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Abstract

During the last two decades there has been a tremendous growth in the production of intensively farmed fish. This growth has been accompanied by a substantial reduction in prices. As this enhances the competitiveness of farmed fish, concerns are often raised with respect to the market impact of new aquaculture species. In this paper we investigate what we know about market interactions for three groups of successfully farmed fish species – salmon, catfish and sea bass/sea bream. We also provide a discussion of factors in the value chain and attributes that may make farmed species unique relative to wild fish.

Keywords: Aquaculture, market interaction, salmon, catfish, sea bass, sea bream

1. Introduction

During the past 20 years new production technologies have allowed farmed fish to become an important segment of the world fish market. At the same time, landings of wild fish have been stagnant whilst demand for fish and seafood has been perceived to increase. The supply of species like Atlantic salmon, salmon trout, American catfish, coho, sea bass and sea bream has multiplied and these species are now amongst the most important in large seafood markets in the European Union and the United States. These species have in common not only a substantial increase in production, but also a substantial fall in prices that has accompanied the increased production. However, there are also important differences between these species, in particular regarding the price level. Prior to the development of aquaculture, catfish was a low-unit-value (LUV) species, whereas the others were high-unit-value (HUV).

An interesting issue is the impact of the additional supplies of farmed fish on the world's fish markets. Many hypotheses have been put forward including *a*) increased supplies of farmed fish depress the prices of wild-caught fish destroying fishermen's livelihoods,[1] *b*) increased supply of farmed fish is necessary to maintain the supply of fish protein as populations grow and landings are stagnating, *c*) farming enhances wild stocks as reduced prices lead to lower fishing effort, *d*) farmed fish increase the demand for fish in general as stable fish supplies with reliable quality also allow for more outlets with seasonally supplied wild fish. Depending on your stand, these hypotheses indicate that increased farmed fish production may be positive or negative. Moreover, while the market impact from farmed fish is likely to be closest for "similar" species, it may also be important with respect to other types of fish and seafood products and different types of meat. Although many observers have been most concerned with the impact of farmed fish on wild caught fish, market structure is also important for the farmers. If their product competes in large market, increased aquaculture production will have only a limited price effect. This may make it easier for the industry to grow than in the case where there are few or no substitutes, and the farmers have to create the market for their product. In addition there are a number of issues related to growing aquaculture production such as environmental issues and coastal use.

In this paper the focus is on the market impact of farmed fish, or how the increased supplies and reduced prices of farmed fish affect demand for potentially competing products. As these

[1] This hypothesis apparently led to riots in France in 1993-1994, see e.g. Peridy, Guillotreau and Bernard (2000).

questions to a large extent are related to market structure, the discussion will mainly be about what is known about the market structure for these types of farmed fish. As noted by Anderson (1985), this problem becomes particularly interesting for a subset of the potentially competing goods, other fish. This is because the biological constraint on the supply of wild caught fish makes the supply schedule for these products backward bending. However, since landings of wild fish and fish farming are very different methods of producing fish, farmed fish will have a number of unique attributes compared to the wild caught fish even if the meat sold is largely the same.

The paper is organised as follows: section 2 presents some background information on the three groups of species which are of greatest concern: salmon, catfish plus sea bass and sea bream. In section 3 a brief account of market interactions, using a simple economic model is given, while methods for measuring market interaction are discussed in section 4. In section 5 market interactions of the three groups of species are studied; this is followed in section 6 with some discussion of the unique factors of farmed fish and its value chain. In section 7 some concluding remarks are provided.

2. Background

This section provides a brief overview of the development for some of the most successful species produced in intensive aquaculture operations, namely, salmon, American catfish and sea bass and sea bream. These species have all witnessed a rapid growth in production and declining prices.

Salmon

The term ‘farmed salmon’ refers to Atlantic salmon, coho and salmon trout, which are very similar species and seem to be highly substitutable.[2] Salmon is the most successful of the intensively farmed species when measured by the quantity produced. Salmon aquaculture became commercially interesting in the early 1980s. From then on the availability of salmon increased substantially, as shown in Figure 1. In 1980 the total supply of salmon was about 500,000 tonnes, of which only 13,000 tonnes were farmed. During the 1980s the landings of wild Pacific salmon increased substantially to historically high levels; in the 1990s, these have been about 800,000 tonnes, although with much variation. However, the most significant

[2] In 1999 about 80% of the farmed salmon were Atlantic, and its share seems to be increasing. It should also be noted that in Canada about 10 000 tonnes of farmed chinook are produced each year.

change in the salmon market is the huge increase in the supply of farmed fish. From 13,000 tonnes in 1980 farmed production has increased to over one million tonnes in 1999, making the total supply of salmon about 1.9 million tonnes, or almost a quadrupling since 1980.

Figure 2 shows total aquaculture production, the real Norwegian export price and production cost.[3] It is evident that the increase in production has been accompanied by a substantial reduction in prices; in real terms, the price in 1999 was only one third that of 1982. However, production costs have also declined, hence expansion has been possible because of substantial productivity growth (Asche, 1997a). Although this suggests that a large part of the growth in salmon aquaculture has been a move down along the demand schedule, there is also evidence that this has been amplified by market growth, partly due to generic advertising programmes (Bjørndal, Salvanes and Andreassen, 1992; Kinnucan and Myrland, 1998).

It is also worthwhile noting that farmed salmon is produced in large quantities in only a few countries. With their 1999-share in parenthesis, Norway (46%), Chile (20%), the UK (14%) and Canada (8%) make up about 90% of the total quantity produced. Given that Canada and the UK are members of respectively NAFTA and the EU, this has lead to a number of trade conflicts (Asche, 1997, Anderson and Fong, 1998). The main target has been Norway, not surprisingly given its dominant share of production, but recently Chilean producers have also been found guilty of dumping in the US, and they also face penalties on their exports.

American Catfish

The production of American catfish (or channel catfish) has increased from about 21,000 tonnes in 1980 to about 270,000 tonnes in 1999. In the same period, the real price has almost halved from about US$ 3/kg to 1.6/kg. This development is shown in Figure 3. Although cost data are not available, productivity must have increased for the industry to stay profitable with the declining price. Hence, the declining price and increase in production implicitly provide evidence of substantial productivity growth. As was noted in the case of salmon, industry growth has been amplified by market growth fuelled at least partially by generic marketing (see Kinnucan and Miao (1999) and references therein).[4] However, in contrast to salmon,

[3] The markets for different species and product forms of salmon seem to be highly integrated (Asche and Sebulonsen, 1998, Asche, Bremnes and Wessells (1999) and Asche (2000). Therefore, there should be no problem to interpret the Norwegian export price as the global price of salmon.
[4] See also Kinnucan (1995) for information about the growth of the American catfish industry.

there are no large supplies of wild fish, and catfish therefore has had to build new markets at the expense of other fish species or meat. It is also worthwhile to note that whereas salmon when introduced as a farmed species was of HUV status, catfish was positioned as a LUV species. Although this depends on demand structure, it is not surprising that the price reduction for catfish has been slower and less than for salmon, since it competes in a potentially larger market.

The first stages in the value chain have received more attention for catfish than for other farmed fish species. Studies indicate that productivity growth takes place not only in producing the fish, but also in processing, marketing and moving the fish down the value chain (Kinnucan *et al*, 1988; Zidack, Kinnucan and Hatch, 1992). This is as expected since it is likely that there are returns to scale in the value chain with larger quantities. However, importantly, it also implies that figures on productivity growth will tend to understate the total productivity growth in the industry because most cases tend to use data derived from the production end of the value chain rather than post-processing and marketing.

European Sea Bass and Sea Bream

Sea bass and sea bream are two different species, both produced and marketed in a similar manner, and therefore often are treated as one.[5] There are some landings of these species, but these are becoming small relative to farmed production. Farmed quantities started to grow in the late 1980s, somewhat later then for salmon and catfish. Production and real import price to Italy, which is the main market, are shown in Figure 4. Like salmon and catfish, the price has declined substantially but at an even faster pace and at comparatively low quantities. Once again the declining prices combined with maintained growth in production may be interpreted as evidence of substantial productivity growth.

Sea bass and sea bream are mainly Mediterranean species, and most farming operations are located there. Although farming was pioneered in Italy and France, during the 1990s Greece took over as the largest producer with close to half the production by the end of the decade. However, in recent years production has expanded rapidly in non-EU countries, notably Turkey and Egypt in addition to a number of others around the Mediterranean. A scenario of

[5] There also exist a third species, Japanese sea bream, which is farmed in Japan. This is not discussed here.

increased trading at declining levels of profitability is again unfolding with yet another new aquaculture product category.

3. A Simple Model for Market Interactions

Market interactions, such as the ones considered here, are the core of microeconomic theory. A formal, albeit simple model of market interactions will be developed to highlight some of the relationships under investigation. In particular, an interesting relationship is due to the fact that an important subset of the potentially competing goods to farmed fish, captured fish, has a backward bending supply schedule (Anderson, 1985). Moreover, as many of the world's fish stocks are reported to be fully or overexploited, it is likely that the market equilibrium for many of the world's fish stocks is on the backward bending part of their supply schedule.

Consider a very simple model with two goods, the aquaculture product and a potentially competing product. Let q_i^D be the quantity demanded, p_i and p_j the prices of the two products and I consumer expenditure or income. The demand for the two products can be written as

(1) $$q_i^D = a_i - b_i p_i + c_j p_j + d_i I$$

where $i=A$ and $j=O$ if it is the demand for the aquaculture product, and $i=O$ and $j=A$ if it is the demand for the competing product. For the interaction between farmed and other products the parameter c_j is of key interest, as this gives the strength of the substitution effect. In particular, if $c_j=0$, there is no substitution effect and therefore no market interaction.

The supply of farmed fish, q_i^S, is a function of output price, p_i, and input price(s), w_i, as is the supply of the competing product if it is a traditionally produced product. This can be written as

(2) $$q_i^S = m_i + n_i p_i + o_i w_i$$

The main cause for the increased supply of farmed fish is productivity growth. This may take two forms, productivity growth in the farming operation and productivity growth for the suppliers of input factors.[6] The first corresponds to a reduction of m_i, while the second results in reduced input price(s), w_i. Productivity growth leads to a downward shift in the supply schedule.

[6] A decomposition of productivity growth in salmon farming can be found in Tveterås (1999).

Possible market interactions are illustrated in Figure 5, where demand and supply both for farmed fish and for a potentially competing product are shown. Assume that the prices are normalised so that they initially are equal for the two products, and that the supply of farmed fish shifts downward due to productivity growth. This leads the supply of farmed fish to increase from q1 to q1' and the price to decrease from p1 to p1'. The effect on the market for the potentially competing product depends on the parameter c_A in the demand equation for this good, since this parameter determines the cross-price effect of the competing product with respect to a price change for farmed fish. If this parameter is zero, there will be no effect, price and quantity demanded remains at p2, q2, and there is no market interaction. If the parameter is positive, implying substitutes, a price reduction for farmed fish will lead to a downward shift in the demand for the competing product. At most, the demand schedule for the competing product can shift down sufficiently for the relative price to remain constant. This corresponds to the demand schedule D2' in figure 5, with quantity demanded reduced to q2' and price to p2'. If there is a weaker substitution effect, the demand schedule for this product will shift down to e.g. D2''. This gives a reduction in price and demanded quantity, but the shift in demand is not sufficient to keep the relative price stable.

If the competing product is a wild caught fish species, the supply will also be a function of the biological characteristics of the stock and/or the regulatory system. In open access equilibrium the supply schedule is backward bending. Using the same bioeconomic model as Anderson (1985), the supply of wild caught fish can then be written as

(3) $$q_i^S = \frac{rC}{p_i}\left(1 - \frac{C}{p_i K}\right)$$

where r is the intrinsic growth rate of the fish stock, C is cost per unit of effort in the fishery and K is the environmental carrying capacity for this fish stock.[7] If the fishery is managed with a quota, and in most cases this is based on biological considerations only, this makes the supply schedule vertical.

Market effects are illustrated in figure 6. Figure 6 differs from figure 5 in that that the supply schedule for the competing product, captured fish, is backward bending. If the fishery is on the upward bending part of the supply schedule, the description of the effects is as for a conventional product. The most interesting part is if the fishery is on the backward bending

[7] See Anderson (1985) for a discussion of the underlying bioeconomic model and the specific parameters.

part of the supply schedule. This may also be most representative with regard to world fisheries, as a large number of wild fish stocks are overexploited (FAO, 2000).

Assume again that productivity growth gives a downward shift in the supply schedule for farmed fish, reducing price to p1' and increasing quantity supplied to q1'. The effect on the market for the potentially competing product again depends on the parameter c_A, which determines the cross-price effect of the competing product with respect to a price change for farmed fish. As above, if this parameter is zero, there will be no effect, and therefore no market interaction. If the parameter is positive, implying substitutes, a price reduction for farmed fish will lead to a downward shift in the demand for the competing product. At most, the demand schedule for the competing product can shift down sufficiently for the relative price to remain constant. This corresponds to the demand schedule D2' in the figure, which implies that the quantity demanded of this good is *increased* to q2' while the price is reduced to p2'. If there is a weaker substitution effect, the demand schedule for this product will shift down to e.g. D2''. This gives a reduction in price and an increase in quantity, but the shift in demand is not big enough to keep the relative price stable. The main difference from the case with a conventional product is the quantity effect for wild caught fish. When the price is reduced, this leads to lower fishing effort, which gives a higher fish stock and higher landings.

While one of the primary concerns with respect to market structure for farmed fish often is the effect of farmed fish on other products, it may also be worthwhile to comment upon the effect of the market structure for possible growth of aquaculture production. Let us look at conventional products first. If production of farmed fish is increasing relative to the other product, this implies that the productivity for farmed fish production increases faster than for the other product. If the two products are close substitutes, farmed fish can then win market shares from the other product. However, if the goods are not substitutes there are no market effects, and the increase in the supply of the farmed fish will only lead to a move down the demand schedule for farmed fish. Hence, for the producers of farmed fish it is easier to expand when the farmed fish has substitutes with established markets. As observed by Anderson (1985), this situation changes if the potential substitute is fish from a fishery located on the backward bending part of the supply schedule. The increased supply of farmed fish will then also lead to a higher supply of wild caught fish, leading to keener competition. Anderson also shows that in some cases, this keener competition may drive the farmed fish producers out of business.

No mention has been made of the possibility that farmed fish and other products may be complementary. This is mostly because it increases the complexity of the model, as there always must be at least one substitute if there is any market interaction on the demand side. However, even though complementarity is a possible effect, it is most likely not a very important effect.

4. Testing for Market Interactions

In general micro economic theory assumes that there exists a market place constituted by a group of commodities. The group of commodities compete in the same market because goods are substitutable for the consumer. Whether goods are substitutes, or not, can be measured by estimating demand equations to test whether there are cross-price effects (Triffin, 1940). If there are, the goods compete in the same market, while if there are not, the goods do not compete. The most common measure of a cross-price effect is a cross-price elasticity.

A common problem is obtaining the necessary data to estimate demand equations. Often price data are available but not quantity. Moreover, while one can often find a price that is a good proxy for market price, it is hard to get reliable estimates of demand equations if data are not available for the full quantity consumed in a market at different price levels. This has also led to markets being defined only based on price information. For instance, Cournot defines a market in the following way:

"It is evident that an article capable of transportation must flow from the market where its value is less to the market where its value is greater, until difference in value, from one market to the other, represents no more than the cost of transportation" (Cournot, 1971)

When looking at figure 5, the intuition behind this kind of definition can be seen by looking at the effect of shifts in supply and demand schedules from the price differential. When the supply curve for farmed fish shifts, the price changes. This can then have three types of effects on the price of the other good. If there is no substitution effect, the demand schedule does not shift and there is no movement in price. If there is a substitution effect, the demand schedule shifts, and the price shifts in the same direction as the price of farmed fish. At most, the price of the other product can shift by the same percentage as the price of farmed fish, making the relative price constant so that the Law of One Price (LOP) holds.

Hence there are at least two ways of testing for market integration, or if two or more products are substitutes. One is to estimate the demand function for a product and to test for cross-price effects. Alternatively, one can look at the effects only in the price differential, where one can test whether there is a price effect (i.e., substitution), and if the relative price is constant, i.e., whether the Law of One Price (LOP) holds.

If consideration is given to the four hypotheses about the impact of farmed fish on wild fish, demand interactions are sufficient to investigate some but not all aspects of these hypotheses. In particular, it gives all the information one needs to evaluate hypothesis *a*, whether increased supplies of farmed fish leads to reduced prices of wild fish, and hypothesis *d*, whether farmed fish increase fish demand in general. Hypothesis a will be true if there is a substitution effect between farmed and wild fish. To test hypothesis *d*, there must be at least three goods in the model, because in the two goods case the products must be substitutes. However, if farmed fish and wild fish are complements, hypothesis d will hold. For farmed fish to enhance wild stocks, i.e. hypothesis *c*, it must be the case that farmed and wild fish are substitutes. However, although this is necessary, it is not sufficient, since the effect will depend on the regulatory system. Knowledge about demand interaction will not shed light on hypothesis *b*, that increased supply of farmed fish is necessary to maintain the supply of fish protein.

5. Market integration

There are substantial differences with respect to knowledge about market interaction for different species. A number of studies of salmon markets have been conducted and there is also a body of literature for catfish, but very little for sea bass, sea bream and indeed other farmed species. Knowledge about market interaction between farmed fish and other species is therefore to a large extent dependant on what we know about market structure for salmon.

The demand for salmon has often been modelled with different product forms of salmon other fish species, and meats as potential substitutes. These studies include Bjørndal *et al*., (1992), DeVoretz and Salvanes (1993), Herrmann *et al*., (1993), Wessells and Wilen (1993, 1994), Bjørndal *et al*., (1994), Asche (1996, 1997b), Asche and Hannesson (1997), Asche *et al.,* (1997), Eales *et al*., (1997), Salvanes and DeVoretz (1997), Asche *et al*., (1998), Johnson *et al*., (1998), Kinnucan and Myrland (1998), Eales and Wessells (1999) and Asche and Steen (2000). In addition, a several studies have investigated interaction between prices. These include Gordon *et al.,* (1993), Asche and Hannesson (1997), Asche *et al*., (1997), Asche and Sebulonsen (1998), Asche *et al.,* (1999), Clayton and Gordon (1999), Asche (2000) and Jaffry *et al.* (2000). The results can be divided into three groups: interactions between different species and product forms of salmon, interactions between salmon and other seafood and finally, interaction between salmon and meat.

For different salmon species and product forms of salmon the results indicate that these are close substitutes. In particular, where tested, the Law of One Price holds, indicating that relative prices are stable. Hence, increased production of farmed salmon has had a substantial impact on the markets and prices for wild Pacific salmon. One could interpret the increased supplies of Pacific salmon as evidence that one has moved down along a backward bending supply schedule and that salmon farming therefore has been beneficial for wild salmon stocks. However, several factors cast doubts with respect to such an interpretation. As noted above, the landings are now at historically high levels, so if one is moving down the supply schedule this must have had a substantial outward shift. This may be the case since substantial hatching programmes were implemented in the 1980s (Boyce *et al*, 1993). But these programmes may also be the underlying cause for the increased landings and hence, although number of fishermen and their revenues have decreased, salmon farming may not have had any impact on landings. This is likely due to the regulatory structure, because in regulated open access fisheries substantial overcapacity will tend to emerge (Homans and Wilen, 1997). In such fisheries reduced revenues will reduce the overcapacity but as long as overcapacity persists, it will have little effect on landings.

For other species, there is some evidence that salmon competes with high-valued fish, and also a greater range of fish in Japan. However, salmon does not in general seem to compete with big volume species of fish as in the global whitefish market. Furthermore, the results from Japan are often for the period prior to the substantial increase in the supply of farmed salmon. Hence, these results are based mostly on lower valued wild species which are sold, at least partly, in product forms that farmed salmon are not used for. While these results may seem surprising, there are good reasons that this is the case. In particular, salmon is sold mostly as fresh or smoked, which are product forms that are not very common for most wild caught species. Furthermore, farmed salmon is not sold as fish fingers, frozen blocks and many other product forms that are important for many wild species, and particularly for big volume species. A somewhat surprising result is reported in Asche and Steen (2000), in that they find evidence of several fish species in the EU being complements for salmon, implying that the expansion in the salmon market has made more room for other species as well. Although it is possible that the increased availability of salmon may make it easier to sell other fish, and marketing campaigns for salmon may spill over to other fish, at least in some market segments, it seems less plausible that this is generally the case.

There is little knowledge about any possible relationship between salmon and meats. In general the evidence indicates no interaction. However some evidence from more recent years in Japan may present a possible exception; Eales and Wessells (1999) provide evidence of a shift from no interaction to some competition in the mid-1990s.

Most studies on the demand structure for catfish have been primarily interested in the effect of generic marketing programmes. However, as part of the evaluation process, demand equations are estimated. These studies include Kinnucan and Venkateswaran (1990), Kinnucan and Thomas (1997) and Kinnucan and Miao (1999). Meat product like poultry have been tested as substitutes, without finding any evidence that these products are competing with catfish. In unpublished work no relationship between an index of fish prices and the demand for catfish has been found.[8] However, in recent years imports of catfish have increased and this fish has been found to be a substitute to the US raised catfish (Kinnucan and Miao, 1999).

Literature searches suggest that the only study testing the market structure for sea bass and sea bream is Asche and Steen (1998). They investigated the relationship between the price of sea bass/sea bream and a number of other fish species in the EU, and found that sea bass/sea bream may compete with portion trout and several white fish species. However, there are some problems with the time series properties of the sea bass/sea bream data as they are very close to being stationary. These results do not make too much sense since sea bass/sea bream are consumed to a very limited extent in the areas where these competing species are

[8] Personal communication, Henry Kinnucan.

consumed and vice versa. It is therefore likely that these results indicate that sea bass/sea bream are stationary and that there is no relationship between sea bass/sea bream and these other species.

With the exception of the close relationship between different salmon species, the main conclusion seems to be that there is little market interaction between farmed fish and other products, independently of whether these products are other fish or meats. Generalisation from this result would seem to indicate that a farmed species competes mainly with the same wild species (and other species in the same segment), and not with other species. Some support for this view can be found in the results of most demand studies of seafood products, since it is indicated that the seafood market is highly segmented. Still, since the production of the farmed species makes up substantial quantities and there obviously is demand for the fish, they must win market share somewhere. It may, of course, be that the data or tools are not good enough to detect the relationships, or possibly that the appropriate goods as potential substitutes have yet to be tested. However, it seems more plausible that farmed fish partly creates new market segments and partly wins market share from such a large varieties of goods that the effects are too small to pick up for any one good in isolation. Some further explanation may lie in considering the key characteristic differences of the cultured and captured products with particular focus upon their perceived value in the value chain.

6. What Makes Farmed Fish Different from Wild Fish?

If farmed fish compete with wild caught fish only to a limited extent with the exception of the same species, this may be because farmed fish have some unique attributes. For example, it was earlier identified that the main product forms of farmed fish are often fresh. This is commonly not the case for other big volume species such as cod, pollock or tuna. In this penultimate section some further discussion of possible differentiating features of farmed fish is warranted. These are considered firstly within the supply chain, and then as a potential substitute to similar wild caught fish of the same species.

Supply chain

During the last decade there have been substantial changes in the distribution and retail sector for food, notably with the growth of large supermarket chains. In many European countries the share of fish being sold by supermarkets has increased from less then 20% in the late

1980s to over 60% in the late 1990s (Guillotreau, 1998). Advanced logistics and economies of scale in the distribution have been major drivers of this development, and farmed fish seems to be much better suited for this kind of distribution than captured supplies. The inherent reliability and regularity in supply of cultured product has obvious advantages and should enable producers to negotiate better prices than would be possible if the risk of financial penalties for supply failures had to be incorporated. Farmed production systems are also more suited to responding to the reduced product ordering periods within the retail sector (Young *et al*, 1993). Captured supply chains, because of the effective fixity and seasonality of supply, cannot respond readily to changes in retail demand other than from buffer stock, hence creating a greater likelihood of failing to supply, especially if the order is for fresh product.

Within the contemporary retail and catering markets, buyers increasingly demand that products can be traced to determine their origins and history. This is now commonly required to be verifiable through some Hazard Analysis Critical Control Point (HACCP) process (Smith *et al*, 1999). Farmed product supply chains generally afford much greater ease of traceability compared to the captured product because the supply chains that have evolved with the fisheries tend to be more complex and so obscure product tracks. Exceptions may exist where the catch is logged, marked, kept apart in the hold and then subsequently differentiated through the process of exchange (typically through fish auctions), subsequent processing and then transportation; but even when this is accomplished, exact product origins are less certain.

Farmed systems' control over production inputs (and outputs) enables proactive customer participation in creating product attributes. Customer preferences may extend to determining exact specifications for the colour, texture and fat content of the fish grown and delivered. Such differences may be important and provide critical comparative advantages in the final product marketed (Muir and Shaw, 1987). For example, purchasing fish of a size grade within a fine tolerance may realise significant yield gains; similarly specifying the exact fat content may enable a particular smoked flavour to be produced. While many of these parameters may seem to be of minor importance, their cumulative effect is likely to be significant. Superior control of farmed product chains permits more reliable delivery schedules and associated contractual agreements to supply product of a given size and quality grades. Inherent uncertainty pervades many aspects of capture fisheries (species availability, size, quality etc) and this is likely to remain a differentiating characteristic. In addition to affording control over the attributes included within the product, the more controlled environment of aquaculture may also enable reassurance of what is *not* in the product too, notably chemicals, pesticides, GMOs and other additives perceived to be unwelcome.

Product Substitution - Tendency to Inverse Market presence?

When the price of wild fish tends towards higher levels this will encourage the supply of farmed fish to the market; however, higher prices for captured fish will only tend to occur when supplies are low. Historic evidence of this interaction is limited because there are comparatively few species where significant supplies from both captured and farmed products have co-existed. Salmon probably represents the main exponent of this and hitherto the data is occluded. While the expanding volume of species from aquaculture may increase price competition on capture products the (price) effects of this are also likely to be limited for most species because of the comparatively small volumes of the same farmed species. On the other hand, when the supply of the farmed species is high, this is likely to determine the price because the control the farmers have over the production process. This has indeed happened with salmon (Asche *et al*., 1999).

In some key market segments where wild supplies are limited and the species commands a premium price, the effects are potentially more significant. Candidate species for this category would include turbot and halibut, although current farmed product is still perceived to be an inferior substitute. Nonetheless, technical progress in husbandry is likely to lessen the difference and the propensity for this to occur will increase as long as the size of the price differential remains significant (Muir and Young, 1999). As the range of farmed species launched onto the market increases, they are likely to prove a more significant competitor since consumers will have greater opportunities to select between the farmed and captured versions of the same species. Currently this consumer choice is typically limited to only a few cases, but this will certainly change.

A key determinant of the pace of change will also be the respective positions that the products are perceived to command in the market. Hitherto most aquaculture products have relied upon some initial honeymoon period wherein they could gradually re-position from premium quality high unit value (HUV) species to a more diverse location.[9] However, as the number of new species, and associated products on the market increases, it can be expected that this honeymoon period will be reduced. In effect producers of aquaculture products may need to think more strategically from the outset as to where their products will be positioned at different points in their life cycle, rather than leaving this to chance emergence. Similarly the range of value added (processed) products based upon farmed species will extend competition. Adding perceived consumer values will make farmed products more competitive and may tend to mask differences perceived in the market, and hence potentially price differentiation too.

Branding of products may become a more widely adopted tool to promote differentiation of farmed and captured supply chains. This may be done at a variety of different levels extending from the species/country of origin generic level through to the private brands within individual retailer chains (Burt, 2000). Scope clearly exists to build upon existing consumer perceptions of origins of supply and the mutual incorporation of farmed and captured supplies should not be excluded. Where mutual brand associations are established, these should enable extension of the product range. From the perspective of the (generally) more recent aquaculture producers these linkages may tend to lessen consumer resistance to new product innovations, including new species, not least because of greater consumer awareness and favourable perceptions.

The potential for farmed product to deliver (high) specified quality standards could positively influence the wider consumer perception of the quality of the generic fish product. Clearly this would only serve to the advantage of the farmed product if it delivers a product of no lesser standard. Farmed product which is able to establish and hold more upmarket positions could increase consumer willingness to pay premium price levels for the product, and may too be capitalised upon by the farmed product, assuming that commensurate product standard is delivered (Paquotte, 1999). For these reasons, pertaining to the quality and increased diversity of the farmed product, it is conceivable that as capture fish supplies remain static or diminish further, the presence of additional (farmed) fish products on the wider food market could help to maintain consumers' interest in fish compared to other non-fish substitutes.

[9] This can clearly be seen in Figures 2 and 4, respectively, for salmon and sea bass / sea bream.

Green Concerns

Hitherto fish, or aquatic foods, has largely escaped food consumers' increasing propensity to be environmentally concerned in their consumption decisions. Nonetheless it is unlikely that this situation will prevail. Indeed in both capture fisheries and aquaculture there are growing consumer concerns about their impacts upon phenomena such as the environment, sustainability and, probably yet to really emerge, animal welfare (Aarset *et al*, 2000; Jaffry *et al*, 2000; Wessells *et al*., 1999; Gujja and Finger-Stitch, 1996; Beveridge *et al*, 1994). Moreover, since aquaculture is more industrialised then traditional fisheries, this industry is likely to receive more attention.[10]

Animal welfare is potentially problematic within farmed (and captured) fish production systems. The very act of constraining a wild animal within an enclosure may be seen as contrary to an individual's ethics and animal rights. Even although husbandry of animals is generally accepted in all other domesticated animals, subject to certain conditions such as "free range", it remains contentious in the case of fish for the time being at least. Certainly it would seem that adverse impacts are more likely within the aquaculture sector. This may well be because aquaculture species are generally perceived as a new phenomenon and often individual consumers have yet to make the link between a traditional species and its farmed counterpart. For example consumer research has found that Spanish consumers tend to think that the (farmed) salmon market in Spain is based upon wild (Aarset *et al*, 2000). This may suggest that consumers' perceptions and reactions to the concept of a farmed product are not yet fully apparent. Moreover, this may be an important factor in explaining the apparent market interactions noted earlier.

Aquaculture has generated an increasingly adverse press as production has intensified. Environmental degradation and the visual impact of sites are a common perception which do not sit happily with the general thrust of positive product promotional activity. Concerns about terrestrial farming practices and other food scares have undoubtedly raised consumers' concerns about other, especially new, food production chains (Smith *et al*, 1999). Perceptions about product modified with chemicals, antibiotics and other substances, including GMOs, will need to be actively monitored and appropriate communications delivered to ensure that farmed product has a desirable perceived position in the mindset of the consumer. More

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[10] This is true even though aquaculture industries often may be quite good at correcting environmentally bad practices since these also harm productivity (Asche, Guttormsen and Tveterås, 1999).

recently consumer concerns have extended to include feeds for aquaculture product and have ranged from issues such as the dioxin levels accumulated in wild fish used to manufacture fish feeds and the often overfished status of many of these stocks (Millar, 2001). Alternative options such as feeds based upon soya also carry undesirable associations, including possible contamination through GMOs. More trenchantly some have suggested that attempts to alter the diet of species to one which is unnatural, such as salmon being fed a vegetarian diet, constitutes cruelty to animals (Aarset *et al*, 2000).

7. Concluding remarks

The strong reduction in the price for new aquaculture species gives an indication that the markets for these species are not strongly linked to the markets for other products. Since few if any other goods can show a similar development in prices, the relative price between farmed fish and most other goods have changed substantially. As perfect substitutes have a constant relative price and close substitutes have highly correlated prices, this is an indication that farmed fish does not compete too closely with other goods. The limited knowledge we have about the market structure for these species also indicates that market interactions between farmed fish and other fish and meat are very limited with the exception of the wild supplies of the species that are farmed. However, since the production of these farmed species makes up substantial quantities and there obviously is demand for the fish, it must win market share somewhere. We think it is difficult to find where farmed fish win market shares because farmed fish partly creates new market segments and partly wins market share from such a large variety of goods that the effects are too small to pick up for each good.

There are many possible reasons why new aquaculture products should not interact too much with traditional market segments. Most of these are related to unique attributes of the farmed fish. In particular, relative to other species, and particularly big volume species, a very large share of the farmed fish is sold in fresh product forms. This is possible because the higher degree of control of the production process gives the farmers the opportunity to decide when to market their product. This allows a supply chain very different from that of wild caught fish. The changes in food distribution and the retail sector are a further advantage for farmed fish relative to captured supplies, since farmed production is much better suited to this kind of supply chain than landings from traditional fisheries. However, although the unique production process gives farmed fish many positive attributes, there are also some negative factors. In particular, aquaculture production has received increased attention because of its sometimes-adverse environmental impact. Hence, on balance the continued success of aquaculture may well be determined by how consumers perceive the value of the unique attributes of aquaculture. Whatever, the greater incorporation of such more qualitative factors in determining fish product preferences is likely to make analysis of captured and cultured fish market interactions all the more challenging.

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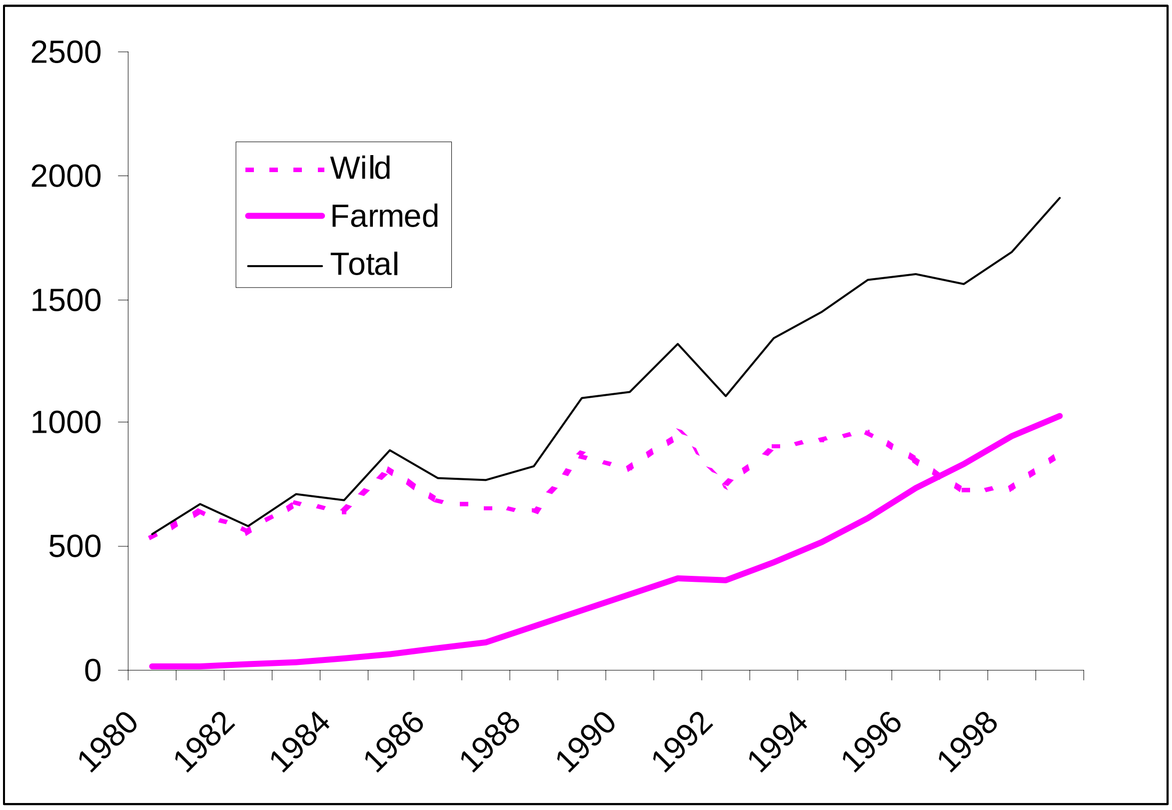

Figure 1. Global supply of salmon, 1980-1999

Figure 2. Global supply of salmon with real Norwegian export price and production cost, 1982-1999

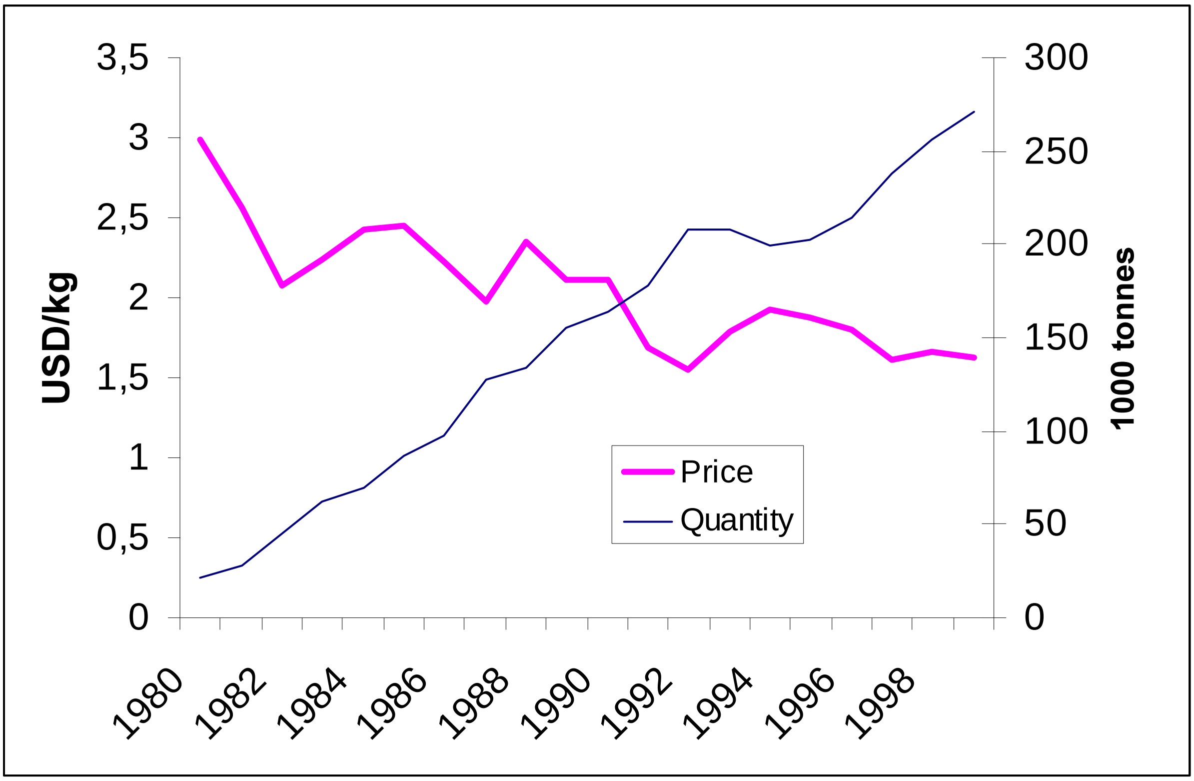

Figure 3. Catfish production and real price

Figure 4. European production of sea bass and bream and real Italian import price

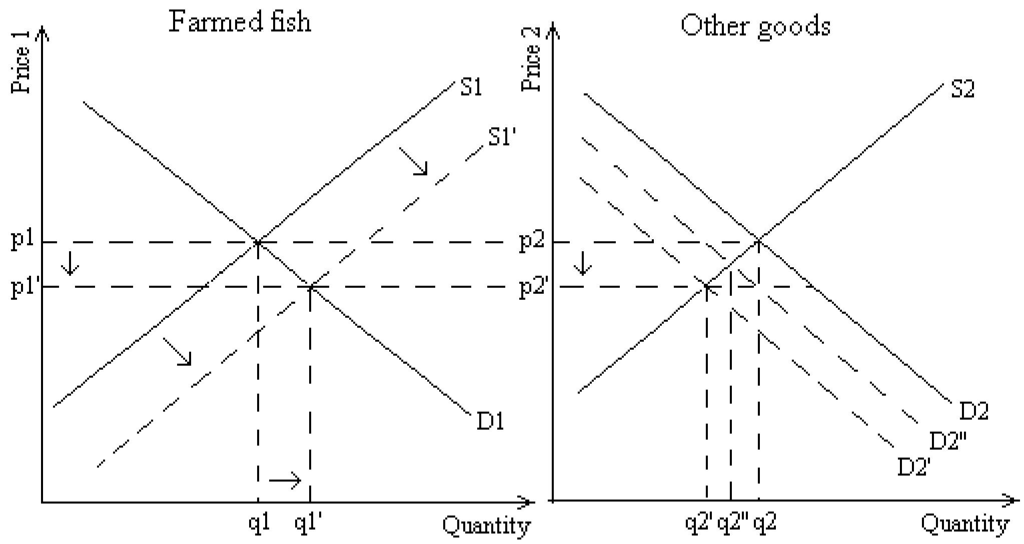

Figure 5. Potential market interaction between farmed fish and traditional goods

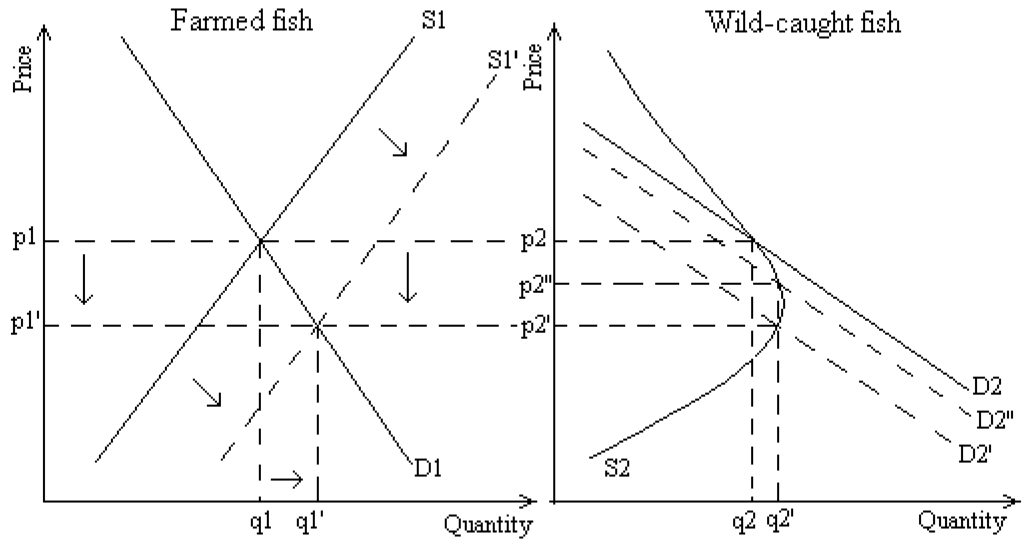

Figure 6. Potential market interaction between farmed fish and wildcaught fish