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Game-theoretical model for marketing cooperative in fisheries

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ABSTRACT

The classical game-theoretical models described the conflict in fisheries arising from harvesting a 'common pool resource' which without an efficient regulation leads to an overexploitation of a renewable but not unlimited resource, known as the 'tragedy of the commons'. Unlike these studies, the present paper deals with a marketing cooperative of micro or small enterprises in fishing industry, formed to negotiate a contracted price with large buyers, sharing risk among members of the cooperative. In the paper a game-theoretical model for the behaviour in this cooperative is set up. By the time of the actual commercialization of the product, the market price may be higher than what the cooperative can guarantee for members, negotiated on beforehand. Therefore some "unfaithful" members may be interested in selling at least a part of their product on the free market, the cooperative, however, can punish them for this. This conflict is modelled with a multi-person normal form game. An evolutionary dynamics is proposed for the continuous change of the applied strategies, which in the long term leads to a particular Nash equilibrium, considered the solution of the game. This strategy dynamics is continuously influenced by an "exosystem" describing the dynamics of fishing, based on a classical fishing effort model. This approach focuses only on the conflict within the marketing cooperative, since it is supposed that the single enterprises fish from independent resources.

1. Introduction and preliminaries

1.1. Introduction

A cooperative in a given region may perform several activities, ranging from product processing to complex marketing, see e.g. Cobia [1]. In particular, concerning fisheries, Freeman [2] gives a quick checklist of benefits and drawbacks of fishing cooperatives. Micro and small enterprises often have difficulties in the commercialization of their product.

Varga et al. [3] analyses a game-theoretical model for the behaviour in a marketing cooperative. The model studies a 'one-shot game', where at the end of a given production cycle, each member of the cooperative may decide to sell a part

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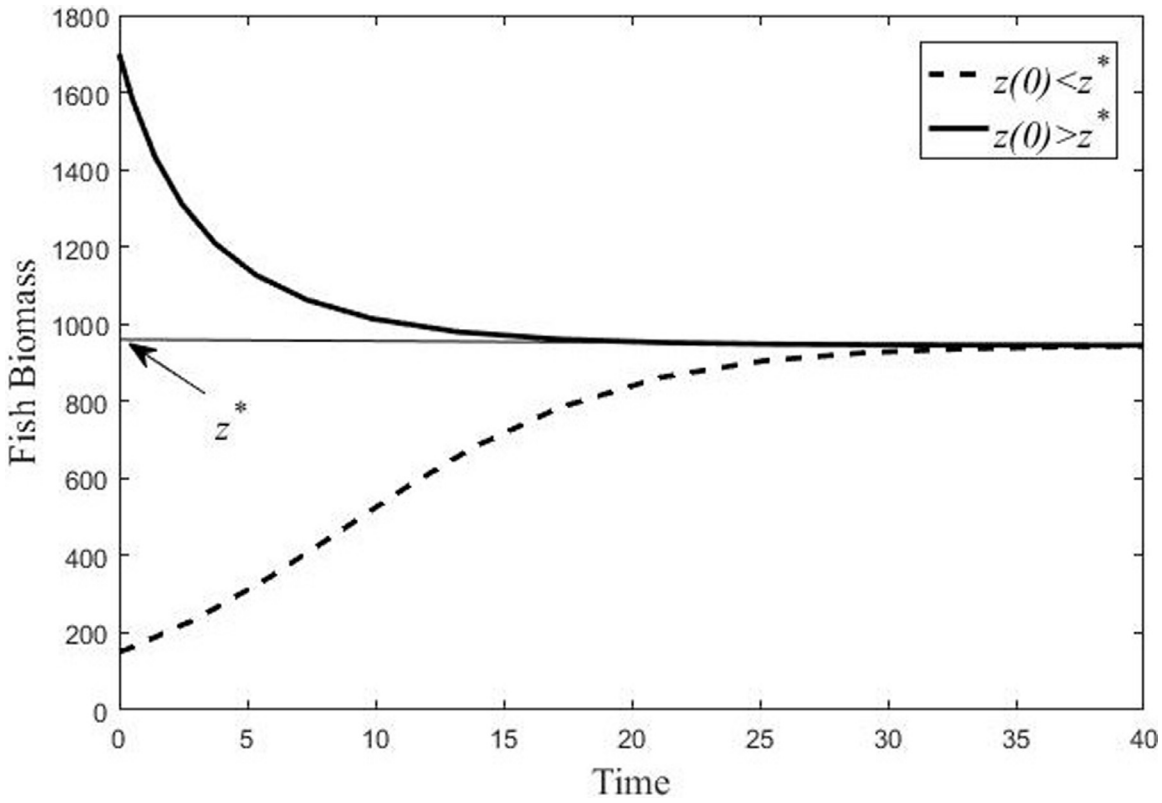

Fig. 1. Solutions of fishing effort model (1.1).

of its production on the free market, if the market price is higher than the price set by the cooperative beforehand. In the present study we will deal with a similar conflict, but in the context of fisheries based on a dynamic fishing effort model.

An overview of different conflicts fishery management should face, is given e.g. in Caddy [4], Cochrane et al. [5], Castilla and Defeo [6]. From these papers and the references therein it is clear that the classical game-theoretical conflict of exploiting a common-pool resource has been widely studied over the last decades. Less attention has been paid to the marketing conflicts related to fisheries. As examples of dealing with conflicts in oligopoly market environment, we recall Szidarovszky and Okuguchi [7] and Bischi et al. [8].

In the present paper a model of marketing cooperative in fisheries is set up and studied, where in a given time period a continuous production (harvested biomass) is being sold, under the condition that the actual offer is determined by the dynamics of the harvested fish population. We emphasize that in the considered situation the game-theoretical conflict arises on the marketing side, while the production in unit time $L_i(t)$ of each cooperative member i, comes from the solution of the corresponding classical logistic fishing effort model (see e.g. Clark, [9]).

First we set up a normal form game to describe the considered conflict and apply a solution concept called attractive solution, which is a special type of Nash equilibrium, introduced by Larbani [10], see also Larbani and Lebbah [11]. Then this solution concept is also studied in dynamic context, applying an evolutionary dynamics introduced by Garay [12]. The reason for the application of this solution concept is that it takes into consideration that in the definition of an equilibrium there is a distinguished player which in our case will be the cooperative, and the rest of the players will be its members.

The paper is organized as follows. In the rest of Section 1, a classical fishery model is recalled that will be a component of the model we will set up. In Section 2, following a general description of a marketing cooperative, the oligopoly market environment is formalized, where the price is determined by the total offer. In Section 3 a time-dependent game-theoretical model of the cooperative is introduced, and the existence of an attractive solution is proved. In Section 4 a model of dynamic strategy choice is introduced and sufficient conditions are given under which the strategy choice of the players leads to the desired attractive solution of the game. In Section 5 the strategy dynamics with discrete-time delivery of the catch is shortly touched on. A Discussion and outlook section closes the main body of the paper. In the Appendix, for the reader's convenience some further details of the applied classical fishing effort model are recalled.

Finally, we note that the simulations illustrating our theoretical study have been programmed in MatLab environment.