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Analysis

The tragedy of the commons in a fishery when relative performance matters

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ABSTRACT

This paper presents a simple model of a common access fishery where fishermen care about relative performance as well as absolute profits. Our model captures the idea that status (which depends on relative performance) in a community influences a person's well-being. In our main specification, relative performance depends on the absolute difference in after-tax profits. We show that overharvesting resulting from the tragedy of the commons problem is exacerbated by the desire for higher relative performance, leading to a smaller steady-state fish stock and smaller steady-state profit for all the fishermen. We also consider alternative specifications where status depends on the absolute difference in harvests or relative difference in profits, or where there is heterogeneity in the degree to which status matters, or allowing for the possibility of extinction. In all these specifications, status further reduces the steady-state fish stock. We examine taxes and an individual quota as policy alternatives and find support for using the direct quantity method to implement the socially efficient stock level.

1. Introduction

The tragedy of the commons has long been recognised in the fisheries (Gordon, 1954; Hardin, 1968) and the Food and Agriculture Organisation has reported that, in 2007, 80% of stocks are fished at or beyond their maximum sustainable yield (FAO, 2009). Recent empirical work by McWhinnie (2009) found that shared stocks are indeed more prone to overexploitation, confirming the theoretical prediction based on a dynamic game model of Clark and Munro (1975), that an increase in the number of players reduces the equilibrium stock level. Fisheries managers are tackling this problem with a variety of instruments including individual quotas, licences and cooperative management.[1] Of note is that management instruments are generally quantity-based (quotas or permits) rather than price-based (taxes).[2]

In this paper we add another factor that reduces the equilibrium stock level: the degree of concern about one's status, as reflected in a measure of relative performance. We start by measuring relative performance as the absolute difference in after-tax profit and subsequently consider alternative specifications where status depends on: the absolute difference in harvests; the relative difference in net profits; and when the degree to which status matters is heterogeneous. We do this within the context of a standard, dynamic fisheries model as this allows us to clearly demonstrate the impact of a relative performance distortion on the equilibrium stock level. It also allows us to evaluate quantity- and price-based policy responses in this multiple-externality situation.

In our model, agents act in their own best interests when harvesting from a common-pool resource. What differs from the standard Clark–Munro model is that, instead of simply maximising profits, our agents also care about status and thus they maximise utility which is a function of both own profit and performance relative to the average. We find that this relative performance distortion exacerbates the tragedy of the commons by providing yet another reason to overharvest. The result of a lower equilibrium stock level holds when relative performance is measured in terms of absolute or relative differences in profit, differences in harvest, and when there is heterogeneity about status concerns, although heterogeneity reduces the impact. Status concerns also expand the range for which extinction is possible.

We consider policy responses that would achieve the social planner's solution. Specifically, we determine the optimal sales tax needed and show how much it must be amplified in the presence of status as

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[1] See Hilborn et al. (2005) for a survey of successes and failures and Woodhams et al. (2011) for a description of biological and economic status and management practice of fisheries managed by the Australian government.

[2] See Hannesson (2004) for a description and evaluation of the global trend in quota systems in fisheries.

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well as commons concerns. When we use alternative measures of relative performance, a sales tax is not effective for all levels of the weight given to status thus we also consider alternative policy options. We find that using the quantity-based mechanism of individual quotas may be preferred to a tax system as it is independent of the degree to which status matters and therefore more directly achieves the target harvest level. This provides some support for the use of direct quantity instruments (such as quotas or permits) when multiple externalities exist, as may be the case for a variety of environmental and natural resource issues.

The facts that relative performance reflects one's status in the community, and that status matters, have been well recognised in the theoretical and empirical literature on interpersonal comparison.[3] Schoeck (1966) discusses the role of envy in social behaviour; Boskin and Sheshinski (1978) show that when agents care about relative income, an optimal redistributive tax must be designed differently; Rayo and Becker (2007) argue that evolutionary forces favour happiness that depends on relative performance. Our analysis of steady-state distortions is related to Konrad (1992) and Liu and Turnovsky (2005). Konrad (1992) found that if agents care about relative wealth, they will over-accumulate the capital stock. Liu and Turnovsky (2005) explore the effects of concerns about relative consumption on the rate of capital accumulation and growth. They show that, when labour is endogenous, these concerns lead to the over-accumulation of capital. In contrast, in our context, relative performance concerns exacerbate the under-accumulation of the stock of natural resources. This occurs because the status distortion increases the value of harvesting today rather than investing in the natural capital stock whereas in Liu and Turnovsky (2005) leisure is sacrificed to allow more capital accumulation and consumption. Our result is more in line with Dupor and Liu (2003): concern for relative consumption leads to over-consumption.

Empirical research by Neumark and Postlewaite (1998) shows that relative income consideration is an important factor that influences the decision of women to join the work force; using U.S. data, Luttmer (2005) finds that the levels of wellbeing of individuals, as reflected by several indicators, depend on relative income. Additionally, a growing body of experimental research (see for instance Solnick and Hemenway, 1998, 2005; Johansson-Stenman et al., 2002), highlights the importance of consumption externalities. These experiments present the subjects with a series of hypothetical questions regarding their choice among alternative outcomes where these choices reveal their concern for their consumption relative to others. Up to one-half of the participants are willing to accept a lower level of absolute income in order to achieve higher relative income.

Research on status concerns has also been applied to environmental economics. Ng and Wang (1993) point out that the concern for social status causes excessively high levels of consumption, and hence environmental damages. Howarth (1996) explores the implications of a status race for the design of efficiency-inducing policies for the environment, in a static, competitive economy. Howarth (2000, 2006) argues that the optimal level of emissions of greenhouse gases tends to be overstated because analysts ignore the role of interdependence of preferences in consumption; he concludes that, when the relative consumption effects are properly taken into account, the optimal taxes on carbon dioxide emissions should be higher than those obtained under the benchmark model in which preferences are independent of social context. Brekke and Howarth (2002) point out that factors such as social identity and relative economic status may lead agents to substantially underestimate the full social benefits of public goods and non-market environmental services. Extending the work of Stokey (1998) on the environmental Kuznets curve by incorporating status motives, they show that consumption interdependence exacerbates the rate of environmental degradation, because the desire to signal one's status leads to a significant bias in the trade-offs between pollution abatement and consumption.

In the natural resource literature, Alvarez-Cuadrado and Long (2009a) have shown that relative consumption concerns can cause agents to over-exploit renewable resources even when these are private properties. They also model the common access case, where there is a continuum of agents.[4] Our model is different from theirs, in that we consider a finite number of agents playing a Cournot dynamic game, taking into account the effect of the fishing effort of other agents on the evolution of the stock, in other words, we are dealing with a differential game of fishery with status concerns.[5,6]

2. The Model

The basis for our model is Clark and Munro's (1975) dynamic, single species model. That is, we consider a fish stock exploited by n symmetric fishermen who live in the same community. They do not coordinate their harvesting decision. We assume that the fish is sold in a larger market, so that the aggregate quantity of fish they catch does not influence the market price, which we assume to be a constant p. Let x_t denote the stock size and L_{it} the effort level of agent i at time t. Following Schaefer (1957) the harvested amount of each agent is

$$h_{it} = qx_tL_{it} \tag{1}$$

where q is the catchability coefficient. Individual efforts cannot exceed the maximum level $\bar{L}$. Effort cost is c per unit. Agent i's profit at time t is

$$\pi_{it} = pqx_tL_{it} - cL_{it}. \tag{2}$$

Now, we diverge from the standard model and suppose that agents care about relative performance as well as own profit.[7] We define the relative performance of agent i to be the absolute difference of own profit compared to the average:

$$R_{it} = \pi_{it} - \frac{1}{n-1}\sum_{j\neq i}\pi_{jt}. \tag{3}$$

We assume the agent's utility function is a concave function of a weighted average of own profit and relative performance:

$$u_{it} = \frac{1}{1-\alpha}[(1-\gamma)\pi_{it} + \gamma R_{it}]^{1-\alpha} \tag{4}$$

[3] There is also some relationship to the literature following Baumol (1958) where market share matters.

[4] There is some relationship to Ostrom's work in examining collective action situations for common-pool resources where she has shown that similarities of interest are an important variable in determining successful outcomes (see Ostrom, 1990).

[5] See Dockner et al. (2000) for a comprehensive guide to differential games in economics. The equilibrium concept we use is the open-loop Nash equilibrium for analytical simplicity. For some recent papers that use this solution concept, see Sorger (2002), Benchekroun et al. (2009, 2010), and Bernard et al. (2008). The alternative concept of Markov-perfect Nash equilibrium, while attractive, typically requires extensive numerical approximation of the value function (except for a very small class of games with special structures).

[6] In fisheries specifically, contacts in the Australian fisheries community have provided anecdotes suggesting that status matters, particularly with respect to harvest. Some examples include a captain being fired for having the lowest harvests, simple statements at meetings proposing management change such as “I like fishing because it means going out each day to see if I can catch more than the next guy”, and fishermen transferring the race-to-fish to species that are not covered by individual quota management or converting it to seeing how fast they can catch their quota to say they had a “golden day” or a “big score”.

[7] Our specification of status is most closely related to Ljungqvist and Uhlig (2000), Dupor and Liu (2003) and Chugh (2008) where status also depends on the difference between own and average performance. Brekke et al. (2003) compare the additive formulation with the ratio formulation and report some differences in implications that depend on whether the cost of acquiring status is increasing. In Section 2, we show that our general results are basically unchanged when status depends on the *relative difference* but that the policy response will differ. Another alternative would be to consider the desire to be the best and hence measure status relative to the *maximum* of all other players. In the symmetric equilibrium used here, these measures are the same.