Problem definition

Common-pool resources (CPR) are natural or human-made resource systems whose size or characteristics make it costly, but not impossible, to exclude potential users from withdrawing the resources. Irrigation systems, fishing grounds, and pasture lands are examples of such systems that are usually shared among multiple appropriators. In some cases, these resources can be entirely exhausted if the harvest rate is higher than the regeneration rate. For example, underground water can be depleted, fisheries can collapse due to overfishing, and pastures can degrade into unproductive deserts due to excessive livestock grazing. These situations, often known as the tragedy of the commons, occur because of two main reasons that cause a greater rate of resource consumption than the regeneration rate:

Competition: Each resource user, motivated by self-interest, has an incentive to harvest as much as possible to maximize individual gains ("If I don't use the resources as much as I can, someone else surely will"). Even users who might otherwise prefer sustainable usage of the resources may feel compelled to compete aggressively due to the fear of missing out.

Stock management problem: At its core, the CPR issue is a stock management problem, and research shows that even by ruling out the commons problem (i.e., only a single user benefiting from the limited resources), overexploiting and exhaustion of resources frequently occur. Time delays in resource generation or capital expansion (e.g., fleet expansion in fisheries) are the fundamental reasons for suboptimal decision-making.

The combined effect of competition and the stock management problem makes governing common-pool resources (CPRs) particularly challenging, especially in scenarios where external authorities such as governments cannot effectively control fierce competition. However, research indicates that communities can successfully develop internal regulatory mechanisms to facilitate sustainable resource consumption. One common self-regulating mechanism involves setting withdrawal limits on resource usage based on thresholds collectively perceived by the community as sustainable. Violations of these established limits typically result in community-imposed sanctions to discourage excessive exploitation.

For example, fisheries management in Turkey provides a compelling illustration of successful community-driven governance. Fishing cooperatives in Turkey have historically implemented a licensing system designed to limit fishing efforts and protect marine biodiversity. Fishers who exceed their designated quotas or employ illegal fishing practices face penalties, including fines and the revocation of their licenses, enforced by local cooperative committees. This locally enforced system ensures rapid compliance due to close monitoring and community-level accountability. As a result, many fisheries in Turkey have managed their resources sustainably over several decades, effectively avoiding collapse and maintaining productive fish stocks.

Imposing sanctions is not cheap, and users enforcing it would need to pay (sometimes) significant costs. There are several reasons for the cost. For example, ensuring compliance requires regular

monitoring and oversight, which may involve significant time, financial resources, and labor. Punishing violators entails administrative processes, such as fines collection, license revocation, or other disciplinary actions, all of which consume community resources. Enforcing sanctions can lead to social conflicts within the community, particularly if violators resist or dispute their penalties. This can strain interpersonal relationships and community cohesion. Finally, community members who participate in monitoring and enforcing sanctions typically incur opportunity costs because the time and resources they invest in enforcement could otherwise be used for productive economic activities.

However, a large body of experimental research shows that even when these sanctioning and punishment mechanisms are costly, they are actually very effective in sustainable resource management, and resource users willingly incur such costly activities to control the overall trajectory of their shared resources. Yet some studies suggest otherwise. In this exercise, we want to see under which circumstances the costly punishment is effective for managing CPRs and what the reason for its failure would be.

a. For simplicity, consider shared resources (e.g., groundwater, fish, pasture) and two users. The users own some types of capital (e.g., orchards, fleets, livestock) that rely on the CPR to generate revenue. Investing and maintaining the capital resources is costly. At the same time, harvesting the resources imposes costs, too. More importantly, as resources become scarce, the cost of obtaining an additional unit of resource increases in a nonlinear way. Based on the profitability the users see, they invest in increasing the capital, which can be operationalized with a considerable delay.

b. Introduce the punishment mechanism. User A can impose punitive measures on User B if there is a deviation from an agreed-upon resource consumption rate. Punishment is costly for both punisher (user A) and much more costly for the sanctioned user (user B), which can reduce their profit and lead to corrective actions.

c. Is punishment effective in preventing overexploitation of the CPR? What is the impact of capital acquisition delay on the effectiveness of the punishment?

d. Bonus: One might argue that the rate of resource consumption might not be directly measured, and users may rely on other signals to impose the punitive measure. For example, users might only see the stock of available resources, which would be a determinant of the desired level of punishment. How would that structure be different from the one you created earlier?

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Spring 2025

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