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Increased competition for aquaculture from fisheries: Does improved fisheries management limit aquaculture growth?

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ABSTRACT

The global fisheries sector has been characterized by three main trends over the last 2–3 decades; fish stocks have been overexploited and supply from wild fisheries is stagnating; fisheries management has improved slowly with the aims of achieving biological sustainability and rent maximization; and supplies from aquaculture have grown continuously. In this paper, the impact of improved fisheries management on aquaculture growth is studied assuming perfect substitution between farmed and wild fish. We find that improved fisheries management, ceteris paribus, reduces the growth potential of global aquaculture in markets where wild fisheries constitute a large share of total supply.

1. Introduction

Aquaculture is the fastest growing animal food production industry in the world. Global supply from aquaculture has grown at an annual average rate of 9% (FAO, 2011) between 1980 and 2008. In 2008, 46% of the global human consumption of fish, crustaceans and mollusks originated from aquaculture (FAO, 2011). This development has mainly been driven by productivity growth (Anderson, 2002; Asche, 2008) and an increasing demand for fish (Delgado, 2003).

Over the same period, supply from fisheries has stagnated due to overexploitation. Today, 82% of global fish stocks are fully exploited, overexploited, depleted or recovering, of which 32% are overexploited, depleted or recovering (FAO, 2011). Simultaneously, in the United Nations Environmental Programme (2010) it is estimated that an overcapacity of 80–180% exists in global fisheries. The same level of overcapacity in relation to what provides the maximum economic yield is also identified in existing fisheries. In the Mid-Atlantic surf clam and ocean quahog fishery Weninger (1998) find that the number of vessels under an individual transferable quota scheme will be significantly reduced. Recently, Pascoe (2007) also finds considerable overcapacity for the demersal whitefish trawlers in United Kingdom while Asche et al. (2009) estimate that overcapacity exists for trawlers fishing cod in Norway. Hence, many fish stocks appear to be utilized above both the maximum sustainable and the economic yield.

However, fisheries management is improving, especially with the appearance of incentive-based management in which managers seek to maximize the potential rent from fisheries activities. Another important reason for the improvement is the need to address overexploitation. An international agreement has been reached in order to reduce the exploitation of all fish stocks to the maximum sustainable yield level in 2015 (World Summit of Sustainable Development, 2002). Today, open-access is largely non-existent (Homans and Wilen, 1997) and pure incentive-based individual transferable quota systems exist in an increasing number of countries. Furthermore, Arnason (2012) estimates that as much as 25% of global harvest currently occur within an individual transferable quota system. The long run consequence of individual transferable quota schemes is, therefore, an increased supply of fish and reduced overcapacity (Asche et al., 2009).

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Aquaculture developed in a period when fisheries management was inadequate. Provided that substitution between farmed and wild fish exists, poor management of fisheries makes it easier to develop aquaculture. Today, the fisheries management of several fish stocks has improved and the consequence might be an increased supply over time, caught with reduced costs and marketed at a lower price. As a result, there will be less potential development opportunities in aquaculture.

The purpose of this paper is to contribute to the understanding of the continued long-term growth potential of global aquaculture. The question addressed is whether increased competition from fisheries due to improved fisheries management leaves room for aquaculture. This question has, to the knowledge of the authors, not previously been analyzed in the scientific literature.

In the economics literature Anderson (1985), Berck and Perloff (1985) and Valderrama and Anderson (2010) analyze how the development of aquaculture impacts on fisheries. The results indicated that the entry of competitive aquaculture increases the biomass of wild fish stocks, reduces price and increases total supply both under open-access and limited-entry regulation. In contrast, this paper argues that improved fisheries management is driven by political endeavors to improve fishermen's earnings and resource rents and not by competition from aquaculture. Hence this paper analyzes the causality where fisheries affect aquaculture, where earlier studies focus on the causality in the opposite direction.

The interaction between aquaculture and fisheries through the market can be analyzed with general and partial equilibrium models. The analysis of the fisheries sector with general equilibrium models is based on traditional renewable-resource economics, starting with Schaefer (1957). The Schaefer production function forms part of the two-good, two-sector, two-factor general equilibrium model with one of the goods being renewable-resource based (Brander and Taylor, 1997a,b; Emami and Johnson, 2000). The models study the effect of opening a closed economy for trade in renewable-resource based goods, whereas our model considers a closed economy, interpreted as the whole world. Another cluster of articles uses partial equilibrium models to study fisheries. In these, the backward-bending supply curve of open-access fisheries is identified, either by using a Schaefer production function, or the age-structured bio-economic Beverton and Holt (1957) approach (Copes, 1970; Nielsen, 2006). Furthermore, the issue is extended to dynamic models, starting with Quirk and Smith (1970). This paper uses the renewable-resource from the general equilibrium model, although we do not need the full model. For the sake of simplicity, we depart from the partial equilibrium model and extend it with the aquaculture sector.

The paper is organized as follows. In Section 2 we discuss the policy background of the paper using an example while the basic model is presented in Section 3. Section 4 contains the results obtained in the basic model while Section 5 analyzes various model extensions. In Section 6 the paper is concluded.

2. Policy background

One policy implication of this paper is that improved management of overexploited fish stock reduces the growth potential of aquaculture, especially when aquaculture provides a minor share of supplies. This holds for species for which aquaculture is in its infancy. The current situation on the world market for cod (*Gadus morhua*) exemplifies the finding. Cod forms part of the competitive, global whitefish market and large volumes of several species caught around the world are supplied to the market. Substitution exists between countries and to some extent between species (Nielsen, 2005).

Global aquaculture production of cod reached 21 thousand tons in 2009 of which 84% was produced in Norway. Farmed cod is presumed to be supplied to the same market as wild cod, with farmed and wild cod being perfect substitutes. In 2008, farmed cod contributed 3% of the total cod supply, and a substantially smaller share of the total supply of whitefish.

The cod fishery was important in the North Atlantic Ocean in the 1960s and 1970s, reaching almost 3 million tons annually. Since then, catches have declined due to reduced stocks, mainly caused by overexploitation. Cod appears both in the Northwest and Northeast Atlantic Ocean. In the 1960s, half of the catches originated from Northwest stock, mainly from the Grand Bank. In the early 1990s, the Grand Bank cod stock collapsed and it has still not recovered. In 2008, the catch of cod in the Northeast Atlantic area was 0.7 million tons, corresponding to a 56% reduction in the peak catch in the early 1970s. Several stocks exist in this area with the Barents Sea, Baltic Sea, North Sea and Icelandic stocks being the most important. If the management of these stocks improves, it is likely that the supply of wild cod from the area will increase in the future.

In the same period, fisheries management has been transformed, changing from open access to regulated open access and regulated restricted access, to optimal management. National management developed following the introduction of the 200 nautical mile extended economic zone in the late 1970s and early 1980s. Regulated open access mainly consisted of catch, gear and effort restrictions and was based on biological advice for the sustainable exploitation of the stocks. The regimes limited catches, but they did not stop the race for fish, nor did they reduce overcapacity. More recent regulations have, therefore, combined catch restrictions with property rights regimes, such as individual transferable quotas. These ensure that stocks are exploited sustainably, thereby reducing overcapacity and maximizing rent. Today, management in many OECD countries is based on regulated restricted access, but is moving toward property rights regimes.

In the Northeast Atlantic area, the total biomass (spawning stock biomass) of the main cod stocks declined from the early 1970s until 2000, when the biomass of the Iceland and Barents Sea stocks began to increase. The biomass of the North Sea and the Baltic Sea cod stocks has increased slightly since 2005–2006. The effect on landings remains limited, because the stocks have been severely overexploited and still need to recover to be able to provide a long-term increase in catches. Hence, it seems possible that the existing management will increase the supply of Northeast Atlantic cod in the future. This will result in, ceteris paribus, reduced prices for cod. Furthermore, reducing overcapacity causes a reduction in costs and thereby prices in the long run. These effects will most likely have a negative influence on the potential growth of aquaculture cod production, owing to the presumed substitution between farmed and wild cod.

In 2012, the Norwegian aquaculture production of cod was reduced to 10 thousand tons (Norwegian Directorate of Fisheries) and only a limited number of companies were still operating. That might be due to favorable developments in the Northeast Atlantic cod stocks and in particular in the Barents Sea stock, appearing among other from increased water temperatures (ICES 20×13), leading to increasing supply of wild cod and resulting in lower prices.

3. The model

In this section we introduce a model for traditional open-access and an optimally managed fishery (Section 3.1). We also introduce considerations regarding aquaculture supply (Section 3.2). In addition, traditional open-access, optimally managed fisheries and aquaculture are combined into an aggregate supply model