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Article under review
M. Zarezadeh, K. Madani, and S. Morid. Resolving conflicts over trans-boundary rivers using bankruptcy methods

This paper adapts bankruptcy methods to determine allocations of water in a transboundary river system when water supply is insufficient. I think that it makes a contribution, but it raises several issues that it does not address, and that what it does say it could say better. I recommend "Major Revision" in light of the comments below.

The Introduction points out that there are many international rivers in the world; nonetheless the main example, a river that lies entirely in Iran, is not one of them. In fact, there is no discussion of the conditions under which an interprovincial river (or, in the USA, an interstate river) is effectively equivalent to an international river. Another issue with the example is that it has two main branches (Fig. 2), but the theory (Fig. 1) assumes a linear river (with no tributaries, effectively), so it is not clear how the theory applies to the example.

The authors claim that they are going to develop a new water allocation mechanism that (1) requires minimal utility information from the riparians, (2) is not limited to problems in which cooperation must result in quantifiable benefits, and (3) provides allocations that can vary temporally and spatially as flows vary. Do they achieve these objectives? They do a good job on (1); (2) I don't understand; and they can accomplish (3) by rerunning the analysis every time inputs or demands change, which is an easy solution but doesn't yield any insights.

In fact, what they do is adapt several standard bankruptcy procedures to the river water allocation problem. A bankruptcy procedure produces an allocation of assets among claimants when the total of the claims exceeds the assets. Usually bankruptcy procedures are expressed in money, but here the assets and the claims are amounts of water. Because bankruptcy rules adjudicate claims only, they take no account of the importance (utility) any particular claim: All claims are of equal weight, and differ only in amount. Because of this property, objective (1) is automatically satisfied.

I think that the authors understand bankruptcy methods, at least in a technical way, but there is an issue about applicability that they do not address. Bankruptcy methods have been applied to water resources previously (the Caspian Sea, for example), but the previous applications have all (quite rightly) involved parties in symmetric positions. For example, any riparian can draw water from a lake, or by withdrawing less water make a transfer to any other riparian, who can then withdraw more.

This is not the case for provinces (or states, or countries) along a river, as in Figure 1. For example, if $I_{3,t}$ happens to be very large, can province 3 transfer some of its excess water to province 1? Not easily, because water runs downhill, so the flow in province 2 must be non-negative. Perhaps this is not a practical issue, since in typical river basins the inflows are highest near the source. But it is an issue for the fairness of a bankruptcy method, which is not fair if all of the transfers must be downhill. This methodology cannot be expected to show the widely perceived strategic advantage that geography gives to upstream riparians over downstream.

In a technical sense, the authors could address the problem by a condition like $O_{i,t} \geq 0$. The fact that they don't do this suggests that they haven't thought of this possibility, which in practice is admittedly unlikely to be feasible. But the possibility of any transfer is essential to the fairness of bankruptcy allocations, which have little to recommend them if they cannot be seen as "fair." This point seems to make conclusions about fairness fundamentally flawed.

The description of an allocation rule, such as **3.1**, would be easier to understand if it were clarified what are the data and what is specific to the method. I think that the data are the initial conditions (at $t = 0$) and the inflows, $In_{i,t}$. As the authors point out, (2)–(9) are common to all rules, so the presentations would be simpler if they appeared only once. The calculation of $\lambda_{P_{i,t}}$ is clear, but it's not clear how to calculate λ_{P_t}, since (11) is only a constraint, and all λ's are positive.

This paper adds some material on stability, but it does not make much of a contribution. The "plurality index" amounts to the result when provinces "vote" for their most-preferred method. As any Social Choice text will demonstrate, plurality voting is a poor way to carry out a group decision. (There is no agreement on which way is best, but there is general agreement that plurality is the worst of the methods in common use.)

The power index introduced in (25) is also rather simple (assuming that X_i and x_i are intended to be the same), as the denominator on the right side of (25) is the same for all values of i, so player i's power is simply the amount by which i's allocation falls short of i's claim. Minimizing the variability of the stability (actually, instability) measure S_α can then be understood as favoring allocations that are, as nearly as possible, equally far below the corresponding claims. It is therefore hardly surprising that the CEL (Constrained Equal Losses) rule comes out best according to this index.