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The tragedy of the commons in international fisheries: An empirical examination

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ABSTRACT

Historically, all capture fisheries have proven hard to manage; internationally shared stocks face an additional impediment to effective management. Previous fisheries studies estimate gains from cooperation for particular species or locations, but evidence is lacking on the wider effect that international sharing has in relation to other variables that affect stock status. This paper is an attempt to shed a broader light on the effect of sharing by identifying whether shared fish stocks are systematically more exploited. I compile exploitation status, biological and economic data into a unique two-period panel of more than 200 fish stocks from around the globe with which I test the theoretical implications of sharing. The empirical results from ordered category estimation suggest that shared stocks are indeed more prone to overexploitation.

1. Introduction

The tragedy of the commons has long been recognized with respect to fisheries [17,19]. This problem of the common pool is pervasive amongst both international and domestic fisheries and managers are trying to cope with limited success. The United Nations Convention on the Law of the Sea [38] was intended to alleviate the pressure on the international commons by extending from a usual three to a 200 nautical mile exclusive economic zone (EEZ) around a nation. Unfortunately, the Food and Agriculture Organization (FAO) has reported that the percentage of stocks harvested at levels above maximum sustainable yield (MSY) has increased from 10% in the early 1970s to 30% by the late 1990s, with another 40% of stocks fished at MSY [10]. This evidence suggests that limiting international entry into the fishery has not resolved the tragedy of the commons.

This paper analyses international sharing by using a unique two-period panel of species from around the globe to identify whether shared fish stocks are systematically more exploited.[1] As this is the first time global variation has been used in fisheries, I compile data on exploitation status along with economic and biological characteristics. The data come from a variety of sources and include newly available catch and price information on more than 200 fish stocks. The use of biological and economic data together allow me to test standard predictions from fisheries economics theory to determine how important international sharing is in relation to other determinants of stock status.

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[1] I follow FAO terminology and use the term "shared" generically to refer to transboundary, straddling and highly migratory stocks. Transboundary stocks are shared by two or more nations' EEZs and straddling and highly migratory stocks cross into international waters.

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The results of my ordered category estimation indicate that the probability of a fish stock being over- (under-)utilised rises (falls) with the number of countries sharing the stock. This negative effect of sharing is apparent when stocks are harvested from either large or small portions of nations' waters, suggesting that access is all that is required to have an effect on stock status. In addition to the detrimental impact of international sharing, some economic and biological characteristics affect stock status, for example, higher valued and slower-growing stocks face further exploitation pressure.

The theory of shared fisheries is considerable and various. It studies, for example, optimal management strategies [29], the noncooperative effects on harvests and stock levels [7,23], mechanisms to attain cooperation for specific fisheries [24], and the interaction between coastal states and distant water fishing nations [27]. While the focus, techniques and applications of these papers may differ, the consensus is that a prisoner's dilemma outcome may result due to both static and dynamic incentives to overharvest even when the countries involved have good management otherwise. This paper explicitly tests this hypothesis across species and countries.

To date, the empirical fisheries literature has considered the potential gains of cooperation for specific stocks rather than testing the degree to which sharing exacerbates the problem of the common pool [1–3,22]. None of these papers investigate the importance of sharing relative to other variables that affect stock status. In addition, case studies, by their very nature, are unable to systematically identify the impact of sharing on different fish stocks. Understanding the relative contributions of international sharing, domestic management, and economic and biological characteristics on fish stocks from around the globe will facilitate appropriate policy advice for fisheries management, particularly amongst countries that must choose where to focus their management resources and in regions where shared stocks are the rule rather than the exception.

Empirical analysis of international sharing has been carried out within other contexts. The success of international pollution reduction agreements has been found to depend on the ability to reduce international externalities [30,31] and studies have shown that international and interstate river pollution and toxic releases from border counties are higher than domestic pollution [20,33,34]. In this paper, I investigate whether the externalities found in the international pollution studies are consistent with the overuse of internationally shared fisheries.

In order to address the fisheries commons problem I take predictions from the Clark–Munro dynamic, single species model and examine these empirically. I find that, consistent with results from fisheries case studies and pollution analyses, international sharing is indeed a driving force in determining stock status.

2. Theoretical foundations

The theoretical foundation needed to determine the necessary control variables and provide predictions for their effects is a multiple player, dynamic, single species model [8]. The Cournot–Nash solution yields a modified golden rule that determines the equilibrium stock level. While the model, and associated equilibrium, is simple and standard, the purpose is to find implications for the variables important in determining fisheries status. Moreover, the variables and implications are consistent with other theoretical work in fisheries. Of particular importance for this paper, it is easy to interpret the number of players as the number of countries that own the fish stock in question.

The competitive problem for n symmetric players is to choose individual effort levels (L_{it}) to maximise their own sequence of profits, taking others' effort levels ($L_{jt}, j \neq i$) and the natural growth of the fish stock as given.

$$\max_{L_{it}} \int_0^\infty e^{-\delta t}[pqL_{it}x_t - cL_{it}]\,dt \tag{1}$$

$$\text{s.t. } \dot{x}_t = rx_t\left(1 - \frac{x_t}{K}\right) - qL_{it}x_t - \sum_{j \neq i} qL_{jt}x_t \tag{2}$$

where profit depends on the price (p), technical capability (q), effort level (L_{it}), stock size (x_t), and average cost of effort (c). Growth of the fish stock is based on the logistic natural growth function, with an intrinsic growth rate (r), natural maximum stock size (K), and stock size (x_t), less the amount of harvesting done by all players. The Hamiltonian for player i is

$$H = e^{-\delta t}[pqL_{it}x_t - cL_{it}] + \lambda_t\left[rx_t\left(1 - \frac{x_t}{K}\right) - qL_{it}x_t - \sum_{j \neq i} qL_{jt}x_t\right] \tag{3}$$

Taking first-order conditions and assuming a symmetric equilibrium, the steady-state equilibrium stock level, $\tilde{x}$, equates the discount rate (δ) with the return from leaving another fish in the ocean:

$$\delta = r\left(1 - \frac{2\tilde{x}}{K}\right) - \frac{r}{n}\left(1 - \frac{\tilde{x}}{K}\right)\left[(n-1) - \frac{c}{pq\tilde{x} - c}\right] \tag{4}$$

The return, on the right-hand side, depends upon the natural growth of the fish stock and the profits from the share of the growth in stock that each player will harvest. The second, longer term on the right gets larger as n rises showing that the incentive to overharvest today, or underinvest in the fish stock for tomorrow, compared to the socially optimal level (that is, with $n = 1$) is due to the possibility that other players may harvest the fish today.