

Peaceful Management of International River Claims

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Abstract: As global water scarcity increases, both scholars and leaders have suggested that water will be a leading cause of future armed conflict. Yet other scholars argue that states typically cooperate rather than fight to manage their shared water resources. We address these arguments by examining the management of internationally shared rivers in the Americas, Western Europe, and the Middle East from 1900-2001. We propose hypotheses on the factors that lead states to become involved in disagreements over shared rivers as well as the factors that lead them to negotiate over these disagreements. Heckman probit analysis suggests that water scarcity -- found by past work to be an important influence on armed conflict over rivers -- is also an important influence on peaceful efforts to settle river problems; river claims are more likely where water supply is lower and demand is greater, but negotiations are also generally more likely in these same situations. Furthermore, while the existence of river treaties does not prevent the emergence of river claims, the presence of at least one treaty over the specific subject of the claim provides an important starting point that greatly increases the likelihood of negotiations over such claims. We conclude that the more pessimistic views of water management are missing an important part of the story. States are much more likely to negotiate in the most dangerous situations, and institutionalization of river resources can make an important contribution to negotiations over any disagreements that do emerge.

Keywords: Transboundary rivers, freshwater, conflict management, water scarcity, treaties, international institutions.

Introduction

Transboundary waters are widely believed to be associated with international conflicts, especially in political rhetoric. Systematic empirical analyses have suggested some level of support for this belief -- at least for low-level conflicts, if not for full-scale "water wars" (e.g. Tose et al. 2000; Gleditsch et al. 2006; Brochmann and Gleditsch 2006; Hensel and Brochmann 2007). But conflict is not the whole story, and scholars are now beginning to emphasize the cooperative dimensions of shared rivers. Empirical evidence seems to suggest that states cooperate over their shared water resources much more than they engage in conflict over these resources, and that scarcity problems or potential conflicts can be overcome by peaceful means (e.g. Brochmann and Gleditsch 2006; Hensel et al. 2006; Tir and Ackerman 2007). This paper investigates both dimensions of river management, examining conflict in the form of explicit disagreements over the use of rivers as well as cooperation in the form of peaceful negotiations to settle these disagreements. More precisely, we ask under which conditions states are most likely to try to solve their ongoing river disagreements through peaceful means. In a previous special edition of this journal, Dinar and Dinar (2000) emphasized the need to investigate and learn about the macro-investigation level. More specifically, they called for analyses to discover and "...attempt to predict the variables that constrain nations from overcoming initial difficulties and reaching the negotiation phase" (Dinar and Dinar 2000: 194). They further uphold the importance of trying to foster negotiation and cooperation over water disputes since water, especially in unstable regions, may be a catalyst for further instability and conflict. Eight years later, this is still an important topic for investigation.

Water is essential for human survival and we know that states interact frequently over their shared waters. Yet we do not know as much about factors that affect whether states try to

resolve their disputes peacefully or through military force. Uncovering these factors may provide valuable insights for policy makers trying to govern international rivers. To address this issue we build on a theoretical framework from liberal institutionalism and negotiation theory, and present a simple model for interaction over shared rivers. As transboundary rivers are essential for the states sharing them, those states may find themselves taking opposing positions over the use of shared rivers, which they may then pursue through either conflictual or cooperative means. We argue that factors affecting the perceived importance of the shared river, the level of institutionalization already existing in the river, and the general context of the relations between the riparians will be decisive for the nature of the interaction. We test hypotheses focusing directly on attempts to settle river disputes in multivariate analysis using data from the Issue Correlates of War (ICOW) project.

Our results lend support to the general emphasis on the importance of sufficient access to freshwater resources, as well as the beneficial effects of treaties over the management of rivers. Most important, both explicit disagreements over rivers and negotiations over these disagreements are more likely over longer rivers and where water scarcity is greatest, suggesting that water scarcity is an important source of at least diplomatic conflict but also an important motivator of cooperation to manage or settle this conflict. The existence of explicit treaties governing the use of rivers has not been able to decrease the risk of new disagreements emerging (and indeed seems to be associated with an increased risk), but both river-specific treaties and generally more cooperative relationships between riparian states significantly increase the likelihood of peaceful negotiations over these disagreements. In short, there is reason for optimism over the future of transnational rivers, as even the most dangerous situations of water scarcity seem to be pushing states toward greater levels of cooperation, and institutionalist

solutions appear to be very effective in pushing cooperation as well. We conclude by discussing several promising directions for future research to follow up on these results.

We begin by presenting our theoretical framework and model before we turn to the empirical design and data used. The analysis is performed using a Heckman selection model and followed by a discussion of the main findings and their implications, for policy makers as well as for further research.

Theoretical Framework

Conflict and cooperation are at the heart of international relations research, and although often examined separately from each other, the two concepts are closely connected. On the one hand, international conflicts can range from large scale wars with many thousands of casualties to smaller disagreements between states that never produce a single casualty. As previous research has shown (e.g Wolf 1998; Yoffe et al. 2003), most international water conflicts are not full-scale wars, but rather diplomatic conflicts; from this perspective we understand a water conflict as “a situation in which the status quo allocation and use of the resource is contested.” (Dombrovsky 2007: 27) The term "cooperation," on the other hand, is not simply the opposite of this, which would imply absolute harmony of interests and a complete lack of disagreement between actors. Keohane (1984) explicitly distinguishes cooperation from harmony by noting that the former features an underlying difference of interests that requires policy coordination and making adjustments in each state’s behavior. From this perspective, cooperation is connected with conflict, and in fact is often a reaction to conflict as states seek to avoid or manage disagreements. We thus consider cooperation as involving a situation where the parties have some sort of diverging interests, in which there is some potential for policy adjustment and coordination that can benefit each of them.

Ideas from liberal institutionalist theory as well as bargaining theory offer useful frameworks for analyzing such interaction. States in the international system can be understood as rational egoists that pursue their own interests in an anarchic state system that lacks any unitary, overarching international government above them. In such a system, states are bound to interact based on reciprocity whenever their interests collide. (Keohane and Ostrom 1994) States will primarily cooperate for either of two reasons; (1) if they expect to gain more from collective action than unitary action (e.g. Keohane 2002); or (2) to prevent a pending threat from leading to a costly conflict (e.g. Stein 1989; Zartman 1989). Conflicts, on the other hand, can come about if states fail to reach agreements, misunderstand each other or simply regard the cost of cooperation as higher than the cost of a conflict. According to liberal institutionalists, international organizations and treaties are central to facilitating international cooperation and avoiding conflicts. According to Keohane (2002):

In particular, institutions reduce the costs of making, monitoring, and enforcing rules – transaction costs – provide information, and facilitate the making of credible commitments. In this theory, the principal guarantors of compliance with commitments are reciprocity (including both threats of retaliation and promises of reciprocal cooperation) and reputation. (Keohane 2002: 3).

Along these lines, Fearon (1995: 380ff) argues that in any interaction between states there will always exist a peaceful solution that both sides would prefer over a violent conflict. War is a costly event, and both parties would be better off if an issue could be resolved without turning violent. But private information and incentives to misrepresent information can limit the

apparent bargaining range and lead to conflicts instead, even with rational leaders in place. Morrow (1994) similarly argues that all issues that are candidates for cooperation face four critical problems that must be addressed to attain lasting cooperation: distribution, information, monitoring and sanctioning. In a world of perfect information and zero transaction costs, there would be few obstacles to cooperation between rational states with shared interests. These conditions are of course rarely met, but nevertheless states enter into negotiations to overcome differing interests and settle disputes.

From this general perspective, in order for states to cooperate over an issue, there needs to be an underlying difference of interest, and the issue must be considered important enough to be worth pursuing one's own interest over rather than simply ceding it to the adversary. When states do disagree over such an issue, they are likely to negotiate over its allocation, seeking to determine how the good may be shared or distributed in a manner that satisfies all interested parties. The obstacles discussed by Fearon and Morrow suggest that cooperative outcomes are most likely when the parties have sufficient information about each other to trust that the other will fulfill an agreement, and when the expected gains from cooperation are seen as outweighing the expected net gains from both violent conflict and continuing the *status quo*.

Shared river resources fit this general description. First, water is a vital resource for which there is no effective substitute, which renders it important enough to states to justify contention (whether via conflictual or cooperative means) in order to guarantee sufficient access. Beyond the irreplaceable importance of water for human consumption, international rivers offer the possibility of further benefits ranging from fishing or irrigation to hydroelectric power generation or commercial navigation. Yet while water is a renewable resource, access to it is not unlimited. Only 3% of the world's water is fresh water, and most of that amount is not directly

available for use -- whether because it is locked up in icecaps or deep aquifers or because it is polluted. According to recent volumes of the UNDP *Human Development Report* and UNEP *Global Environmental Outlook* (UNDP 2006; UNEP 1999), more than one billion people currently lack access to clean water, and present patterns of increasing consumption suggest that two out of every three persons will live under water-stressed conditions by 2025. These figures vary across countries or regions, though, as accessible freshwater is distributed very unevenly: North America has an annual run-off of 17,000 m³ per capita per year, while Africa has 6,000 and Egypt just 50. Less than 1% of the world's usable freshwater is located in the Middle East or North Africa, yet this region contains 5% of total world population.

Furthermore, the shared nature of many water resources means that many states experience diverging interests with respect to their neighbors who share the same resource, necessitating some level of interaction with respect to these interests. A finite amount of water traverses the river system, and any action regarding the river by one state may affect the amount or quality of water available to other state(s) in the basin. Indeed, according to Elhance (2000), the complexity of hydropolitics makes it one of the most challenging arenas of interstate interaction and negotiation in some regions of the world.¹ Many rivers are also shared by more than two states, complicating river management because of the potentially large number of states whose interests must be taken into account.²

This combination of water's importance, scarcity, and often shared nature has led to rhetoric about the pending threats of water wars and water as a serious and complex security issue. Accordingly, research on transboundary waters has traditionally focused on conflict, mostly informed by the so-called Neomalthusian tradition (e.g. Gleick 1993; Homer-Dixon 1994, 1999; Klare 2001). Such scholars typically argue that the combined effect of population growth,

increased industrialization, resource degradation, and maldistribution of fresh water resources will lead to competition between groups, with armed conflict as a probable outcome.

It is not necessarily clear whether this recognition of diverging interests will produce more conflictual or more cooperative outcomes, though. Unilateral actions by one state, particularly an upstream state that has access to the river's water before it reaches the territory of one or more downstream states, may indeed result in diplomatic or military conflict. Yet states sharing a water resource may also recognize the importance of cooperation for guaranteeing each sufficient access to water resources, in which case the shared resource can be a catalyst for cooperation. Some scholars have claimed that water-sharing parties are more likely to solve their water issues through cooperation than conflict (see for instance Lonergan 2001; Wolf 1998, 2002; Kalpakian 2004), with several studies identifying factors that promote the signing of treaties over rivers (Song and Whittington 2004; Tir and Ackerman 2007), and others finding stronger cooperative than conflictual effects of shared rivers (e.g. Brochmann and Gleditsch 2006; Hensel et al. 2006; Yoffe et al. 2003). Dinar and Dinar (2005) also find evidence of an inverted U-shaped relationship between scarcity and cooperation over water; two states with similar extreme levels of scarcity, whether very low or very high, are less likely to cooperate than if they both have intermediate scarcity levels or different scarcity levels.

One of the goals of this study is to determine the extent to which shared water resources push states in conflictual or cooperative directions. While earlier research on interaction over international rivers tended to treat conflict and cooperation as two mutually exclusive events, recent scholarship has begun to take a different approach, which we follow in this study. Rather than examining conflict and cooperation in isolation from each other, this approach suggests that a sufficient understanding of interaction over international rivers requires that these concepts be

studied together (Spector 2000; Brochmann and Gleditsch 2006; Dinar et al. 2007). The next section of this paper develops explicit hypotheses on the management of international rivers, considering both conflictual and cooperative dimensions.

A Simple Model of Conflict and Cooperation over International Rivers

We propose a simple conceptual model of states' interactions over a transboundary river. The model begins with two states that share an international river. One state -- the upstream state -- has access to the water resources of the river before they reach the downstream state, and may choose to take advantage of these resources for such purposes as human consumption, industry, irrigation, and damming for hydroelectric power generation. If it chooses to do so, there may be some effect on the quantity or quality of the river's water that reaches the downstream state, or even on the downstream state's ability to navigate the river. If the downstream state believes that the upstream state's actions are having such an effect (or will have this effect in the future), it may respond by making explicit demands that the upstream state stop or modify its actions in such a way as to protect the downstream state's interests. Finally, if such demands are made, the two sides may choose from any number of actions to address the demands: the upstream state may decide to comply with the demands, the two states may attempt to settle the issue peacefully (whether through bilateral negotiations, talks with non-binding third party assistance, or submission of the issue to a binding third party judgment), or either state may threaten or use military force to support its position.

An earlier paper (Hensel and Brochmann 2007) considered the militarization of disagreements over rivers; the present paper focuses instead on peaceful negotiations over river disagreements. Also, unlike earlier work on cooperation over rivers (e.g. Tir and Ackerman

2007; Song and Whittington 2004), we focus on cooperation in the form of efforts to manage specific disagreements, rather than the signing of treaties (which may come about through mutual agreement with little hint of conflict or disagreement). Our approach is twofold: we first examine the conditions under which explicit disagreements over a shared river break out between states, and then the conditions under which states seek to settle these specific disagreements through peaceful negotiations. Negotiation theory offers reasons to expect that the decision to enter into negotiations is based on several factors, concerning both the river itself and the relationship between the riparian states; these factors combine the arguments from general cooperation theorists like Fearon (1995) and Morrow (1994), as well as more river-specific factors that scholars such as Spector (2000) have held to be decisive when dealing with interaction over rivers.

River Importance

Central to nearly all theorizing about shared rivers is the notion that water is essential to human livelihood. In order for state leaders to be willing to take action to secure access to or preserve a certain good it has to be considered to be of critical importance. Most prominently this has been acknowledged through the concept of scarcity in the literature. But a river is important beyond just this aspect. Such issues as the need for water for agricultural uses, industry or power production are also likely to affect a river's perceived importance. Access to sufficient supplies of water will always be essential, and where water is scarce or under heavy demand it is likely to be considered more important by states sharing water resources such as rivers.

Neomalthusians in particular argue that when water is scarce, competition over the limited access to the resource is likely to lead to conflicts. Keeping in mind that water conflicts

often are small-scale, this is also in line with our theoretical argument. We therefore expect that a claim is more likely to begin where water is scarce. Previous research has suggested that claims were more likely to become militarized once begun when water was more scarce and when demands on water were greater. At least partly because of the risk of military escalation, we argue that the parties will be more eager to attempt to settle their differences peacefully in these same situations. This is because there arguably is very little to gain from a costly war, and both parties will be better off cooperating and sharing the water (see also, e.g., Wolf 1998; Dinar et al. 2007). It should be emphasized, of course, that attempting to settle differences peacefully is no guarantee of success, and that the repeated failure of peaceful efforts may well lead to armed conflict at a later time.

Scarcity by itself does not sufficiently cover the importance of a river. Beyond the relative scarcity and demand for water, we also expect that specific details of individual rivers will have an impact on how they are managed. Historically people tended to settle down along river beds, and agriculture and industry have also frequently been developed along rivers. The longer the river then the more likely it is that it is put to important use and the more interaction opportunities it provides. Thus, the longer the river, and the more uses to which its waters are put (such as irrigation, hydroelectric power generation, and navigation), the more likely we expect it to be to lead to river claims as compared to relatively short rivers that are not used for many purposes. The more essential the river's waters are for sustaining the livelihood of those living along the river, and the more important for the country as a whole, the more likely is it that states will pursue their interests over the river through both conflictual (river claims) and cooperative means (negotiations over their claims).

The same should also be true for rivers that cross an international border from one state's territory into another's, rather than flowing along (and forming) but not crossing the border. In such cross-border rivers, there is a greater opportunity for the upstream state to take actions that reduce the value of the river for the downstream state. This in turn should increase the risk of explicit river claims, as well as the need for negotiations to resolve these claims. We thus propose the following hypotheses:

Hypothesis 1: *A river claim is more likely to begin, and more likely to experience peaceful settlement attempts, where water is more scarce.*

Hypothesis 2: *A river claim is more likely to begin, and more likely to experience peaceful settlement attempts, where demands on water are greater.*

Hypothesis 3: *Longer rivers are more likely to experience a river claim, and more likely to experience peaceful settlement attempts over such claims if they occur.*

Hypothesis 4: *Cross-border rivers are more likely to experience a river claim, and more likely to experience peaceful settlement attempts over such claims if they occur.*

Hypothesis 5: *Claims over more salient rivers are more likely to experience peaceful settlement attempts.*

River Institutionalization

While we accept the general arguments of the Neomalthusians about the possibility of disagreements and perhaps military force over scarce water resources (*ceteris paribus*), we have also argued in the first few hypotheses that this scarcity can induce cooperation. We further believe that the chances for cooperation are higher where greater levels of cooperation already

exist. This follows from the theoretical discussion where insufficient or misleading information and high transaction costs were mentioned as obstacles to cooperation. Former cooperation is likely to ease these uncertainties and provide safer grounds for cooperation. This basic argument has already received some empirical support with respect to rivers, although never for the onset of river claims. Hensel, Mitchell, and Sowers (2006) argue that the presence of institutions in a basin increase the chances of positive conflict management. Brochmann (2006) finds that a signed treaty increases the chances of later water-specific cooperation in a dyad, and at least under special conditions, may reduce later water conflicts.

River-related treaties or institutions are likely to decrease uncertainty and provide grounds for more extensive cooperation than would be expected in the absence of any such arrangements. As a result, the presence of institutional rules and/or procedures for managing a river -- combined with a history of past cooperation under a treaty, and the existence of the treaty's specific provisions as a reference point for the beginning of negotiations -- should offer peaceful alternatives that leave little need for the threat or use of armed conflict. We expect then, that relevant treaties will increase the chances for peaceful settlement attempts over an already issued claim.

Concerning the onset of the claim, the case is less straightforward. As we assume that former cooperation breeds the ground for easier and more open information flows, it is likely that the threshold to issue a claim lowers as the claimant can feel more secure that a dialogue will follow and not a violent attack. Also, by establishing rules for the use of a river at one point in time one can actually set the stage for future disagreements if the situation changes or implementation fails. Nonetheless, we still expect that the overall risk of a claim when some former river cooperation is in place is lower than without such agreements, as one can expect

that possible disagreements might be handled before reaching the level where they would be raised as official claims between heads of state. This leads us to propose the following hypothesis:

Hypothesis 6: *A river claim is less likely to begin, and more likely to experience peaceful settlement attempts, between states that share at least one treaty over the river.*

Context of Relations

We have argued that scarcity and river institutionalization should have positive effects on water cooperation. This should also hold for a more general cooperative relationship in a dyad. Following ideas from liberal institutionalism, we expect that also cooperation in general will increase the chances for peaceful settlement attempts of river claims. Spill-over effects and a general cooperative atmosphere contribute to this. Also, a general environment of trustful relations helps overcome the obstacles to negotiations such as trust issues and information sharing. It is also perceivable that general interaction costs will be lower between to states that already share a cooperative relationship. In addition, as argued by liberal institutionalists, the political environment of domestic politics matters. More precisely, democratic regimes are more likely to cooperate than other states. We therefore expect two democracies to attempt to settle their claims peacefully more often than other dyads. Dinar and Dinar (2005: 7) argue that the political stability of countries most probably will affect the probability of reaching agreements. Scarcity may create an impetus for cooperation, but if one state cannot trust a fellow state to honor and fulfill the agreement, the treaty may never be negotiated.

Regarding the onset of claims the same argument can be used as above to explain why democracies may have more claim onsets. But again we argue that the environment for early dialogue prevents issues to reach the level of explicit claims.

Hypothesis 7: *A river claim is less likely to begin, and more likely to experience peaceful settlement attempts, between states that share a more cooperative general relationship.*

Hypothesis 8: *A river claim is less likely to begin, and more likely to experience peaceful settlement attempts, between two democracies than between other pairs of states.*

We now present our data and variables before we turn to the analysis and discussion of the results.

Research Design

Our empirical analyses investigate the conditions under which states engage in explicit disagreements over shared rivers, as well as the conditions under which they seek to settle these disagreements peacefully. The best way to investigate these two related phenomena is with Heckman selection models, also known as censored probit models or probit models with sample selection, which provide a two stage estimator to deal with non-random selected samples (Heckman 1979). These models allow for the study of a dependent variable of interest (such as peaceful negotiations) that is only observed as the result of a non-random selection process (such as the onset of river claims). This is important because when examining events that are conditioned upon previous events, one must also take into account the cases where the first event did not happen (for the present paper, dyads that never experienced claims in the first place, and

thus could not have had any negotiations). If these cases are not considered, variables that determine the outcome of both events (both claim onset and settlement attempts) may produce selection bias (Reed 2000), and ignoring this selection effect may produce biased standard errors and overstate the significance levels (Heckman 1979).

The Heckman model essentially runs separate probit models for both the selection process and the outcome process, using the predicted probabilities from the first stage of the model (the selection equation) in the second stage.³ This model estimates the impact of each covariate on each stage of the model, as well as estimating the correlation between the two processes' disturbance terms in the model's rho parameter, which helps to indicate whether or not a systematic selection process is at work. For our present purposes, the Heckman probit model will allow us to determine whether our key independent variables have a systematic impact on peaceful settlement attempts after we consider the impact of these variables on the outbreak of claims. It is quite plausible, for example, that factors such as water stress or river institutionalization are most relevant in the initial onset of disagreements over rivers, with little separate impact on the likelihood that the parties involved in the claim will try to resolve it peacefully (once it has begun).

ICOW River Claims

Our research question will be tested using a data set with one observation for each year that two nation-states share a major international river, with separate observations for each such river that they share; Hensel, Mitchell, and Sowers (2006) and Hensel and Brochmann (2007) offer a more thorough description of the dataset.⁴ Due to data availability, this data set currently only includes rivers in the Americas, Western Europe, and the Middle East, although work is

currently underway to expand this to the rest of the world. The list of rivers has been compiled by the Issue Correlates of War (ICOW) project, which defines a major international river as a river of at least 100 miles length that forms or crosses an international border. This information has been collected for the years 1900-2001.

Dependent Variables

River Claim

Our first dependent variable involves the existence of a river claim between two states that share an international river, and is taken from the ICOW project's data set on river claims. An ICOW river claim is defined as explicit contention between two or more states over the usage of an international river; this could involve concerns over the quantity of water flowing through the river, the quality of water, and/or navigation along the river. Official representatives of the government of at least one state must make explicit demands over the quality or quantity of river water reaching their state through the territory of another state or over navigation rights on the river; if only local or provincial officials make such claims or demands and they are not backed up by their national-level counterparts, no claim is coded. This variable is coded as a dummy variable, with a value of one indicating that a claim is underway and zero indicating that there is no claim between these two states over this river during the year of observation.⁵

Negotiation Onset

This variable is also taken from the ICOW project's data on peaceful attempts to settle river claims. It is measured as a dummy variable, taking the value of one if at least one new round of negotiations began over the river claim in a given year, and zero otherwise. This

includes any form of peaceful negotiations, ranging from strictly bilateral negotiations between the claimants to negotiations with the non-binding participation of third parties (as in good offices or mediation) or submission of the claim to a binding third party decision. For more details, see Hensel, et al. (2006).

Independent Variables

River Importance

We conceptualize the importance of a given river in a number of ways. We begin with basin-level data on both water supply and water demands, which allows us to determine the amount of pressure on fresh water resources in the area; a river that flows through an area where water is scarcer or where demands are greater should be considered more important in the sense that we describe in this paper. The Transboundary Freshwater Dispute Database (TFDD) spatial data set at Oregon State University (TFDD 2008) includes two particularly useful basin-level measures of water supply: water discharge (the volume of water that flows through rivers in the basin) and water runoff (the amount of water -- whether from rain, snow melt, or other sources -- that flows over the land surface) in each basin; each measure is log-transformed for our analyses.⁶ It should also be noted that the TFDD data that we employ is only available in snapshot form, with one observation per river basin; there is no time series equivalent that could come close to covering the century-long domain of this study. We thus use this data for the entire time period of the study, arguing that while imperfect, this approach is better than the alternative of excluding water scarcity variables from the analysis entirely.

The TFDD also includes a number of possible basin-level measures of water demands, which offer a second way to measure the relative importance of different rivers (with rivers in

areas experiencing higher water demands being considered more important). We use the average population density in the river basin (logged) to capture the impact of human settlement on water demands. In followup analyses not included in this study's tables, we also test the percentage of the basin covered by cropland to capture the agricultural demand for water (also from TFDD). The population density and cropland variables are too highly correlated to be included in the same models, but their effects are similar, so we only report the results for population demand in this study's tables.

Our third measure of importance comes from the ICOW project and estimates the length of the river, using the best estimates that can be obtained from a number of major world atlases and geographic reference sources; this variable is also log-transformed.⁷ While the basin-level water scarcity and demands data discussed above describe the general hydrological setting in which a given river flows, there is likely to be substantial variation in the relative importance attributed to individual rivers within this setting. All else being equal, we suggest, a longer river should be considered more valuable than a shorter river. These same reference sources are used to identify each river's course, in order to distinguish rivers that cross from one state's territory into another's from those that do not pass through at least one of the state's territory (e.g., by forming the border but only passing separately through one or neither state's territory).

Finally, where a river claim has already begun, we measure the importance of that specific claim using the ICOW project's index of river claim salience (Hensel, Mitchell, and Sowers 2006; Hensel, et al. 2008). This index attempts to measure the overall value of the river that is involved in the claim, based on six factors that are believed to make the river more valuable to one or both of the claimants: (1) river location in the state's homeland territory rather than in colonial or dependent territory, (2) navigational usage of the river, (3) level of population

served by the river, (4) the presence of a fishing or other resource extraction industry on the river, (5) hydroelectric power generation along the river, and (6) irrigational usage of the river. Each factor contributes up to one point per state to the overall salience index, producing a dyadic measure that can range in principle from zero (for a river with essentially no measurable salience) to twelve. For more detail on the coding of salience see Hensel, et al. (2006, 2008).

River Institutionalization

The institutionalization of rivers is measured by the presence of river treaties, and is collected from the TFDD project. We focus on the subset of TFDD treaties that directly address river issues related to the three types of ICOW river claims mentioned above: treaties over the allocation of water quantities between two or more riparian states, treaties with specific water quality provisions, and treaties concerning navigation of international rivers. Treaties with other provisions (e.g. setting the price of hydroelectric power that is produced by a dam on a shared river or agreeing to share technology) are not included.

For studying claim existence, we consider the presence of any qualifying treaty of any of these types over the river. For studying negotiations once a river claim has begun, we only consider the presence of treaties that are relevant to the concern(s) involved in the claim. For a river claim over navigational issues, then, a treaty is only relevant if it directly addresses navigational issues for the dyad in question. For river claims that involve multiple types of river issues, the presence of a treaty covering any of the issue types is considered sufficient to code the river as being covered by a relevant treaty.⁸

Context of Relations

The general context of relations between two riparian states will be measured in several different ways. The main approach that is reported in this paper's tables involved measuring two states' shared memberships in international organizations (IGOs). If two countries have many joint memberships, it is reasonable to assume that they share at least a minimum of common preferences and are more likely to seek to cooperate again. IGOs provide a forum for information sharing and ease transaction costs of cooperation and we expect spill-over effects to other forms of cooperation. We measure joint memberships in IGOs by summing the number of IGO memberships shared by the two countries in a dyad based on the most updated IGO membership data described in Pevehouse, Nordstrom, and Warnke (2004).⁹ This variable covers a range of organizations from large multilateral bodies like the UN to highly specialized organizations like the Mekong River Commission.

In additional models not reported in this paper's tables, we also measure the context of relations between two riparian states by the amount of trade between them in any given year. Liberal institutionalists emphasize the importance of spill-over effects and interdependence, particularly as measured through international trade, as facilitators of cooperation and peace. Here we follow Espey and Towfique (2004), who use trade to predict an increased likelihood of states entering into treaties. Dinar and Dinar (2005) argue that a record of trade between states indicate a history of cooperation that may lower the threshold to enter into negotiations and eventually sign treaties. We include a trade variable in our models with the expectation that countries that trade will have a lower risk of a claim onset between them, but if a claim is started, trade level will have a positive impact on the chance of a settlement attempt. We measure trade using version 2.0 of the COW trade data set.¹⁰

Our final measure of the context of relations concerns joint democracy, which we expect (based on past research) to create an expectation of stability and an atmosphere where agreements are likely to be honored. Joint democracy is measured using the Polity IV data (Marshall, Jaggers, and Gurr 2008), in the form of a dummy variable indicating whether both riparian states are considered democratic (as measured by a value of seven or greater on the Polity index that subtracts a 10-point index of autocratic characteristics from a 10-point index of institutionalized democracy).

Control for Relative Capabilities

Our analyses control for the relative capabilities of the two states, as measured by the percentage of the total dyadic capabilities held by the downstream state in the dyad for the claim onset stage of the model and the percentage held by the claim's challenger for the negotiation stage of the model.¹¹ We believe that this is a reasonable way to capture the impact of capabilities on interactions over rivers; to the extent that the downstream state is stronger than its upstream counterpart, it may not need to pursue an explicit river claim or begin formal negotiations because it may be able to pressure its opponent to accept its demands through less formal means. Once a claim has begun, the challenger's capabilities are most relevant -- whether this is the upstream or downstream state on the river -- because this is the state that is pursuing the claim and seeking to change the status quo on the river. Each state's capabilities are measured by the Composite Index of National Capabilities (CINC) score from the Correlates of War (COW) project's National Material Capabilities data set, which ranges from zero to one and indicates the total percentage of the international system's capabilities are held by the state in question during the year of observation (COW 2008).

Empirical Analyses

Table 1 presents a Heckman probit analysis of the sources of both river claims and, where these claims exist, negotiations to manage or settle the claims. The rho parameter in this model misses conventional levels of statistical significance ($p < .14$), suggesting that there is little systematic relationship between the error terms in the two stages of the model, although the Heckman model still offers important advantages over traditional probit models by being able to measure the impact of variables at each stage of the process. Table 2 supplements Table 1 by examining the marginal effects of the key variables, in order to evaluate the substantive significance of the findings and assist in the interpretation of the results.

[Tables 1 and 2 about here]

Hypothesis 1 explores the role of water scarcity, suggesting that explicit river claims are more likely to begin where water is more scarce, and that negotiations over the resulting river claims are also more likely in these situations. While the hypothesis is worded in terms of scarcity, which is the way most observers conceptualize this situation, this concept is measured in Table 1 by total basin runoff -- meaning that lower values represent higher scarcity, and that the hypothesized effect in this table should be negative (with higher runoff predicting a lower likelihood of river claims and negotiations). The results in Table 1 strongly support these expectations. Greater water availability (and thus lower scarcity) significantly reduces the likelihood of a new river claim ($p < .001$), with Table 2 indicating that moving from the minimum to the maximum levels of water availability in our data decreases the predicted probability of a new claim from .181 (the highest probability reported anywhere in Table 2) to .002. This means that the probability of a claim is reduced roughly a hundred times; river claims appear to be quite

common where water is scarce, and quite rare where it is plentiful. Furthermore, once a river claim has begun, greater availability (meaning lower scarcity) significantly reduces the likelihood of negotiations ($p < .001$), with negotiations being less likely in Table 2 at the maximum level of water availability -- with a predicted probability of .222, or roughly one round of negotiations per five years -- and more likely (.386, or slightly more than one round every three years) where water is scarcest.

Hypothesis 2 suggests that both river claims and negotiations are more likely in areas where demands on water are greater. Table 1 offers mixed support for this hypothesis, which is evaluated using the population density of the river basin's area to measure water demands.¹² Greater demands on water significantly increase the probability of a river claim ($p < .001$), with a nearly sevenfold rise in predicted probability from .003 to .020 when increasing the water demands from the minimum to maximum values in the data set. There is no systematic effect on negotiations within ongoing claims ($p < .38$), though, suggesting that water scarcity is a stronger source of negotiations -- or perhaps that water demands are too complicated to capture their full impact in a single measure.

Hypothesis 3 suggests that longer rivers are more likely to experience river claims, as well as more likely to lead to negotiations during the claim. Table 1 strongly supports both portions of this hypothesis, with highly significant results in both stages of the Heckman model ($p < .001$). Moving from the minimum to maximum river length in the data set produces a substantial increase from .001 to .078 in the predicted probability of a river claim in any given year. The impact on negotiations, while statistically significant, seems to have little substantive significance; moving from the shortest to the longest river length in the data set only changes the predicted probability by approximately .05, or one round of negotiations per twenty years.¹³

Similarly, Hypothesis 4 suggests that cross-border rivers are more likely to experience both river claims and negotiations over these claims. Table 1 supports the first expectation, but not the second. Cross-border rivers are significantly more likely ($p < .001$) than other rivers to produce river claims, with the predicted probabilities in Table 2 increasing nearly fourfold from .003 to .011 for such rivers. The shape of the river has little systematic impact on the onset of negotiations, though ($p < .23$).

There is also little support for Hypothesis 5, which suggests that negotiations are more likely in claims over more salient rivers ($p < .21$). It appears that the importance of river claims -- at least with respect to negotiations -- is largely captured by the combination of river length, runoff, and population density, although other research has found that this salience index has a significant impact on the militarization of river claims (e.g. Hensel et al. 2006; Hensel and Brochmann 2007).

Hypothesis 6 suggests that river claims are less likely to begin over rivers that are covered by at least one treaty. Somewhat surprisingly, the first half of this hypothesis must be rejected, because there is actually a strong positive relationship between river treaties and river claim onset ($p < .001$), with the predicted probability roughly quadrupling from .008 to .035 for rivers that are covered by a treaty. It appears that the existence of at least one treaty over a river offers the basis for new claims, possibly related to one side's failure to meet the terms of the treaty or to one side's desire to extend the treaty to a new area or situation that was not originally addressed. When a claim does begin over a river that is already covered by a treaty, though, negotiations are much more likely ($p < .001$), roughly doubling in probability from .243 to .456 when there is at least one relevant treaty over the subject of the claim on that river. This latter result suggests that negotiations are held roughly every other year when the river is covered by a

relevant treaty, *ceteris paribus*, which is the highest predicted probability anywhere in Table 2. Even if treaties do not prevent the emergence of new claims, then, they appear to create a solid basis for peaceful management of the resulting claim.

Hypothesis 7 suggests that river claims are less likely to begin, and more likely to be managed peacefully through negotiations, between states that share a more cooperative general relationship. The model reported in Table 1 measures this relationship by the number of shared IGO memberships, although similar results are also found using the level of dyadic international trade. There is no systematic impact on river claim onset ($p < .18$), although negotiations are much more likely between states with a stronger general relationship ($p < .001$), with the predicted probability of negotiations nearly doubling from .190 to .346 when the number of shared IGOs rises from the minimum to maximum values in the data set. If the general relationship is measured by trade rather than shared IGO memberships, there is still no systematic impact on claim onset ($p < .96$), but a closer trading relationship significantly increases the likelihood of negotiations ($p < .02$), with a more than fourfold increase in the predicted probability of negotiations from .097 to .464 when moving from the minimum to maximum value of trade in the data set.

Finally, Hypothesis 8 suggests that river claims are less likely to begin, and more likely to be managed peacefully, when the two states are both democratic. As expected, claims are much less likely to begin between democracies than between other pairs of states ($p < .001$), with a decline in predicted probability from .008 to .001. There does not appear to be a systematic impact on negotiations, though ($p < .62$).

Finally, with the clearly close relationship between many of the variables in this model, we ran a number of alternative model specifications to assess the robustness of these results.

Replacing basin runoff figures with basin discharge figures produces nearly identical results; river discharge has a consistently strong and negative effect, with greater levels of discharge reducing both claim onset and negotiations. Replacing population density with the percentage of the basin's total area devoted to cropland produces largely similar results, with neither measure attaining statistical significance. Furthermore, dropping each individual variable from the model produces little change in the effects of the remaining variables. The one exception is that the effect of population density on negotiations becomes highly significant ($p < .001$) and positive when runoff (or discharge) is removed from the model, suggesting that water scarcity is quite important whether measured by supply or demand, although the individual effect of greater water demands is generally washed out by an even greater effect of smaller water supplies when both are included in the same model. In short, we are confident that these results are robust and do not depend on any specific model specification.

Discussion and Concluding Remarks

While armed conflict over rivers has captured the popular imagination, recent research has suggested that states are even more likely to cooperate than fight over shared rivers. This study has attempted to examine the sources of such cooperation, against the backdrop of diplomatic disagreements over the use of rivers. The results of this preliminary effort are quite promising, and suggest a variety of directions for future research.

Together, the results for the first four hypotheses suggest that the value of a given river to the countries sharing it is a very important predictor of states' negotiating behavior. Lower levels of water availability (and thus higher levels of water scarcity), higher demands on water, longer rivers, and cross-border rivers all increase the likelihood that riparian states will come into

diplomatic conflict over a shared river. Furthermore, lower water availability and longer rivers increase the likelihood that states involved in such disagreements will negotiate to try to manage or settle the issues.

A more direct comparison of the substantive effects of the different variables included in our analyses suggests that the availability of water is the most important factor when considering river interaction. If we look at the size of the change in probabilities from Table 2, the increase in water availability is actually the factor that reduces the probability of a claim the most, and it also reduces the probability of negotiation. Water availability is thus key to interaction over rivers. As fresh water is vital, low access will increase competition over the limited resource and disagreements are likely to occur -- but this is also when states are most likely to enter into negotiations to solve these disagreements. This supports the theoretical argument presented earlier, that states will seek to cooperate when an issue is considered vital. However, as Fearon (1995) and Morrow (1994) have noted, negotiations may be hampered by lack of trust and insufficient information sharing. Indeed, an earlier study (Hensel and Brochmann 2007) that uses methodology to the present similar to study the militarization of river claims, finds that lower water availability increases the probability that a given river claim will lead to militarized conflict. This suggests that states are aware of the risk involved in such situations, and that they are likely to take active measures to settle matters peacefully before armed conflict begins -- although these efforts may fail.¹⁴ These results seen together strengthen the theoretical argument as well as the earlier empirical findings (e.g. Brochmann and Gleditsch 2006) that conflict and cooperation over shared water resources are closely intertwined. Policy efforts in international basins should thus focus on overcoming uncertainty and other obstacles to negotiations to prevent disagreements from escalating to militarized conflicts. And as our results also show, at

the dyadic level at least, initiating negotiations may also be helped by an already existing environment of cooperation between the riparians, river specific as well as general.

Water availability thus appear to be key to river interaction. In fact, it is so important for negotiation attempts that the overall salience of a claim does not have any further systematic impact. Although we argued that the importance of the issue raised in the claim will affect the onset of negotiations, this does not seem to be the case when the supply of water is at stake. And as water availability (not surprisingly) is so central, policy makers should focus on securing equitable use among all river riparians as a primary task in governing international river basins. Furthermore, the length and course of the river both proved to have an important impact on the onset and -- for river length -- negotiation of river disagreements. We argued that river length is a measure for the importance of rivers, as a longer river will offer more windows of opportunity for interaction as well as being more ready for development projects and carrying more fish. These rivers are more likely to have several riparians, and the fact that these rivers experience more negotiations than others suggests that cooperative environments in many of the large rivers seem to work; important lessons can likely be learned from more thorough examination of these rivers' experiences with river management and negotiation.

As the above discussion also indicates, previous cooperation and existing treaties increase the chances for negotiations. Hypotheses five and six focused on this. The presence of at least one treaty over the river appears to increase the likelihood of a new river claim, but it also greatly increases the likelihood that the resulting claim will be managed through negotiations. The positive effect of a treaty on claims may seem counterintuitive, but keep in mind that claims are diplomatic disagreements. Although a treaty signing can be considered a particularly significant event in the relationship between dyads in a river basin and it provides an atmosphere of cooperation, this may not last. Failed or insufficient implementation by one or both parties, new

issues emerging not covered by the treaty, and changing political or physical environments are but a few examples of what can cause problems after the signing. Also, as argued earlier, a treaty may in fact lower the threshold for issuing new claims if the claimants feel secure that the disagreement will not be followed by a violent attack. This again underlines the interconnectedness of conflict and cooperation in international basins.

In addition to river-specific cooperation, a more cooperative general relationship between the riparian states also generally contributes to the avoidance of claims and the peaceful management of claims that begin. Even where water supplies are scarce and water demands are high, then, there are reasons for optimism, as other factors can help to avoid or manage river-related disagreements. These results are in line with the theoretical ideas from liberal institutionalism. Cooperation does indeed seem to increase in scope and spread. A general cooperative environment fosters more cooperation.

These results offer an interesting contrast with the results of an earlier analysis of the same cases, which focused on the militarization of river claims (Hensel and Brochmann 2007). Many of the same factors that were found in earlier work to increase the likelihood of armed conflict also appear to increase the likelihood of peaceful negotiations, and we have argued throughout for the need to consider conflict and cooperation together when investigating interaction over shared water resources. This is also consistent with other recent research on the management of territorial and maritime issues as well as river claims (Hensel et al. 2008), which finds that all three issue types -- territorial, maritime, and river -- are generally managed similarly and that more salient issues of each type are likely to see both more conflictual and more cooperative interactions. Future work would do well to investigate these commonalities, in order to explore the specific situations where states are most likely to choose cooperative rather than conflictual techniques to manage or settle their disagreements (over rivers or otherwise).

Another important followup to this study's analyses involves the sources of river treaties. This study has found that river treaties -- while not preventing the emergence of new claims over the use of rivers -- are very effective at promoting peaceful negotiations over any claims that do emerge. Further research would do well to investigate the conditions in which these treaties have been most likely to be signed, following the pathbreaking example of Tir and Ackerman (2007). This would help researchers determine whether such treaties are generally signed in relatively cooperative settings marked by low levels of scarcity and generally positive relations between the riparians, or whether they have also been relatively likely to emerge in the settings where there is the greatest need for their benefits.¹⁵

Finally, one more essential followup to this study's analyses involves the effectiveness of negotiation efforts. In this paper we have explored the conditions under which states are most likely to pursue peaceful negotiations over their river claims, but simply negotiating is no guarantee of success. Indeed, in the ICOW data that we used in this paper, less than one-third of all peaceful settlement attempts ended with a treaty or agreement, and not all of those agreements were able to resolve the entire underlying issue. It would thus be desirable for future work to explore the conditions under which peaceful negotiations are most likely to be successful, which would go a long way toward offering useful policy advice regarding the optimal timing and techniques to be used in efforts to settle issues peacefully.

Endnotes

¹ The negotiation of the Indus River Treaty provides a good example of such complexity. The negotiation of the treaty lasted for almost ten years with periods of high tension and stalemate before the treaty was finally signed in 1960 (see Baxter 1967 for more on the Indus River Treaty).

² At the extreme, Wolf et al. (2005) note that river basins can be shared by as many as eight (Amazon and Lake Chad), nine (Rhine and Zambezi), ten (Nile), eleven (Congo and Niger), or even seventeen states (Danube).

³ The probabilities are transformed into the inverse of Mill's ratio. See Heckman (1979) for a full mathematical explanation of the model.

⁴ The data and coding documentation can also be found at <<http://www.icow.org>>.

⁵ This is somewhat different from coding the variable as a one only in the first year that a new claim begins and a zero in any other year. The approach used in the current study allows us to observe the impact of being involved in a river claim on negotiations. Only coding the first year of the claim would remove most of the benefit of using a selection model such as the Heckman probit that we employ here, because we could only measure the presence or absence of negotiations in observations where the selection variable is present -- i.e., in the first year of the claim. Furthermore, this paper's approach makes substantive sense because the two states involved in a claim must decide to continue it each year, rather than dropping it. Even if they are not beginning a new claim each year, their decisions still keep the previous claim going, and we can then use a Heckman probit model to study the possible relationship between these decisions and the decision to negotiate.

⁶ Where one or both sides of a given international river are governed as colonies or other

dependencies of a foreign power, the water scarcity variables that are used reflect the value for the colony rather than the colonizer, because that is the area affected by the river in question. For example, the water supply and demand figures for France have very little impact on the demand for rivers shared by French Guiana and Brazil, although French Guiana's water supply and water demands likely have a significant impact. All other variables in our analyses (such as democracy and relative capabilities) reflect the colonial ruler, though, as this is the actor that is involved in any conflict or negotiations over the use of the river.

⁷ These rivers have been identified, and their length measured, using a number of sources: the *National Geographic Atlas of the World*, 8th edition; *Times Atlas of the World*, 10th comprehensive edition; *Hammond Concise World Atlas*; Macmillan's *Planet Earth Atlas*; *Merriam-Webster's Geographical Dictionary*; and the *Columbia Gazetteer of the World*.

⁸ It should be noted that this measure is not tautological -- the presence of a relevant river treaty is no guarantee that no river claim will begin, or that any claim will undergo negotiations in any given year. A river treaty may reflect the interests, water supply/demand levels, or relative capabilities of the time period in which it was signed, all of which may be dramatically outdated when compared with the time being studied.

⁹ The dataset used to compile this variable records membership in 495 different IGOs of all kinds, dating back to 1815 (Pevehouse, Nordstrom and Warnke 2004).

¹⁰ The data is available at <<http://www.correlatesofwar.org>>.

¹¹ For rivers that do not cross directly from one state's territory to another's, the upstream and downstream riparians are determined from the overall course of the river. For example, if a river passes through one state's territory before forming the border but never directly enters the other state, then the first state is coded as upstream. Similarly, if a river begins elsewhere, forms the

border for a while, and then enters one state's territory, then that state is considered to be downstream because actions taken upstream have a much greater effect on it than on its partner.

¹² Admittedly, population density only measures one dimension of the demands that may be placed on water. We have run the same analysis while replacing population density with the percentage of the basin's area that is used as cropland, in order to investigate the impact of agricultural demands on water; the results are essentially identical. We are unable to include both measures in the same model, though, because they are highly correlated ($r=.73$).

¹³ The predicted probabilities for this variable seem to move in the opposite direction from what is expected. We believe that this results from the two-stage nature of the Heckman model, in which the impact of variables in the outcome/negotiation stage of the model is influenced by the selection/claim stage of the model. In any case, the substantive effect is not large.

¹⁴ In that earlier study, two additional factors that were not statistically significant in this model of negotiations -- population density in the basin and the salience of the river claim -- significantly increased the risk of armed conflict over the river claim.

¹⁵ Our robustness checks, reported at the end of this paper's empirical analyses, suggest that there is not a strong selection effect with respect to the decision to sign river treaties. Removing the "river treaty" variable from the model did not alter the effects of the other statistically significant variables, nor was the effect of this variable altered by removing other variables from the model. Nonetheless, future work could benefit from much closer consideration of this possibility.

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Table 1: Accounting for River Claims and the Onset of Negotiations, 1900-2001

<u>Variable</u>	<u>Coefficient (Robust S.E.)</u>
<i>Outcome: Negotiation Onset</i>	
Log(basin runoff)	- 0.15 (0.04)***
Log(pop. density in basin)	- 0.06 (0.07)
Log(river length)	0.26 (0.09)***
Cross-border river	- 0.50 (0.41)
Salience of river claim	0.04 (0.03)
Relevant river treaty	0.36 (0.13)***
Log(shared IGOs)	0.08 (0.03)**
Joint democracy	- 0.10 (0.21)
Challenger capabilities	- 0.35 (0.27)
Constant	- 2.02 (0.81)***
<i>Selection: River Claim</i>	
Log(basin runoff)	- 0.18 (0.01)***
Log(pop. density in basin)	0.11 (0.01)***
Log(river length)	0.39 (0.03)***
Cross-border river	0.41 (0.07)***
Any river treaty	0.59 (0.05)***
Log(shared IGOs)	0.02 (0.01)
Joint democracy	- 0.60 (0.06)***
Downstream capabilities	- 0.27 (0.07)***
Constant	- 2.97 (0.15)***
Rho (S.E.):	0.84 (0.24)
X ² :	77.22 (9 df, p<.001)
N:	19,907 (509 in 2nd stage)

* p < .10, ** p < .05, *** p < .01

Table 2: Marginal Effects of Statistically Significant Variables

<u>Variable/Value</u>	<u>Probability of River Claim</u>	<u>Conditional Probability of Negotiations</u>
<i>Water Availability (basin runoff)</i>		
3.71 (minimum)	.181	.358
11.95 (mean)	.008	.243
14.57 (maximum)	.002	.222
<i>Water Demands (population density)</i>		
0.00 (minimum)	.003	--
2.74 (mean)	.008	--
6.08 (maximum)	.020	--
<i>River Length</i>		
3.91 (minimum)	.001	.274
5.65 (mean)	.007	.244
8.28 (maximum)	.078	.228
<i>Cross-Border River</i>		
Other river course	.003	--
Cross-border river course	.011	--
<i>River Treaties</i>		
No river treaty	.008	.243
At least one river treaty	.035	.456
<i>Shared IGOs</i>		
0.00 (minimum)	--	.190
1.71 (mean)	--	.241
4.65 (maximum)	--	.346
<i>Democracy</i>		
One or both not democratic	.008	--
Both states democratic	.001	--
<i>Relative Capabilities</i>		
0.00 (minimum)	.012	--
0.54 (mean)	.008	--
0.99 (maximum)	.006	--

Notes

- Predicted probabilities computed with the MFX command in STATA 9.2, based on Table 1. All other variables are held at their mean or modal values while calculating marginal effects.