

I Introduction

I.1 WHAT ARE COMMON POOL RESOURCES?

If we ask you to find examples of common pool resources (CPRs), you may consider fishing grounds, hunting grounds, or forests, along with oil fields, pastures, irrigation systems, and aquifers. Other, more recent, examples may include the use of a computer facility or Wi-Fi internet connections that require no password. But, what are the distinctive features that these examples, and CPRs in general, exhibit? For us to qualify a good or service as a CPR, it needs to satisfy two properties:

1. It must exhibit *rivalry* (rival goods), that is, its consumption by one individual reduces the amount of the good available to other individuals. This property holds in all the above examples, where a larger fishing catch by one fisherman reduces the available stock that other fisherman can catch; or the internet browsing by one more individual reduces the Wi-Fi speed other individuals can enjoy.
2. It must be *nonexcludable*, which means that preventing an individual from enjoying the good is costly or impossible. Again, the above examples satisfy this property, since preventing a new fisherman from accessing a fishing ground is relatively costly.

I.2 DIFFERENCES BETWEEN CPRS AND OTHER GOODS

How do CPRs differ from the other types of goods and services we encounter every day? Table 1.1 classifies different types of goods according to whether they satisfy the above two properties: the rows consider whether the good is rival, while the columns evaluate whether the good is excludable. As suggested above, CPRs are rival in

Table 1.1 *Different types of goods.*

	<i>Excludable</i>	<i>Nonexcludable</i>
<i>Rival</i>	private goods (e.g., apple)	common pool resources (e.g., fishing ground)
<i>Nonrival</i>	club goods (e.g., gym)	public goods (e.g., national defense)

consumption but nonexcludable, leaving us with three other types of goods to discuss:

- a. **Private goods:** Starting from private goods, such as an apple, we see that its consumption is rival (if you eat it, I cannot enjoy the same apple) and excludable (if you don't pay for an apple, you cannot eat it).
- b. **Club goods:** We can then move on to club goods, such as a gym membership. Club goods are nonrival since the good can be enjoyed by several members without affecting each other's utility, unless the gym becomes congested. In addition, they are excludable since gym owners can easily prevent nonmembers from accessing the center by requiring users to show a membership card.¹
- c. **Public goods:** Finally, public goods are rival (consumption by one individual does not reduce the amount of the good available to other individuals) and nonexcludable (preventing an individual from enjoying the good is extremely expensive, or impossible). A common example is national defense, since my consumption does not reduce your consumption, and if you were to not pay your taxes tomorrow it would be essentially impossible for the government to prevent you from enjoying national defense even if you didn't help in its funding.² Another common example is clean air, since it also satisfies the two features of nonrivalry

¹ A more recent example of club goods is satellite TV, or pay-TV channels, since their consumption is indeed nonrival (if you watch my favorite TV series, my consumption is not reduced), but excludable since you cannot watch a specific TV channel if you did not pay for it. Generally, most types of copyrighted works, such as books, movies, and software, are club goods since they all satisfy nonrivalry and excludability.

² Well, the government could deport you so you don't get to enjoy national defense, but this is not a penalty for tax evasion. At least not yet!

(your consumption of clean air does not reduce my own) and nonexcludability (how can we prevent you from not enjoying clean air?). Other examples include public fireworks, official statistics, and publicly available inventions through unpatented R&D.

1.3 OVEREXPLOITING THE COMMONS

CPRs share a key feature with public goods, namely that both are nonexcludable, thus making it difficult to prevent individuals or firms from enjoying the good. This can lead to an excessive number of agents seeking to enter into the CPR, as they know that their exclusion is rather costly or, in some cases, infeasible. Unlike public goods, however, CPRs are rival in consumption, which, informally, “makes things worse.” To see this, consider a fishing ground. As a rival good, each fisherman’s appropriation (e.g., 10 tons of fish) cannot be appropriated by other fishermen; a feature that does not apply to public goods where all agents can benefit without affecting each other’s utility (think again about national defense).

The rivalry feature of CPRs can, alternatively, be understood as a negative externality: When a fisherman appropriates one more ton of fish, this ton is not available to other fishermen, which increases their appropriation costs if they seek to maintain their appropriation level unaltered. Intuitively, the commons is more scarce after fisherman i increased his appropriation, forcing all other fishermen $j \neq i$ to spend more time or resources to catch the same amount of fish than before. From this perspective, we can then anticipate that, when fisherman i chooses her appropriation level, she considers her private benefits and costs from appropriation, but ignores the external effects that this imposes on other fishermen (less stock available to catch). If, instead, all fishermen coordinated their appropriation decisions – or if a regulator set appropriation decisions to each fisherman using policy instruments like fishing quotas – they would consider the joint profits of all, internalizing the external effects that each of their appropriations would impose on other fishermen’s costs.

1.4 THE “TRAGEDY OF THE COMMONS” – STATIC AND DYNAMIC COMPONENTS

From our discussion above, the appropriation decisions that each fisherman chooses when left unregulated (which we refer to as the “equilibrium appropriation”) exceed the appropriation level that they would choose if they coordinated their decisions (which is often known as “socially optimal appropriation” as it maximizes welfare for all agents in the society). This means that equilibrium appropriation is *socially excessive* or, more compactly, that the resource is overexploited. This problem is often referred to as the “tragedy of the commons,” as we highlight directly below, and is recurrent in many CPRs such as fishing grounds, forests, and aquifers simultaneously being exploited by several firms, and extends nowadays to policies mitigating climate change.³

Tragedy of the Commons: Equilibrium appropriation exceeds the socially optimal appropriation.

Importantly, the “tragedy of the commons” arises even in static settings where fishermen exploit the commons during only one period, as we discuss in Chapter 2; is emphasized when firms interact during several periods in a dynamic setting, as we show in Chapter 3; and further augmented when firms face entry threats in future periods and use their current appropriation to deter entry of potential competitors, as demonstrated in Chapter 4. This can inform regulators about the relative size of inefficiencies in different CPRs, namely, being:

- nil in those resources where a single firm operates during all periods, as this firm fully considers the effect of its appropriation decisions (i.e., it internalizes these effects), both in its current and future profits;
- larger in commons where more than one firm operates (even if they only interact once) since they ignore the external effects that their individual appropriation imposes on the other firm or firms costs or profits;

³ In the Middle Ages the commons was a meadow that belonged to all farmers in a region (often known as the “commoners”).

- larger in CPRs where a single firm expects (with certainty) that another firm or firms will enter in future periods; and
- even larger in those commons facing entry threats where the incumbent can use her current appropriation to deter the potential entrant from joining the CPR.

I.5 THE “TRAGEDY OF THE COMMONS” UNDER INCOMPLETE INFORMATION

In Chapters 5–7, we insert the standard CPR problem in a different setting. First, Chapter 5 considers contexts in which firms interact repeatedly, either for a finite or infinite rounds, and identifies under which conditions firms have incentives to cooperate, decreasing their appropriation, and thus protecting the commons. Chapters 6 and 7, instead, insert the CPR problem into a setting where firms interact under incomplete information. Chapter 6 considers environments in which all firms face a common source of uncertainty, such as what the available stock is or how they will be affected by each other's appropriation decisions. In that context, we seek to evaluate whether firms' appropriation is lower when they operate under certainty than under uncertainty, as that could help policy makers predict which CPRs will experience a more intense overexploitation.

Chapter 7 considers, instead, a context in which the incumbent is better informed than the potential entrant about the initial stock, which could occur when the incumbent has operated in the CPR for a long time thus accumulating detailed information about the stock. In this setting, the potential entrant observes the incumbent's appropriation, using it as a signal of the (unobserved) initial stock. This signal helps the entrant decide whether the stock is sufficiently abundant to merit entry, or scarce enough to remain outside the CPR. We investigate under which conditions the incumbent has incentives to decrease its appropriation of the resource enough to signal that the stock is low, thus deterring entry. This type of behavior will actually protect the commons, and arises because of the incomplete information setting in which firms interact. In other words, incomplete

information can serve to reduce the above inefficiencies – so prevalent in the commons – if they induce the incumbent to reduce its appropriation to deter future entry. However, we also identify conditions for which the incumbent chooses to increase its appropriation to deter entry.

We then evaluate under which conditions this appropriation reduction is welfare improving – implying that incomplete information generates a larger welfare than complete information settings – and in which contexts incomplete information becomes welfare reducing. These results suggest a role for information management (i.e., regulators choosing to disseminate or conceal information about the stock, or other properties of the commons) that is often ignored in policy discussions.