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Abstract

Market integration occurs when prices among different locations or related goods follow similar patterns over time. Current knowledge on market integration between aquaculture and wild-caught fish is based on a small number of species and markets. Most studies show the existence of market integration between wild and farmed conspecifics, with the clear exception of European seabass and gilthead seabream in Southern European countries. In this study, we investigate whether this lack of market integration between wild and farmed conspecifics for European seabass and gilthead seabream in Southern European countries is specific for these species or is representative for the area. Therefore, we investigate the existence of market integration in Spain between wild and farmed conspecifics for a large variety of different species: turbot (*Scophthalmus maximus*), sole (*Solea spp.*), blackspot (red) seabream (*Pagellus bogaraveo*), Atlantic cod (*Gadus morhua*), and meagre (*Argyrosomus regius*).

Keywords: market integration, price competition, aquaculture, fisheries, Spain.

Introduction

The development of prices over time provides important information on the relationship between products, as has been widely recognized by economists such as Cournot (1838), Marshall (1947) and Stigler (1969). When prices at different locations or of related goods follow similar patterns over time, market integration occurs. The existence of market integration (competition) between products implies that these products behave as substitutes.

Market integration between capture fisheries and aquaculture can be observed, for the most part, when increased aquaculture supply leads to decreases in wild-caught seafood prices (Anderson, 1985). Considering the stagnation in world wild capture fisheries and the fast growth in the aquaculture sector, it is reasonable to expect that the productivity improvements in aquaculture thanks to technological innovation will lead to a reduction in the cost of production. If the two products (farmed and wild fish) are integrated in the market, farmed fish will win market share from wild fish. When market integration is verified, it means that there is substitutability between wild and farmed products. If demand is not perfectly elastic, the price of both products will decline, as will the income of fishermen. However, if the two products are not substitutes, so that there are no market effects, the increase in the supply of the farmed produce will only lead to a price decrease for farmed products and not affect the price of wild-caught produce (Asche et al., 2001).

Current knowledge on market integration between farmed and wild fish is based on a limited number of species and markets. Studies have mostly focused on the EU, Japan and the US markets, which are the main consumer markets (Bjørndal & Guillen, 2016a). The EU, Japan and the US received 65% of the value of all seafood imports in 2011. In fact, in 2011, Japan (14%) and the US (13%) were the individual countries that received most of the imports, with almost 18 billion USD each, followed by China (7.8 billion USD) and several EU countries (the 28 EU countries totalled 38%). The only other non-EU country in the top 10 was the Republic of Korea, occupying the ninth position with 3.2 billion USD (FAO, 2015).

Concerning the species, studies have mostly focused on salmon and trout, shrimp and prawn, catfish and tilapia, and seabass and seabream, which are the most traded species (Bjørndal & Guillen, 2016a). A summary of the most relevant findings is provided below.

The Japanese market is the largest and most diversified salmon market in the world, where wild and farmed species from Europe and South and North America compete. Asche et al. (2005) found that wild-caught sockeye salmon (*Oncorhynchus nerka*), coho salmon (*Oncorhynchus kisutch*), farmed coho salmon (*Oncorhynchus kisutch*) and salmon trout (large rainbow trout, *Oncorhynchus mykiss*) are close substitutes in the Japanese market. Likewise, in Finland, imported farmed Atlantic salmon (*Salmo salar*), wild-caught salmon (*Salmo salar*) and farmed salmon trout (*Oncorhynchus mykiss*) are close substitutes, with imported farmed Atlantic salmon being the one that determines the price of the others (Mickwitz, 1996, Setälä et al., 2003; Virtanen et al., 2005). Similarly, Nielsen et al. (2007) showed that imported farmed frozen trout was perfectly integrated with imported farmed Atlantic salmon (*Salmo salar*) in the German market. Therefore, the expansion of farmed salmon has led to decreases in prices for all salmon species as well as other salmonid species such as trout.

Asche et al. (2012) proved that US capture shrimp and imports of farmed “shell-on frozen” shrimp are substitutes in the US market. This explains why US capture shrimp prices do not increase when domestic production decreases. Similarly, Béné et al. (2000) found that imports of wild brown shrimp (*Penaeus subtilis*) from French Guyana were substitutes for the imports of cultured Thai black tiger shrimp (*Penaeus monodon*) in the French market.

The US is not only the main international market for catfish and tilapia, but also the only developed country that has a significant national production of one of these species. The US produced 163 thousand tons of channel catfish (*Ictalurus punctatus*) in 2013 (FAO, 2015). US catfish producers have often complained that imports of catfish and tilapia affect their prices in the US market. However, Norman-López and Asche (2008) found that none of the tilapia product forms competed with catfish. Instead, there is a single market for domestic catfish in the US, with fresh and frozen catfish fillets. Conversely, results also show that the markets for fresh and frozen tilapia fillets are separated. This is explained, at least in part, by varying production technologies, quality and/or transportation costs between different tilapia producer countries. In fact, fresh tilapia fillets are mainly shipped from Latin America, while the frozen products are primarily imported from South-East Asia. These results are confirmed by Norman-López and Bjørndal (2009) who found no relationship between different tilapia products: between imports of whole, frozen tilapia and frozen tilapia fillets from Asia, Africa and South and Central America in the US market, as well as between the highest quality, whole, fresh tilapia (grade 1) and frozen tilapia fillets in Egypt.

About 95% of the gilthead seabream (*Sparus aurata*) and European seabass (*Dicentrarchus labrax*) production comes from aquaculture, while 96% of their total production comes from Mediterranean countries. Bjørndal and Guillen (2016b), in a more comprehensive analysis than previous studies (e.g. Brigante & Lem, 2001; Alfranca et al., 2004; Rodríguez et al., 2013; Regnier & Bayramoglu, 2014) investigate the market integration (substitutability) between wild and farmed gilthead seabream and European seabass in the Barcelona and Madrid wholesale markets, and in the French retail market. Indeed, when it comes to Southern Europe, existing knowledge on market integration in the area is more limited, and it is based solely on the few studies investigating gilthead seabream and European seabass, as well as a few dated studies on salmon (Gordon et al., 1993; Jaffry et al., 2000).

In this study, we investigate if the general lack of market integration between wild and farmed conspecifics for European seabass and gilthead seabream in Southern European countries is specific for these species or is a more general result. Hence, we investigate the existence of market integration in Spain between wild and farmed conspecifics for different and a larger variety of species. The species analyzed are turbot (*Scophthalmus maximus*), sole (*Solea spp.*), blackspot (red) seabream (*Pagellus bogaraveo*), Atlantic cod (*Gadus morhua*), and meagre (*Argyrosomus regius*).

This paper is organized as follows. Section two introduces the Johansen cointegration methodology to estimate the existence of market integration. Data used for the analysis are presented in section three. Section four shows the results obtained, while section five provides a discussion and interpretation of the results. The paper is summarized in the final section.

Methodology

Market integration analysis using time series data for prices has been used for a number of seafood products. It is particularly useful when there is the need to analyze a large number of products, as demand analysis in such cases is not feasible (Asche et al., 2004).

Following Ravallion (1986), market integration is analyzed by looking at whether the prices of products are related over time, which allows price adjustment between markets to take time. Therefore, we investigate whether the price of a product (dependent variable P_1) can be explained by the price evolution of another product (explanatory variable P_2), as well as its own previous price evolution. We use the following model specification:

$$P_{1,t} = \alpha + \sum_{j=1}^{m} \beta_j P_{1,t-j} + \sum_{i=0}^{n} \delta_i P_{2,t-i} + e_t \qquad \text{(Eq. 1)}$$

Here α is a constant term and e is a white noise error term. Hence, if δ_i is equal to 0, there is no relationship between the prices of both products, so there is no market integration. While, if δ_i is different to 0, there is a relationship between the prices of both products, and consequently there is market integration.

The relationships between variables have traditionally been studied with ordinary regression analysis. Such methodology can only be used when variables (i.e., prices) are stationary (Squires et al., 1989; Asche et al., 2004), but many economic variables show trends, and so they are non-stationary. When non-stationary time series (e.g. prices) are used in a regression model, relationships that appear to be significant may emerge from unrelated variables (spurious regression). Therefore, the use of cointegration methodology is required to estimate real long-run relationships between non-stationary variables (Ardeni, 1989; Whalen, 1990; Goodwin & Schroeder, 1991). Since most seafood prices have been found to be non-stationary, cointegration is currently the most commonly used empirical tool to test for market integration (e.g. Nielsen et al., 2007; Norman-López & Asche, 2008; Nielsen et al., 2009).

The idea of cointegration is that even if two or more variables are non-stationary in their levels, linear combinations (so-called cointegration vectors) that are stationary may exist (Engle & Granger, 1987). When cointegration is verified, the variables exhibit (one or more) long run relationships. Variables may drift apart due to random shocks, sticky prices, contracts, etc. in the short run, but in the long run, the economic processes force the variables back to their long run equilibrium path (Engle & Ganger, 1987). Hence, the economic interpretation of cointegration is that "if two (or more) series are linked to form an equilibrium relationship spanning the long-run, then even though the series themselves may contain stochastic trends (that makes them non-stationary) they will nevertheless move closely together over time and the difference between them will be stable (so stationary)" (Harris, 1995, p22). Therefore, prices for products in the same market are part of a long-run equilibrium system, although significant short-run deviations from equilibrium conditions may still be observed due to stochastic supply and demand shocks. If the products are substitutes, there will be market forces working to re-equilibrate the price ratio after a shock occurs in the market. Thus, when cointegration is verified, it implies the existence of a stable long-run relationship between the prices; from which it can be assumed that a price parity equilibrium condition exists; and consequently the variables form part of the same market. Thus, cointegration theory is consistent with Stigler and Sherwin's market definition[1] and the stochastic behavior of prices.

[1] Stigler and Sherwin (1985) define substitute products as those which are "in the same market" and whose relative prices "maintain a stable ratio".

Most recent market integration studies have used the multivariate Johansen cointegration test (Johansen, 1988, 1991; Johansen & Juselius, 1990), solving the problems faced in bivariate methods by providing a matrix with all possible distinct cointegration vectors based on all the variables. Thus, the Johansen test enables testing for both cointegration and hypothesis testing on the parameters in the cointegration vector.

Under the Johansen approach, the data are divided into two groupings, the variables in their levels and their first differences. Using the technique of canonical correlation, the linear combinations of the data (in their levels) that are highly correlated with the differences are found. If the correlation is sufficiently high, then it follows that these linear combinations are stationary, and thus are the cointegration vectors.

The multivariate approach developed by Johansen starts by defining a vector Z_t, containing *n* potentially endogenous variables, where it is possible to specify a data generating process and model Z_t as an unrestricted vector autoregression (VAR) with up to k-lags of Z_t:

$$Z_t = A_1 Z_{t-1} + \dots + A_k Z_{t-k} + \Phi D_t + \mu + \varepsilon_t \qquad \text{(Eq. 2)}$$

where Z_t is (n×1), each of the A_i is an (n×n) matrix of the coefficients, D_t are seasonal dummies orthogonal to the constant term μ and ε_t ~ niid $(0,\Omega)$, so it is assumed to be an independent and identically distributed Gaussian process. Equation 2 can be reformulated in vector error-correction (VECM) form by subtracting Z_{t-1} from both sides:

$$\Delta Z_t = \Gamma_1 \Delta Z_{t-1} + \dots + \Gamma_{k-1} \Delta Z_{t-k+1} + \Pi Z_{t-k} + \Phi D_t + \mu + \varepsilon_t \qquad \text{(Eq. 3)}$$

where, $\Gamma_i = -(I - A_1 - \dots - A_i)$, $(i = 1, \dots, k-1)$, and $\Pi = -(I - A_1 - \dots - A_k)$. (Eq. 4)

The system of equations 2 and 3 contains information on both the short- and the long-run adjustment to changes in Z_t. The rank of Π, denoted as r, determines how many linear combinations of Z_t are stationary.

Determining the lag order to take into account in the model is a key issue in cointegration. This happens because in order to apply cointegration, a series should be non-stationary; but the stationarity properties of a series can change with the number of lags considered as explanatory variables. In other words, test results on whether a series are stationary changes with the number of lags considered as explanatory variables. The optimal number of lags for one series (e.g. found using a unit root test) may be different to the optimal number of lags for another series we want to use as a comparison. In addition, these lag-lengths may be different from the optimal number of lags when applying cointegration methodology. Thus, estimating the optimal number of lags for one series using a unit root test may be of little help initially. In addition, different lag length selection criteria often lead to different conclusions regarding the optimal number of lags that should be used. Meanwhile, the choice of the lag length can considerably affect the results of the cointegration analysis (Emerson, 2007). Therefore, we determine the number of lags using three different criteria:

- Log Likelihood
- Akaike Information Criteria
- Schwarz Criteria

Determining how many cointegration vectors exist is equal to testing for cointegration. If $r = N$, the variables in levels are stationary. While if $r = 0$ so that $P = 0$, none of the linear combinations are stationary. When $0 < r < N$, r cointegration vectors, or r stationary linear combinations of Z_t exist.

Therefore, four different outcomes can be obtained from the cointegration tests of bivariate systems when estimating them for the number of lags obtained using the previous criteria:

- All tests show two cointegration equations. Then prices are stationary and cointegration methodology cannot be applied.
- All tests show zero cointegration equations. Then prices are not cointegrated, and consequently products are not in the same market.
- All tests show one cointegration equation. There is the need to investigate the stationarity properties of the series. There are two options. It could be that both series are non-stationary and they are cointegrated (i.e., are part of the same market), so there is only one cointegration equation. However, it is possible that one of the series is stationary and the other one is non-stationary, and consequently they are not cointegrated.
- Outcomes from the tests report different numbers of cointegration equations depending on the lag chosen. There is the need to investigate the stationarity properties of the series, and results should be considered with caution.

When cointegration methodology cannot be applied because two cointegration equations are found, regression methodology is used to investigate the relationships between variables because they are stationary.

Data

In this section, the data used are described. Wild and farmed price data from the Barcelona and Madrid wholesale markets have been used. Unfortunately, no data with the required specifications was available for other species, markets or countries.

The use of cointegration methodology is very data demanding, it requires a large number of observations (close to 100 observations depending on the characteristics of the series) in order to obtain robust results. In addition, in order to perform our study for each species analyzed we require price data disaggregated between farmed and wild origin. However, these data are rarely available, in part because (i) few countries collect and report detailed price data, and (ii) there are few markets where both wild and farmed conspecifics supplies are present and properly differentiated.

In order to carry out this analysis we use weekly price data for the following fresh whole wild and farmed species (see Figures 1 to 6):

- Turbot (*Scophthalmus maximus*), at the Madrid wholesale market for the period 2003-14, and at the Barcelona wholesale market for the period 2006-14;
- Sole (*Solea spp.*[2]), at the Madrid wholesale market for the period 2012-14;
- Blackspot (red) seabream (*Pagellus bogaraveo*), at the Barcelona wholesale market for the period 2006-14;
- Atlantic Cod (*Gadus morhua*), at the Barcelona wholesale market for the period 2006-14;
- Meagre (*Argyrosomus regius*), at the Barcelona wholesale market for the period 2006-14.

(Figures 1 to 6 to be placed around here)

The descriptive statistics (mean, standard deviation, coefficient of variation and number of observations) for the data we used are presented in Table 1.

(Table 1 to be placed around here)

From Table 1 it can be seen that wild products are more expensive, but they also suffer from higher price volatility (i.e., their coefficient of variation is higher).

[2] Sole refers to two species, Common sole (*Solea solea*) and Senegalese sole (*Solea senegalensis*). Both species are almost indistinguishable to consumers and are often combined in production and market statistics (Bjørndal & Guillen, 2016c).

In Spain, wild fish products are often commercialized through the traditional supply chain stages of ex-vessel (auction), wholesale and retail markets (Guillen & Franquesa, 2015). Half of all the seafood products consumed in Spain are commercialized through the "*merca*" wholesale market stage (Mercasa, 2015). However some high value fresh wild seafood products, especially the largest and most expensive individuals of certain species, may not reach the retail market stage, but they go directly to restaurants (Guillen & Maynou, 2015). On the other hand, the first sale of farmed products often happens at the wholesale level or very close to it. Therefore, the wholesale market becomes the best place to compare wild and farmed products. Mercabarna and Mercamadrid, Barcelona and Madrid's wholesale markets, are the main wholesalers in Spain commercializing more than half of the seafood at the *"merca"* wholesale stage. Mercabarna was responsible for almost 1/3 and Mercamadrid for almost ¼ of the seafood traded in 2014 (Mercasa, 2015).

The annual average traded volume and price in USD per kg and wholesale market of the wild and farmed species analyzed for the period 2006-14 are presented in Table 2.

(Table 2 to be placed around here)

From Table 2 it can be seen that wild species are always more expensive than their farmed conspecifics. On the other hand, wild quantities traded are lower than the farmed quantities traded for consolidated aquaculture products such as turbot. Wild quantities traded are only higher than farmed quantities for species that have been farmed for a few years and still their farmed production levels are relatively small (e.g. cod, blackspot seabeam and meagre).

Results

In this section, we report the results from the market integration analysis between wild and farmed conspecifics.

The lag length selection for the bivariate AR models is done considering three different criteria (Log Likelihood, Akaike Information Criteria, and Schwarz Criteria). The different values obtained for each criterion at each lag length can be provided by the corresponding author upon request. In Table 3, we present the optimal lag length for each criterion, summarizing the previous outcomes.

(Table 3 to be placed around here)

Table 4 presents the cointegration results for wild and farmed conspecifics according to the lag length previously obtained.

(Table 4 to be placed around here)

For sole in the Madrid wholesale market and meagre in the Barcelona wholesale market, all likelihood ratios of the cointegration tests show the existence of no (0) cointegration equations between wild and farmed conspecifics, consequently, there is no market integration between both products.

For turbot in the Madrid wholesale market, and blackspot (red) seabream and Atlantic cod in the Barcelona wholesale market, all likelihood ratio tests of the cointegration tests show the existence of two cointegration equations between wild and farmed conspecifics, consequently, market integration between both products should be investigated using regression methodology.

For turbot in the Barcelona wholesale market, the likelihood ratio test of the cointegration tests show the existence of one cointegration equation between wild and farmed conspecifics, so there is a need to investigate the stationary properties of the price series in order to determine the existence of market integration.

The stationary properties of the turbot prices in the Barcelona wholesale market were investigated using the augmented Dickey–Fuller test (ADF). Results are reported in Table 5.

(Table 5 to be placed around here)

All the ADF Test statistics for wild turbot prices in the Barcelona wholesale market are higher than the MacKinnon critical value for rejection of the hypothesis of a unit root at a 5% significance level (-2.866). Thus, wild turbot prices in the Barcelona wholesale market behave as non-stationary series. The farmed turbot prices behave as stationary, because all their ADF Test statistics are lower than the critical value. Therefore, there is no market integration between wild and farmed turbot in the Barcelona wholesale market.

Regression methodology should be used to investigate the existence of market integration between wild and farmed turbot in the Madrid wholesale market, and blackspot (red) seabream and Atlantic cod in the Barcelona wholesale market. The lag-length has been chosen so that the Akaike information criteria are minimized (3 and 4 lags for turbot, 1 and 5 for blackspot (red) seabream, and 3 and 5 lags for cod). Table 6 provides a summary of the six different regressions required, outcomes of the different regressions can be provided by the corresponding author upon request.

(Table 6 to be placed around here)

Farmed turbot prices cannot explain the evolution of turbot sole prices, and vice versa. Consequently, results from the regression methodology show that there is no market integration between wild and farmed turbot in the Madrid wholesale market. On the other hand, farmed cod prices can explain the evolution of wild cod prices, and vice versa. Likewise, farmed blackspot (red) seabream prices can explain the evolution of wild blackspot seabream prices, and vice versa. Consequently, results from the regression methodology show that there is market integration between wild and farmed cod and blackspot seabream in the Barcelona wholesale market.

Therefore, there is no market integration between wild and farmed conspecifics for turbot (*Scophthalmus maximus*), sole (*Solea spp.*), and meagre (*Argyrosomus regius*), while there is market integration between wild and farmed conspecifics for blackspot (red) seabream (*Pagellus bogaraveo*) and Atlantic cod (*Gadus morhua*).

Concluding remarks

Aquaculture already supplies half of the total fish consumption. The aquaculture share in the total fish consumption has been increasing and this trend is expected to continue in the future (Lem et al., 2015). This is mainly because aquaculture is probably the fastest growing food sector, while world capture fisheries are stagnated.

Aquaculture has become one of the key and fastest-growing food production sectors in the world (Asche, 2008). World aquaculture production reached 90.4 million tons (live weight equivalent) in 2012 (US$144.4 billion), including 66.6 million tons of food fish (US$137.7 billion) and 23.8 million tons of aquatic algae (mostly seaweed, US$6.4 billion). World food fish aquaculture production expanded from 32.4 million tons in 2000 to 66.6 million tons in 2012 which corresponds to an average annual rate of 6.2% (9.5% between 1990 and 2000) (FAO, 2014).

Therefore, market integration between capture fisheries and aquaculture can generally be perceived when prices of wild-caught fish decrease (even when their capture production is stable or decreasing) because of the increased aquaculture supply. However, if wild and farmed products are not integrated, only farmed product prices will decrease due to increased aquaculture supply.

Bjørndal and Guillen (2016a) analyze the literature on market integration between wild and farmed fish. Current knowledge on market integration between aquaculture and wild fish is still based on a small number of species and markets. Studies have mostly focused on the EU, Japan and the US markets, which are the main consumer markets. At the species level, studies have mostly focused on those most commonly traded in the EU, namely salmon and trout, shrimp and prawn, catfish and tilapia, and seabass and seabream.

Most studies support the existence of market integration between wild and farmed conspecifics or with related species (e.g. salmon and trout). However, there are a few exceptions for tilapia and catfish, and especially for seabass and seabream in Southern European countries. Apart from the few studies on market integration for European seabass and gilthead seabream, there are only a couple of older studies on market integration in Southern Europe for Atlantic salmon (Gordon et al., 1993; Jaffry et al., 2000).

In this study we investigate the existence of market integration between wild and farmed conspecifics for a larger number of species: turbot (*Scophthalmus maximus*) in the Barcelona and Madrid wholesale markets, sole (*Solea spp.*) in the Madrid wholesale market, blackspot (red) seabream (*Pagellus bogaraveo*), Atlantic cod (*Gadus morhua*), and meagre (*Argyrosomus regius*) in the Barcelona wholesale market.

Results show that there is no market integration between wild and farmed conspecifics in Spain for turbot in both markets, sole, and meagre; while there is market integration between wild and farmed conspecifics for blackspot (red) seabream and Atlantic cod.This corroborates that the general lack of market integration between wild and farmed conspecifics for European seabass and gilthead seabream in Southern European countries is not a species-specific issue, but it is a common characteristic of the markets in the area.

In particular, farmed turbot represents almost 90% of all fresh turbot commercialized in the wholesale markets. In fact, domestic landings are minimal and perceived as a different product compared to farmed production. It is only in spring, when significant amounts of wild turbot are imported from the Netherlands that producers believe that wild turbot may compete with farmed, because in some years wild turbot can be cheaper than farmed (see Figure 1). Results from this study confirm the differentiation between both products. On the other hand, sole farmed production is quite small (about 1% of the total fresh sole commercialized), but the product is still under development and the marketed sizes of farmed sole are very small, sometimes even smaller than the minimum landing size of wild sole. So, the two products can be easily differentiated in the market. Similarly, farmed meagre production suffers several technical issues and production is still limited. It is not a very popular species all over the country and consumption is quite concentrated in some areas in the south and east of Spain. Meagre producers also failed marketing it, by selling big fish of 2-3 kg, which is not very convenient for household consumption. So, there is also still work to do in technology and product development for farmed meagre.

This general lack of substitutability between farmed and aquaculture products can be explained, at least in part, by the negative perception aquaculture products have in comparison to wild fish in Spain, and Southern Europe in general (Fernández-Polanco & Luna, 2010, 2012; Claret et al., 2012; Fernández-Polanco et al., 2013). Indeed, Southern European consumers always prefer wild fish compared to farmed fish (Claret et al., 2012), because they perceive farmed fish as being of lower quality and affected by more health and safety issues than wild fish (Kole, 2003; Verbeke et al., 2007; Fernández-Polanco & Luna, 2010). Farmed fish is also perceived as more processed or manipulated than those from the wild (Claret et al., 2012). This implies that farmed fish attracts lower prices than wild (capture) fish. In fact, some fine restaurants only serve wild fish products, specifying this on the menu. As a result, a share of the high value wild production will not enter into the more traditional market chain. Therefore, wild and farmed products target different market segments, and consequently different consumers.

The existence of market integration between wild and farmed conspecifics for Atlantic cod can be explained because both products are imported and the low volumes of farmed cod commercialized. Supply of wild cod was expected to decline opening an opportunity for aquaculture, but landings of wild cod recovered and marketing of fresh wild Norwegian cod improved, leading to renewed popularity of this species across Spanish consumers. This has lead almost to the collapse of the farmed cod industry. Only small size farmed cod is commercialized and is less frequent than wild (farmed cod represented the 22% of all fresh cod commercialized at the wholesale level). On the other hand, the existence of market integration between wild and farmed conspecifics for blackspot (red) seabream is a bit more unexpected. There is a very small number of farms producing blackspot (red) seabream and consequently its commercialization has been very reduced (representing only 2% of all fresh blackspot (red) seabream commercialized). Some retailers may even reject selling this product due to deformities in the black spot, which is not always visible as it is in the wild conspecifics. Thus, it could be possible to consider that because of their low volumes commercialized, the price of farmed products follow similar trends than the price of their wild conspecifics.

Finally, this general lack of market integration between wild and farmed conspecifics in Southern Europe implies that prices of wild-caught species do not decrease when aquaculture production increases. Market integration has only been found for meagre and cod, whose farmed supply is very limited and no supply increases are expected in the near future. Therefore, the local capture fisheries sector, as well as importers, should not experience a decrease in their revenues and profits due to increased aquaculture supply. This allows for the existence of high fish prices in the area (e.g. Mediterranean Sea), and consequently more pressure on the already heavily exploited fish stocks. There is no immediate reason to expect changes in these results, as farmed production is likely to continue increasing, while wild production may remain stagnant, unless consumers' perceptions of aquaculture products change significantly.

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Figure 1: Price evolution of wild and farmed turbot in Madrid wholesale market

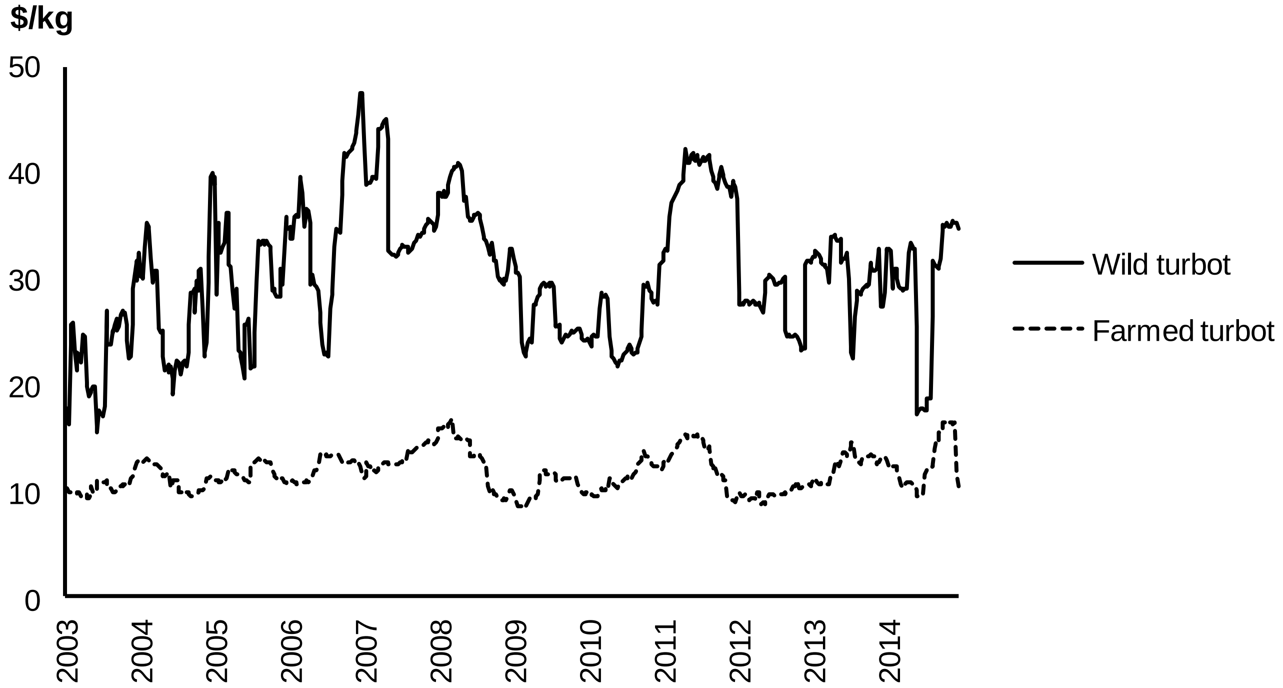

Figure 2: Price evolution of wild and farmed turbot in Barcelona wholesale market

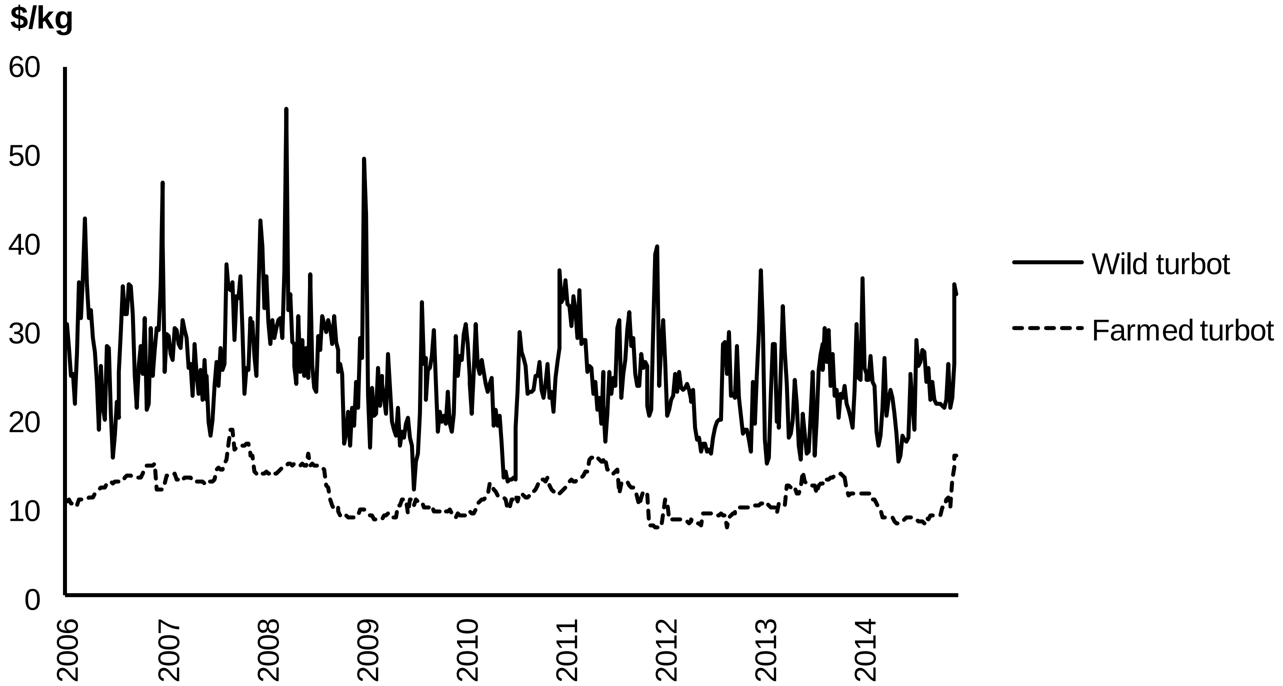

Figure 3: Price evolution of wild and farmed cod in Barcelona wholesale market

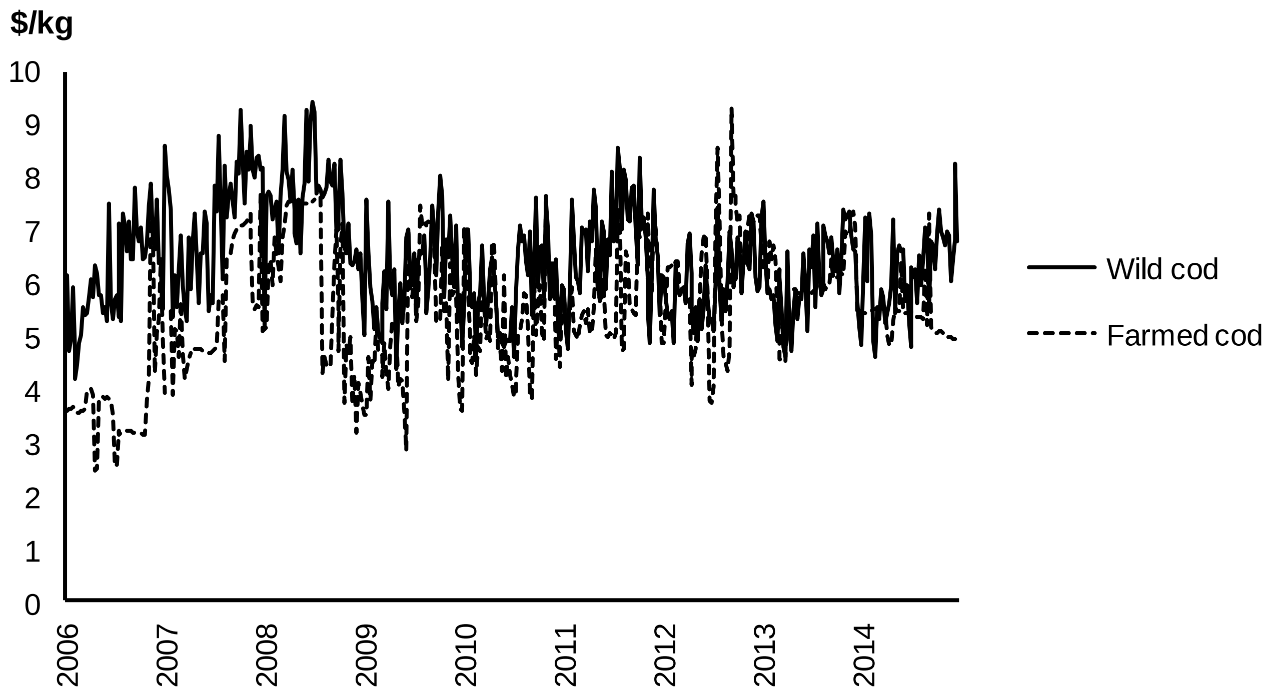

Figure 4: Price evolution of wild and farmed meagre in Barcelona wholesale market

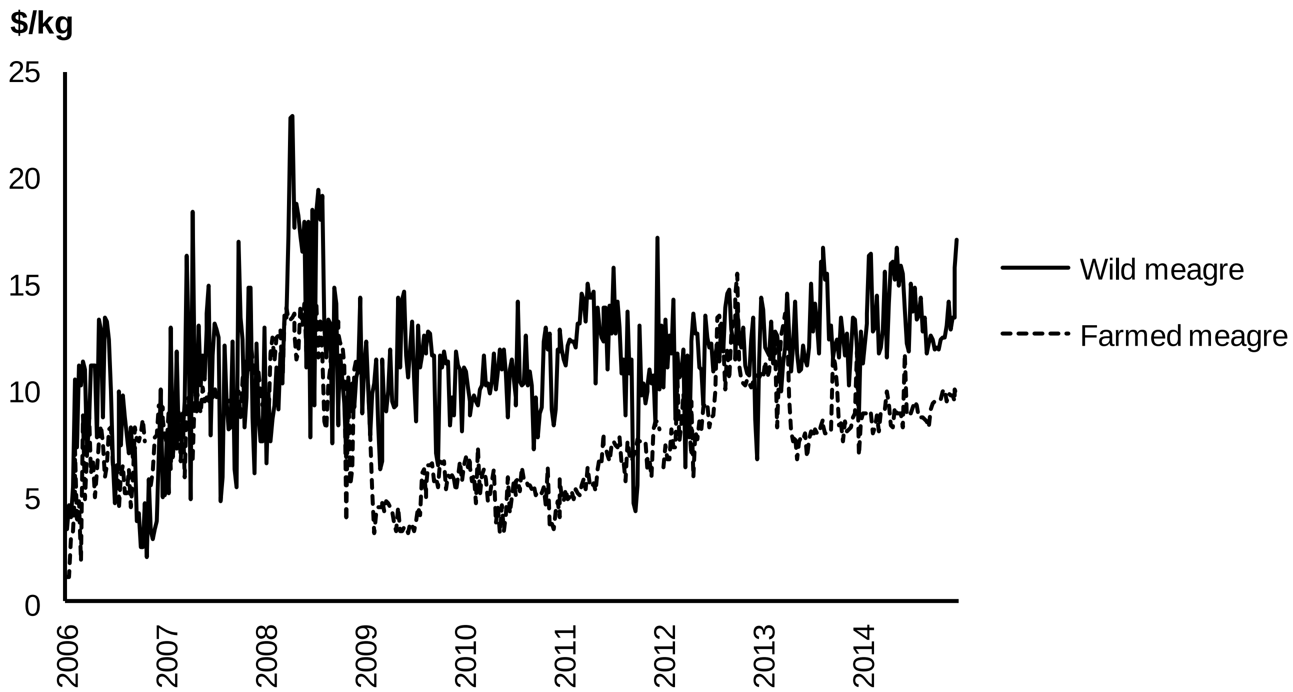

Figure 5: Price evolution of wild and farmed sole in Madrid wholesale market

Figure 6: Price evolution of wild and farmed blackspot (red) seabream in Barcelona wholesale market

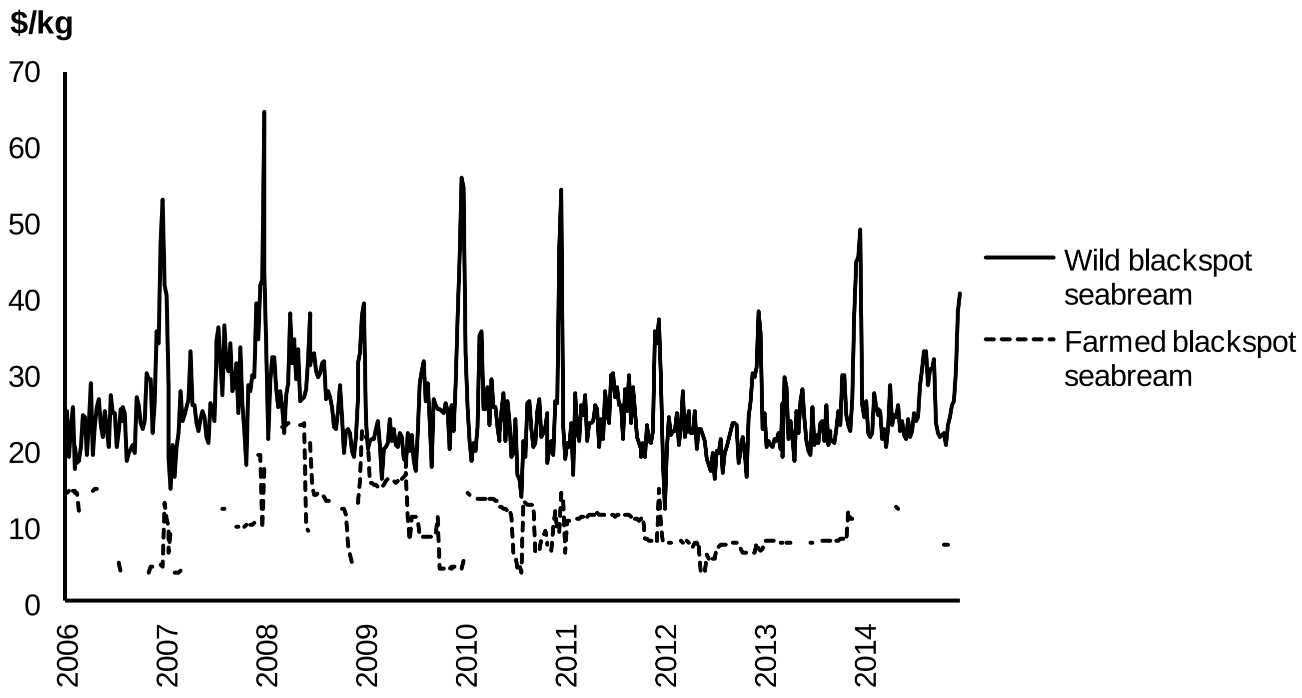

Table 1: Descriptive statistics of the wild and farmed species price series data

Species	Market	Origin	Mean	Std. Dev.	C.Var.	Observations
Turbot	Madrid	Wild	23.13	4.41	19.08	623
		Farmed	8.94	1.23	13.80	623
	Barcelona	Wild	18.64	4.30	23.08	468
		Farmed	8.59	1.57	18.30	468
Sole	Madrid	Wild	17.43	1.65	9.48	141
		Farmed	11.82	1.47	12.47	141
Blackspot (red) seabream	Barcelona	Wild	18.83	4.51	23.94	468
		Farmed	7.67	3.10	40.45	326
Atlantic cod	Barcelona	Wild	4.77	0.64	13.46	468
		Farmed	4.02	0.83	20.64	453
Meagre	Barcelona	Wild	8.35	2.17	26.00	468
		Farmed	5.96	1.93	32.36	465

Table 2: Average traded volume and price per year of the wild and farmed species analyzed for the period 2006-14

	Species	**Origin**	**Market**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Tons	Turbot	Farmed	Madrid	223.7	274.7	439.3	733.1	952.5	990.4	855.6	1097.6	786.9
	Turbot	Wild	Madrid	55.9	68.7	109.8	154.4	168.1	115.2	95.1	122.0	87.5
	Turbot	Farmed	Barcelona	380.5	430.3	404.1	466.8	460.4	458.5	517.1	549.7	527.1
	Turbot	Wild	Barcelona	95.3	72.9	66.2	74.7	69.9	65.3	76.3	85.3	74.7
	Sole	Farmed	Madrid							6.6	11.6	9.5
	Sole	Wild	Madrid							876.0	1157.6	941.3
	Atlantic cod	Farmed	Barcelona	90.1	46.6	89.5	144.1	143.6	136.3	159.0	180.0	96.5
	Atlantic cod	Wild	Barcelona	372.4	259.7	293.6	351.4	297.7	251.7	247.8	237.2	341.3
	Blackspot seabream	Farmed	Barcelona	4.8	3.1	5.7	17.5	6.6	8.6	6.9	6.5	1.3
	Blackspot seabream	Wild	Barcelona	78.6	77.9	69.7	80.7	59.1	57.5	68.2	64.4	64.7
	Meagre	Farmed	Barcelona	55.0	76.8	63.9	96.7	136.1	161.1	74.3	54.9	62.2
	Meagre	Wild	Barcelona	37.2	33.8	23.4	20.8	26.0	52.6	55.8	73.7	77.6
Price ($/kg)	Turbot	Farmed	Madrid	12.2	13.1	12.7	10.4	11.2	12.9	9.7	12.5	12.8
	Turbot	Wild	Madrid	34.8	35.8	35.4	27.1	25.3	38.6	28.2	30.4	29.8
	Turbot	Farmed	Barcelona	12.4	14.4	12.7	9.7	11.3	12.6	9.2	12.0	9.8
	Turbot	Wild	Barcelona	27.5	27.5	28.0	21.5	22.4	26.1	21.1	22.2	22.7
	Sole	Farmed	Madrid							16.8	16.3	13.7
	Sole	Wild	Madrid							20.3	21.5	25.1
	Atlantic cod	Farmed	Barcelona	3.8	5.6	6.2	5.0	5.0	5.8	5.9	5.9	5.3
	Atlantic cod	Wild	Barcelona	5.8	6.9	7.5	6.1	5.8	6.5	5.9	6.0	6.0
	Blackspot seabream	Farmed	Barcelona	9.2	9.6	16.2	9.5	9.2	10.8	6.9	8.5	8.1
	Blackspot seabream	Wild	Barcelona	25.5	27.7	27.9	24.0	24.4	24.4	22.7	24.3	25.7
	Meagre	Farmed	Barcelona	6.2	9.6	11.6	5.2	5.1	6.4	9.7	9.4	9.2
	Meagre	Wild	Barcelona	6.2	9.9	12.4	10.9	10.7	10.9	11.8	12.5	13.6

Table 3: Optimal lag length for wild and farmed species by criteria

Species	Wholesale market	Likelihood Ratio	Akaike Information Criteria	Schwarz Criteria
Turbot	Madrid	3	3	1
	Barcelona	0	0	0
Sole	Madrid	2	2	0
Blackspot (red) seabream	Barcelona	0	0	0
Atlantic cod	Barcelona	2	3	1
Meagre	Barcelona	12	12	5

Table 4: Cointegration test for wild and farmed conspecifics

Species	Wholesale Market	Lags	Eigenvalue	Likelihood Ratio	5% Critical Value	No. of CE(s)
Turbot	Madrid	1	0.056	47.353	19.96	None *
			0.019	11.630	9.24	At most 1 *
		3	0.044	41.282	19.96	None *
			0.021	13.225	9.24	At most 1 *
	Barcelona	0	0.155	83.716	19.96	None *
			0.011	5.321	9.24	At most 1
Sole	Madrid	0	0.036	7.670	19.96	None
			0.018	2.572	9.24	At most 1
		2	0.047	8.645	19.96	None
			0.015	2.061	9.24	At most 1
Blackspot (red) seabream	Barcelona	0	0.129	56.400	19.96	None *
			0.076	20.541	9.24	At most 1 *
Atlantic cod	Barcelona	1	0.151	113.003	19.96	None *
			0.092	41.733	9.24	At most 1 *
		2	0.097	72.624	19.96	None *
			0.065	28.806	9.24	At most 1 *
		3	0.068	53.070	19.96	None *
			0.053	23.139	9.24	At most 1 *
Meagre	Barcelona	5	0.031	19.810	19.96	None
			0.013	5.704	9.24	At most 1
		12	0.017	10.270	19.96	None
			0.006	2.766	9.24	At most 1

* denotes rejection of the hypothesis at 5% significance level

Table 5: Unit root test considering intercept for wild and farmed turbot

Species	Market	Origin	Lags	ADF Test Statistic
Turbot	Barcelona	Wild	0	-2.273
		Farmed	0	-8.620*

* denotes rejection of the hypothesis at 5% significance level. Critical values at 1%: -3.45, 5%: -2.87, 10%: -2.57.

Table 6: Summary of the regressions for wild and farmed turbot in Madrid and blackspot seabream and Atlantic cod in Barcelona wholesale markets

Species	Market	Dependent variable	Explanatory variable	Total lags	0 lags expl. var.	1 lags expl. var.	2 lags expl. var.	3 lags expl. var.	4 lags expl. var.	5 lags expl. var.
Turbot	Madrid	Wild	Farmed	4	0.038	0.020	-0.034	-0.027	-0.003	
		Farmed	Wild	3	0.008	-0.023	0.033	-0.026		
Blackspot seabream	Barcelona	Wild	Farmed	5	0.166*	-0.220*	0.156	-0.070	-0.054	-0.022
		Farmed	Wild	1	0.154*	-0.037				
Atlantic cod	Barcelona	Wild	Farmed	5	0.132*	-0.045	-0.117*	0.052	-0.014	-0.016
		Farmed	Wild	3	0.217*	0.090	-0.122	-0.123*		

* Denotes significant at a 5% level.

APPENDIX

Lag selection: Turbot (*Scophthalmus maximus*) at the Madrid wholesale market

Table A1: Lag interval selection for wild and farmed turbot in the Madrid wholesale market

Lags	Rank or No. of Ces	Log Likelihood by Rank	Akaike Information Criteria by Rank	Schwarz Criteria by Rank
Lags interval: No lags	0	2117.713	-6.809368	-6.809368
	1	2132.299	-6.840189	-6.804554
	2	2137.272	-6.840102	-6.768833
Lags interval: 1 to 1	0	2126.261	-6.834979	-6.806435
	1	2144.122	-6.876400	**-6.812177**
	2	2149.937	-6.879024	-6.779123
Lags interval: 1 to 2	0	2124.908	-6.828736	-6.771578
	1	2142.786	-6.870277	-6.777396
	2	2149.206	-6.874859	-6.746255
Lags interval: 1 to 3	0	2142.476	-6.883606	-6.797762
	1	2156.505	-6.912777	-6.791165
	2	**2163.117**	**-6.917986**	-6.760606
Lags interval: 1 to 4	0	2141.242	-6.877804	-6.763203
	1	2154.501	-6.904535	-6.754121
	2	2162.481	-6.914180	-6.727952

From the lag selection table, we can see that under the Log Likelihood and the Akaike Information Criteria the optimal lags are 3 lags and 1 lag under the Schwarz Information Criteria. So, cointegration tests are run for 1 and 3 lags.

Lag selection: Turbot (*Scophthalmus maximus*) at the Barcelona wholesale market

Table A2: Lag interval selection for wild and farmed turbot in the Barcelona wholesale market

Lags	Rank or No. of Ces	Log Likelihood by Rank	Akaike Information Criteria by Rank	Schwarz Criteria by Rank
Lags interval: No lags	0	941.6926	-4.032945	-4.032945
	1	980.8899	**-4.179400**	**-4.135007**
	2	**983.5505**	-4.169381	-4.080595
Lags interval: 1 to 1	0	945.2929	-4.039884	-4.004311
	1	979.0243	-4.163195	-4.083157
	2	981.7117	-4.153269	-4.028766
Lags interval: 1 to 2	0	950.6946	-4.054600	-3.983340
	1	978.2768	-4.151728	-4.035929
	2	980.7318	-4.140782	-3.980445
Lags interval: 1 to 3	0	955.0115	-4.064705	-3.957639

	1	978.2162	-4.143173	-3.991497
	2	980.4546	-4.131270	-3.934982
Lags interval: 1 to 4	0	955.3436	-4.057640	-3.914651
	1	976.9710	-4.129464	-3.941792
	2	979.0335	-4.116775	-3.884419

From the lag selection table, we can see that under the Log Likelihood, the Akaike and Schwarz Information Criteria the optimal lags are no lags; consequently, cointegration tests are run only for no lags.

Lag selection: Sole (*Solea spp.*) at the Madrid wholesale market

Table A3: Lag interval selection for wild and farmed sole in the Madrid wholesale market

Lags	Rank or No. of Ces	Log Likelihood by Rank	Akaike Information Criteria by Rank	Schwarz Criteria by Rank
Lags interval: No lags	0	571.4617	-8.163738	**-8.163738**
	1	574.0108	-8.128726	-8.023668
	2	575.2968	-8.075669	-7.865552
Lags interval: 1 to 1	0	571.2381	-8.161699	-8.077253
	1	574.6160	-8.138360	-7.948358
	2	576.2593	-8.090062	-7.794504
Lags interval: 1 to 2	0	574.5791	**-8.211292**	-8.041596
	1	577.8710	-8.186536	-7.910780
	2	**578.9017**	-8.129010	-7.747194
Lags interval: 1 to 3	0	570.0202	-8.146280	-7.890515
	1	573.4847	-8.123865	-7.761531
	2	574.7470	-8.069299	-7.600397
Lags interval: 1 to 4	0	572.7825	-8.187979	-7.845313
	1	576.2887	-8.166010	-7.716262
	2	578.5713	-8.126048	-7.569217

From the lag selection table, we can see that under the Log Likelihood and the Akaike Information Criteria the optimal lags are 2 lags, while under the Schwarz Information Criteria the optimal lags are no lags, consequently, cointegration tests are run only for 0 and 2 lags.

Lag selection: Blackspot (red) seabream (*Pagellus bogaraveo*) at the Barcelona wholesale market

Table A4: Lag interval selection for wild and farmed blackspot seabream in the Barcelona wholesale market

Lags	Rank or No. of Ces	Log Likelihood by Rank	Akaike Information Criteria by Rank	Schwarz Criteria by Rank
Lags interval: No lags	0	128.1625	-0.985866	-0.985866
	1	146.0919	-1.085323	**-1.016848**

	2	**156.3623**	**-1.125864**	-0.988914
Lags interval: 1 to 1	0	101.2478	-0.88007	-0.818565
	1	119.6521	-1.001376	-0.86299
	2	127.5447	-1.027554	-0.812286
Lags interval: 1 to 2	0	92.75395	-0.882854	-0.747125
	1	109.9868	-1.010279	-0.789719
	2	115.7323	-1.018044	-0.712654
Lags interval: 1 to 3	0	82.54147	-0.844808	-0.620761
	1	106.7777	-1.075182	-0.757782
	2	110.8441	-1.064001	-0.653248
Lags interval: 1 to 4	0	85.97225	-0.952003	-0.626514
	1	101.4360	-1.094367	-0.667163
	2	103.972	-1.060844	-0.531924

From the lag selection table, we can see that under the Log Likelihood, the Akaike and Schwarz Information Criteria the optimal lags are no lags; consequently, cointegration tests are run only for no lags.

Lag selection: Atlantic Cod (*Gadus morhua*) at the Barcelona wholesale market

Table A5: Lag interval selection for wild and farmed cod in the Barcelona wholesale market

Lags	Rank or No. of Ces	Log Likelihood by Rank	Akaike Information Criteria by Rank	Schwarz Criteria by Rank
Lags interval: No lags	0	471.1776	-2.127213	-2.127213
	1	530.1068	-2.370685	-2.324482
	2	561.1630	-2.488321	-2.395915
Lags interval: 1 to 1	0	518.2373	-2.369757	-2.332218
	1	553.8724	-2.510933	-2.426469
	2	574.7387	-2.584049	**-2.452661**
Lags interval: 1 to 2	0	539.4415	-2.483371	-2.407500
	1	561.3505	-2.562385	-2.439094
	2	**575.7537**	-2.606326	-2.435615
Lags interval: 1 to 3	0	545.8391	-2.530043	-2.415019
	1	560.8047	-2.577273	-2.414323
	2	572.3742	**-2.608409**	-2.397531
Lags interval: 1 to 4	0	546.6693	-2.551295	-2.396268
	1	557.8781	-2.581145	-2.377673
	2	567.8461	-2.605029	-2.353111

From the lag selection table, we can see that under the Schwarz Information Criteria the optimal lags are 1; under the Akaike Information Criteria the optimal are 3 lags, while under the Log Likelihood the optimal lag is 2. So, cointegration tests are run for 1, 2 and 3 lags.

Lag selection: Meagre (*Argyrosomus regius*) at the Barcelona wholesale market

Table A6: Lag interval selection for wild and farmed meagre in the Barcelona wholesale market

Lags	Rank or No. of Ces	Log Likelihood by Rank	Akaike Information Criteria by Rank	Schwarz Criteria by Rank
Lags interval: No lags	0	31.40852	-0.135968	-0.135968
	1	89.21035	-0.364547	-0.31979
	2	114.3514	-0.451737	-0.362223
Lags interval: 1 to 1	0	127.7939	-0.539407	-0.503424
	1	159.9796	-0.657863	-0.576901
	2	174.5773	-0.699683	-0.573743
Lags interval: 1 to 2	0	153.5512	-0.638382	-0.566058
	1	177.7931	-0.722777	-0.60525
	2	186.6859	-0.739851	-0.577121
Lags interval: 1 to 3	0	167.1812	-0.685127	-0.576097
	1	183.8603	-0.73669	-0.582231
	2	191.416	-0.747974	-0.548085
Lags interval: 1 to 4	0	188.6898	-0.76751	-0.621404
	1	198.9739	-0.790995	-0.59923
	2	204.1866	-0.791941	-0.554517
Lags interval: 1 to 5	0	204.9168	-0.827368	**-0.643809**
	1	211.9695	-0.836552	-0.607103
	2	214.8216	-0.826942	-0.551603
Lags interval: 1 to 6	0	211.0501	-0.842568	-0.621172
	1	217.2988	-0.848193	-0.580673
	2	220.4005	-0.839642	-0.525998
Lags interval: 1 to 7	0	213.243	-0.840104	-0.580482
	1	219.2137	-0.844506	-0.538524
	2	221.6879	-0.833052	-0.480708
Lags interval: 1 to 8	0	224.8005	-0.880368	-0.582123
	1	230.9516	-0.885624	-0.540779
	2	235.0911	-0.881695	-0.490249
Lags interval: 1 to 9	0	243.8583	-0.95567	-0.61840
	1	249.2874	-0.957643	-0.57353
	2	251.557	-0.94509	-0.514134
Lags interval: 1 to 10	0	247.6691	-0.961431	-0.584725
	1	253.2295	-0.964025	-0.540231
	2	255.3112	-0.950515	-0.479632
Lags interval: 1 to 11	0	260.0142	-1.007059	-0.5905
	1	263.2549	-0.998858	-0.534962
	2	265.0365	-0.983853	-0.472621
Lags interval: 1 to 12	0	264.4287	**-1.016097**	-0.559259
	1	268.1803	-1.010236	-0.50581
	2	**269.5635**	-0.993256	-0.441243
Lags interval: 1 to 13	0	262.4651	-0.995107	-0.497558
	1	266.0772	-0.988545	-0.443154

	2	267.3252	-0.970805	-0.377573

From the lag selection table, we can see that under the Log Likelihood and the Akaike Information Criteria the optimal lags are 12, while under the Schwarz Information Criteria the optimal is 5 lags. So, cointegration tests are run for 5 and 12 lags.

Regression methodology: Turbot (*Scophthalmus maximus*) at the Madrid wholesale market

Table A7: Regression considering 3 lags for farmed and wild turbot in the Madrid wholesale market

Dependent Variable: Turbot farmed Madrid				
Method: Least Squares				
Sample(adjusted): 4 623				
Included observations: 620 after adjusting endpoints				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.083066	0.024163	3.437689	0.0006
Turbot farmed Madrid (-1)	1.125581	0.040279	27.94474	0.0000
Turbot farmed Madrid (-2)	-0.113931	0.063231	-1.801833	0.0721
Turbot farmed Madrid (-3)	-0.038059	0.045636	-0.833968	0.4046
Turbot wild Madrid	0.008451	0.019989	0.422773	0.6726
Turbot wild Madrid (-1)	-0.023344	0.029341	-0.795607	0.4266
Turbot wild Madrid (-2)	0.032841	0.029340	1.119329	0.2634
Turbot wild Madrid (-3)	-0.026144	0.019745	-1.324103	0.1860
R-squared	0.952517	Mean dependent var		2.181020
Adjusted R-squared	0.951974	S.D. dependent var		0.138100
S.E. of regression	0.030264	Akaike info criterion		-4.144866
Sum squared resid	0.560554	Schwarz criterion		-4.087708
Log likelihood	1292.908	F-statistic		1753.817
Durbin-Watson stat	2.004249	Prob(F-statistic)		0.000000

Wild turbot prices cannot explain the evolution of farmed turbot prices when considering a regression with 3 lags, at a 5% significance level.

Table A8: Regression considering 2 lags for wild and farmed turbot in the Madrid wholesale market

Dependent Variable: Turbot wild Madrid				
Method: Least Squares				
Sample(adjusted): 3 623				
Included observations: 621 after adjusting endpoints				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.103335	0.048377	2.136022	0.0331
Turbot wild Madrid (-1)	1.082801	0.039705	27.27145	0.0000
Turbot wild Madrid (-2)	-0.163416	0.039324	-4.155643	0.0000
Turbot farmed Madrid	0.044728	0.081276	0.550322	0.5823
Turbot farmed Madrid (-1)	-0.020657	0.122298	-0.168906	0.8659
Turbot farmed Madrid (-2)	0.044336	0.082389	0.538130	0.5907
R-squared	0.901550	Mean dependent var		3.123630
Adjusted R-squared	0.900749	S.D. dependent var		0.194056
S.E. of regression	0.061136	Akaike info criterion		-2.741831
Sum squared resid	2.298598	Schwarz criterion		-2.699016
Log likelihood	857.3385	F-statistic		1126.363
Durbin-Watson stat	2.010463	Prob(F-statistic)		0.000000

Farmed turbot prices cannot explain the evolution of wild turbot prices when considering a regression with 2 lags, at a 5% significance level.

Regression methodology: Atlantic Cod (*Gadus morhua*) at the Barcelona wholesale market

Table A9: Regression considering 3 lags for farmed and wild Atlantic cod in the Barcelona wholesale market

Dependent Variable: Atlantic cod farmed				
Method: Least Squares				
Sample(adjusted): 4 467				
Included observations: 428				
Excluded observations: 36 after adjusting endpoints				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.174044	0.106883	1.628361	0.1042
Atlantic cod farmed (-1)	0.652379	0.048468	13.45998	0.0000
Atlantic cod farmed (-2)	0.077248	0.056575	1.365414	0.1729
Atlantic cod farmed (-3)	0.074783	0.046570	1.605820	0.1091
Atlantic cod wild	0.217223	0.059297	3.663312	0.0003
Atlantic cod wild (-1)	0.089681	0.066082	1.357126	0.1755
Atlantic cod wild (-2)	-0.122449	0.065597	-1.866696	0.0626
Atlantic cod wild (-3)	-0.122959	0.060841	-2.020974	0.0439
R-squared	0.599476	Mean dependent var		1.371293
Adjusted R-squared	0.592800	S.D. dependent var		0.215364
S.E. of regression	0.137429	Akaike info criterion		-1.112907
Sum squared resid	7.932406	Schwarz criterion		-1.037035
Log likelihood	246.1620	F-statistic		89.80362
Durbin-Watson stat	2.022227	Prob(F-statistic)		0.000000

Wild Atlantic cod prices can explain the evolution of farmed Atlantic cod prices when considering a regression with 3 lags, at a 5% significance level.

Table A10: Regression considering 5 lags for wild and farmed Atlantic cod in the Barcelona wholesale market

Dependent Variable: Atlantic cod wild				
Method: Least Squares				
Sample(adjusted): 6 467				
Included observations: 416				
Excluded observations: 46 after adjusting endpoints				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.409548	0.090624	4.519178	0.0000
Atlantic cod wild (-1)	0.387678	0.050823	7.627969	0.0000
Atlantic cod wild (-2)	0.057666	0.054472	1.058645	0.2904
Atlantic cod wild (-3)	0.115342	0.054559	2.114080	0.0351
Atlantic cod wild (-4)	0.045902	0.054397	0.843839	0.3993
Atlantic cod wild (-5)	0.137477	0.050367	2.729492	0.0066
Atlantic cod farmed	0.131681	0.039378	3.344056	0.0009
Atlantic cod farmed (-1)	-0.045211	0.047168	-0.958526	0.3384
Atlantic cod farmed (-2)	-0.116941	0.047263	-2.474266	0.0138
Atlantic cod farmed (-3)	0.051717	0.047188	1.095989	0.2737

Atlantic cod farmed (-4)	-0.013826	0.045881	-0.301355	0.7633
Atlantic cod farmed (-5)	-0.016017	0.038123	-0.420135	0.6746
R-squared	0.355302	Mean dependent var		1.549504
Adjusted R-squared	0.337749	S.D. dependent var		0.135649
S.E. of regression	0.110390	Akaike info criterion		-1.541175
Sum squared resid	4.923113	Schwarz criterion		-1.424905
Log likelihood	332.5644	F-statistic		20.24094
Durbin-Watson stat	1.984237	Prob(F-statistic)		0.000000

Farmed Atlantic cod prices can explain the evolution of wild Atlantic cod prices when considering a regression with 5 lags, at a 5% significance level.

Regression methodology: blackspot (red) seabream (*pagellus bogaraveo*) at the Barcelona wholesale market

Table A11: Regression considering 1 lag for farmed and wild blackspot seabream in the Barcelona wholesale market

Dependent Variable: Blackspot seabream farmed				
Method: Least Squares				
Sample(adjusted): 2 462				
Included observations: 260				
Excluded observations: 201 after adjusting endpoints				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.118046	0.186558	-0.632758	0.5275
Blackspot seabream farmed (-1)	0.881265	0.028292	31.14905	0.0000
Blackspot seabream wild	0.153931	0.071492	2.153129	0.0322
Blackspot seabream wild (-1)	-0.036651	0.076784	-0.477322	0.6335
R-squared	0.792277	Mean dependent var		1.943651
Adjusted R-squared	0.789843	S.D. dependent var		0.421168
S.E. of regression	0.193075	Akaike info criterion		-0.436207
Sum squared resid	9.543192	Schwarz criterion		-0.381428
Log likelihood	60.70695	F-statistic		325.4708
Durbin-Watson stat	2.421581	Prob(F-statistic)		0.000000

Wild blackspot seabream prices can explain the evolution of farmed blackspot seabream prices when considering a regression with 1 lag, at a 5% significance level.

Table A12: Regression considering 5 lags for wild and farmed blackspot seabream in the Barcelona wholesale market

Dependent Variable: Blackspot seabream wild				
Method: Least Squares				
Sample(adjusted): 55 412				
Included observations: 147				
Excluded observations: 211 after adjusting endpoints				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.623646	0.302727	5.363398	0.0000
Blackspot seabream wild (-1)	0.772977	0.085571	9.033116	0.0000

Blackspot seabream wild (-2)	-0.169049	0.101957	-1.658049	0.0996
Blackspot seabream wild (-3)	0.029991	0.102485	0.292643	0.7702
Blackspot seabream wild (-4)	-0.118069	0.100221	-1.178079	0.2408
Blackspot seabream wild (-5)	-0.053471	0.092120	-0.580444	0.5626
Blackspot seabream farmed	0.165703	0.066761	2.482043	0.0143
Blackspot seabream farmed (-1)	-0.220419	0.084205	-2.617666	0.0099
Blackspot seabream farmed (-2)	0.155832	0.088490	1.761006	0.0805
Blackspot seabream farmed (-3)	-0.069374	0.089288	-0.776963	0.4385
Blackspot seabream farmed (-4)	-0.054242	0.086766	-0.625157	0.5329
Blackspot seabream farmed (-5)	-0.022267	0.067387	-0.330433	0.7416
R-squared	0.521328	Mean dependent var		2.867458
Adjusted R-squared	0.482325	S.D. dependent var		0.217011
S.E. of regression	0.156139	Akaike info criterion		-0.798033
Sum squared resid	3.291217	Schwarz criterion		-0.553916
Log likelihood	70.65542	F-statistic		13.36638
Durbin-Watson stat	1.995746	Prob(F-statistic)		0.000000

Farmed blackspot seabream prices can explain the evolution of wild blackspot seabream prices when considering a regression with 5 lags, at a 5% significance level.