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Sunk costs equal sunk boats? The effect of entry costs in a transboundary sequential fishery

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ABSTRACT

Climate change is likely to result in the uncertain relocation of fish stocks. As a result new countries will emerge that compete for the resource. Although several authors have investigated this issue, most authors assume that entry is free. Although true for some fisheries, this ignores the fact that for other fisheries substantial sunk investments are needed. In this paper I investigate the effect of such sunk entry costs in a sequential fisheries. I model the uncertainty as a shock to the stock dependent fishing costs, in a two player game, where one of the players faces sunk entry costs. I find that, depending on parameters, sunk costs can i) increase the competitive pressure on the fish stock compared to a game where entry is free ii) act as a deterrence mechanism and iii) act as a commitment device. I conclude that entry costs can play a crucial role because they can change the outcome of the game substantially compared to a similar game where entry is free.

1. Introduction

In recent years there has been an increasing interest in the management of fish stocks that are likely to exhibit responses due to climate change. Climate change is expected to have a multitude of yet partly unknown impacts on fish stocks, such as shifts in distributions and changes in recruitment (Britten et al., 2016; Cheung et al., 2010; Rijnsdorp et al., 2009).

These changes pose challenges to the management of these fish stocks, especially when the stocks are transboundary, that is, shared between nations. Additionally, when fish stocks spend part of their life cycle or their full life cycle in the high seas they have to be managed, in principle, by regional fisheries management organizations (RFMOs). In such organizations every country that wants to join the fishery has to be accommodated. Therefore, in principle, they are also shared stocks, although the number of participants is typically larger than with transboundary stocks.

The difficulties in managing these shared stocks have been shown both theoretically for both transboundary fish stocks (see e.g. Clark 1980; Munro 1979 for early contributions) and regional fisheries management organizations (Pintassilgo et al., 2010; Pintassilgo and Lindroos 2008), as well as empirically (McWhinnie 2009). The literature on achieving cooperative outcomes in management of transboundary stocks and RFMOs is broad. Problems addressed include the influence of sequential fishing as opposed to joint fishing (e.g. Hannesson 1995; Laukkanen 2003; McKelvey 1997), the potential of different sharing rules (e.g. Kronbak and Lindroos 2007), the influence of marine protected areas (Punt et al., 2010; Punt et al., 2013; Sumaila 2002), and the influence of the number of players (Hannesson 1997). A broad overview of this literature can be found in Hannesson (2011) and Bailey et al. (2010). The general message of this literature is that it is hard to engage in cooperative management of fish stocks.

These difficulties in achieving a cooperative outcome are further exacerbated by the potential changes due to climate change. Several authors have looked into the potential effects of climate change-induced changes on stability of fisheries agreements. Ekerhovd (2010) studies how the stability of potential agreements for blue whiting changes with changes in stock distribution. He finds that it basically depends on the direction of the change. Brandt and Kronbak (2010) carry out a similar study for the cod stock in the Baltic. They find that climate change effects reduce the set of stable coalitions if it decreases the resource rents. Walker and Weikard (2016) investigate the influence of a changing stock location on the stability of fisheries agreements within RFMOs. They employ both internal stability and a farsighted solution, called farsighted downwards stability as solution concepts.[1] They find that farsightedness is more likely to result in stable

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[1] The difference between these concepts is that internal stability only considers single deviations by players, restricting the other players to the previously formed coalition. Farsighted downward stability also allows other players to respond in kind by leaving the coalition (Walker and Weikard, 2016).

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coalitions than internal stability, but that it is also more vulnerable to changes in stock location.

A special case of such changes is a fishery where a new player emerges due to the stock redistribution. Early contributions in this respect come from Mason and Polasky (1994) and Mason and Polasky (2002). They consider an incumbent agent that worries about potential entry in a deterministic two-period model (Mason and Polasky, 1994) and deterministic continuous time (Mason and Polasky, 2002). In both cases they find that the incumbent has an incentive to deter entry by manipulating the current resource stock and future growth. If entry costs fall over time, the incumbent may even find it profitable to drive the resource to extinction (Mason and Polasky, 2002). Hannesson (2007) investigates a stock that stochastically changes its distribution from a sole owner, through a transition period to another sole owner. He finds that extinction is likely in the case of stock-independent harvest costs, and depletion in the case of stock-dependent harvest costs. Diekert and Nieminen (2016) analyze a similar situation with a fish war model.[2] They find that, as the shift progresses the receiving country will decrease its harvest and the losing player will increase its harvest, unless they are constrained by the share of stock available to them. They also investigate the possibilities for cooperation through sharing of the stock, and find that scope for cooperation increases if the shift is slower and less gradual. Ellefsen (2013) investigates the effect of new entrants on the stability of a fishing agreement of mackerel in the North-East Atlantic. He finds that new entrants destabilize fishing agreements, although the effects are mitigated if entry into the fishing agreement is restricted, or prices are heterogeneous. In a follow-up paper Ellefsen and co-authors allow for entry deterrence and ecological uncertainty. They show that entry deterrence has a positive influence on rents compared to a scenario where entry deterrence is not possible, although both scenarios are worse than the cooperative solution. They also show that if countries disagree about the ecological state of the stock, negotiation of a self-enforcing agreement is difficult (Ellefsen et al., 2014).

An important aspect emphasized by these papers is that the possible shifts of stocks due to climate change are uncertain, and therefore future benefits and costs are uncertain. When combined with a commitment or signaling device the uncertainty can be harnessed to deter entry, as is well known from the industrial organization literature,[3] although much depends on the type of uncertainty and whether or not information is asymmetrical between incumbent and entrant. Maskin (1999), for example, shows that uncertainty about future demand and costs combined with capacity limits entry deterrence possibilities compared to full certainty. Polasky and Bin (2001) show in a two-period game that, if a firm has private information about a non-renewable resource stock, it can either use extraction rate to influence beliefs about stock size to deter entry or deter entry by making entry unprofitable. Creane and Miyagiwa (2009) show that a monopolist facing potential entry and uncertain future production costs for both players may forego a cost-reducing invention in order to deter entry.

However, uncertainty is not necessary to be able to deter entry. Another possible mechanism is the existence of sunk entry costs. This aspect has received relatively less attention in the renewable resource literature. Mason and Polasky (1994) and Mason and Polasky (2002) show the importance of sunk entry costs in a deterministic framework, with the above-mentioned conclusions. Espínola-Arredondo and Muñoz-García (2013) investigate a similar setting with multiple firms instead of two. They find that entry deterrence is welfare improving relative to when there is no entry threat if the resource is scarce, but welfare losses may arise when the resource is abundant.

Although entry costs are thus important in a deterministic framework, because they increase the possibility for entry deterrence, they are even more important in the presence of uncertainty. The reason is that in the presence of uncertainty it may pay to wait with incurring sunk costs until some or all of the uncertainty is resolved, known as the option value in the real option literature (e.g. Dixit and Pindyck, 1994). If, on the other hand, there is competition, this value may be reduced or removed (Dixit and Pindyck, 1994). The literature dealing with the optimal timing of investments in the presence of uncertainty, flexibility and oligopoly is the real option games literature, recently reviewed by Azevedo and Paxson (2014). However, this literature typically deals with continuous time and two potential investors rather than an incumbent and a potential entrant (Azevedo and Paxson, 2014). Finally, sunk costs in combination with uncertainty may act as a commitment device for potential entrants, thereby reducing the threat of entry deterrence by incumbents (Cabral and Ross, 2008).

The earlier mentioned papers that examine the effects of uncertain shifts in fish stocks all assume that entry for the new entrant is free (Diekert and Nieminen, 2016; Ellefsen, 2013; Ellefsen et al., 2014; Hannesson, 2007). Although this is a reasonable assumption for some fish stocks and countries, it is unlikely for others. A country may not yet have a suitable fishing fleet, it may need more boats or another gear type, for example switching from bottom trawl to purse seine. The country will therefore have to incur an investment cost, which are often considered irreversible in fisheries and therefore sunk (e.g. Clark et al., 1979; Sandal et al., 2007; Sumaila, 1995). In this paper I will therefore study the effect of sunk entry costs on a stochastic sequential fishery. I focus on a sequential fishery to simplify the analysis in terms of timing. In addition, whether a fishery is better modeled as sequential or simultaneous fishing is an empirical question because both types exist.

My contribution to the literature is that I show the importance and possible effects of entry costs in a fishery, and contrast them with a situation where no entry costs exist. Also, in contrast to most of the existing literature on entry deterrence in the industrial organization literature my model is dynamic because I consider a renewable resource, and in contrast with the real options game literature I consider a game with an incumbent and a new entrant. I find all effects described above, that is, i) sunk entry costs extend the possibility for entry deterrence and, related, overly aggressive harvesting by the incumbent compared to a case without entry costs, ii) the possibility of an option value for the entrant, and, related, less aggressive harvesting by the incumbent compared to a case without entry costs, and iii) the possibility for commitment, and, related, less aggressive harvesting by the incumbent compared to a case without entry costs. Which of these effects dominates is an empirical question.

2. The model

2.1. Preliminaries

Consider a fish stock that currently migrates between the Exclusive Economic Zones (EEZs) of two countries. Until recently the stock could only be profitable exploited by country 1, but recent changes in the climate make fishing potentially profitable for country 2 as well. Currently, however, country 2 does not yet have the capacity to start fishing, and it has to incur a sunk entry cost the first time it starts fishing. Within one year fishing, if done by both countries, is sequential: country 1 fishes first, then the stock migrates to the EEZ of country 2, and country 2 can start fishing. After that, the stock regenerates and the regenerated stock returns to the EEZ of country 1 and so forth. Such a setting is most naturally modeled in discrete time.

A further climate shock is expected and modeled, for analytical convenience, as uncertainty over next year's harvest costs. This assumption can for example be defended on the grounds that if a stock, due to climate change, spends a longer time within the calendar year within one EEZ, fishing the stock there becomes easier and hence, per unit of harvest, cheaper. The uncertainty is negatively correlated, if the

[2] This model has been named after the article "The great fish war: an example using the dynamic Cournot-Nash solution" by Levhari and Mirman (1980) that first introduced this model.

[3] See Gilbert (1989) for an early overview of uncertainty and other possible ways to deter entry in the industrial organization literature.