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Cointegration analysis of wild and farmed sea bream and sea bass prices in Turkey

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Abstract: Market integration is an indicator of the extent to which different products are interrelated, and the presence of market integration between products suggests that they are substitutes. The objective of this study was to determine the market interaction between wild and farmed products of two fish species, namely sea bream and sea bass. For this purpose, the relationship between the producer price time series of cultured sea bream, wild sea bream, cultured sea bass, and wild sea bass in the period of 2009–2017 was tested using the cointegration analysis technique. It was found that the wild sea bream and sea bass prices and the farmed sea bream and sea bass prices were cointegrated in the long term, followed each other's patterns, and were affected by the prices in the previous period. It was concluded that farmed sea bream and sea bass and wild sea bream and sea bass were substitutes in terms of market prices.

Key words: Aquaculture, cointegration, fisheries, sea bass, sea bream

1. Introduction

In Turkey, sea bream (*Sparus aurata*) and sea bass (*Dicentrarchus labrax*) are supplied to the market through both farming and fishing. In 2017, 61,090 tons of sea bream and 99,971 tons of sea bass were produced through farming [1]. In the same year, 590 tons of sea bream and 135 tons of sea bass were captured [2]. These products are supplied both to the domestic market and export markets through various marketing channels. When the closed season starts, the increase in domestic demand for culture fishery products is furthered by the touristic season. While the prices generally increase during the closed season, they fall when the closed season ends [3]. When considering the market prices, in direct proportion to the cost of production, the sale prices of sea bass produced by farming are reported to be higher than those of sea bream [4]. The capture fishery products are sold by auction in wholesale fish markets after being brought to the wholesaler through the existing marketing channels [5]. The quantity of the captured species and the period of capture play a role in price formation. The prices are high in the beginning of the season when the captured fish species newly enter the market, whereas the prices for the same product may become lower during the periods when the supply amount increases and at the end of the tourism season. In 2017, the average retail prices of captured sea bream and sea bass were 35.84 and 55.43 Turkish lira (TL)/kg, respectively, while the farmed sea bream and sea bass were 15.57 TL/kg and 17.42 TL/kg, respectively, in Turkey [6].

Market integration is an indicator of the extent to which different markets are interrelated [7]. The presence of market integration (competition) between two products suggests that they are substitutes. The available information about market integration of farmed and captured fishery products is based on the data of a limited number of species and market information. Various studies have shown the presence of price interaction between captured and farmed fishery products. The studies conducted on particular species mainly focus on salmon, trout, tilapia, sea bream, and sea bass, which are the most commonly traded species [8]. Bronnmann et al. [9] tested, through cointegration analysis, the market link between farmed (pangasius and tilapia) and captured (Alaska pollock, cod, and saithe) frozen white fish using the monthly import prices in Germany for the period of January 2010 to December 2014. Regnier and Bayramoglu [7] researched, through a bivariate cointegration approach, the market integration between captured and farmed sea bream and sea bass using the monthly domestic prices in France for the period of January 2007 to September 2012. Asche et al.

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[10] conducted cointegration analysis to examine market integration between captured and farmed salmon using the monthly prices in the Japanese market for the period of 1994–2000.

These studies provide insight regarding to what extent farmed fish prices affect captured fish prices. The general insight regarding market integration is that an increase in the supply of farmed products results in a fall of the prices of captured products [11]. However, there is limited information with regard to the price interaction of different wild products and the price interaction of different farmed products.

The purpose of this study was to test the relationships between the price time series of captured sea bream and sea bass and farmed sea bream and sea bass in Turkey for the period of 2009–2017 using a cointegration analysis technique.

2. Materials and methods

2.1. Dataset

In order to properly analyze the relationship between the price time series of captured and farmed species, the prices of the same species of fish should be compared at the level of the same market.

The dataset addressed in this study regarding capture and farm fishery in Turkey consists of the monthly producer prices of cultured sea bream (CSBR), wild sea bream (WSBR), cultured sea bass (CSBA), and wild sea bass (WSBA) for the period between August 2009 and July 2017 [6].

2.2. Statistical analysis

The relationship between the producer price time series of the variables was tested using the Johansen cointegration analysis technique. The first difference of the monthly price series was used for the analysis of the variables. While the graphical representation of the variables may be useful to have an idea with regard to whether the variables have a unit root, formal tests should be conducted to be definite about it. For this purpose, augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) tests were used.

Final prediction error (FPE), Hannan–Quinn (HQ), Schwarz (SW), likelihood ratio (LR) and Akaike information criteria (AIC) data were used to determine the common lag length of the variables [12].

Hatemi-J [13] asserted that SW and HQ are more effective in determining the optimum lag length than the other criteria. However, the SW criterion tends to give a longer lag length than the HQ criterion in some cases. Taking into account such disadvantages, the Hatemi-J criterion (HJC) consists of the combination of those two criteria:

$$HJC = \ln(\det \hat{\Omega}_j) + j\left(\frac{n^2 \ln T + 2n^2 \ln(\ln T)}{2T}\right), j = 0,\ldots,K \quad (1)$$

The HJC as well as the other criteria were used to determine the lag length of the cointegration system in our study.

The Johansen method was employed for the cointegration study. The long-term relationship between variables is examined in a synchronous model structure. Therefore, the Johansen method was employed in this cointegration study. The method of Engle and Granger [14] is a method that is easy to calculate and implement. However, it has some shortcomings or difficulties. When different equations are estimated for each variable in the system, e.g., in a system containing two variables, the covariance relationship is observed in the equation of the other variables, whereas the variable has a cointegration relationship in one equation. This may result in ambiguity among the variables. If there is more than one variable in the system, this ambiguity will be an issue. This method has no dedicated procedure to decompose more than one variable.

Due to the abovementioned difficulties and shortcomings, Johansen [15] and Stock and Watson [16] suggested a test to compute the estimators of cointegrating vectors through the maximum likelihood method.

The Johansen method is a generalized representation of the Dickey–Fulley method.

$$X_t = \Pi_1 X_{t-1} + \ldots + \Pi_k X_{t-k} + e_t, t = 1,2,\ldots, \quad (2)$$

Here, X denotes the vector of the variables represented by past values. This denotation refers to the variables using the past model values in the VAR model. If we express the model in moving averages, we reach the following equation:

$$A(e) = I - \Pi_1 e - \ldots - \Pi_k e_k \quad (3)$$

The rank r of matrix A gives the number of matched vectors, and in equations where r < p the variable with dimension p can be at most one less than the vectors. The error term has white noise process.

$$A(e)\big|_{e=1} = \Pi = I - \Pi_1 - \ldots - \Pi_k, \Pi = \alpha\beta' \quad (4)$$

The coefficients matrix Π is the sum of the matrices α and β with dimensions (p × r). α denotes the adjustment rate and β denotes the matrix obtained by the maximum likelihood method where the number of rows is equal to the number of cointegrating vectors.

This method is used for evaluating the hypothesis that there are at most r cointegrating vectors through maximum likelihood estimation.

$$-2\ln(Q) = -T\sum_{i=r+1}^{p} \ln(1-\hat{\lambda}_i) \quad (5)$$

The critical values for which the statistical values of λ_{trace} and $\lambda_{\max}$ are obtained as a result of the tests were highlighted in the study of Johansen and Juselius [17].

Deterministic components can also be included in the test when required. If the series has an increasing and decreasing trend or seasonality, the relevant components can be included in the model. The test may already contain the deterministic components introduced by the Engle–Granger method.

3. Results

Longitudinal price graphs of the variables are given in Figure 1.

Results of the ADF and PP tests as to whether the time series of the variables were stationary are given in Table 1.

Since all of the variables have a unit root according to the results in Figure 2 and Table 1, a cointegration test was conducted on the variables with I(1) process [12].

According to the results obtained, the test is successful in determining the optimum lag length in more than 85% of the small samples (T = 40). Its success is further enhanced in large samples.

The criteria used to determine the lag length of the variables are given in Table 2.

The results in Table 2 indicate that all criteria provide the same result as the optimum lag length. Hence, a synchronization can be used as an optimal lag in a synchronicity study.

The test results are given Table 3.

According to the results in Table 3, a statistically significant cointegration relationship was found between the variables. At an error margin of 5%, there is a long-term relationship between the variables. As can be seen in Table 3, both eigenvalue and max-eigenvalue statistics indicate that there is a long-term relationship between the variables.

It was found that the wild sea bream and sea bass prices and farmed sea bream and sea bass prices were cointegrated

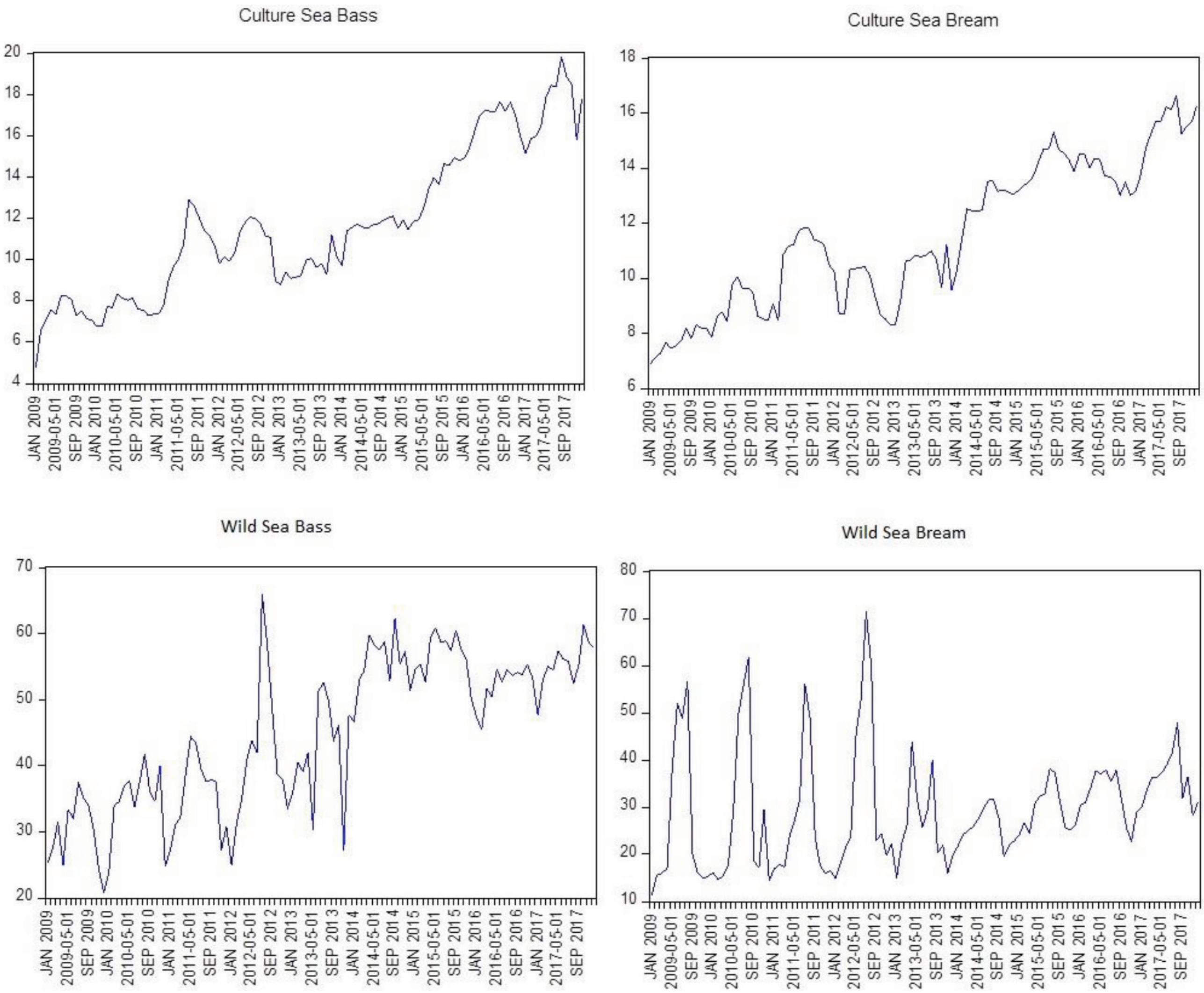

Figure 1. Longitudinal price graphs of the variables.

Table 1. Results of ADF and PP tests

Variables	ADF	PP
ΔCSBR	−10.89	−10.64
ΔWSBR	−5.21	−19.12
ΔCSBA	−10.41	−10.43
ΔWSBA	−13.66	−21.12

First difference of ΔCSBR, ΔWSBR, and ΔCSBA was taken, and they were subjected to unit root test after adding a constant and trend. Critical value for ADF and PP is −3.62 at 5%. ΔWSBA was included in the regression analysis after its first difference was taken and without any constant and trend. Critical value is −1.96 at 5%.

in the long term, followed each other's patterns, and were affected by the prices in the previous period. This results in the captured and farmed products being traded as a single product in the markets, thereby suggesting that the two markets are cointegrated.

4. Discussion

Capture fisheries production has been decreasing in recent years because of fishing pressure, negligent fishing practices, and continuous decline of natural stocks. However, the production level of aquaculture products in inland waters and seas is increasing. Capture fisheries production of sea bream and sea bass were 1186 tons and 615 tons in 2009, whereas these numbers declined to 590 tons and 135 tons in 2017, respectively [2]. On the other hand, the amount of sea bream and sea bass production by culture fisheries rose from 28,362 tons and 46,554 tons in 2009 to 61,090 tons and 99,971 tons in 2017, respectively [1].

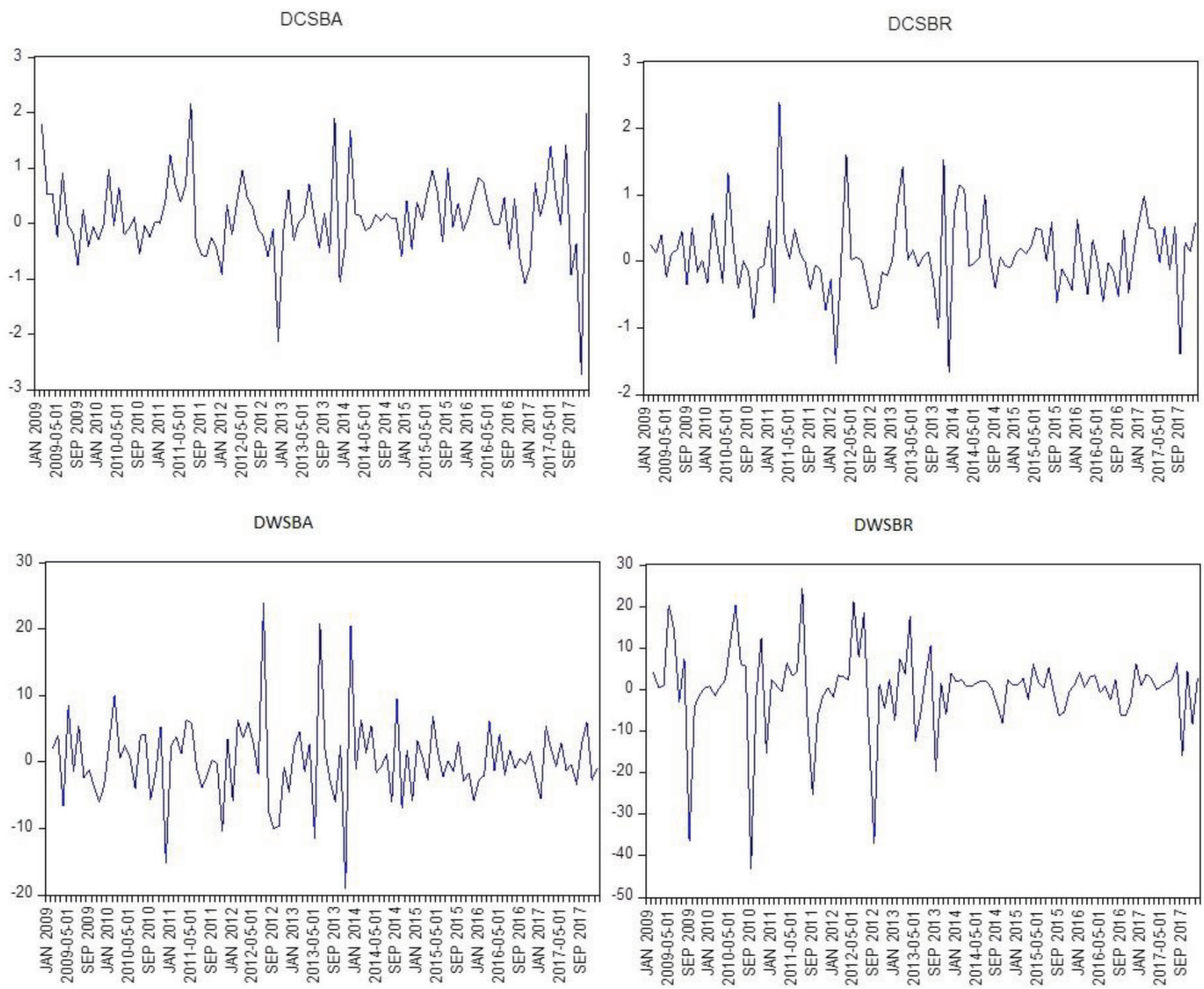

Figure 2. First difference of the variable prices.

Table 2. Criteria used to determine the lag length of the variables.

Lag	LogL	LR	FPE	AIC	SW	HJC
0	–836.8264	NA	572.5517	17.70161	17.80914	17.74506
1	–820.1382	31.61973	564.5343	17.68712	18.22478	17.90437
2	–806.0866	25.44086	589.2847	17.72814	18.69592	18.11920
3	–791.7332	24.77844	612.9031	17.76280	19.16072	18.32767
4	–783.1508	14.09321	722.7309	17.91896	19.74700	18.65763
5	–766.9454	25.24636	729.8289	17.91464	20.17280	18.82711
6	–750.4839	24.25897	738.1441	17.90492	20.59322	18.99120
7	–732.6068	24.83984	730.9165	17.86541	20.98382	19.12548
8	–723.3527	12.07893	877.0411	18.00743	21.55597	19.44130
9	–711.6727	14.26196	1012.837	18.09837	22.07704	19.70605
10	–692.9588	21.27471	1024.317	18.04124	22.45004	19.82272
11	–664.2650	30.20403	855.3369	17.77400	22.61292	19.72929
12	–647.8538	15.89297	945.9655	17.76534	23.03439	19.89443

Table 3. Results of Johansen cointegration test.

Hypothesized no. of CE(s)	Eigenvalue	Max-eigen Statistic	0.05 Critical value	Prob.
None	0.502702	73.34944	24.15921	0.0001
At most 1	0.472664	67.19125	17.79730	0.0001
At most 2	0.375655	49.46046	11.22480	0.0001
At most 3	0.237348	28.45012	4.129906	0.0001

The production data suggest that the amount of sea bream and sea bass produced by capture fisheries will continue to decrease and the aquaculture production will continue to increase in the years to come.

Considering the rapid growth and increased productivity in the fish farming sector, the production costs can be expected to decrease. However, farmed species will steal market share from captured species when market integration is achieved for the two products (captured and farmed). This means that captured and farmed products are substitutable [8].

As the structure of production costs is quite different for captured fishery and farming businesses, the market integration between the captured and farmed products arises from the demand behavior of consumers. Indeed, the fact that captured sea bass has a higher price than farmed sea bass indicates that consumers are more sensitive to captured products [7].

In this case, if the consumer demand is not perfectly elastic, the prices of both products will decrease. However, in the case that market integration between the captured and farmed product cannot be achieved, an increase in the amount of farmed products will only result in a decrease in the price of farmed products and will not have an effect on the captured products [18].

There are various studies focusing on price interaction of captured and farmed fish. A study focusing on the market link between farmed (pangasius and tilapia) and captured (Alaska pollock, cod, and saithe) frozen white fish reported that the two markets were highly integrated and that the competition between the two product groups was associated with the increased supply of captured products, rather than the increased demand for farmed products [9]. It was found that sea bream produced by fishing and farming is partially integrated into the fresh fish markets, but this was not the case for sea bass. It was reported that the considerably higher price of captured sea bass compared to farmed sea bass was due to the fact that consumers were more sensitive to the production process of fisheries when it comes to fish species with a high economic value [7]. It was reported that captured and farmed salmon fish in Japan were close substitutes, and that an increase in the supply of farmed salmon resulted in a decrease in the price of both farmed and captured salmon.

It was also highlighted that farmed and captured salmon competed in the same market, which was exceptionally integrated, and that there was a single market rather than interlinked market segments [10].

As the results of the present study indicate market integration between farmed and captured products in Turkey, it can be said that the competition between the products is driven by consumer preference, consumer income level, price, seasons, and fishing bans. With the start of fishing bans and the effect of the tourism season, consumer demand is met by farmed products and prices increase in this period. This arises from the substitutability of farmed products and captured products in the integrated market. On the other hand, the end of the period of hunting bans and consumer demand from hunting products cause increases in prices. However, different econometric models are needed in order to explain that hunting bans are integrated into market integration due to their effects on both hunting and tourism season. The cultivation of sea bream and sea bass using the same production methods and their marketing through the same channels add to their substitutability. Similarly, the use of the same capturing methods to produce wild sea bream and sea bass and the use of the same marketing channels following the end of the closed season account for the concurrence of their price movements.

The results indicate that the price time series of captured and farmed sea bream and sea bass have a cointegration relationship, and that they are substitutes. It is clear that captured and farmed sea bream and sea bass are substitutes in terms of prices, and that any change in the price of one product affects the price of the other as well.

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