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Incomplete water securitization in coupled hydro-human production sytems

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Due to the dynamics, the externalities and the contingencies involved in managing local water resource for production, the water allocation at basin-level is a subtle balance between laws of nature (gravity; flux) and laws of economics (price; productivity). We study this balance by looking at inter-temporal basin-level water resource allocations in which subbasins enjoy a certain degree of autonomy. Each subbasin is represented as an economic agent i, following a gravity ordering with i=1 representing the most upstream area and i=I the downstream boundary.
The water allocation is modeled as a decentralized equilibrium in a coupled conceptual hydro-human production system. Agents i=1,2,...,I in the basin produce a composite good according to a technology that requires water as a main input and that is specific to the subbasin. Agent i manages her use Xi and her storage Si, conceptualizing surface and subsurface water, of water with the purpose of maximizing the utility derived from consumption Ci of the composite good, where Ci is a scalar and Xi and Si are vectors which are composed of one element for each time period and for each contingency. A natural way to consume the good would be to absorb the own production. Yet, the agent may have two more option, namely, she might get a social transfer from other agents or she could use an income from trading water securities with her contiguous neighbors.
To study these options, we compare water allocations (Ci, Xi, Si) all i=1,2,...,I for three different settings. We look at allocations without water securitization (water autarky equilibrium EA) first. Next, we describe the imaginary case of full securitization (contingent water markets equilibrium ECM) and, in between, we study limited securitization (incomplete water security equilibrium EWS). We show that allocations under contingent water markets ECM are efficient in the sense that, for the prevailing production technologies, no other allocation exists that is at least good as for all the agents and that makes at least one agent better off . On the other hand, allocations under autarky EA will tend to be inefficient, meaning that other allocations may exist that would be preferred by some agents without compromising the interest of the others. By the same token, the in-between case with water securities will generally also fail to achieve full efficiency. Nonetheless, some securitization will always be at least as good as none while it will be better under conditions of water scarcity that are common in dryland area river basins. Hence water allocations under EWS will generally lead to an improvement over those under EA.
It should be noted that the fully efficient equilibrium is only imaginary because it requires a separate water security for every agent, for every period and for every contingency that nature might hold. Clearly, because of dimensionality, this amount of securities will be beyond reach. Therefore, water securitization with a limited number of securities remains as the only practical option to deal with the inefficiency of water allocations under autarky.
The economic theory of incomplete markets provides a useful framework to study limited water securitization. We apply the theory in the context of our water allocation framework using an institutional setting where downstream agent i may secure water from upstream agent (i-1) through an agreement that pays for (i-1)'s water savings. In this manner we identify (I-1) water securities, one for each pair of contiguous agents. Each security addresses, at the local level, the interaction of flows over time and over contingencies that might occur.
Under scarcity conditions prevalent in many river basins, agents will show an interest to supply and demand such securities. In particular, downstream area can often make more productive use of water. Accordingly, in the water autarky equilibrium EA, they would be willing to pay for more water, while, at the same time, upstream users would be prepared to make water savings to the extent that the payment for the security will exceed the value of foregone production losses.
Thus, although inevitably incomplete, water securitization could play a significant role in increasing the efficiency of the allocation of water resources at the basin-level. Evidence from river basins in various parts of the world suggests that gains could be sizeable. This paper dwells upon the advantages and challenges of a transdisciplinary

approach that blends the laws of nature with those of economics. It aims to identify efficiency gains from water securitization while addressing the institutional difficulties of implementation due to inherent incompleteness in markets that allow trade in such securities.