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Summary

With the growing population and fixed amount of water resources, water availability per capita has been reduced by 60-80 percent over the last 50 years. According to the United Nations Human Development Report 2006, about two-thirds of the world's population could be living under water stressed conditions by 2025. The previous United Nations Secretary General, Kofi Annan declares that "Fierce competition for fresh water may well become a source of conflict and wars in the future." On the cover of a book by Robin Clarke and Jannet King, it says "If the wars of the twentieth century were fought over oil, the wars of this century will be fought over water."

Disputes over water resource allocation within a nation may be peacefully and efficiently resolved under the law. However, it is more difficult to resolve disputes in trans-boundary river basins due to the simple fact that no third party has the authority to enforce an agreement among relevant nations. The partition of British India in 1947 created a conflict over the use of the Indus River between the two newly formed states of India and Pakistan. Another example is that in fear of changing the river flow pattern in the Nile River due to the Grand Millennium Dam in upstream Ethiopia, Egypt strongly objects this dam project.

In almost all cases, the cooperation among all nations within a trans-boundary river basin delivers maximum benefits and so offers possibilities for mutual gain. As our empirical results in Chapter 5 regarding the Mekong River Basin demonstrate, the economic gains from non-cooperation to cooperation among basin-wide states are substantial. However, there exist several obstacles to the basin-wide cooperation: firstly, each country in the same river basin differs in their dependence on the shared river; secondly, there is no census regarding the property rights for international rivers thus this creates more possibilities for conflicts; thirdly, countries also vary in their own characteristics, e.g., population size and political power, etc, and this in turn affects each country's bargaining power when determining the distribution of total benefits from cooperation.

The problems existing in trans-boundary river management have drawn attention from researchers. Although economics is one of the building blocks of cooperation over shared waters, it is surprising that the economic literature is not sufficiently endowed with works related to international waters. In this dissertation, we address three relevant questions in trans-boundary river sharing problems from an economic perspective.

The first problem concerns two fundamental issues in trans-boundary river basin management: efficiency and fairness. Two important seminal works address these two problems and they both assume each agent's welfare is composed of a direct benefit from water consumption and monetary transfers. In the respect of efficiency, Marc Kilgour and Ariel Dinar developed a flexible mechanism that produces an efficient allocation for every possible flow volume in a river. With respect to fairness, Stephan Ambec and Yves Sprumont incorporated two legal principles from the International Water Law into the distribution of total benefits from cooperation. According to the principle of Absolute Territorial Sovereignty, they argue that each group of agents should not get less than the welfare they could obtain by using the water they

control. Using the principle of Unlimited Territorial Integrity, they argue that no group of agents could achieve a welfare higher than what they could obtain in absence of the remaining agents. They show that only one solution satisfies the above two requirements. This solution, the downstream incremental solution, gives each agent their welfare just as their marginal contribution to the groups of agents composed of their predecessors along the river. Both references consider the special case of a line river geography, i.e., all agents position subsequently on a line from upstream to downstream.

In Chapter 3, we extend the river geography from a line to a more realistic river geography by allowing branches to merge at certain locations. We show that the optimal water allocation plan in the above mentioned realistic river geographies has a similar feature as the line river, i.e., in the optimal allocation, each agent's willingness to pay is non-increasing from upstream to downstream. In reality, trans-boundary river basin management will be established through international negotiations by governments. Asymmetry in bargaining powers (related to the GDP, population sizes, political factors, military powers) might exist among all countries. The asymmetric Nash bargaining solution implements the efficient allocation in the trans-boundary river basin management and also distributes the total benefits according to these asymmetric bargaining powers. The essential idea of the asymmetric Nash bargaining solutions is that each agent gets their disagreement welfare plus a fraction (i.e., their bargaining power) of surpluses. We investigate the effect of two possible disagreement outcomes that are based upon two interpretations of the International Water Law: the principles of Absolute Territorial Sovereignty and Unlimited Territorial Integrity. The surplus is calculated by using the total benefits subtract the sum of all agents' disagreement outcomes.

The second problem regards delay in reaching the international environmental agreements. Though cooperation involving all countries delivers maximum benefits, the negotiation process of international environmental agreements is often tedious and countries may strategically manipulate the timing of participation to obtain a higher share of benefits. On the other hand, the benefits of cooperation "lure" all countries to cooperate. We explain this phenomenon from a bargaining perspective by investigating the coalitional bargaining game. In Chapter 2, we study a general coalitional bargaining game based on Gomes (2005) and derive a necessary and sufficient condition for the immediate formation of international environmental agreements composed of all relevant parties. An intuitive result is that if the losses from non-cooperation compared with cooperation are large, all countries might "rush" to cooperate immediately. In Chapter 4, we study what we call a V-shaped river basin in greater detail: two upstream agents control the same amount of water and the downstream agent at the confluence has the highest demand for water. Some intuitive results follow: two upstream agents might form a monopoly first and extract a larger share of benefits when bargaining with the third downstream agent; one upstream agent might "rush" to form a coalition with the downstream agent and extract the maximal marginal benefits. All these "forces" may delay reaching international environmental agreements composed of all relevant parties.

The third problem concerns the plans for dam construction and their impact on trans-boundary river basins. In order to efficiently manage river basins and make the best use of water resources, dam projects are often built for water storage, flood control, hydropower generation, etc. On the negative side, dams change the river flow pattern and endanger the local or even the basin-wide

environment. In Chapter 5, we incorporate dam projects and also their externalities into trans-boundary river basin management. In case no agreement exists in a trans-boundary river basin, each agent will pursue their own interests and ignore other agents' benefits. In case a basin-wide agreement exists, we arrive at a scenario in which all agents in the basin cooperate and the dam externalities might be properly resolved. However, in general, basin-wide cooperation is difficult to attain and partial cooperation involving some agents often exists. For example, four Lower Mekong countries signed the 1995 Mekong Agreement for a long-term sustainable development of the Lower Mekong River Basin. We investigate the internal stability of the agreement, i.e., the benefits from the agreement are sufficient to satisfy each agent within the agreement and no agent will leave.

A detailed study regarding the Mekong River Basin is presented in Chapter 5. The ongoing issue in the Mekong River Basin is that the upstream dam construction in Laos might impact the fishery income in downstream Cambodia. Indeed, as our empirical results in Chapter 5 demonstrate, in case Laos and Cambodia cooperate, Laos might refrain from building some dams in its territory. In the disagreement scenario in which each agent pursues their own interests, almost all dams in Laos will be built to extract hydropower benefits to meet the higher energy demand from neighboring Thailand and Vietnam. We also examine the internal stability of the 1995 Mekong Agreement and our empirical results demonstrate that the 1995 Mekong Agreement is internally stable in terms of unilateral deviation.

In the final chapter of this dissertation, we consider the different topic of pricing issues in the two-sided market. For instance, in a shopping mall, there exist both buyers and sellers. More sellers might cover a large varieties of goods thus stimulate more buyers to visit the mall. Reversely, more buyers might bring more chances for the sellers to extract more profits. Thus, there exist cross-group externalities between the buyers and sellers in the shopping mall. Jean Charles Rochet and Jean Tirole have defined that "Two-sided (or, more generally, multi-sided) markets are roughly defined as markets in which one or several platforms enable interactions between end-users and try to get the two (or multiple) sides 'on board' by appropriately charging each side. That is, platforms court each side while attempting to make, or at least not lose, money overall." In the example of the shopping mall, the price mechanism is largely dependent on the cross-group externalities. We incorporate within-group externalities in the final chapter. For example, more sellers in the same category of product providers might intensify the competition among those sellers. In Chapter 6, we add within-group externalities in the competition of the two-sided market and examine three scenarios of market competition (i.e., monopoly platform, duopoly platform and competitive bottleneck platform). In the previous two cases (the monopoly and duopoly platforms), we conclude that the agent should be priced lower by the platform if they contribute to their own group, i.e., positive within-group externalities. The opposite also holds for negative within-group externalities. In the competitive bottleneck platform, a novel phenomenon may arise that the platform attracts more agents compared with the social optimum.