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Economic theory

Economic theory can be used either directly or indirectly to explain resource problems and to settle disputes over scarce resources, such as water. Economic concepts are applicable in the case of resource conflicts arising from market failure; to the design of institutions and organizational solutions in terms of rules and structures that are socially desirable; and to identify solutions that are associated with gains to all parties involved in the dispute (Loehman and Dinar, 1995). The literature provides several methods that can be adapted to the resolution of conflicts. This section reviews various approaches and how they have been applied to resolving water as well as other resource-related conflicts.

Optimization models

Optimization models provide solutions that, economically, are preferable to all parties and to each of the parties involved. A class of optimization models applied to resource allocation problems can be found in the literature. The optimization models in this review are classified by several approaches: regional planning, social planner approach, inter and intraregional allocations, and markets.

Optimization models and regional planning

Chaube (1992) applies a multi-level hierarchical modelling approach to international river basins, in order to evaluate possible resolution arrangements of the India-Bangladesh-Nepal-Bhutan conflict over the water of the Ganges-Brahmaputra river basin. The modelling approach, as applied in this paper, allows the utilization of existing models and institutional frameworks for the analysis of large-scale real life problems. By breaking the overall problem into hierarchical stages, this modelling approach can analyse the physical, political, economic, and institutional systems.

In contrast to Chaube who uses a static framework, Deshan (1995) presents a large system hierarchical dynamic programming model, which is applied to the Yellow river in China. By incorporating intertemporal effects, this approach allows for the testing of the likely future impact of water availability scenarios on the urban, storage, and hydropower sectors that compete for the scarce water of the river.

North (1993) applies a multiple objective model (MOM) to water-resource planning and management. MOMs are particularly important in water-related conflicts because water conflicts may arise when each party has different objectives in using the scarce resource. MOMs can compare the results of various optimization problems in terms of incommensurate values for economic, environmental, and social indicators.

Fraser and Hipel (1984) modify and apply the hypergame framework (Bennett, 1987) to analyse and solve actual conflicts, such as the Poplar river water diversion conflict between Saskatchuan, Canada and several US states. Hypergames are conflicts in which one or more of the players are not fully aware of the nature of the conflict situation. Such unaware players may not be aware of all the relevant parties; they may have a false understanding of other players' preferences, or may have an incorrect understanding of the options available to the other players. The conditions under which a hypergame approach is needed are relevant to many other water-related conflicts.

Kassem (1992) developed a river basin model that is driven by water demand in each of the nodes (stakeholders, users, countries, etc.) in the river basin. This comprehensive approach takes into account both the available water resources and the characteristics of water use by each of the use sectors. In addition, the model also allows for policy interventions in each of the river basin parties, in order to affect water conservation. Pricing, storage, and administrative quota restrictions are among such interventions.

Social planner approach

Rogers (1993) employs an engineering-economic approach to demonstrate the economic value of cooperation in river basin disputes. Using game theory concepts and technical-engineering data from the Ganges-

Brahamaputra basins, several cooperative solutions to the conflict of regional water sharing are introduced. The common nature of these solutions is that they are technically and economically feasible, they are individually and regionally rational, and they are Pareto-admissible in the sense that no other solution can be preferred by any of the parties.

LeMarquand (1989) suggests a framework for developing river basins that is economically and socially sustainable. At the core of the approach is a river basin authority to coordinate basin-wide planning and execution of basin-wide, multi-purpose projects (water and other regional development). In the case of developing countries, the approach also includes a component to coordinate donor activities. Especially in international rivers, LeMarquand suggests the following conditions for successful water-sharing agreements: (1) similar perceptions of the problem, (2) similar characteristics of the utility function of the parties, (3) similar water production functions, (4) existence of some level of dialogue, (5) a small number of parties involved, and (6) at least one party having a desire to resolve the conflict.

Kally (1989), while evaluating the potential for cooperation in water-resources development between Middle East countries, examines a particular approach that is based on individual water-related projects among two or more parties in the region. It should be noted that in Kally's approach, the water-related projects cut across basins and do not focus on a particular basin. The author suggests that it is possible to envisage different combinations of various projects of potential interest to the particular parties as well as to all parties in the region. However, political considerations other than those related directly to water are likely to determine the level of cooperation in the region and the particular subset of projects to be selected.

Inter and intraregional allocations

Sprinz (1995) investigates the relationships between local (state) production-pollution, and international pollution-related conflicts. Although very specific to international environmental pollution conflicts, there are some features in this work that can be adapted to international water conflicts. The move from closed economies to a situation that allows international trade, international pollution regulation, and global environmental problems, produces a more stable and acceptable solution.

Using the Coase Theorem, which indicates that assigning of property rights to water users will allow optimal allocation of the scarce resource among users, Barret (1994) proves that when there is international interdependence, there is no guarantee that the allocation of water resources will be efficient. Barret applies simple modifications of the Prisoner's Dilemma game to various international water dispute case studies (Columbia, Indus, Rhine), under various treaty and institutional arrangement scenarios. The main conclusion from this work is that the allocation of the joint benefits from an allocation scheme of the basin water among the riparians is the key to an acceptable agreement.

Just et al. (1994) suggest an economic framework to deal with transboundary water issues, and apply it to the Middle East. The core of the approach is joint (with international help) planning and finance of water-related projects that may expand the resource base among countries in the region. Better use of existing sources can occur because the political and economic costs of changing the existing water use patterns are reduced when supply is higher.

Markets

Dudley (1992) introduces the concept of common property and capacity (of a water system such as a reservoir or a river) sharing in the context of water markets and potential disputes over water in large water systems. It is argued that because capacity sharing minimizes the interdependencies of behaviour between users of a water system, it provides a good basis for dividing up the system among the system users.

Case studies

Dinar et al. (1995) review pollution of international lake and reservoir water. It is obvious from the evidence accumulated over time and across the world that the nature of the resolution arrangement to water pollution-related disputes depends on the nature of the pollutant (monitoring and enforcement ability, remediation difficulty). Several case studies are used for illustration (Great Lakes, Aral sea, Mono lake).

Guariso et al. (1981) address the question of efficient use of scarce Nile water resources. Although not directly related to resolution of international conflicts over scarce water resources, one could use the argumentation in the analysis for further discussion of a regional approach. The multi-objective model of using Nile river water for Sinai suggests a trade-off between economic and political objectives, and introduces new (to the region) efficiency concepts, such as irrigation technologies, new cropping patterns, water application scheduling, crop rotation, and more.

Whittington and McClelland (1992) address future possible cooperation strategies for the Nile river basin. The common denominators of international cooperation opportunities discussed are joint development, monitoring, and management of the resource. Suggested mechanisms include individual projects that will benefit each of the riparians, and projects that will benefit some of the riparians. Included are trade-offs between investment – either directly in water-related projects or indirectly in agriculture – and water savings which may benefit all riparian countries.

Okidi (1988) examines macro-policy issues of state involvement in international water basin management in Africa. The paper suggests several issues to be considered concerning effective management: (1) over-politicization of institutions and programmes, (2) proliferation of institutions, (3) mix-up of economic exigencies with political prestige in water projects, and (4) over-centralization of institutions.

Giannias and Lekakis (1994) develop an optimization model for allocation of the Nestos water between water-user sectors in Greece and Bulgaria. Although the general framework of the model is similar to many others that have been reviewed here and elsewhere, it also includes some policy mechanisms to be agreed upon between the countries. Such policies include output price policy, price policy, taxes and subsidies for water-related industries, and trading in water rights. The model also takes into account the outcome of the settlement of the water allocation between these countries and the quality of water discharged to the Mediterranean.

Summary

Economics is one discipline that is used independently or jointly with other disciplines in explaining scarce resource disputes and indicating a set of possible and agreeable arrangements between the parties.

Solutions offered by economic approaches may look promising, but it is always necessary to identify the set of assumptions leading to such solutions. Even with this identification in mind, one can still argue that economic principles are among the sufficient, but not the necessary, conditions for a dispute to be solved.

Using economic terms, for a solution to a dispute to be attractive to the participants and to be economically sustainable, it needs to fulfil requirements for individual and group rationality. This need signifies that the resolution of a dispute for each participant is preferable to the status quo outcome, and to participation in any partial arrangement that includes a subset of the regional participants. The regional arrangement also fulfils requirements that all costs or gains are allocated.

As we well know, economics and politics play interactive roles in the evaluation of dispute resolution. Just as political considerations can effectively veto a joint project with an otherwise favourable economic outcome, a project with potential regional welfare improvements might influence the political decision-making process to allow the necessary cooperation.

Therefore, both economic and political considerations should be incorporated into evaluations of dispute resolution arrangements.

Game theory

Game theory is a relatively new branch of mathematics and the social sciences that has been used successfully to engineer improvements in policy and understanding of many market and non-market events. It is used to clarify decision-making in contexts where one player's best choice in a particular interaction depends, to some extent, on the choice of another player. This "best" choice is termed the "strategic choice." By working out the logic behind the purposeful behaviour of actors involved in some strategic interaction, it is possible to determine how individuals ought to make choices in a particular interaction if they adhere to principles of rationality. The principles of rational choice require that the players' behaviour is motivated by their own goals and values, as modified by their updatable expectations, and as constrained by their resources and the rules of the institutional context in which they find themselves. In the jargon of the theory, we say that a game's outcome depends upon the set of feasible outcomes, participants' choices, and the rules of the game.

This theory is easily shown to be relevant to the engineering of social outcomes.[1] Trying to guide social policy involves two steps: (1) the specification of social goals and (2) the design of institutions, rules, or strategies to channel the social outcomes toward those goals. The theory of games coupled with experimentation is ideally suited for these goals. After all, the idea behind a game is that institutions and agreements determine the rights and powers of participants. They determine both the acts available to players and the consequences that result from any pattern of acts taken by the set of participants.[2] The acts of the participants, and hence the social choice from among the feasible alternatives, depend upon both the choices of the actors and the institutions which define the processes and their rules. These rules, which govern, or at least influence, the outcome of the overall game, form the basic context of the decisions.

As in all science, the theory cannot be "sufficiently closed" without empirical understanding of the exact details of the rules, the institutions. Thus, any useful policy applications require a continual interplay between theoretical formulations, manipulation of real world assumptions, and careful observation to monitor the status of the theoretical predictions.

For us, game theory allows for an analysis of the economic and political aspects of a shared regional water problem in a manner that promises some increased leverage. International water disputes typically involve a relatively small number of participants, each with different objectives and perspectives.

A quantitative and theoretical analysis can be performed to show how a number of players might react to a situation in order to identify the likely properties of the outcomes resulting from rational choice on the part of the participants. One can then examine the likely outcomes to see if they conform to such criteria or goals as "Pareto-optimality," or whether they have standard stability characteristics (e.g. no player can gain by unilaterally moving away from that point). Therefore, one can investigate, using the tools of game theory, the prospects for cooperation in environments of choice. Such analysis can then be used to help design different and preferable contexts of interaction and negotiation.

Game theory has been applied to issues as diverse as national security, social justice, and religion. But it has been applied to international water conflicts only sporadically. Rogers (1969) analyses conflicting interests along the Lower Ganges and suggests strategies for cooperation between India and Pakistan. Dufournaud (1982) applies game theory to both the Columbia and the Lower Mekong to show that "mutual benefit" is not always the most efficient criterion to measure cooperative river basins. Dinar and Wolf (1994) use cooperative game theory to explore the economic pay-offs that might be generated in a technology-for-water exchange between Israel and Egypt, and how those pay-offs might be distributed to induce cooperation.

Many specific games have become models for particular problems. Certainly the most famous of such games is the two-person Prisoner's Dilemma game (2-PD). In such games one can examine the relationship between cooperation, self-interested behaviour, and efficiency. Political scientist R. Axelrod, has argued, in two-person situations, involving specific sorts of games,

> A player who in an opening move acts generously and on a responding move acts cooperatively, never initiating attack, will outscore any other strategy, given time and averaging.[3] (cited in Painter, 1988)

In practice, however, the games being played between competing nations are far more complicated and the ensuing relationship between cooperative stances and receipt of rewards may be far weaker:

> A strong positive relationship exists between tendencies to initiate and to receive international conflict. The correlation between cooperative initiation and receptive tendencies, however, is much weaker. (Platter and Mayer, 1989)

Nevertheless, other games can and have been used successfully as models of international conflict. In these and other essays it can be seen that game theory offers a framework for some level of analysis that might shed light on international water conflicts. For example, when the demand for water of a population in a water basin begins to approach its supply, the inhabitants have three choices:

- They can work unilaterally within the basin (or state) to increase supply – through wastewater reclamation, desalination, or increasing catchment or storage – or decrease demand, through conservation or greater efficiency in agricultural practices.
- They can cooperate with the inhabitants of other basins for a more efficient distribution of water resources. This cooperation usually involves a transfer of water from the basin with greater resources.
- Or, they can make no changes in planning or infrastructure and face each cycle of drought with increasing hardship. This is the option most often chosen by countries that are less developed or are racked by military strife.

These options are equally applicable to the problems facing inhabitants of a single basin that includes two or more political entities. Each can be modelled (see Falkenmark, 1989a and LeMarquand, 1977) for related work.

Although the last alternative may seem unreasonable, game theoretic models can help to explain how nations may make choices based on their underlying interests and the strategic structure of the game itself.[4] The modeller can then try to make prescriptions in such cases to change the contexts so as to lead to more efficient and welfare enhancing outcomes.

To solve the problem of water allocations cooperatively within an international water basin, a number of problems can be analysed using game theory:

- In international contexts, each sovereign party is free to break any agreement at little cost. Hence any engineered solution must be sensitive to the stability aspects of the proposed outcomes.
- For cooperation to occur, the parties must have some incentive which can justify the cooperation.

This latter point implies that for a cooperative solution to be accepted by the parties involved, it is required that (a) the joint cost or benefit is partitioned such that each participant is better off compared to a non-cooperative outcome; (b) the partitioned cost or benefit to any subset of participants (in the cooperative solution) are preferred by the subset to any other possible outcome they can guarantee themselves. Of course, in the real world of international relations, it also must be that all the costs are allocated.

The economic literature dealing with application of game theory solutions does not provide many examples of regional-international water sharing problems. As indicated above, Rogers (1969) applied a game theory approach to the disputed Ganges-Brahmaputra sub-basin that involves different uses of the water by India and Pakistan. The results suggest a range of strategies for cooperation between the two riparian nations that will result in significant benefits to each. In a recent paper, Rogers (1991) further discusses cooperative game theory approaches applied to water sharing in the Columbia basin between the US and Canada, the Ganges-Brahmaputra basin between Nepal, India, and Bangladesh, and the Nile basin between Ethiopia, Sudan, and Egypt. In-depth analysis is conducted for the Ganges-Brahmaputra case where a joint solution improves each nation's welfare more than any non-cooperative solution (Rogers, 1993).

Application of metagame theory, which is a non-numeric method to analyse political conflicts, has been applied to water-resources problems by Hipel et al. (1976). The resulting outcome of a conflict is a set of strategies most likely to occur and their pay-offs to each participant.

Becker and Easter (1994) have analysed water management problems in the Great Lakes region between different US states and between the US and Canada. A central planning solution is compared to a game theory solution with the result being in favour of the game theory solution.

Dinar and Wolf (1994), using a game theory approach, evaluate the idea of trading hydrotechnology for interbasin water transfers among neighbouring nations. They attempt to develop a broader, more realistic approach that addresses both the economic and political problems of the process. A conceptual framework for efficient allocation of water and hydrotechnology between two potential cooperators provides the basis for trade of water against water-saving technology. A game theoretic model is then applied to a potential water trade in the western Middle East, involving Egypt, Israel, the West Bank, and the Gaza Strip. The model allocates potential benefits from trade between the cooperators. The main findings are that economic merit exists for water transfer in the region, but political considerations may harm the process, if not block it entirely. Part of the objection to regional water transfer might be due to unbalanced allocations of the regional gains and, in part, to regional considerations not directly related to water transfer.

As the amount of water surplus decreases over time, however, the impetus towards conflict or cooperation (pay-offs) might change, depending on such political factors as relative power, level of hostility, legal arrangements, and form and stability of government.

Notes

1. See Plott (1978: 207) for a similar analysis.
2. The principles of game theory are not discussed here in detail, but can be found elsewhere. (See, for example, Shubik, 1982, and the other entries under "texts.")
3. Actually, even in the limited domain of his inquiry, his claim was suggestive, but wrong. To see the errors, read Bendor and Swistak (1995: 3596–600).
4. Bueno de Mesquita and Lalman (1992), for example, show how choices leading to war can be rational, despite a mutual preference by disputants for peacefully negotiated agreements.