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Can incomplete information lead to under-exploitation in the commons?

Ana Espínola-Arredondo^a, Félix Muñoz-García^{b,*}^a School of Economic Sciences, 111C Hulbert Hall, Washington State University, Pullman, WA 99164, United States^b School of Economic Sciences, 103G Hulbert Hall, Washington State University, Pullman, WA 99164-6210, United States

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ABSTRACT

This paper analyzes the protection of a common pool resource (CPR) through the management of information. Specifically, we examine an entry deterrence model between an incumbent perfectly informed about the initial stock of a CPR and an uninformed potential entrant. In our model, the appropriation of the CPR by the incumbent reduces both players' future profits from exploiting the resource. In the case of complete information, we show that the incumbent operating in a high-stock common pool overexploits the CPR during the first period since it does not internalize the negative external effect that its first-period exploitation imposes on the entrant's future profits. This inefficiency, however, is absent when the commons totally regenerate across periods. Under incomplete information, we identify an additional form of inefficiency. In particular, the incumbent operating in a low-stock CPR under-exploits the resource in order to signal the low available stock to potential entrants, deterring entry.

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1. Introduction

The “tragedy of the commons” has been analyzed by scholars in different disciplines. Specifically, the “tragedy” examines how open access common pool resources (CPRs), such as fishing grounds, forests and water systems are prone to overexploitation. Indeed, users do not internalize the external effect that their independent decisions impose on other agents also exploiting the commons, leading to an overuse of the resource.¹ As a result, multiple studies focus on how to prevent the overexploitation of the commons by analyzing the CPR game as part of a larger environment in which agents interact, examining whether agents select socially optimal actions.

This paper follows a similar approach by analyzing the CPR game within a context of incomplete information among players. We investigate under which conditions this informational setting helps prevent the “tragedy of the commons.” In particular, we consider an incumbent who privately observes the commons' initial stock and an entrant who infers the level of the stock by observing the incumbent's previous exploitation, deciding then whether or not to join the CPR. This environment describes multiple CPRs which are initially operated by an incumbent, who usually gathers more accurate information about the available stock than potential entrants. For instance, Pinkerton and Ramirez [2] study CPRs in seven coastal fishing communities in Loreto (Mexico), where local fishers have access to more precise information about the

* Corresponding author. Fax: +1 509 335 1173.

E-mail addresses: anaespinola@wsu.edu (A. Espínola-Arredondo), fmunoz@wsu.edu (F. Muñoz-García).

¹ Note that agents exploiting a CPR hence share similar incentives with those competing in a prisoner's dilemma game, or in a public good game as in Bergstrom et al. [1]. In particular, the equilibrium of the game does not necessarily coincide with the Pareto optimum for the group.

state of the stock than those located at different fishing grounds, who base their entry decision upon the incumbents' actions. Our paper analyzes agents' use of the resource in these informational contexts by focusing on how the incumbent's exploitation of the CPR can convey or conceal information about the actual stock to potential entrants. In addition, we investigate under which conditions the incumbent's incentives to deter entry can serve as a tool to actually promote the conservation of the resource.

As our benchmark, we first study equilibrium appropriation under complete information. When the initial stock is low, the entrant does not join the CPR. The incumbent is hence the only agent exploiting the resource across time, fully internalizing the negative effect that an increase in first-period exploitation causes on its own future profits. In this case, the incumbent exploits the resource at the socially optimal level. In contrast, when the initial stock is high the entrant joins the CPR and both incumbent and entrant compete for the resource in the second period of the game, leading to the standard overexploitation result in CPR games, i.e., the "tragedy of the commons" emerges. Furthermore, we identify an *additional* form of inefficiency. In particular, the incumbent does not internalize the negative external effect of its first-period appropriation on the entrant's second-period profits. Hence, the resource is overexploited not only in the second but also in the first period.

We then introduce incomplete information in the CPR game. First, we show that in the separating equilibrium the incumbent's first-period appropriation conveys information about the actual level of the stock to the potential entrant, attracting entry when the stock is high but deterring entry when it is low. In particular, when the initial stock is high entry occurs, as in the complete information environment, inducing the incumbent to overexploit the resource in both the first and second period. Mason and Polasky [3] describe an example about the Hudson's Bay Company that illustrates this result. Faced with the threat of entry from French furtraders during the 18th century, the company increased beaver harvests. Rather than dissuading them from entering, French furtraders built an outpost in the area in 1741. Hence, the overexploitation of the resource by the Hudson's Bay Company could be interpreted as a signal of a high initial stock by the French furtraders.

When the initial stock is low, in contrast, we show that the incumbent's appropriation is below that of complete information. Specifically, in the separating equilibrium the incumbent facing low-stock commons *underexploits* the CPR in order to deter entry. The introduction of incomplete information moves this incumbent away from the complete information equilibrium and thus from the social optimum. The separating equilibrium hence presents the same inefficiencies as the complete information game when the stock is high, but identifies an additional inefficiency—associated with the underexploitation of the commons—when the stock is low. Importantly, this inefficiency is novel in the literature of CPRs and arises from our incomplete information setting, where the incumbent operating in a low-stock common pool conveys the state of the stock to potential entrants in order to prevent entry. The case of the silver hake provides an interesting example of this type of informative signaling. After two decades of intense exploitation by mechanized U.S. and Canadian fishing boats in the North Atlantic from 1960 to 1980, the available stock became significantly depleted. This low stock led to a reduction in the number of vessels and annual catches. More importantly, the incumbent fleet has consistently underexploited the resource below its annual sustainable catch since the late 1990s; see United Nations Food and Agriculture Organization [4]. Such strategy can be interpreted as a signal to potential entrants, informing them that the stock, despite experiencing a mild recovery, has not yet become sufficiently high to support the entry of additional vessels.²

When the incumbent, regardless of the initial stock, chooses the same first-period exploitation (in the pooling equilibrium) no information is revealed to the entrant deterring entry. This result suggests that the incumbent operating a high-stock commons can deter entry as if it owned a property right for the use of the resource. Therefore, the informational asymmetry among players acts in this case as an "implicit protection right" for the incumbent. We then evaluate the efficiency properties of this equilibrium outcome. In the second period, we find that the tragedy of the commons does not emerge since the incumbent is still the only agent exploiting the resource. In the first period we show that the pooling exploitation level coincides with the social optimum when the initial stock is low. When the initial stock is high, however, the pooling equilibrium lies below the social optimum, and hence the high-stock incumbent *underexploits* the resource during the first period.

We finally compare the efficiency properties of separating and pooling equilibria. When the initial stock is high, we show that the separating equilibrium supports an overexploitation of the commons, while the pooling equilibrium predicts an underexploitation of the resource. A precise policy recommendation would hence depend on which type of inefficiency (under or overexploitation) society prefers to avoid the most. If social preferences assign a larger welfare loss to the overexploitation than to the underexploitation of the commons, then our results imply that environmental regulators would increase social welfare by promoting the pooling equilibrium, e.g., setting a quota. Otherwise, the separating equilibrium becomes welfare improving. This policy makes the separating equilibrium less attractive for the

² Underexploitation has also been reported in several other fishing grounds. For instance, Haughton [5] highlights the underuse of blackfin tuna, dolphinfish and diamond back squids, among others, in the Caribbean region. Similarly, a comprehensive study by the United Nations Food and Agriculture Organization [4] indicates the underexploitation of the Argentine anchovy in the Southern Atlantic and the yellowfin sole in the Pacific Northwest. The underexploitation observed in the previous examples could be explained by the difficulty of access or the fishing technology. Our paper suggests that incomplete information can potentially exacerbate this underexploitation.

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