Common Pool Resources

Common pool resources (CPRs) include, for instance, fishing grounds, irrigation systems, forests, and the atmosphere. Now more than ever, how we responsibly share and use those goods is a vital issue. This textbook introduces students of economics, business, and policy studies to the key issues in the field. It uses a game-theory approach to help readers understand the mathematical representation of how to find equilibrium behavior in CPRs, how to identify the socially optimal appropriation, and how to measure the inefficiencies that arise. Algebra and calculus steps are clearly explained, so students can more easily reproduce the analysis and apply it in their own research. Finally, the book also summarizes experimental studies that tested theoretical results in controlled environments, introducing readers to a literature that has expanded over the last decades, and provides references for further reading.

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Strategic Behavior, Inefficiencies, and Incomplete Information

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Contents

Figures

Matrices

Preface

This textbook offers an introduction to the analysis of common pool resources, such as fishing grounds, aquifers, and forests, using game-theory tools familiar for most undergraduate students in economics, business, and social sciences.

Since Gordon (1954) and Hardin (1968), a large body of literature has emerged – theoretical, but especially experimental and field studies – seeking to understand the main incentives behind individuals and firms exploiting a common pool resource (CPR). These studies also focus on identifying which institutions and information contexts help ameliorate the so-called tragedy of the commons, where every individual ignores the effect that their appropriation causes on other individuals exploiting the resource, leading to its overexploitation. While several authors develop literature reviews, they mostly focus on the institutional arrangements that induce individuals to reduce their appropriation in the commons; see Ostrom (1990,1994, and 2000), Carpenter (2000), Faysee (2005), or Araral (2014).

These are important points, but literature reviews often overlook (or significantly summarize) the mathematical representation of how to find equilibrium behavior in CPRs, how to identify the socially optimal appropriation, how to measure the inefficiencies that arise, and how incomplete information affects equilibrium behavior. This textbook seeks to fill this gap by providing a relatively brief introduction to CPR models and results, specifically targeted to upper-level undergraduate and graduate students.

Our presentation emphasizes the intuition behind each modeling assumption, the steps we need to follow to solve similar CPR problems, and the economic interpretation of each result. In addition, it assumes only a basic background in intermediate microeconomics, and perhaps some game theory, but does not require readers to have a

good command of dynamic programming techniques and differential game theory, as opposed to Dockner et al. (2000).[1] While CPR problems are often presented using these techniques, we believe that the main incentives behind players exploiting a resource can be discussed without the need to rely on advanced mathematical tools. As a result, we expect our text to be appropriate for undergraduate courses in environmental economics and in natural resource economics for students undergoing economics and business degrees, environmental policy for students undergoing public policy or political science degrees, or as a first introduction to the topic for graduate students.

ORGANIZATION OF THE BOOK

Introduction and Static Inefficiencies

Chapter 1 provides an introduction to CPRs and discusses their main features, how they differ from other goods, and why we can expect them to be more intensively exploited when firms (e.g., fishing or logging) do not coordinate their appropriation decisions. Chapter 2 presents the first model, where N firms exploit a CPR during a single period. While the setting is static, it helps us understand how to find equilibrium appropriation for each firm, and how to identify the socially optimal amount that maximizes welfare, where we present different definitions of social welfare. With these two ingredients, we can then evaluate whether equilibrium appropriation is more significant than socially optimal appropriation, and thus a socially excessive exploitation of the resource occurs in equilibrium. In other words, even when firms interact only once, a *static* inefficiency can arise in their equilibrium appropriation.

Dynamic Inefficiencies

Chapter 3 extends our analysis to settings where fishermen interact with each other dynamically. For simplicity, we consider a CPR where

[1] Other intermediate presentations of the topic include Dasgupta and Heal (1979), Conrad and Clark (1987), and Conrad (2010), which also focus on dynamic programming tools.

a single firm operates in the first period and a new firm joins the commons in the second period. In this context, we show that a new form of inefficiency arises: a *dynamic* inefficiency, since the firm exploiting the CPR in the first period ignores the effect of its first-period appropriation on its rival's profits during the second period. The static inefficiency still emerges, but only during the second period, as every firm ignores how its appropriation decisions affect its rival's current costs. We also identify the socially optimal amount of appropriation in each period, letting us precisely measure the size of the dynamic and static inefficiencies.

Greater Dynamic Inefficiencies: Entry Deterrence

In Chapter 4 we still consider the dynamic CPR from Chapter 3, but make an important observation: in the previous chapter, the incumbent exploiting the commons took future entry for granted, as if it could not do anything to prevent it during the first period.

This may, of course, not be the best strategy for the incumbent. In Chapter 4 we examine under which conditions the incumbent may have incentives to intensively deplete the resource during the first period to make entry unprofitable for the potential entrant in the second period. In short, we identify in which cases the incumbent practices "entry deterrence" by exploiting the CPR more intensively than in Chapter 3. Needless to say, this intense appropriation gives rise to a new form of inefficiency or, alternatively, expands the dynamic inefficiency found in Chapter 3; an inefficiency that is due to the incumbent facing an entry threat.

Repeated Interaction

Chapter 5 continues our exploration of dynamic settings, focusing now on CPRs where firms interact repeatedly, such as fishermen operating in the same fishing ground for several periods. For presentation purposes, we consider a context with two firms, each choosing between a high or low appropriation level. We start showing that, in the unrepeated version of the game (one-shot interaction) every

firm finds high appropriation to be a strictly dominant strategy, that is, a strategy that provides the firm with an unambiguously higher payoff than low appropriation regardless of the strategy its opponent selects. In other words, every firm chooses a high appropriation in the equilibrium of the unrepeated game, while the social optimum would call for every firm to choose a low appropriation yielding a higher payoff.

We then consider the finitely repeated version of the game, showing that a similarly inefficient result emerges as when the game is unrepeated, namely, every firm selects a high appropriation in every period of the game. Finally, we consider the infinitely repeated version of the CPR game, demonstrating that cooperation (in the form of low appropriation levels) can now be sustained, as long as firms care enough about their future payoffs. We study different extensions and how the literature tested these theoretical results in controlled experiments.

Incomplete Information

Chapters 6 and 7 introduce elements of incomplete information into our previous CPR models. In Chapter 6, we consider settings where firms simultaneously choose their appropriation levels and one (or both) firms face uncertainty about the available stock. This can occur when firms' technology does not let them precisely know the available fish in a CPR, or how difficult the CPR is to access.

We first analyze a setting where all firms face uncertainty about the available stock, identifying the appropriation that emerges in equilibrium, the socially optimal appropriation, and the inefficiency that arises due to incomplete information. That is, we seek to measure if inefficiencies become greater than when all firms observe the stock (i.e., under complete information). We then consider a similar setting where only one firm is uninformed about the available stock while its rival accurately observes the stock, also finding equilibrium appropriation, socially optimal levels, and the inefficiencies that emerge.

Chapter 7 extends our analysis of incomplete information to settings where firms interact sequentially. Specifically, we consider a CPR where an incumbent firm operated for a long period, being able to accumulate precise information about the available stock, and a potential entrant, uninformed about the stock. The latter can, nonetheless, observe the incumbent's appropriation to infer the stock's abundance, e.g., if the incumbent appropriates large amounts (bringing tons of fish to port every day) the stock is likely abundant. The potential entrant uses this information to update its beliefs about the stock, and then choose whether to enter or stay out.

We find an equilibrium where the incumbent chooses to appropriate the resource less intensively than under complete information (underexploit) to "convey" the stock to the potential entrant, making the latter interpret that the stock is too low to merit entry. A similar equilibrium can be sustained where the incumbent facing a large stock chooses a low appropriation level to "conceal" the abundant stock from the potential entrant and deter entry. In both cases, underexploitation can help ameliorate the excessive exploitation of the resource that arises under complete information, thus mitigating the inefficiencies we encountered in previous chapters. We then discuss the role of information in the commons, and its welfare improving or reducing effects.

ANCILLARY MATERIALS

The following ancillary materials are available online at www.cambridge.org/9781108831031.

1. *Solutions Manual for "Common Pool Resources"* (only available to instructors). This includes step-by-step answer keys to all end-of-chapter exercises.
2. *PowerPoint slides* (only available to instructors). They cover the main topics in every chapter of the textbook. The slides include all definitions, equations, short explanations, and figures, thus facilitating class preparation. Slides can also be distributed to students as a first set of lectures notes they can complement with in-class explanations.

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