Packaging and Sequencing of Policy Interventions for Sustainable Groundwater Management

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Introduction

Groundwater represents the main source of fresh water on Earth. Like many other water resources, groundwater is mismanaged, leading to overexploitation, aquifer collapse, and ecosystem disasters in many countries. This situation calls for regulation in order to protect aquifers and ecosystems, which are common property. Almost all of the policy interventions considered in the literature have been implemented individually, in isolation from each other, without taking into account the possible interactions and impacts among policies. In reality, applying a single policy to govern an aquifer may neither be effective nor efficient.

We implemented two main policy instruments: water quota and water tax, which have been used in many regulated aquifers reported in the literature. These instruments are applied individually and jointly. The combination of both policy instruments is expected to achieve more efficient results in aquifer management.

The policy instruments are applied to the Western la Mancha aquifer in Eastern Spain, which is used mostly for irrigated agriculture affecting the water table and, thus, affecting the wetland Tablas de Daimiel. The survival of this wetland depends on the recovery of the water table level. Under no regulation, farmers extract more water than the social optimal level, due to not internalizing all the external costs of their activity. Farmers usually ignore two types of externalities generated by their activity: (1) extraction costs externality, and (2) environmental externality. Extraction costs externality is defined as the increase in the cost of groundwater pumping, due to a decrease in the water table level. Environmental externality is defined as the damage to ecosystems connected to the aquifer from a reduction in the water table level.

As an incentive for farmers to internalize the environmental externality, four different instruments are proposed: a water quota, a uniform water tax, a differential water tax (by crop type), and, finally, an instrument of packaging and sequencing of both quotas and taxes along the planning horizon. The paper demonstrates how sets of policy interventions that are packaged and sequenced, with possible triggers to initiate their time of implementation, may be more effective in achieving a sustainable groundwater management than single policies.

Packaging and Sequencing

The concept of packaging and sequencing of policy interventions for groundwater regulation is demonstrated using a hydro-economic model that was developed for the Western la Mancha aquifer, which is managed by a command and control approach. The model evaluates the effect of these
policy interventions on the net present value of the users’ private profits, on the stock of water in the aquifer at the end of the planning period (30 years), and on the net present value of the regional social welfare. The main conclusion is that when policies are packaged and sequenced with triggers that dictate their implementation, there is an increase in efficiency (higher benefits, welfare, and water stock) compared with the implementation of individual policies.

The study demonstrates the usefulness of these two concepts: the use of bundled sets of policies and their sequential implementation. The model calculates and compares the steady state value of the water table level, the net present value of farmers’ profits (gross margin), and the net present value of the social welfare. With this instrument, the social planner can choose the best policy every period and increase the efficiency of the policy instrument.

When policies are implemented individually, the results of the model show that water taxes (both uniform and differential) are preferred to a quota, both in terms of social welfare and gross margin. In the case of the water taxes, a differential tax outperforms the uniform tax. A differential tax is not only more equitable (polluter pays) but also more efficient in terms of social welfare and farmers’ gross margin. However, the differential tax instrument has two complications: on one hand, the derivation of the tax level depends on the value of the environmental damage; on the other hand, the implementation of this instrument is not obvious, due to information needs and administrative costs.

**Conclusion**

The results of the sequential package of quota and tax outperform those of the individual policy instruments in obtaining both higher net present value of total gross margin and higher values of net present value of total social welfare. There is clearly an increase in efficiency with the sequential package of quota and tax, compared with the implementation of individual policy instruments.

We should also provide some words of caution. While a sequential package is the efficient policy instrument, one has to observe that it is the longest to reach a steady state; and the least stable along the planning horizon path. While not the focus of this paper, we would like to mention that such policy reforms could open the door for political economy considerations on the part of the farmers and likely failure of the policy.

Another important conclusion of the paper is the importance of the aquifer’s physical parameters. A sensitivity analysis is made with the aquifer storativity coefficient (this value greatly varies, depending on the aquifer area and geological formation). The sensitivity analysis indicates that the package of policies is always the preferred policy instrument in terms of efficiency (social welfare, private benefit, and environmental protection).

This policy note is based on a paper “Collective Action and the Commons: Are Cooperative Groundwater Institutions Stable in the Presence of Environmental Externalities?”

(http://wspc.ucr.edu/working_papers/WSPC_WP_01_0911_policy%20interventions%20groundwater.pdf)