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A dynamic economic equilibrium model for the economic assessment of the fishery stock-rebuilding policies

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ABSTRACT

The paper develops and analyses a dynamic general equilibrium model with heterogeneous agents that can be used for assessment of the economic consequences of fish stock-rebuilding policies within the EU. In the model, entry and exit processes for individual plants (vessels) are endogenous, as well as output, employment and wages. This model is applied to a fishery of the Mediterranean Sea. The results provide both individual and aggregate data that can help managers in understanding the economic consequences of rebuilding strategies. In particular, this study shows that, for the application presented, all aggregate results improve if the stock rebuilding strategy is followed, while individual results depend on the indicator selected.

1. Introduction

Policies regarding rebuilding of fisheries involve important resources at the European Union (EU) level. The consistent evaluation of these policies is a necessary instrument to provide the foundations for their improvement. Indeed, the evaluation of policies requires a general equilibrium model capturing the endogenous character of the agents decisions, and their effects on the variables of interest, as function of the policies. In this paper a dynamic general equilibrium model with heterogeneous agents is proposed in which stock rebuilding policies change endogenously the behaviour of plants. The model presented allows the computation of the changes in most of the socioeconomic variables of interest for policy makers as a function of the implemented policies.

The general equilibrium models explicitly state the existence of an economy with agents, markets and equilibrium conditions. A model with heterogeneous agents in fisheries has been used in the context of individual transferable quotas (ITQ) by Terrebonne [1] and Da-Rocha and Sempere [2]. General equilibrium analysis of the fisheries can also be found in the studies of multiple uses of the ecosystem [3]. It can also explain how the inputs are over-allocated to an open access resource and create a general equilibrium tragedy of the commons in the artisanal fisheries, as in Manning et al. [4]. All these aspects have been analysed in discrete time. The model presented here is not based on the general fishery equilibrium models described above but inspired by the recent developments in macro-economic theory, as explained by Achdou et al. [5]. It can be used to assess how the economy adapts to a policy shock, for heterogeneous plants, in continuous time. The shock tested is a fish stock-rebuilding policy.

The present paper starts with a description of the current economic scientific advice within the EU. It explains the main shortcomings of it and how can they be reduced using a dynamic general equilibrium model. Section 3 develops the theoretical model and the equilibrium conditions required for its solution. An application of this model is presented in Section 4, using a Mediterranean Sea fishery as an example. The Results section interprets the obtained values, using the economic theory on which this approach is based. A discussion of the usefulness of this modelling approach in the economic assessment of the EU fisheries policies and the future prospects is provided in Section 5. The paper ends with a summary of the main conclusions obtained.

2. The fisheries economic scientific policy advice within the EU

Stock assessment within the EU waters is conducted on a single stock basis by the International Council for the Exploration of the Sea (ICES) in the Atlantic waters, the General Fisheries Commission for the Mediterranean (GFCM), in the Mediterranean and the Black Sea and the International Commission for the Conservation of Atlantic Tunas

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(ICCAT), for tunas. Using different types of stock assessments (e.g., analytical, using trends of catch per unit of effort, etc.), these organisations provide a Total Allowable Catch (TAC) and/or effort advice on the basis of achieved Maximum Sustainable Yield (MSY), when known. A precautionary approach is employed when the reference points cannot be calculated with sufficient precision. In the same region, the Scientific and Technical Committee for Fisheries (STECF) is a scientific body in charge of assessing the economic and social consequences of that advice.

The Data Collection Framework (DCF) [6] collects the economic data in fisheries at a fleet segment level. The segments are based on categories of fishing gear and vessel length. Biological data are also collected by the DCF but at a higher disaggregated level.

The latest economic data at for EU fleets is contained in the Annual Economic Report on the EU Fishing Fleet (AER) [7], where economic indicators are provided on a fleet segment basis. The AER along with other data (fishing effort, catches, landings and biological data) are used in the economic impact assessment of the multiannual plans (MAPs) [8–11].

The AER presents fishing fleet results based on general accounting rules. However, these rules are only giving a partial overview of the economic impact of the fishing fleets (i.e., financial and employment indicators of the fishing fleets). This procedure is probably followed to avoid the double accounting. Fisheries involve other economic sectors in their activity having their own economic analysis (i.e. ship building). The sum of the economic performance of these sectors, at individual basis, can be done, although, potentially, can also underestimate the macro-economic consequences of the fisheries policies. Projections of economic variables are also provided by the AER. However, as the STECF [12] notes, the projection models used to forecast are based on the correlations between variables. It implies that are not grounded in any economic theory.

MAPs contain the goals for fish stock management and a “road map” for achieving these objectives. As pointed out by Punt [13] objectives for fisheries management can be categorized as either “conceptual” (strategic) or “operational” (tactical). Conceptual objectives are generic, high-level policy goals, while operational objectives are expressed in terms of the values for performance measures. Article 1 of the Common Fisheries Policy (CFP) [14] has the conceptual strategy of rebuilding stocks in a way that is consistent with the objectives of achieving economic, social and employment benefits, and of contributing to the availability of food supplies. Article 2 of the CFP has the operational objective that the stock status rebuilt has to be done up to, on single stock basis, levels compatible with the MSY. That is, the final (operational) objective is purely stock-driven and the economic assessment of it is based on a conceptual one.

The economic assessment provided in these MAPs is founded, generally speaking, on the projection of the financial performance of fishing firms based on fishing management implementation models. In other words, the aim is to project the changes in the relationship between nominal fishing effort and fishing mortality and to use identities to convert them into financial variables (i.e, gross revenues, profits) at fishing fleet, fleet segment or metier[1] level. The methods used to provide an economic assessment of the MAPs model a feedback between the biology and the financial results or the financially induced behaviour of the fleets. Some of the models used in the economic assessment of MAPs are based on pure simulation, others on Management Strategy Evaluation (MSE) and others, on ecosystem balancing and simulation. They are all very useful in providing an empirical framework for scenario comparisons and/or checking the robustness of different management scenarios (MSE-based models). However, they have several shortcomings:

i) The complexity of the feedback mechanisms is a hindrance (see Prellezo et al. [15]). The models tend to interrelate (feedback) the biological and economic features using complex assumptions. The feedback processes used by these models rely on the levels of catches not coinciding with the advised level (output based regulations) or on the non-linear relationship between the fishing effort and fishing mortality (the so called hyperstability) in the input based regulated systems. This might happen as a result of the overall selectivity changes, the different evolution of the individual fleets, the tactical behaviour of these fleets (including different objectives or different spatial behaviour), and/or the changes in the capacity of the fleets. However, if the economic aspects of the model are not correctly modeled this feedback process cannot be properly captured.
ii) The estimation of the economic performance leading from the current stock status (often far from the intended target) to an MSY status implies substantial changes for many of the stocks. This is well beyond the scope and, in many cases, out of range of most projection models. This is an extremely important issue; given that some projections can be based on strong assumptions in terms of factors availability (except fishing opportunities) and can potentially ignore the likely impact of these factors on stock-rebuilding strategies (or the other way around).

Shortcoming (i) makes the economic results difficult to interpret because of the feedback mechanisms embodied in the models. The general macro-economic theory does not help, simply because the models have been built without considering it. The projections of economic variables (shortcoming (ii)) are not based on the economic theory [12], and especially, when made for several years, cannot be relied on to reflect any kind of economic equilibrium.

The dynamic general equilibrium model presented here demonstrates a different way of thinking to provide economic assessment of stock rebuilding policies (bringing fish stocks to abundance levels compatible with the MSY), using AER data, providing indicators similar to those presented in different impact assessments of the MAPs. It also obtains other indicators (aggregate indicators such as households utility), useful in the interpretation of the economic results, that could potentially help policy makers on designing fisheries policies.

3. Dynamic economic equilibrium model for assessing the economic impact of stock-rebuilding policies

Economic equilibrium models help to reduce the shortcomings (i) and (ii) described in Section 2. These types of models take into account the price system, which plays the crucial coordinating and equilibrating role in the economy. The fact that everyone in a given economy faces the same prices generates the common information needed to coordinate individual decisions. This approach has several properties that could allow managers to understand the economic implications of the management policies within the EU.[2] Firstly, it is based on the economic equilibrium, not on the accounting rules; this allows the interpretation of the results using the economic theory. However, it also provides the same indicators as those obtained by using accounting rules. Furthermore, the definition of core economic concepts (i.e. consumer and producer surplus) using an equilibrium approach –i.e. stationary solutions– and disequilibrium approach –i.e. transitional dynamics– is identical. That is, at equilibrium, these identities hold; the results can be read in the same way but might be interpreted using the economic theory. It also provides a new set of aggregate indicators that cannot be calculated using accounting rules. Overall, equilibrium models can provide disaggregated and aggregated economic and social

[1] The fishing activity which is characterised by one catching gear and a group of target species, operating in a given area during a given season, within which each vessels effort exerts a similar exploitation pattern on a particular species or group of species.

[2] Note that the model is general enough to be used in contexts outside the EU.