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Market Differences between Wild and Farmed Major European Marine Fish Species. Evidence from the Spanish Seafood Market

Gonzalo Rodríguez Rodríguez[1,*], Roberto Bande Ramudo[2]

[1] University of Santiago de Compostela, Faculty of Economics and Business Administration, Department of Applied Economics, Av. Burgo das Nacións s/n, 15782, Santiago de Compostela, Spain.
[2] University of Santiago de Compostela, Department of Economics, GAME-IDEGA, Av. Burgo das Nacións s/n, 15782, Santiago de Compostela, Spain.

* Corresponding Author: Tel.: +34. 981.563100; Fax: +34. 981.559965;
E-mail: gonzalo.rodriguez@usc.es

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Abstract

It has long been generally accepted that substitution between wild and farmed fish exists when they are of the same species. While this is true for some species and markets, the relation does not hold for all of them. In fact, using cointegration methodology, this paper proves that farmed and wild gilthead sea bream, sea bass and turbot (with salmon, the major European marine aquaculture species) are not substitutes in the Spanish seafood market. These results have implications for policy makers, fishers and fish farmers, stemming from ecological, economical and social sustainability.

Keywords: Seafood market, farmed and wild fish.

Introduction

European sea bass (*Dicentrarchus labrax*), gilthead sea bream (*Sparus aurata*) and turbot (*Psetta máxima*) are the major marine fish aquaculture species in the Atlantic (with salmon) and the Mediterranean area, being also important for industrial and coastal fisheries, as well as sea anglers (ICES 2012). How wild and farmed fishes compete (or not) in the market determines opportunities and incentives for all theses kinds of producers and, consequently, determines both decisions regarding investment and production (Anderson, 1985) and policy actions in order to achieve sustainability.

The general evidence rule about this issue had beingthat substitution between wild and farmed fish exists when they are of the same species (Bene *et al.*, 2000; Asche *et al.*, 2005; Norman-López and Bjørndal 2009). Following Anderson (1985) the main implication of such definition is that substitutability between wild and farmed species would lead to a fall, or at least limit any increase in wild fish prices, and hence fishermen's revenues, creating incentives for reducing effort and capacity in the fishing fleet. In the end, it will contribute to avoid overfishing.

Nevertheless, while this is true for some species and markets, the relation does not hold for all of them. Work by Brigante and Lem (2001), Rodríguez *et al.*, (2013) and Kim (2014) has shown that this identity does not always occur, being those three works the first one for each respective market. These results may be exceptions reflecting market or species specificity, or may express the sound for a greater questioning of the already referred identity between wild and farmed fish when they are of the same species. In this sense, it is necessary, firstly, to check if species such as sea bream and sea bass are integrated (or not) in markets different from the Italian one. And, secondly, as sea bass and sea bream are both produced and marked in a similar manner and, therefore, are often treated as one (Asche *et al.*, 2001), it is necessary to add differently marketed species, as turbot. If no substitution is identified, it will have implications both for economic and ecological sustainability. On the one hand, increasing competitive pressure and the reduction in income of fishermen cannot be attributed (al least directly) to competition from aquaculture. On the other hand, increasing pressure on wild stock should be expected and, hence, precautionary policy measures should be considered.

It is worth noting that over the last three decades (1980–2010), world food fish production of aquaculture has expanded by almost 12 times, at an average annual rate of 8.8 percent (FAO 2014), not only by increasing production of already farmed species but also by adding new ones. Therefore, impacts derived from the absence of substitutability are likely to appear all over the world.

In contrast with such increasing diversity,

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economic literature on this topic reveals that most of the research supporting the substitution hypothesis is based on a reduced number and type of species, particularly salmon and shrimp. The first one was examined for the U.S. (Clayton and Gordon, 1999), the Finnish (Asche *et al*., 2001; Setälä *et al*., 2002) and the Japanese market (Asche *et al.*, 2005). As regards to shrimp was studied for the French (Bene *et al*., 2000), the U.S. (Vinuya, 2007; Asche *et al*., 2012), the Japanese and the European Union markets (Vinuya, 2007). Finally, four representative species of the South Korea´s market (flounder (*Paralichthys olivaceus*), black rock fish (Sebastes schlegeli), red sea bream (*Pagrus major*), and grey mullet (*Mugil cephalus*) were analysed by Park *et al*. (2012), although in this case the approach was qualitative.

All of this research may be considered still insufficient if we consider the diversity of farmed species, the variety of products commercialized and the different characteristics of the markets. Factors like the volume of retail distribution for fish (Jaffry *et al*., 2000; Nielsen *et al*., 2007), consumers preferences or market segmentation could lead to very different results.

Ultimately, three main reasons justify the present study: i) the insufficient variety of species studied in the literature; ii) the growing variety and volume of world aquaculture production; and iii) the relevance of the results for policy makers, farmers and fishers process of decision.

In the end, the main objective of this paper is to check out if sea bream, sea bass and turbot markets are integrated in Spain or not. The question is relevant, as these are the most representative species in the European and Spanish marine fish aquaculture, being those species of interest for countries like Greece, Turkey, Spain, Italy, France, Portugal, Tunisia, and many others.

The paper is organized as follows. Section 2 analyzes the main characteristics of the Spanish seabream, seabass and turbot markets. Section 3 describes the data used in this analysis as well as the econometric methodology used. Section 4 presents the results, discussions are presented in Section 5, and Section 6 concludes.

Background

One common feature between European sea bass, gilthead sea bream and turbot is that catches have been historically modest, that is to say, the offer of wild fish is relatively low for these species. Even so, they are important for industrial and coastal fishers, as well as for sea anglers in the Mediterranean and the Atlantic Sea, involving an important number of countries in both fishing and farming (Figures 1, 2 and 3). In this regards, in all this area fisher's livelihoods and marine ecosystems health and diversity may be affected, if incentives for fishing increase and fisheries management do not responds effectively.

Since total supply (catches plus farmed production) is dominated by aquaculture, policy actors and stakeholders, following the general vision of market interactions between wild and farmed fish, may expect prices of catches to reduce, pulling down pressure on wild stocks. This may be wrong in certain cases.

Spain has historically been one major producer, trader and consumer of fish in Europe, being a representative arena for testing market interactions between marine species. In fact, the Spanish market is the first European market for fish products, at more or less the same level as the French one, with a consumption of more than 2 million tons per year in live weight equivalent, being one of the countries in the world with the highest consumption of seafood per inhabitant, with more than 50 kg/year in live weight equivalent (Paquotte and Lem, 2008). As regards species focused in the paper and using Fishstat data (FAO 2015) the Spanish apparent consumption of seabream in 2008 was 25.159 t. (an almost identical figure to that of Italy and Greece), 15.610 t. of sea bass (being the 3erd largest market behind Turkey and Italy and, finally, 7.978 t. of turbot, being, by far, the largest consumer in Europe.

Spanish fish aquaculture is highly concentrated in three species: sea bream, sea bass and turbot, which together account for 89.9% of total volume and 78.9% in value (Figure 4). These three species share some similarities but also important differences that need refine. Both seabream, such as sea bass and turbot started up in Spain in the mid-80s, the first two mainly in the Mediterranean area and turbot in the North Atlantic and Cantabrian. They have been characterized by a low volume of catches, being particularly marked in the case of turbot (barely 59 tons in 2013) and with the fisheries captures greatly overtaken by aquaculture as a main source of supply.

Seabream and sea bass are two highly internationalized species, characterized by a high volume production, particularly in the Mediterranean area, an intense international trade and the presence of major international competitors. In 2013 production reached 173,062.2 tons of seabream and 161,059.1 tons of seabass (FAO, 2015), with both Greece and Turkey leading worldwide production, followed in third place, and at distance, by Spain. Exports represent about half of the whole production in both cases, being quasi-monopolistic Greece's position in the international trade of seabream and of clear dominance of this country, followed by Turkey in seabass markets.

Finally, a comparatively low production volume, a modest international trade and greater attachment to national markets characterize turbot. Its production volume reached 76,997.8 tons in 2013, of which 67,000 are attributed to China. If we consider only European production, this was 9890.8 tons, of which 69.7% were contributed by Spain (FAO, 2015), being

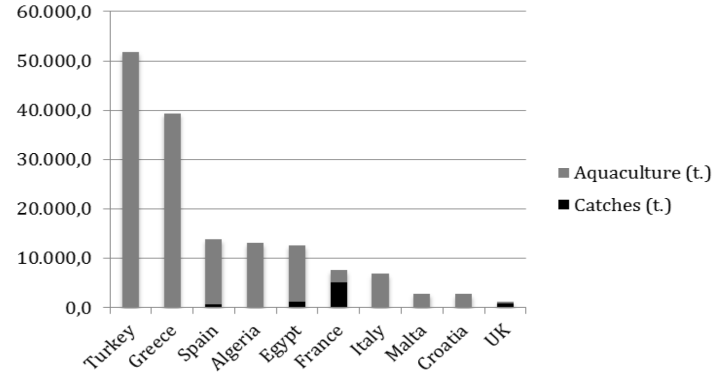

Figure 1. Catches and farmed production of European sea bass. Average production 2008-2012 for the 10 main producers. (Source: FAO, 2015).

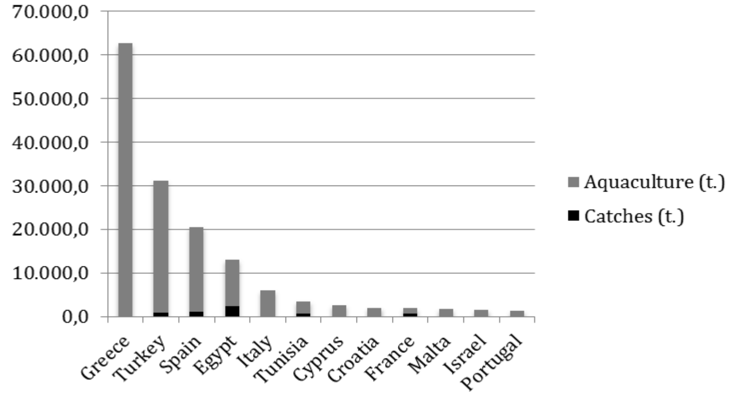

Figure 2. Catches and farmed production of gilthead sea bream. Average production 2008-2012 for the 12 main producers (Source: FAO, 2015).

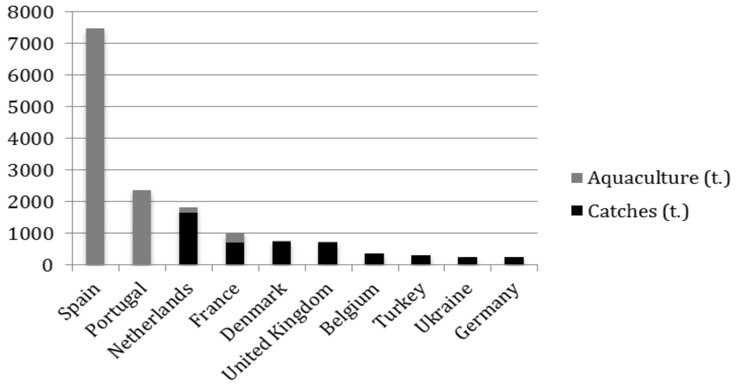

Figure 3. Catches and farmed production of turbot. Average production 2008-2012 for the 10 main producers (China excluded). (Source: FAO, 2015).

Portugal the second larger producer. Recorded exports are reduced and consumption is concentrated on a small group of countries, such as Spain, France or the Netherlands.

Sea bream and Sea bass are still sold almost universally as whole fish, either gutted or intact (DG Fisheries, 2004; Monfort, 2007) and the same is true in the case of turbot (FAO, 2005). Since then until now, we have not identified significant changes in the Spanish market as regards product presentation.

Materials and Methods

Data

The data used for the econometric analysis are monthly wholesale prices from Mercamadrid (Madrid).This is the main wholesale market in Spain, providing data on a regular basis from 2007 for both captured and farmed species. One relevant feature of the fish distribution in Spain is the role played by

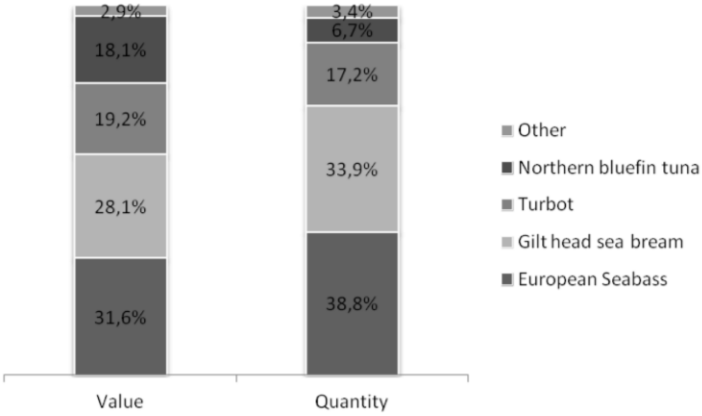

Figure 4. Spanish aquaculture production. 2011. (Source: Spain Ministry of Agriculture, Food and Environment, 2013).

central wholesale markets network ("mercas"), whose market share was about 50% in 2013 (Mercasa, 2015). Of particular importance is Mercamadrid, who commercialised 193.839 tons of fish in 2010 (Mercamadrid S.A. 2011), being the largest fish market in Europe and the second larger in the world after the Tsukiji in Tokio (Clover 2008). In 2008 the share of Mercamadrid in the Spanish market (relative to above mentioned apparent consumption) was about 20,6% of sea bream, 15,2% of sea bass and 7% of turbot including both Spanish and imported products from the main production areas in the Atlantic and Mediterranean coasts.

Specifically, time series covers from January 2007 to May 2015, which implies 101 observations for seabass and turbot and 97 for seabream. Unfortunately, on April 2009, August 2012, April 2013 and August 2014 no transactions with wild seabream were recorded. To maximize the number of observations (a condition required to obtain robust unit root and cointegration tests) we have imputed the missing values, using linear interpolation. This series are composed exclusively of whole fresh fish, being the almost only one product presentation traded in Mercamadrid. Small amounts of frozen sea bream are commercialized but in order to ensure the data comparability they are not included.

Early stages of development of the aquaculture market have been overcome and therefore the situation is stable enough for using cointegration test. After the price shocks of 2001 and 2002, seabream and seabass may already have passed the first part of the growth stage of the business lifecycle (Luna *et al.*, 2004). On the other side, the strong process of concentration suffered by turbot industry in Spain suggests that the early stage was surpassed time ago. In fact, as early as 1992 the sector suffer edits first crisis and the beginning of a process of restructuring and business vertical and horizontal integration (Fernandez 2008). Currently, Spanish production is highly concentrated, with the market dominated by only two firms.

An advantage of using wholesale data is that it is the price from the wholesaler that is measured, with tariffs, transportation costs and all other transaction costs included. Hence it provides a reliable image of the market, defined as "the area within which the price of a commodity tends to uniformity, allowance being made for transportation costs" (Stigler 1969).

We impose a number of *a* priori requirements to our dataset, in order to make sure it correctly represents the market performance of the considered species. Thus, following Rodriguez *et al.* (2013) we require that the data: i) should have a high frequency periodicity, preferably monthly or weekly, in order to isolate results from the lack of seasonality in an annual series; ii) it should be recent, in order to rule out the possibility of analyzing a market in which interactions are not present due to an immature state of development; and iii) it should provide a measure of the Spanish market as a whole Data from Mercamadrid meets all of our prior requirements, and therefore we confidently rely on this dataset to perform our empirical exercise.

Figures 5, 6 and 7 show the prices of captured and farmed seabream, seabass and turbot respectively in euros/kg. Generally speaking, a higher fluctuation in prices for wild species can be observed. This may be due the strong seasonal fluctuations of catches compared with the more regular production of fish farms. The seasonal variations are particularly appreciable in the case of seabass, whose prices tend to fall in the months of February and March. Secondly, prices for wild species are markedly higher than those for the farmed ones, especially for turbot. If we take into account the prices for the latter species during the last 12 months of the series, the average price for the catch is 27.02 Euros/kg (23.30 for the whole period of analysis), while the price for the farmed one is 8.80 Euros/kg (8.65 for the whole period). Even though differences are not so broad for the other two species, prices for captured seabream are double than those for the farmed and in the case of captured seabass are slightly more than three times higher.

Ultimately, descriptive data show differences in prices high enough to support the assumption of no substitution between wild and farmed species. However we must carry out robust test to corroborate this hypothesis.

Methodology

In this section we summarize our econometric methodology. Our main task is to ascertain whether capture and aquaculture species belong to the same market (and therefore should be regarded as substitutes) or not (in which case they should be treated as complementary). The literature has solved the problem of defining a market for a commodity or a group of commodities in terms of prices. Therefore, if the prices of two commodities tend to uniformity (Stigler, 1969), they should be ascribed to the same market. Empirically the general procedure has consisted in using times series econometrics to check if prices move together in the long run, i.e., if they are cointegrated or not. Following Asche *et al*. (2005), evidence of price changes in one market generating price changes in another market reflect a long-run relationship, which may be represented as follows:,

$$p_t^1 - \beta_0 - \beta_1 p_t^2 = \varepsilon_t \quad (1)$$

where p_t^j represents the log of the price observed in market j at time t (j=1,2), β_0 is a constant term reflecting the transportation or transaction costs and quality differences, while β_1 is the relationship between the prices. If $\beta_1=0$, then there is no relationship between these prices. This would indicate that these markets are not integrated. However, if β_1=1, then the law of one price holds and the relative price between both species is constant. Therefore, the main econometric task is to identify the existence of a non spurious long run relationship between the prices of two commodities.

In this context the general procedure is first to check the dynamic properties of the time series involved in the analysis, i.e., whether they are stationary or not, by running unit root tests. If the series are *I(1)* the next step is to check if some linear combination of these series is stationary. If some parameters β_0 and β_1 can be identified, then equation (1) holds and both series would be regarded as cointegrated. If we fail to find such linear combination, then we can statistically reject the existence of a long run relationship between these variables. The issue here is how to obtain the values of β_0 and β_1. The standard approach (see Asche *et al*.,. 2005) is the Johansen methodology. Let Y_t be a 2×1 vector of prices (in logs), and assume that Y_t follows an unrestricted vector autoregression (VAR) on the levels of the variables (Lütkepohl and Krätzig, 2004), of the following type:

$$Y_t = \Pi_1 Y_{t-1} + ... + \Pi_k Y_{t-k} + \Gamma D_t + \mu + e_t, \quad (2)$$

where each of the Π_i matrices is a k×2 matrix of parameters, μ is a constant term, D_t is the vector of deterministic terms with the corresponding vector of coefficients Γ, and e_t is a 2×1 vector of identically and independently distributed residuals, with a zero mean and a contemporaneous covariance matrix Ω. The VAR model above may be written into its error corrected form as follows:

$$\Delta Y_t = \Gamma_1 \Delta Y_{t-1} + ... + \Gamma_{k-1} \Delta Y_{t-k+1} + \Pi Y_{t-k} + \psi D_t + e_t, \quad (3)$$

with $\Gamma_i = -I + \Pi_1 + ... + \Pi_i, i = 1,..., k-1$ and $\Pi_i = -I + \Pi_1 + ... + \Pi_k$. Therefore, Π is the long-run level solution to (1). If Y_t is a vector of I(1) variables, the left hand side and the first (k-1) variables in equation (2) are I(0), while the k-th element in (3) is a linear combination of I(1) variables. Given our assumptions for the error term, the k-th element in (2) must also be stationary, which implies either that Y_t contains a number of cointegrating relationships or Π is a matrix of zeros. The rank of Π, denoted by r, determines the number of linear combinations of Y_t that are stationary. If $r=2$, the variables in the levels are stationary. If $r=0$ and Π=0, none of the linear combinations are stationary. Finally, if 0<r<2, there are r cointegrating vectors. This may be written as $\Pi = \alpha\beta'$, where α and β are $2\times r$ matrices, while β contains the cointegrated relationships and α is the adjustment parameter. Johansen (1988; 1995) provides a procedure to estimate these cointegrating vectors.

The initial stage of the Johansen procedure, therefore, is to check that the involved variables are I(1) or I(0). But classifying variables as stationary of non-stationary on the grounds of unit root tests can be sometimes difficult, given that these tests are known to have low statistical power (see *inter alia* Schwert 1987; Lo and MacKinlay, 1989; Blough, 1988; Cochrane, 1991; Perron and Ng, 1996 or Caner and Kilian, 2001). These authors show that tests for unit roots have low power in finite samples against the local alternative of a root close to but below unity (Cochrane, 1991). Moreover, this standard methodology would prevent the possibility of a framework in which some variables are I(1) and others are I(0). In fact, previous attempts to test market integration of sea bass and sea bream markets stumbled with the stationarity of the data series (Asche *et al*., 2001), limiting the systematization of the knowledge about the substitutability between wild and farmed species.

The procedure suggested by Pesaran*et al.* (1996) and Pesaran and Shin (1998), based on the use of Autoregresive Distributed Lag (ARDL) models may overcome these difficulties. These authors show that the main advantage of this testing and estimation strategy is that it can be applied irrespective of whether the involved regressors are stationary or not,

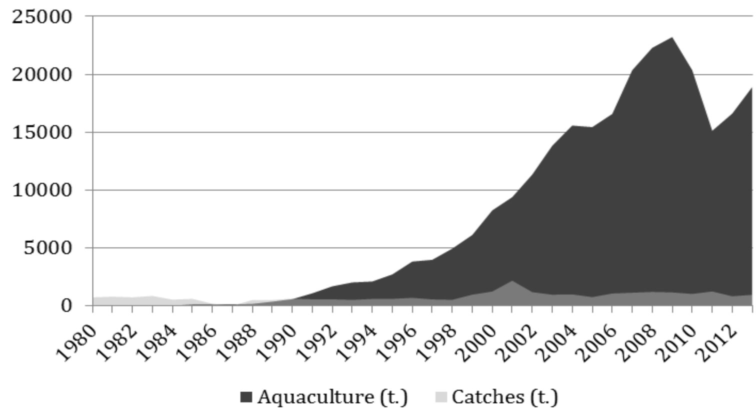

Figure 5. Spanish production of farmed and wild seabream. 1980-2013. (Source: FAO, FishStat, 2015).

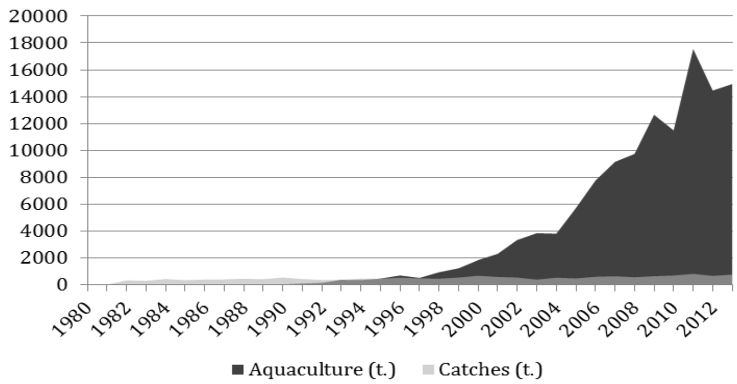

Figure 6. Spanish production of farmed and wild seabass. 1980-2013. (Source: FAO, FishStat, 2015).

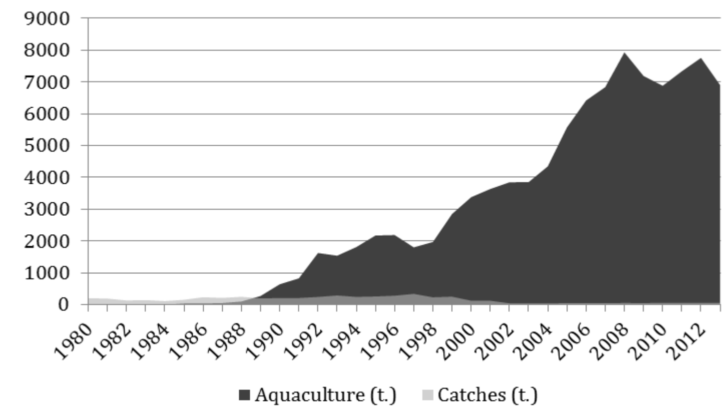

Figure 7. Spanish production of farmed and wild turbot. 1980-2013. (Source: FAO, FishStat, 2015).

and therefore can avoid the pre-testing problems associated with the standard cointegration analysis just described. The procedure involves two stages in the analysis. At the first stage we test for the existence of a long run relationship, i.e., for the existence of cointegration. To do so an Error Correction (ECM) version of the underlying ARDL model involving the variables of interest is first estimated:

$$\Delta p_t^1 = \alpha_0 + \sum_{i=1}^{p} b_i \Delta p_{t-1}^1 + \sum_{j=1}^{q} d_j \Delta p_{t-j}^2 + \delta_1 p_{t-1}^1 + \delta_2 p_{t-1}^2 + u_t \qquad (4)$$

where Δ is the difference operator, p and q are the optimal lag lengths (determined following statistical information criteria, as the AIC or the SBC), **b**, **d** and $\boldsymbol{\delta}$ are parameter vectors to be estimated, and u_t is the error term. After estimation of model (4) the joint significance of the lagged levels of the variables is tested by computing an F-statistic. However, the asymptotic distribution of this F-statistic is non-standard, irrespective of whether the regressors are I(0) or I(1). Pesaran *et al.* (1996) have tabulated the appropriate critical values, and provide for each combination of number of regressors and size of the test two sets of critical values: one set assuming that all of the variables in the regression are I(1) and another computed under the assumption that all of the regressors are stationary. This provides a band covering all of the possible classifications of the variables into I(1) and I(0). If the computed F-statistic falls outside this band we may provide a decision as regards the existence of a long run relationship. If the value of the F-statistics falls within the critical values the results of the test are inconclusive and therefore further testing is needed. Should we conclude that the variables in the ARDL are cointegrated we proceed to the second stage of the modelling procedure, in which the coefficients of the long run relationship are estimated through an ARDL model and inferences about their values may be conducted.

Results

We start analyzing whether the species under scrutiny (sea bass, sea bream and turbot) are I(0) or I(1) and conduct standard unit root tests for each of the price variables, both with and without a constant term (we do not consider the inclusion of a time trend given the behaviour of the series observed in Figures 8 to 10). Table 1 summarises the results of the Augmented Dickie-Fuller (ADF) tests for each variable[1].

Notes: the 5% critical value for the constant versión of the test is -3.455, while for the no constant is -1.944

Results from Table 1 unveil the problems surrounding unit root testing. While for the intercept version of the test we cannot reject the null of a unit root for captured species, the test rejects the null for the farmed species. This would preclude further cointegration analysis, since for two series to be cointegrated it is required that a linear combination of them reduces the order of integration. On the other hand, the results for the no constant version of the test do not allow rejecting the null of a unit root in the levels of the series. Alternative unit root tests (not reported but available upon request) confirm these mixed results. Overall, taking a decision regarding the degree of integration of these series is highly arbitrary. Given these problems we decided to apply the ARDL approach discussed above to each pair of price variables. Our methodology begins by estimating a first-stage ARDL model of the type,

$$\Delta p_t^1 = \alpha_0 + \sum_{i=1}^{p} b_i \Delta p_{t-1}^1 + \sum_{j=1}^{q} d_j \Delta p_{t-j}^2 + \delta_1 p_{t-1}^1 + \delta_2 p_{t-1}^2 + u_t \qquad (4)$$

in which we include up to 12 lags of each differenced variable, given the yearly nature of our data. Next we compute a standard test for the joint significance of the lagged level terms in equation (4), and compare the resulting test statistic with the critical value bounds reported in Pesaran and Pesaran (2009) and Pesaran *et al.* (1996), as discussed in the previous subsection. Results are summarised in Table 2.

Notes: cap. stands for captured and aq. for farmed species (aquaculture)

We observe that in the case of two of the three species (sea bass and sea bream) the value of the F-statistic is below the 95% critical value bound (3.793), which does not allow us to reject the null of no cointegration between the prices of each species irrespective of their order of integration. In the case of the turbot, the statistic falls in the indeterminacy area, and therefore we need to explore further the relationship between the farmed and captured species (assuming that the turbot captured series is difference-stationary, which is true at the 10% size of the unit root test). Moreover, note that we have run sensitivity tests by reversing the order of the long run forcing variables (aquaculture forcing captures) and in two of the three cases (sea bass and sea bream) we cannot reject the null of no cointegration. Therefore, the ARDL approach needs to be complemented by further analysis in the cases of turbot. The conclusion in the

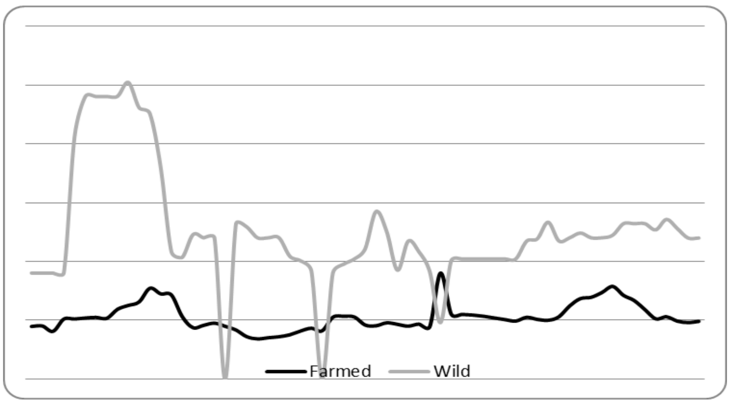

Figure 8. Price evolution of farmed and wild seabream in Mercamadrid. Jan. 2007-May. 2015. (Source: Mercamadrid, 2012).

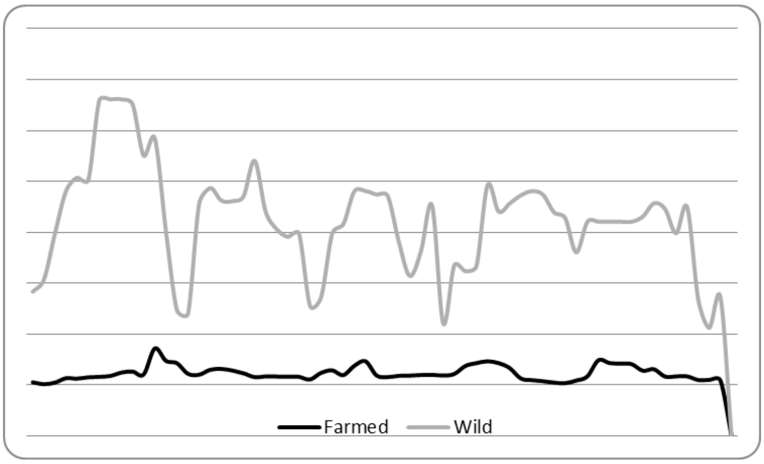

Figure 9. Price evolution of farmed and wild seabass in Mercamadrid. Jan. 2007-May. 2015. (Source: Mercamadrid, 2012).

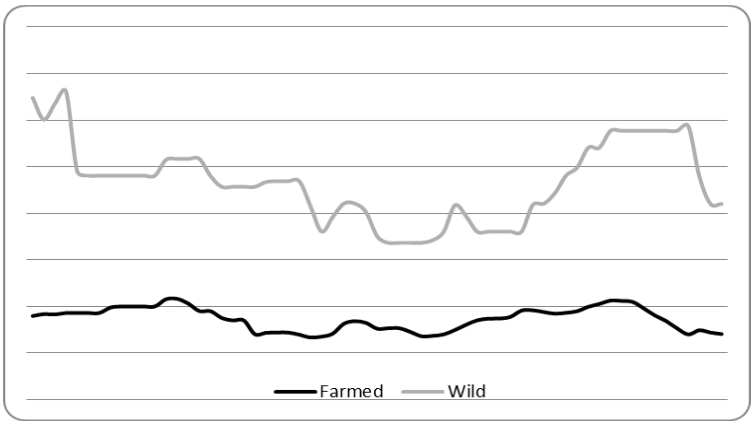

Figure 10. Price evolution of farmed and wild turbot in Mercamadrid. Jan. 2007-May. 2015. (Source: Mercamadrid, 2012).

Table 1. Unit root tests

Variables in logs	Levels		FirstDifferences	
Variable	Constant	No constant	Constant	No constant
Sea Bass (aquaculture)	-4.20	0.51	-6.93	-6.98
Sea Bass (captured)	-2.68	-1.15	-9.25	-9.18
Sea Bream (aquaculture)	-3.53	0.14	-8.46	-8.49
Sea Bream (captured)	-2.84	-0.70	-8.03	-8.06
Turbot (aquaculture)	-4.02	-0.25	-5.73	-5.76
Turbot (captured)	-2.51	-0.40	-6.37	-6.39

Notes: the 5% critical value for the constant versión of the test is -3.455, while for the no constant is -1.944

Table 2. Cointegration tests. ARDL procedure

Sea Bass	cap=>aq	3.15
	aq=>cap	2.92
Sea Bream	cap=>aq	3,530
	aq=>cap	3.74
Turbot	cap=>aq	4.640
	aq=>cap	4.230
Lowerbound	UpperBound	
3.793	4.855	

Notes: cap. stands for captured and aq. for farmed species (aquaculture) case of sea bass and sea bream is definitive; we cannot reject the null of no cointegration between the prices in these markets, which cannot be regarded, therefore, as integrated.

Table 3 summarises the results of the Johansen procedure for the turbot prices. The value of the Maximum Eigenvalue Statistic (11.95) is below the 5% critical value, and therefore the null of no cointegration cannot be rejected. In sum, our empirical analysis suggests that in the case of these three species the Spanish markets for cultured and captured species are not integrated.

Discussion

This research has shown that wild and farmed sea bass, sea bream and turbot do not belong to the same market at Spanish level. Consumers appreciate the different characteristics of the two types of products and pay a different price for them. So, may be accepted, following the Anderson (1985) model, that pressure on wild stocks will tend to increase leading to overfishing? And, on the other hand, may this segmentation be generalized to broader level or represents a wider phenomenon in the Spanish market?

As regards the first question, the available evidence, while far from definitive, suggests a tendency to overfishing in the analysed species. Starting with the sea bream, such evidence is scarce and disperse, nevertheless, since the early assessment by Farrugio and Le Corre (1994) for *Sparus aurata* in the Gulf of Lion all the following reports went in the same direction. Different assessments were carry out for specific areas, as the Bay of Gabes (Dhieb *et al.*, 2007), Port Said (Mehanna, 2007) and also using qualitative methods (fisher´s perception) for the Bay of Cadiz (Sánchez-Lamadrid, 2002) with analogue results. Finally, Bas Peired (2005) has indicated that Sparids and sea breams are heavily exploited across the whole Mediterranean region.

In the case of sea bass, the ICES assessment for Iberian waters (Division IXa) has warned a decline in catches due to overfishing, recommending a catches decrease by 20% in relation to the average catch of the last three years (2009–2011) (ICES 2013). Recreational anglers exacerbate the problem. Recent research has estimated recreational catches to be equivalent to the 30% of commercial catches for the France coast (ICES, 2014; Rocklin *et al.*, 2014). Even though information is still insufficient and temporally discontinuous, the impact is expected to be also relevant in the UK and The Netherlands (ICES, 2012). Although there are no specific assessments in such topic for Iberian waters a high impact may be expected.

Ultimately, to the best of our knowledge, no stock assessments have been done in Iberian waters, which is not surprising as landings in the Spanish ports are quite small. Nevertheless, evidence for other areas, as the North Sea (Area IV), indicates that the fishing mortality in the most recent years has been higher than F_{MAX} (ICES, 2012). In the same vein, turbot in the black Sea can be considered as fully exploited, although the components of the stock on the south coast may be overexploited already (Barros, 2011). This evidence is not directly transposable, either directly linkable to the Spanish seafood market, although if using a precautionary approach we should expect a similar situation.

In many of the former cases the fishing activity was carry out by artisanal fishers (Dhieb *et al.*, 2007; Mehanna, 2007; Sánchez-Lamadrid, 2002; ICES, 2013; Farrugio and Le Corre, 1994), which suggest that also the small scale fisheries have the potential for depleting the fisheries if deficiently regulated.

As to the second question, species from aquaculture in the Spanish seafood market comprises quite more than the three considered in this paper, including other fish species not farmed in Spain (as salmon or tilapia) or mollusc (as mussels, clams, etc). So a further delineation of the phenomena is needed.

The available literature had identified that the markets for the Italian and Spanish striped venus and the Japanese carpet shell are interrelated and to some extent these clams can be considered to be substitutes (Jiménez-Toribio *et al.*, 2007). Not all the clam species are interrelated, as Grooved carpet shell constitutes a single market.

Jaffry *et al.* (2000) had analysed market interactions between salmon and wild caught fish (tuna, whiting and hake) in Spain, with no significant interaction being identified. And, even though it´s generally accepted that wild and farmed salmon and trout are substitutes (Nielsen *et al*., 2007; Asche *et al*., 2005), until now this relation had not been tested for the Spanish market.

Ultimately, two axes seem to be of high importance when explaining those results:

- Preferences steaming from Spanish culinary tradition.
- The belonging to intensive versus extensive

Table 3. Cointegration test. Johansen procedure

	Max. EigenvalueStatisic	0.05 criticalvalue	P-value
Turbot (in logs)			
r=0	11.91	14.26	0.114
r=1	9.81	3.84	0.007

cultured systems.

At large, when compared with farmed fish, wild fish was always preferred among consumer (Claret *et al.*, 2012). In an overall sense, European consumers perceive farmed fish as being of lower quality than wild fish (Kole, 2003; Verbeke *et al*., 2007) in spite of having a positive overall image of both, fishery and aquaculture products (DG Mare, 2008). Regarding Spain, and according to MARM (2009), Guerrero *et al*. (2009) and Fernández-Polanco and Luna (2010), farmed fish species are perceived as having lower quality, as well as more health and safety issues. Normally farmed fish is also perceived as more processed or manipulated than its respective wild equivalent (Claret *et al*., 2012).

In this regard, seafood coming from extensive aquaculture (as clams, mussels, etc) may be perceived as more natural (as they involve less manipulation and use of chemical or pharmaceutical inputs) than those from intensive systems (as farmed sea bream, sea bass, turbot, etc). At the same time, for certain products historically linked to the culinary tradition (as Grooved carpet shell) the autochthonous-locally fished character seems to be important, making the difference between the premium demand for wild sea bass, sea bream or turbot, but not as much for salmon.

Further research is needed to identify the real extension of the market interactions addressed in the paper. Nevertheless the available evidence suggests that in those cases where similar incentives where found the wild fisheries are susceptible of being overfished. Consequently, an scientific advice would be recommended and, if necessary, additional management measures.

Concluding Remarks

In the Spanish seafood market wild and farmed marine fishes do not belong to the same market. This result has, at least, two main implications. On one hand, since this is the biggest seafood market in Europe with a strong and diverse foreign trade, impacts of no substitution between wild and farmed fish could spread through different countries (as Greece, Turkey, Italy) and ecosystems in the Atlantic and the Mediterranean areas. On the other hand, this phenomenon may also occur in other consumer countries as Italy, Portugal, Greece or France. Nevertheless, the latter requires further research in order to be confirmed.

Those results have implications for policy makers, fishers and fish farmers. With respect to commercial fishers, the no substitution between wild and farmed marine fishes means that catches should not suffer the impact derived from the low prices of the aquaculture. On the contrary, fisheries can preserve their own markets by addressing market niches of high quality products. Therefore, *ceteris paribus*, we can expect the social and economic contribution of the fishing activity to the local economies not to be eroded by farmed fish competition.

Generally speaking fishing sector is nowadays facing serious problems (overexploitation, overcapitalisation, etc) and is particularly under a high competition pressure (Villasante *et al.,* 2011). This scenario is also verified for the species analysed both in the Atlantic (ICES, 2012) and the Mediterranean Sea (Barros, 2011). Nevertheless these problems, at least in the case of the species analyzed in this paper, and probably others, are not derived specifically from their farmed pairs.

On the other hand, aquaculture sector has been frequently accused of market displacement of traditional fisheries. Nevertheless, this charge is not true in all of the cases, and therefore the aquaculture has an opportunity to improve its public perception.

To the best of our knowledge, the most remarkable consequence is for sustainability of fish stocks and, therefore, it implies a new challenge for fisheries management. If wild and farmed fish are substitutes, the decreasing prices of the cultured ones mean that catches will suffer from a decreasing demand and prices. Consequently, fisher’s income will be reduced in the short term. Fishermen response is likely to be an effort reduction (or even the abandon of those fisheries), allowing for the improving of the fish stock. But, on the contrary, if they are not substitutes, additional fisheries management measures are likely to be necessary to preserve the fish stock and guarantee the sustainability of the fishery.

Furthermore, as the number of farmed species keeps on growing worldwide this issue should be addressed in order to manage the derived problems for fishers if the new species has wild substitutes, or either the problems for sustainability of the stocks if not.

It is worth noting, finally, that the method used (based on ARDL models) was critical to extend the findings of our research to sea bream and sea bass, while previous attempts stumbled with the limitations of the standard cointegration test when the series are stationary.

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