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Can environmental taxes and payments for ecosystem services regulate pollution when the resilience of water bodies is surpassed?

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Can environmental taxes and payments for ecosystem services regulate pollution when the resilience of water bodies is surpassed?

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Resumen

La naturaleza incierta de la propiedad de resiliencia de los cuerpos de agua y los efectos acumulativos de la polución hacen que los instrumentos económicos tradicionales de regulación ambiental no sean suficientes para asegurar la provisión sostenible de agua potable. Los Pagos por servicios ecosistémicos (PSA) no valoran todos los servicios que los ecosistemas proveen y hay incentivos escasos a demandarlos dada su naturaleza de bienes públicos. Se requieren impuestos ambientales más altos que consideren que los cuerpos de agua tienen un nivel muy bajo de capacidad de resiliencia.

Palabras clave: Polución, Agua potable, Impuestos pigouvianos, Pagos por servicios ambientales, Resiliencia

Abstract

The uncertain nature of the resilience of water bodies and the cumulative effects of pollution make traditional economic instruments for environmental regulation not enough to ensure the provision of drinking water. Payments for ecosystem services (PES) do not value all the services that ecosystems provide and there are scarce incentives to demand them given its nature of public good. High environmental taxes that consider water bodies to have a very low level of resilience will be required.

Key words: Pollution, Drinking water, Pigouvian taxes, Payments for ecosystem services, Resilience

Clasificación JEL: D58, D61, D62, H23

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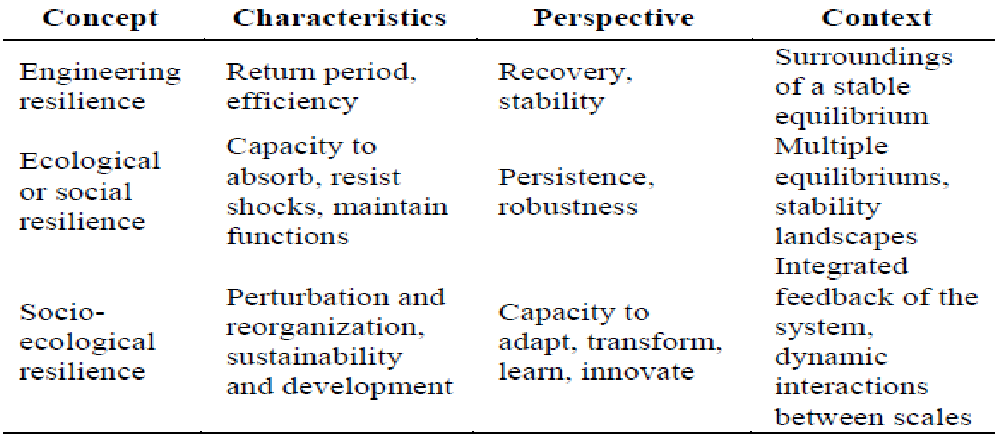
Can environmental taxes and payments for ecosystem services regulate pollution when the resilience of water bodies is surpassed?

Optimally managing the finite availability of water bodies as sinks for natural and man-made pollutants has remained a challenge for researchers and policymakers alike (Tobón, Guerra & Vasco, 2018). This challenge is more important today, given the alarming deterioration of water resources caused by the influence of external events such as climate change that alters the variability in availability of water resources and global market dynamics that push the demand for agricultural and mining products, usually located in vital areas for the provision of drinking water (Florke et al., 2018).

One way to characterize water body availability is according to its resilience. Natural systems' resilience refers to their capacity to recover from a disruption, such as degradation and pollution, which leads to the provision of the necessary resources for economic functioning (Milman & Short, 2008). The cumulative effect of pollution depends on the water body's capacity to recover over time. However, quantifying such capacity is difficult for two reasons. First, it is challenging to measure the initial availability of resources in an environmental system to provide goods and services. Second, environmental system responses to pollution varies as a function of multiple characteristics, including the intensity and magnitude of previous affectations. In consequence, climate change and pollution further strain water availability, affecting both its immediate and future capacity (Calzadilla et al., 2014; Gillingham et al., 2015). Water management systems in general should be designed to ensure not only the provision of public service but also their sustainability and resilience (Blanco-Londoño, Torres-Lozada & Galvis-Castaño, 2016).

Table. Characteristics, perspectives and context of different resilience concepts



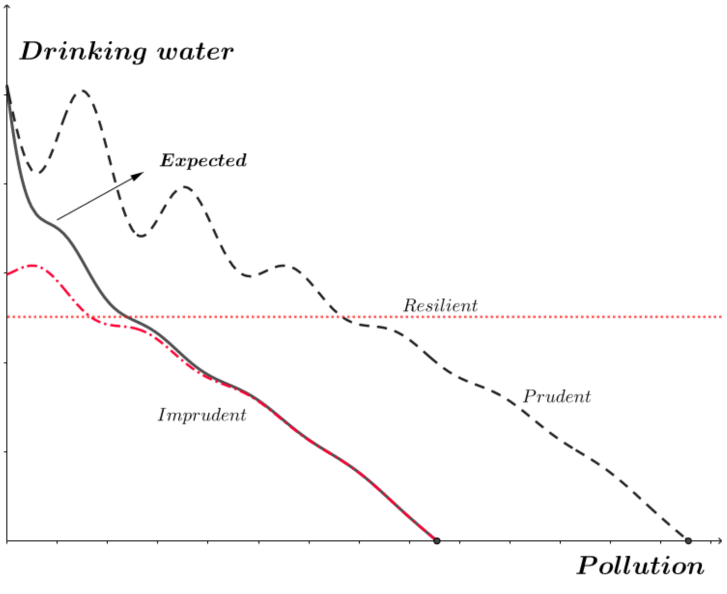
Concept	Characteristics	Perspective	Context
Engineering resilience	Return period, efficiency	Recovery, stability	Surroundings of a stable equilibrium
Ecological or social resilience	Capacity to absorb, resist shocks, maintain functions	Persistence, robustness	Multiple equilibriums, stability landscapes
Socio-ecological resilience	Perturbation and reorganization, sustainability and development	Capacity to adapt, transform, learn, innovate	Integrated feedback of the system, dynamic interactions between scales

Fuente: Blanco-Londoño, Torres-Lozada & Galvis-Castaño (2016).

Using an analytic general economic model we provide an assessment of quantifying the resilience of a water system when it faces a disruption such as a pollution shock (Tobon, Molina & Vargas, 2017), which might have a short and long term effect as a consequence of pollutant concentrations (Gillingham et al., 2015). We assume a starting stock of water body that is used to produce drinking water (D). This stock is renewed naturally each period. However, we also assume the available amount of recharge for D is lessened each period due to increased pollution and for some level of cumulated pollution the deterioration will be absolute. We analyze a relationship that is not proportional between the capacity of response of a natural system to the concentration of pollution and its level of recovery. This means that the technology used to provide D has as a restriction the loss of resilience. If the amount of pollution is such that a threshold of resilience is exceeded, or exceeds a tipping point, the supply of potable water is dramatically decreased whatever the quantity of inputs used to be potable.

Our model allows us to assume either abundant water availability, and thus a high resilience capacity (high scenario), or a non-abundant one, and therefore a low resilience capacity (low scenario). The expected resilience capacity of the body of water to produce D will be in a range between these two states of nature (Figure). The scenario captures uncertainty inherent in many water resource settings where information about the starting capacity and resilience to degradation and pollution is not available. This implies that when thinking about the design of environment regulation to control water pollution, it must be the principle that as pollution increases the probability of being in a low scenario grows at increasing rates.

Figure. Incidence of pollution on drinking water production



Note: Given the characteristics of resilience, D reacts to pollution striving to stay balanced. The solid line characterizes the way D would respond to pollution, where every oscillation in the line represents less valuable steady states. Non-horizontal lines from top to bottom represent: high resilience (dashed line), expected (solid line) and low resilience (dash-dotted line) scenarios. D losses all capacity of recovery when the expected line surpasses the horizontal dotted line (Resilient).

In our baseline scenario, we represent the loss of resilience in the provision of D with a probabilistic distribution, allowing greater probabilities for the provision to be at a more critical level as pollution increases. This indicates that more the provision of D is affected and threatened by pollution, greater its degree of uncertainty, and the higher the risks of losing its resilience capacity. This representation of the relationship between pollution and loss of resilience is a generalization of the probability distributions found by Pindyck (2013), who describes the relationship between greenhouse gases emission and the probability of extreme climate events. Moreover, uncertainty about resilience capacity also must be taken into account (Baumgärtner & Strunz, 2014).

Our general equilibrium model allows to account for different interactions between economic sectors and the drinking water sector, to analyze the overall effects of environmental regulations and social welfare measures. Economy-wide models in these settings are important since the social costs of pollution are a function of productivity losses in other economic sectors if water pollution is not adequately managed.

If polluters are regulated by a tax equal to the social costs generated by the expected loss of resilience capacity, the cumulative effects of pollution will not be accounted for, and thus, it is highly preferred to establish high taxes, in accordance with the belief in a low resilience capacity. However, if social interest means focusing on maintaining resilient capacity in water provision at all times, taxes much higher must be charged (resiliente taxes). This leads to a small reduction in social welfare in comparison with high taxes, given that they are always costlier for the economic system. However, as in our work the possibility that resilience will be reduced at increasing rates as pollution increases has been considered, the application of resilient environmental taxes is socially preferable over time.

Therefore, our model facilitates the valuation of a characteristic damage in natural systems, called resilience, which gives rise to resilient taxes as an application of Pigouvian taxes. These taxes prevent that the pollution exceeds a tipping point from which the capacity of resilience is lost.

We also study the trade-off between environmental taxes and PES (Wunder, 2015). Particularly, in order to identify the effect of each mechanism independently, we estimate alternative scenarios in which environmental taxes are limited (or where their applicability is very low given the high costs of implementation which is very common in emerging countries), and that they are replaced with the private PES initiatives. Alternatively, the sector that provides drinking water will plan to invest in these payments to encourage the polluting sectors to protect the ecosystems required to maintain water bodies, for instance, by planting trees, reducing the crop area and the level of agricultural activity and therefore pollution. However, in this case, the consequences are discouraging. If this sector negotiates payments at the cost of opportunity to reduce polluting sector production, this implies a great reduction in its private profits, which means there will be no private incentives to invest in payments and to protect the ecosystems. To make this alternative viable, policy makers should consider that drinking water companies have incentives other than private earnings, such as protecting the body of water at levels that are much higher than when they maximize their benefits.

When analyzing the influence of PES, it is assumed that no resilient taxes are paid, or that the taxes that are paid are very low or too expensive to administer, which is common in emerging countries. Since PES that replace resilient taxes are very expensive, and as only the drinking water sector is supposed to buy them, this sector will have no incentive to pay for them.

Policy implications

Since it is difficult to measure the effect of pollution on a water body's resilience, prudent taxes are recommendable, which will account for a low resilience capacity and high social costs of pollution. On the other hand, resilient taxes will be recommended if we assume the cumulative effects of pollution, the prediction errors in measuring resilience, and water irreplaceability in production and consumption prices. The prices of polluting sectors increase ostensibly as a consequence of any environmental taxation. This implies the urgent need to increase environmental taxes gradually since these would be much higher than the environmental taxes normally charged. In any case, the principle should be that economic incentives should serve to signal the polluters about the social costs of their actions, and they themselves look for technological options that allow them to reduce the pollution.

As we show in the model, for PES to be effective, it would be necessary for the drinking water sectors to invest in additional environmental services required to protect water bodies, which rarely occurs in practice. In consequence, regulation is essential unless there are any other resources to finance these PES. It might also be possible to think of a hybrid between taxes and PES, so that with the resources raised by taxes, specific funds are created to finance PES.

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