myriad complexities of transboundary water rights, but it can serve as a novel starting point for understanding state (and other stakeholder) motivations and strategies and how to reach cooperative outcomes.[257]

B. Recommendations

Oftentimes, when the discussion turns to water resources, the ubiquitous term "water war" springs up. Recent water wars include such armed conflicts as the Cochabamba struggle in Bolivia in 1997 and the aforementioned ethnic clashes near the Aral Sea, as well as the slightly more civil interactions among southern and southwestern states of the U.S. and the omnipresent Nile River disputes between Egypt and the rest of the watershed's riparian states.[258] This disturbing trend in the way water is discussed paints a pall over the entire area

[254]See, e.g., D. Jaffee and S. Newman, *A Bottle Half Empty: Bottled Water, Commodification, and Contestation,* 26:3 Organization & Environment 318-335 (September, 2013).

[255]Jan Klabbers, *The Relative Autonomy of International Law or the Forgotten Politics of Interdisciplinarity* (Winter, 2004/Spring, 2005), at 39.

[256]*Id.*, at 40.

[257]*Id.*

[258]See, e.g., Leif Ohlsson, *Hydropolitics* (1995); Antoinette Hildering, *International Law, Sustainable Development and Water Management* (2004); Ashok Swain, *Managing Water Conflict: Asia, Africa, and the Middle East* (2004); and John E. Moerlins, Mikhail K. Khankhasayev, Steven F. Leitman, and Ernazar J. Makhmudov, *Transboudary Water Resources: A Foundation for Regional Stability in Central Asia* (2008). An incredible amount of literature exists on water conflicts, armed and otherwise, in recent world history. The examples mentioned are but small sample of the numerous disputes that permeate all corners of the globe.

of study such that conflict seems to be a self-fulfilling prophecy. Thus, as a matter of international discursive policy, it is first recommended that a "softening" of the terminology is pursued. The widespread use of "water war" does nothing but reinforce the default position of narrow self-interest and conflict.

One recommendation is to consider local water use groups as the players, instead of the macro view where states are the sole players. This suggestion has two primary benefits. The first benefit, characterized generically as site-specificity, is that these players already have intimate knowledge of the local water needs which would potentially lead to more efficient water use.[259] The idea is that those closest to an issue (e.g., use groups like farmers or individual communities) would be most acquainted with the nuances of a specific water allocation problem.[260] The second benefit is that NGOs, as a sophisticated entity representing use groups, could thus function as the stakeholder during treaty drafting, rather than merely trying to inform the state as one of many groups trying to get a seat at the table.[261] In this scenario, the international instrument would serve as the governing document, implemented by the use groups actually impacted by water use on a given transnational waterbody. Ostensibly, this approach would minimize the degrees of separation between those using the resource and the instrument which governs this use.[262] Cultural theory, touched on in the beginning of Section III, *supra.*, which encourages community access to the negotiating process, reinforces the site-specific, user group approach.[263]

With the possibility of an expanded role for NGOs in international treaty drafting come ever-creative solutions to coalition-building. The rise of public-private partnerships is one such example of this logical progression.[264] These partnerships are voluntary, multilateral collaborations of myriad environmental stakeholders, which function as intermediaries between the over-arching goals set forth in meetings such as Rio in 1992 or Johannesburg in 2002 and implementation at the local level.[265] Rather than acting as substitutes for intergovernmental commitments, partnerships are designed to strengthen extant agreements by "disaggregate[ing] general worldwide goals into specific local projects."[266]Drawing on the inherent advantage of NGOs, civil society, municipalities, and even private corporations in understanding local nuances, partnerships embody the site-specific knowledge that is becoming increasingly necessary in negotiating effective water allocation agreements.

Significant attention should be paid to unseen transnational waters, such asaquifers.[267] Aquifers are instrumental in nearly any state's freshwater supply regime. But there is evidence that international aquifers lag behind their surface counterparts in terms of protections granted to them by international agreements.[268] Despite Minutes which were adopted in two subsequent addendums to the IBWC, in 1973 and 1979, and the "relatively

[259]Asher Alkoby, *Theories of Compliance with International Law and the Challenge of Cultural Difference* (Winter, 2008), at 169-70.
[260]*Id.*
[261]Marco Verweij, *Transboundary Environmental Problems and Cultural Theory: The Protection of the Rhine and the Great Lakes* (2000), at 47.
[262]*Id.*This could be likened to the euphemism that implores one to bite off only what one can chew.
[263]AsherAlkoby, *Theories of Compliance with International Law and the Challenge of Cultural Difference* (Winter, 2008), at 169-70.
[264]See Christopher C. Joyner, *Rethinking International Environmental Regimes: What Role for Partnership Coalitions?* (Winter, 2004/Spring, 2005), at 89-90.
[265]*Id.*, at 104.
[266]*Id.*, at 105.
[267]See, e.g., George B. Frisvold and Margriet F. Caswell, *Transboundary water management: Game-theoretic lessons for projects on the U.S.-Mexico border* (2000), at 109.
[268]See Heather L. Beach, Jesse Hammer, J. Joseph Hewitt, Edy Kaufman, Anja Kurki, Joe A. Oppenheimer, and Aaron T. Wolf, *Transboundary Freshwater Dispute Resolution* (2000), at 119.

warm political relations" between the U.S. and Mexico, formal agreement on the allocation of transnational aquifers has yet to be achieved.[269]This failure to reach an accord underscores the difficulties groundwater resources still present toinstrument drafting.

A final substantive recommendation is for international water treaty drafting to incorporate the precautionary principle as a fundamental component of allocation instruments. Harkening back to the unpredictability of the hydrologic cycle, the precautionary principle is a wise use (common-sense) approach to uncertain futures.[270]Borrowing from the law, the principle speaks generally about the burdens of proof in policy-making; where uncertainty exists with respect to environmental or public health, the burden rests on those promoting a particular course of action that it is *not* harmful.[271] The sheer magnitude of the issue of clean water availability, already shrouded in uncertainty due to hydrologic variability, mandates the guarded approach of the precautionary principle. The moral duty to provide clean water to mankind, as a fundamental right, should not be jeopardized by the whims of one player.[272]

Ultimately, there is still a great need for aspirational and far-reaching water rights treaties such as the U.N. Convention on the Law of Non-Navigable Uses of International Watercourses. The Convention, and other treaties, such as the Millennium Development Goals (MDG) and the Ramsar Convention (Ramsar), and meetings, such as Rio and Johannesburg, galvanize shared goals and resonate throughout the international community.[273]These instruments shouldstill function as models, or "umbrella" documents, for the drafting of site-specific international agreements. Consistency in the drafting of water rights instruments is desirable; embracing the common themes of equitability and sustainability is not only a noble but also an important cog in mainstreaming a less economic rights-centric, more human rights-driven message with respect to access to water. In the meantime, understanding the economic motivations of riparian states and how these motives can be dovetailed to reach cooperative outcomes will have to suffice.

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[269]*Id.*, at 120.

[270]Seegenerally, Antoinette Hildering, *International Law, Sustainable Development and Water Management* (2004).

[271]*Id.*

[272]*Id.*

[273]See, e.g., Clare Shine and Cyrille de Klemm, *Wetlands, Water and the Law* (1999), at 27. The Ramsar Convention is a 1971 treaty relating to the protection of wetlands, named for the city in Iran in which it was signed. It has evolved to place special attention on international wetlands and those from which freshwater supplies are derived.

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