Price transmission and integration between the Italian and Spanish seafood markets

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Abstract

The characteristics of seafood markets may be strongly affected by several aspects, firstly by the biological cycles and catch trends of every fish species and secondly by several institutional features; however, there are not empirical papers that clearly show how these factors can affect the market of different seafood products landed in the same geographical area. In this paper, we provide a progress in the knowledge of seafood markets evaluating how differences in catch patterns, wholesale organization, and trade needs may influence the transmission of prices along the supply chain, using Italian and Spanish markets as a case study. Five species (sardine, European anchovy, common cuttlefish, common octopus and clam) are analysed. Results support the assumption of market integration at international level between Italy and Spain in the case of small pelagics; for octopus, there is a transmission of price signals from the retail level to the first sale level, while for cuttlefish first sale prices seem to be independent and driven by local catches. These differences can be explained by the biological and institutional characteristics of these submarkets. The case of clam is controversial, since the analysis has not found any correlation among prices at national and international level. These results can be used by the weak agents (i.e., fishers) of the supply chains and by the public institutions to design better forms of horizontal (i.e., producer organizations) and vertical (i.e., interbranch organisations) coordination.

Keywords: Price transmission, market integration, supply chain, VAR test, Causality test.

JEL classification : C32, Q21, Q22

1. Introduction

The market of seafood is characterized by a combination of specific characteristics that cannot be found in any other sector. However, many differences can be found also inside the seafood market, since, even for the products landed in the same harbor, it is in reality composed by many sub-markets. In general, fresh finfish, as well as fresh crustaceans and mollusks, must be consumed in relatively short time after catch since these products are highly perishable. Some products can be stored or processed, but for many species this is not an option since there are not the facilities and channels for this, or because storage (in particular freezing) cause a loss of value compared to the fresh product. This characteristic, linked to the seasonality of fish, may cause fluctuations in the price of some species.

On the other hand, fish can be comfortably conserved alive inside the sea in order to avoid peaks of production and to be caught only when the market needs it (even if common access to the resource and seasonality can represent a difficulty to this strategy). Total volumes of landings and the distribution of these landings in different regions and nations also affect the characteristics of fish markets: most abundant species may be exported and feed large international markets where prices are highly correlated and where they may suffer the competition of similar products (Nielsen et al., 2009). Niche species on the contrary may feed only local markets and their prices are unrelated with the prices of other products or even with the prices of the same species landed in different harbors (Mulazzani et al., 2015).

In the case of Italian fisheries, the difference between species caught in large quantities and species caught in small quantities has also consequences on the ways these products are sold and traded. Species caught in large quantities, such as small pelagics (sardines and anchovies) and clams, can feed export circuits (Camanzi et al., 2012). Furthermore, they are mainly traded by specialized large wholesalers (for small pelagics or clams respectively) that have direct and continuous relationships with fishers. In other words, these products are normally not exchanged on auction markets and wholesalers may inform fishers about the quantities needed day by day. On the other hand, species caught in small quantities (white fish, crustaceans, cephalopods) are caught without direct information about the quantities needed by the market. Products are exchanged in auction markets and buyers are mainly composed by a heterogeneous set of small wholesalers, local retailers, restaurants, etc. These species cannot feed exports circuits, but they can potentially suffer the competition of imported products (Mulazzani & Camanzi, 2011).

These differences should be reflected in the way prices are transmitted along the different stages of the supply chain. Thus, the objective of this paper is to verify if differences are found in the transmission of prices among different market stages in Italy and Spain (ex-vessel, wholesale, and retail) and if differences can be related to the landing and trading characteristics of each species. The coexistence of many interrelated drivers at biological (seasonality, fish stocks size and fluctuations) and market (quantity and nature of wholesalers, import-export relations, diffusion of auction markets or informal contracts) level makes very difficult to foresee the direction of vertical price relations in these five supply chains. The paper aims to shed light on possible price transmission patterns which, if made explicit, could help agents (in particular fishers) to better organize themselves through new forms of horizontal (e.g., producer organizations) and vertical (e.g., interbranch organizations, contractual schemes) coordination that could make more efficient the management of common resources and increase the control on price fluctuation and supply excess.

2. Price transmission

Several studies have dealt with the analysis of vertical price transmission in the European area for objectives that include the evaluation of delivery performance and the reduction of the supply chain disruptions (Ngniatedema et al, 2016; Sharma & Bhat, 2013). In the seafood sector, Guillen and Franquesa (2015) analyzed ten seafood products in Spain for 3 market stages (ex-vessel, wholesale, and retail). The results demonstrate the relevance of asymmetric price transmission of all ten species. Gizaw et al. (2020) conducted a study on the price transmission of fresh and smoked salmon between the Norwegian export market and the retail markets of France and Spain: price transmission relationship is detected only for the fresh salmon chain. In Germany, Ankamah-Yeboah & Bronnmann (2017) studied the presence of price changes and equilibrium adjustment asymmetries, for Alaska pollock, cod, and salmon at different chain levels (Import-Aggregated-Retail, Import-Discounter, Import-Hypermarket, and Import-Supermarket); a complete price transmission occurred only for cod prices between discounter, hypermarket and import prices. Similarly, Fernández-Polanco and Llorente (2015) estimated in Spain the effect of import price on domestic prices for hake, anchovy, and mackerel. Landazuri-Tveteraas et al. (2018) estimated the price transmission of different varieties of salmon using Norwegian export prices and retail markets in UK and France. The results indicate that only eight salmon products (among 17 retail products examined) cointegrated with export prices. For cod, a complete price transmission is detected in Germany between import and retail prices (Bronnmann and Bittmann, 2019), whereas for herring, asymmetries are detected. In France, Simioni et al. (2013) proved the price cointegration of two species (cod and salmon) at two different stages of the chain: production and retailing. Going out of Europe, Singh et al. (2022) attested a cointegration relationship between export and import prices of frozen shrimp to the American and Japanese markets from India. Finally, in Bangladesh, cointegration test was used to determine the existence of long run market integration between wholesale and retail markets for silver carp, rohu, tilapia, and pangasius (Deb et al., 2022).

3. Data

Five species have been chosen for this study on the base of the availability of data and of the specificities of their markets. Weekly price observations are used at four different stages: first sale in Italy, wholesale in Italy, retail in Italy and retail in Spain. The five species considered are sardine

(*Sardina pilchardus*), European anchovy (*Engraulis encrasicolus*), common cuttlefish (*Sepia oficinalis*), common octopus (*Octopus vulgaris*) and clam (*Chamelea gallina*). The weekly dataset is provided by EUMOFA (European Market Observatory for Fisheries and Aquaculture products), who collects data from different institutions (like Agriculture Ministries or national research institutes) and then proceeds with preliminary quality checks and data reliability tests. The prices of individual markets are not taken in consideration; only the average data provided by EUMOFA, aggregated at national level, are considered. It is worth mentioning that EUMOFA aggregates many species of the same family into a wider generic category named Main Commercial Species (MCS), which thereby could contain similar minor species; for example, musky octopus (*Eledone moschata*) is included inside MCS octopus, and round sardinella (*Sardinella Aurita*) within MCS sardine.

These five species are particularly important for the Italian seafood market, but they present specific patterns of catches and trade that have changed and evolved in the latest years. According to the EUMOFA database of Italian landings, ordered by value, anchovy is the second most important species (only below shrimp-miscellaneous), cuttlefish is the third, octopus the fourth, clam the eighth and sardine the fourteenth. These five species in 2018 summed a total value of 274 million Euros, the 28.3% of the total value of landings. The main patterns of catches and trade are described below (using EUMOFA yearly data), highlighting the relationships between the Italian and the Spanish market (Figure 1).

(Figure 1)

Anchovy. After reaching a peak in 2006, Italian landings have been decreasing, while Spanish landing were increasing. Spain's production overtook the Italian one in 2013. Export from Italy to Spain, after being very relevant in the 2000-2012 period, has strongly decreased. A relevant data is the percentage of Anchovy exported to Spain in relation to the Italian landings: this value has stably been over 25% between 2003 and 2010. In the most recent years, it has dropped under 7%.

Sardine. The sardine production is higher in Spain than in Italy, even if from 2012 they started to converge to similar volumes. Imports were very low for both countries until 2012, when Spain started importing more sardine from Italy. The Italian export/landing ratio (only to Spain), after 2012, has always been over 25%.

Octopus. The general trend of octopus landings in Spain is decreasing. In the latest years, landings are higher in Italy and, as a consequence, the export from Spain to Italy is also decreasing. Between 2013 and 2017 more than 30% of the whole Spanish Octopus production was destined to the Italian market, making of Italy an essential market.

Cuttlefish. Even if the Italian production of cuttlefish has been larger than the Spanish one, the trade from Spain to Italy has always been more relevant than the trade in the opposite direction. A massive share of Spanish landings (between 40 and 60%) has been historically destined to the Italian market.

Clam. The Spanish production of clam has always been lower than the Italian one. Spain seems to be dependent from Italian exports at the point that, during 2018, the incoming flows from Italy had a volume higher than Spanish landings. In 2017, 54% of the Italian production was destined to the Spanish market.

Weekly data are collected from 2010 to 2017. Unfortunately, not all stage data are available for all species. At the Spanish retail level, data are missing for Octopus and Cuttlefish. For sardine, data are missing for the Italian retail prices; first sale data are missing for clams. In Table 1 the length of time series is specified for each species. In Figure 2 the weekly price trend is represented for the five species.

(Table 1)

(Figure 2)

4. Methodology

Cointegration techniques and Granger causality test are the most typical tools to deal with vertical, horizontal or spatial price transmission (Jiménez-Toribio et al., 2010). Guillen and Franquesa (2015) used Granger causality to test ten fish products in Spain. Gordon and Hannesson (1996) combined two-stage Engle-Granger and Johansen procedure using VAR for vertical and spatial estimation of fresh cod and frozen fillets between European and US seafood market. Similarly, Jiménez-Toribio et al. (2010) estimated the vertical and horizontal price relationship of canned and frozen tuna within the European market, and versus the world seafood market, combining the bivariate causality tests with bivariate and multivariate cointegration models. Recently, Gizaw et al. (2020) used threshold cointegration model and asymmetric error correction model (ECMs) to estimate vertical transition of fresh and smoked salmon in Spain and France. In Germany, Ankamah-Yeboah and Bronnmann (2017) used bivariate Johansen test and consistent threshold cointegration (TAR and M-TAR) for vertical estimation of Salmon, Alaska pollock and cod. Simioni et al. (2013) used TAR and M-TAR for wild cod and farmed salmon in France. Landazuri-Tveteraas et al. (2018) used only Johansen bivariate time-series approach for vertical estimation of salmon. Guillotreau (2004) combined the cointegration approach with system dynamics model for vertical price valuation of the salmon's European industry. Fernández-Polanco and Llorente (2015) used the Johansen-Juselius test of cointegration for hake, anchovy and mackerel in Spain. Finally, Bronnmann and Bittmann (2019) used a Nonlinear NARDL approach to estimate the price transmission of cod and herring in Germany.

Before choosing the appropriate model for time series analysis, the Augmented Dickey Fuller test is necessary for testing the stationarity of series. In this study, the estimation of the price relationship among series was conducted using the VAR model rather than the VECM model because all series have been found to be stationaries. The VAR(p) model generated by stationary time series

[$y_t = (y_{1t}, \dots, y_{kt})'$] is built as follows:

$$y_t = \sum_{i=1}^{m} \alpha_i \, y_{t-i} + \sum_{j=1}^{m} \beta_j x_{t-j} + \varepsilon_{1t} \tag{1}$$

$$x_t = \sum_{i=1}^{n} \gamma_i \, x_{t-i} + \sum_{i=1}^{n} \mu_j y_{t-j} + \varepsilon_{2t} \tag{2}$$

where:

y_t and x_t are time series; ε_{1t} ε_{2t} are uncorrelated error terms; *m* and *n* are the maximum lags; α_i , γ_i , β_j and μ_j are the constant parameters to be estimated. Prices are expressed in logarithmic form, so that coefficients are interpreted as elasticity of price transmission (EPT).

Before running the VAR model, it is necessary to select an adequate lag order. The Akaike (AIC), Schwarz (SC) and Hannan-Quinn (HQ) criteria are the classical procedures for lags selection (Lütkepohl, 2005).

Successively, we analyse the concept of causality which was introduced by Granger (1969). The Granger test with VAR modelling is one of the most popular and flexible ways highlighting the causal relationship in time series data (Levendis, 2018). The causality is tested in the context of linear regression models. For illustration, consider a bivariate linear autoregressive model of two variables x_1 and x_2:

$$x_1(t) = \sum_{j=1}^{p} A_{11,j} x_1 \, (t-j) + \sum_{j=1}^{p} A_{12,j} x_2 (t-j) + \varepsilon_1(t) \tag{3}$$

$$x_2(t) = \sum_{j=1}^{p} A_{21,j} x_1 \, (t-j) + \sum_{j=1}^{p} A_{22,j} x_2 (t-j) + \varepsilon_2(t) \tag{4}$$

where *p* is the maximum number of lagged observations included in the model (the model order), the matrix *A* contains the coefficients of the model (i.e., the contributions of each lagged observation to the predicted values of $x_1(t)$ and $x_2(t)$), and ε_1 and ε_2 are residuals (prediction errors) for each time series. If the variance of ε_1 (or ε_2) is reduced by the inclusion of the x_1 (or x_2) terms in the first (or second) equation, then it is said that x_2 (or x_1) Granger-(G)-causes x_1 (or x_2). In other words, x_2 G-causes x_1 if the coefficients in A_{12}, are jointly significantly different from zero. This can be tested by performing an F-test of the null hypothesis that $A_{12} = 0$, given assumptions of covariance stationarity on x_1 and x_2.

G-causality can be readily extended to the *n* variable case, where $n>2$, by estimating an *n* variable autoregressive model. In this case, x_2 G-causes x_1 if lagged observations of x_2 help predict x_1 when lagged observations of all other variables $x_3 \ldots x_n$ are also considered. In our case, the causality interaction between variables includes 3 series in the case of sardine (first sale Italy, wholesale Italy and retail Spain), cuttlefish (first sale Italy, wholesale Italy and retail Italy), octopus (first sale Italy, wholesale Italy and retail Italy) and clam (wholesale Italy, Retail Italy and retail Spain); series are four in the case of anchovy (first sale Italy, wholesale Italy, retail Italy and retail Spain).

5. Results

Descriptive statistics of the different price series analyzed are shown in Table 2. The prices considered are all those of the Italian chain (first sale, wholesale and retail price), while in Spain only retail price was considered as a trading market. The coefficient of variation (C.V.) is often used for measuring the price volatility. At the first stage, the C.V. is higher for the cheapest products, sardine and anchovy, which is close to 0.5, and then decreases at wholesale (0.22 for sardine and 0.21 for anchovy) and, even more, at retail level. For the more expensive products (cuttlefish and octopus), the volatility remains more constant along the supply chain. Unfortunately, for clam, the first sale price is not available, while C.V. is similar to the other products at wholesale and retail level.

(Table 2)

Table 3 represents the results of the Augmented Dickey Fuller (ADF) test of the different time series. The results demonstrate the stationarity of all series at 1% level of significance. In Table 4 the optimal lagged value chosen for the different price series is indicated. We considered the AIC to choose the time lag. The order of the lagged values is different for the different species. For sardine, anchovy, cuttlefish and octopus, the lagged value chosen by the AIC model is two. Only for Clam, the lagged value is five according to the AIC criterion.

(Table 3)

(Table 4)

VAR results for the different price series are shown in Table 5 and 6; Granger causality test is shown in Table 7. Relationships are considered only when results are statistically different form zero at 5% level of significance. The most significant effects between price series in the VAR test are recorded at the first lag for all products with the exception of Anchovy's series. The results of the VAR test are totally confirmed by the causality test. The causality test, in some case, indicates significance for relationships that were not significant with VAR.

Sardine. The results demonstrate only the positive effect at 1% significance level of the Italian first sale and wholesale price on the Spanish retail price. The causality test confirmed the results at 1% and 5% significance level, respectively. Thus, both series effectively cause the retailers trading price even if price elasticity (Ɛ) is very low, and close to zero for both effects (in fact, price variability is very high at first stages but low at retail level). Furthermore, the causality test also indicates a causal effect of the Spanish retail price on the Italian first sale price, showing a more complex and interrelated relation between the two countries.

Anchovy. The results indicate an upstream positive effect at 5% of significance level of Italian retail price on both first sale (Ɛ=1.29 as an effect of Lag2) and wholesale prices (Ɛ=0.80 as an effect of Lag2) and from the Italian wholesale price to the Spanish retail price (Ɛ=0.01 as an effect of Lag1).

All these effects are confirmed by the causality test in which the Italian first sale and wholesale prices are caused by local retail price at 1% and 5% significance level, respectively. Furthermore, the causality test suggests a bidirectional relation between the Italian retail prices and the Spanish retail prices, and causal effect of Italian wholesale prices on Spanish retail prices. Thus, results seem to indicate a leadership of the Italian retail stage and a strong integration at international level.

Cuttlefish. Cuttlefish is the most expensive product at first sale and wholesale level (but not at retail level). Only analysis at Italian level is possible (since Spanish data are not available). Here, it is possible to attest a double significant effect from both retail and first sale prices onto wholesale prices at 1% significance level (Ɛ=0.35 and 0.14 respectively, as an effect of Lag1). Both significant relationships are confirmed by the causality test at 5% and 1%, respectively, while no other significant effects are recorded.

Octopus. Octopus is the most expensive species at retail level (more than cuttlefish). Contrary to the case of cuttlefish, the results indicate a positive effect going from the wholesale prices to the first sale prices at 5% significance level (Ɛ=0.18 as an effect of Lag1). This is confirmed by the causality test (with same significance level), which also registers an effect of retail prices on first sale prices at 1% significance level.

Clam. Finally, no correlation effect is found in the case of clam price series. The causality test confirms this situation.

The results of the VAR systems (considering only the results that are significantly different from zero) indicate that the value of price elasticity (Ɛ) between the different stages of the supply chain is less than 1 for most of the species, which indicate relatively inelastic relationships. The highest values can be found for the effects of the Italian retail (which are the more stable series) on the other stages; this happens in the case of anchovy (Ɛ= 1.29 and 0.80 on first sale and wholesale, respectively) and cuttlefish (Ɛ= 0.35 on wholesale). The elasticity related to the effects of wholesale and retail price changes is much lower, in particular in the case of sardine and anchovy where there is a significant effect on Spanish retail prices (Ɛ between 0.02 and 0.04).

(Table 5)

(Table 6)

(Table 7)

6. Discussion and conclusions

The analysis confirmed that it is not possible to identify a common pattern of price transmission for some of the most important species caught and traded in Italy. These differences have probably their primary cause in the landings patterns and trends in Italy (i.e., more and less abundant species); secondly in the landings patterns in other countries, in particular in Spain, which affect import or export possibilities; and thirdly (as an effect of the previous two causes) in the organization of the market and in particular the role of large wholesalers.

Even if all these aspects are certainly relevant for the formation and transmission of prices, distinguishing their specific role is not an easy task. Unfortunately, data of price series are not equally available among different products to permit a clear comparison. However, it is still possible to draw some conclusions.

Anchovy and sardine (i.e. small pelagics) are two species that are very abundant in Italian seas and, as a consequence, in its landings. Anchovy was characterized, in the past, by strong export flows. Later, when Spanish landings increased, thanks to the recovery of the stocks in the Cantabrian Sea, anchovy export was strongly reduced. On the contrary, export of sardine from Italy to Spain has increased in the latest years. Both species are mainly traded by few and large wholesalers who allow the distribution of small pelagics on the entire country and abroad. These elements permit to say that the market of anchovy and sardine is strongly integrated at national and international level. This is demonstrated by two results:

a) the transmission of anchovy price from retail to first sale and wholesale (unfortunately there are no data for sardine retail price); as already indicated, small pelagic fishers generally know which quantities are required by wholesalers, who know which is the demand from supermarkets, Horeca and foreign markets; thus, it is not a surprise that variations at retail level are later transmitted the wholesale and retail level.
b) the transmission of small pelagics price from the Italian wholesale stage (for both species) and the first sale stage (only in the case of sardine) to the Spanish retail stage. This indicates the influence of Italian landings and Italian wholesalers on the Spanish market. Even in the case of anchovy, that is not exported to Spain anymore, the large quantities landed in Italy and the strong relationship between Italian wholesalers (the same that export sardine) and Spanish operators, have an effect on the Spanish market that need to regulate anchovy prices on the base of prices formed in Italy.

Italian cuttlefish and octopus are not traditionally exported to Spain, since quantities landed are not sufficient to feed this trade channel. On the contrary, Italian production suffers the competition of mollusks from abroad, in particular form Spain, which regularly are sold in Italian supermarkets. These species have a more local market, more oriented to fishmongers and Horeca rather than to supermarkets, they have strong seasonality and price is formed in auction markets at harbor level. Looking at price series, it is not possible to identify common patterns between these two species. In the case of octopus, price transmission seems to go from (national) retail markets and (national) wholesale markets to first sale markets, indicating that prices formed in auctions are affected by the general market, including the effect of both national demand and imports. In the case of cuttlefish, we see that wholesale price is affected both by retail and first sale prices, while first sale prices are not "caused" by any other series. This suggests that auction markets are mainly driven by seasonality and by the fluctuations of local catches without being affected by demand. It seems that it is the wholesale sector that needs to adjust prices dealing with two opposite and independent forces (i.e. demand and supply).

Finally, the most controversial case is that of clams. Unfortunately, in this case first sale prices are not available. Production is exclusively sold by large cooperatives directly to large wholesalers; nothing passes through official markets; thus it is not easy to have a clear idea of what happens at this level. The other prices series available do not seem to be correlated. This is strange, since operators indicate that Italian and Spanish markets are strongly integrated and that prices are linked. Maybe wholesale prices collected in official markets are not perfectly representative of exchanges that are mainly realized through bilateral agreements, or maybe weekly prices are not the right level of analysis ant it would be necessary to work with daily price series.

To conclude, the analysis has permitted to highlight some aspects of the complex seafood market that, in reality, results by the combination of many submarkets. Biological aspects are key in the generation of specific attributes of these markets, however institutional factors, such as the preference for auction markets or bilateral agreements, and the role of few large wholesalers, need to be carefully considered. A better understanding of the processes of price formation can help fishers to manage resources in a more efficient way. The results obtained indicate market integration along the supply chain. In this situation, weak agents (i.e. fishers) of supply chains can take advantage of increased forms of horizontal (e.g. producer organizations) and vertical (e.g. interbranch organisations, contractual schemes) coordination. Horizontal coordination, in particular, can be particularly important when price is formed at first sale level, and then transmitted at other stages, since fishers have the possibility to control supply and, as a consequence, price. Vertical coordination, on the other hand, can be important when the price is formed at retail level and then transmitted at first sale level, since fishers can adjust their fishing effort and catches to demand, increasing efficiency and avoiding excess of supply and discards. Public institutions should foster the best forms of organization providing advice and training to fishers' associations.

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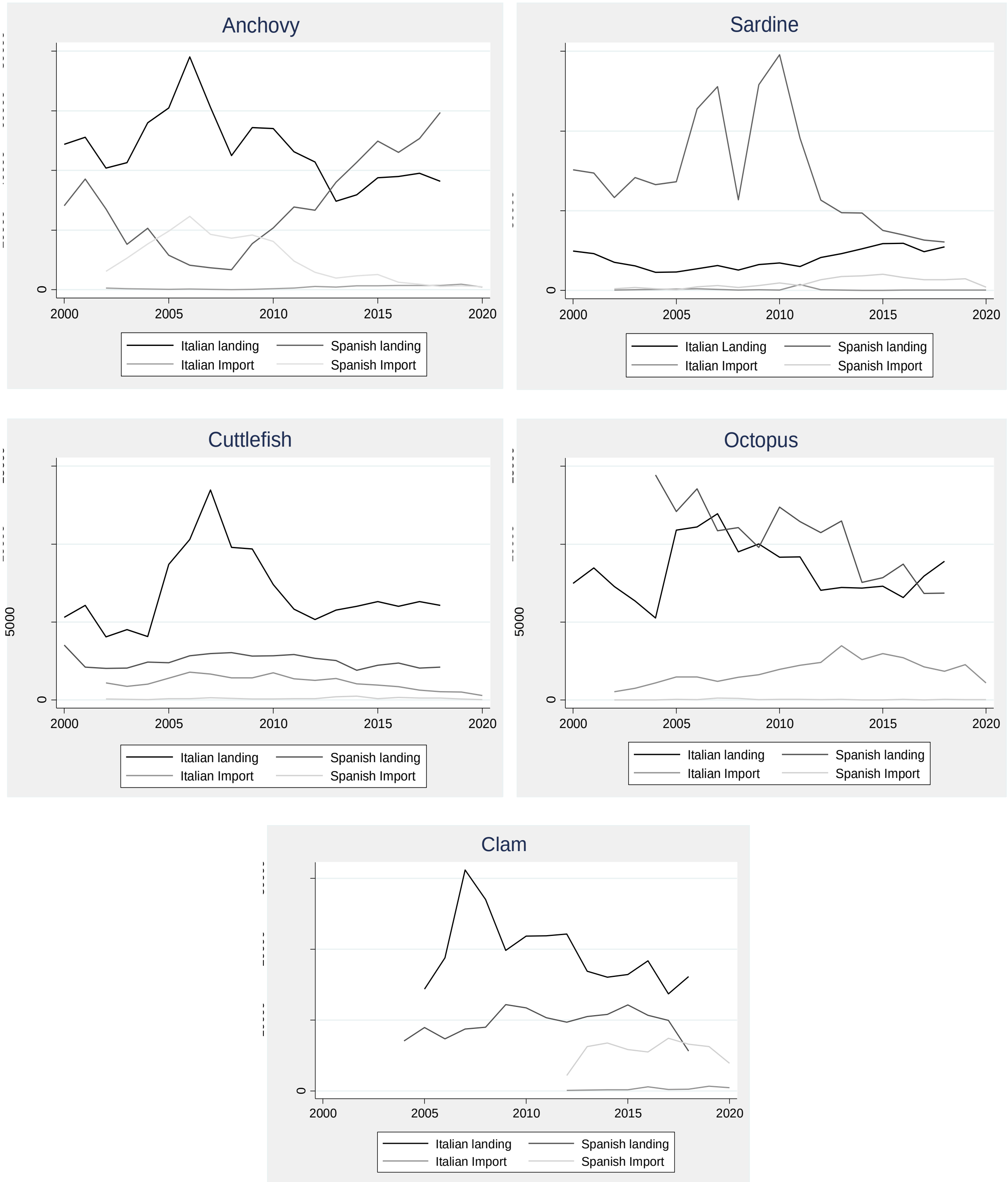
Figures and tables:

Figure 1: *Yearly volume trends of the five species analysed in the paper: landings and import in Italy and Spain (NB: "Italian import" only refers to import from Spain and vice versa).*



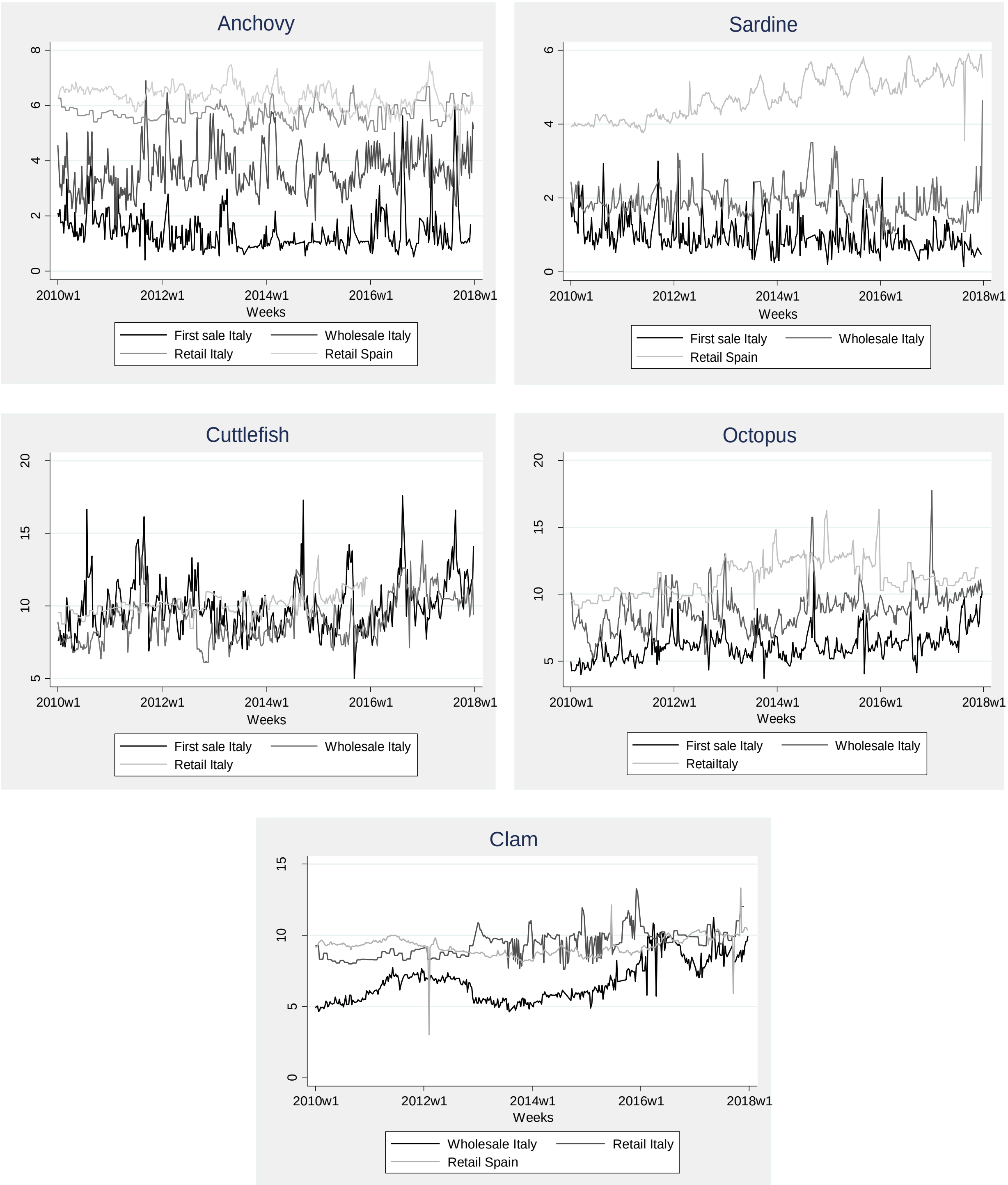
Source: EUMOFA (European Market Observatory for Fisheries and Aquaculture products).

Table 1*: Time series considered for every species.*

Species	Sardine	Cuttlefish	Octopus	Anchovy	Clam
Period	From week 3 of 2010 to week 52 of 2017	From week 3 of 2010 to week 52 of 2017	From week 4 of 2010 to week 52 of 2017	From week 4 of 2010 to week 52 of 2017	From week 3 of 2010 to week 52 of 2017

Source: EUMOFA.

***Figure 2**: Weekly price trends for the different species.*



Source: EUMOFA.

Table 2*: Descriptive statistics for the different price series analyzed*

Series	*First sale price Italy*				*Wholesale price Italy*				*Retail price Italy*				*Retail price Spain*			
	Mean	**Std.Dv**	**C.V**	**Obs**	**Mean**	**Std.Dv**	**C.V**	**Obs**	**Mean**	**Std.Dv**	**CV**	**Obs**	**Mean**	**Std.Dv**	**C.V**	**Obs**
Sardine	0.97	0.44	**46.19**	345	1.89	0.43	**22.75**	373		n.a			4.77	0.56	**11.74**	415
Anchovy	1.39	0.66	**47.48**	360	3.67	0.80	**21.79**	400	5.70	0.34	**5.96**	394	6.32	0.41	**6.48**	415
Cuttlefish	9.92	1.82	**18.34**	400	9.08	1.53	**16.85**	402	10.06	0.67	**6.66**	288		n.a		
Octopus	6.17	1.12	**18.15**	406	8.83	1.52	**17.21**	399	11.21	1.34	**11.95**	395		n.a		
Clam		n.a			6.72	1.43	**21.27**	379	9.38	0.94	**10.02**	394	9.21	0.69	**7.49**	414

"n.a.": Not available data

Source: EUMOFA.

Table 3*: Augmented Dickey–Fuller unit root tests of the different price series.*

		Levels stationarity	
Species	***Price series***	***Test statistic***	***P***
	First sale Italy	-14.06	0.00***
Sardine	Wholesale taly	-9.12	0.00***
	Retail Spain	-3.74	0.00***
	First sale Italy	-11.15	0.00***
Anchovy	Wholesale Italy	-10.68	0.00***
	Retail Italy	-6.08	0.00***
	Retail Spain	-8.08	0.00***
	First sale Italy	-7.42	0.00***
Cuttlefish	Wholesale Italy	-6.06	0.00***
	Retail Italy	-5.76	0.00***
	First sale Italy	-6.95	0.00***
Octopus	Wholesale Italy	-6.80	0.00***
	Retail Italy	-4.71	0.00***
	Wholesale Italy	-3.90	0.00***
Clam	Retail Italy	-6.09	0.00***
	Retail Spain	-12.45	0.00***

Confidence levels: ***99%; **95%; *90%

Source: STATA program.

Table 4*: Choice of the optimal lags for the different price series.*

Max lag order	**Lag1**		**Lag2**		**Lag3**		**Lag4**		**Lag5**	
	AIC	***P***	**AIC**	***P***	**AIC**	***P***	**AIC**	***P***	**AIC**	***P***
Sardine	-3.95	0.00	**-3.96***	0.01	-3.94	0.10	-3.87	0.65	-3.81	0.51
Anchovy	-8.92	0.00	**-9.04***	0.00	-9.02	0.04	-8.95	0.26	-8.89	0.20
Cuttlefish	-7.58	0.00	**-7.60***	0.00	-7.59	0.05	-7.56	0.19	-7.53	0.25
Octopus	-7.34	0.00	**-7.39***	0.00	-7.35	0.53	-7.33	0.23	-7.34	0.01
Clam	-8.85	0.00	-9.36	0.00	-9.48	0.00	-9.56	0.00	**-9.60***	0.00

(*): The sign refers to the optimal lags chosen according to AIC criterion.

Source: STATA program.

***Table 5**: Results of the VAR systems for the different price series (clam excluded).*

Series	**First sale Italy**		**Wholesale Italy**		**Retail Italy**		**Retail Spain**	
	Lag1	**Lag2**	**Lag1**	**Lag2**	**Lag1**	**Lag2**	**Lag1**	**Lag2**
Sardine								
First sale Italy	x	x	-0.12 (0.46)	0.19 (0.22)			-0.55 (0.54)	-0.19 (0.83)
Wholesale Italy	0.02 (0.24)	-0.00 (0.86)	x	x	n.a	n.a	0.12 (0.70)	-0.18 (0.57)
Retail Spain	0.02 (0.00)***	-0.00 (0.55)	0.04 (0.01)***	-0.04 (0.01)**			x	x
Anchovy								
First sale Italy	x	x	-0.07 (0.46)	-0.14 (0.19)	0.01 (0.97)	1.29 (0.04)**	0.40 (0.59)	0.09 (0.89)
Wholesale Italy	0.02 (0.47)	-0.05 (0.08)	x	x	-0.33 (0.31)	0.80 (0.02)**	-0.12 (0.76)	0.24 (0.56)
Retail Italy	-0.01 (0.09)	0.00 (0.40)	0.00 (0.72)	-0.01 (0.39)	x	x	-0.00 (0.98)	-0.08 (0.28)
Retail Spain	0.00 (0.69)	0.00 (0.63)	0.01 (0.03)**	0.00 (0.98)	0.02 (0.66)	0.06 (0.24)	x	x
Cuttlefish								
First sale Italy	x	x	0.05 (0.57)	0.04 (0.63)	0.05 (0.78)	-0.23 (0.28)		
Wholesale Italy	0.14 (0.00)***	-0.03 (0.44)	x	x	0.35 (0.01)***	-0.27 (0.05)	n.a	n.a
Retail Italy	-0.00 (0.86)	-0.00 (0.96)	-0.00 (0.86)	-0.00 (0.93)	x	x		
Octopus								
First sale Italy	x	x	0.18 (0.01)**	-0.08 (0.23)	-0.76 (0.00)	0.80 (0.00)		
Wholesale Italy	0.05 (0.24)	0.00 (0.85)	x	x	0.07 (0.54)	0.01 (0.92)	n.a	n.a
Retail Italy	0.01 (0.53)	-0.00 (0.82)	0.01 (0.62)	-0.02 (0.42)	x	x		

(**x**): The results between the same price series are not taken into consideration. (**n.a**): Not available series

Source: STATA program.

Table 6*: Results of the VAR systems for the clam price series.*

Series	First sale Italy					Wholesale Italy					Retail Italy					Retail Spain				
	Lag1	**Lag2**	**Lag3**	**Lag4**	**Lag5**	**Lag1**	**Lag2**	**Lag3**	**Lag4**	**Lag5**	**Lag1**	**Lag2**	**Lag3**	**Lag4**	**Lag5**	**Lag1**	**Lag2**	**Lag3**	**Lag4**	**Lag5**
Clam																				
Wholesale Italy						x	x	x	x	x	0.06	-0.09	0.01	0.04	0.03	0.01	-0.01	0.02	-0.00	0.07
											(0.38)	(0.31)	(0.88)	(0.58)	(0.69)	(0.77)	(0.74)	(0.67)	(0.93)	(0.13)
Retail Italy			n.a			0.03	-0.03	0.01	0.02	-0.01	x	x	x	x	x	-0.04	-0.00	-0.01	-0.01	-0.00
						(0.44)	(0.43)	(0.77)	(0.57)	(0.79)						(0.22)	(0.83)	(0.69)	(0.62)	(0.81)
Retail Spain						0.05	0.01	0.01	0.05	-0.06	0.09	-0.11	-0.07	0.01	-0.00	x	x	x	x	x
						(0.39)	(0.83)	(0.76)	(0.39)	(0.31)	(0.27)	(0.26)	(0.49)	(0.90)	(0.95)					

Source: STATA program.

***Table 7**: Results of the Granger causality test for the different price series.*

Species	Event (Granger-cause series)	Second event (Effect series)	Chi2	***P***
Sardine	**First sale Italy**	**Wholesale Italy**	1.35	0.50
		Retail Spain	15.56	**0.00*****
	Wholesale Italy	**First sale Italy**	1.48	0.47
		Retail Spain	7.96	**0.01****
	Retail Spain	**First sale Italy**	11.05	**0.00*****
		Wholesale Italy	0.82	0.66
Anchovy	**First sale Italy**	**Wholesale Italy**	2.92	0.231
		Retail Italy	2.75	0.25
		Retail Spain	0.70	0.70
	Wholesale Italy	**First sale Italy**	4.47	0.10
		Retail Italy	0.75	0.68
		Retail Spain	6.53	**0.03****
	Retail Italy	**First sale Italy**	12.72	**0.00*****
		Wholesale Italy	6.99	**0.03****
		Retail Spain	7.48	**0.02****
	Retail Spain	**First sale Italy**	2.35	0.30
		Wholesale Italy	0.57	0.75
		Retail Italy	6.40	**0.04****
Clam	**Wholesale Italy**	**Retail Italy**	2.72	0.74
		Retail Spain	10.22	**0.06***
	Retail Italy	**Wholesale Italy**	3.88	0.56
		Retail Spain	4.35	0.50
	Retail Spain	**Wholesale Italy**	3.26	0.65
		Retail Italy	3.84	0.57
Cuttlefish	**First sale Italy**	**Wholesale Italy**	14.64	**0.00*****
		Retail Italy	0.05	0.97
	Wholesale Italy	**First sale Italy**	2.84	0.24
		Retail Italy	0.18	0.91
	Retail Italy	**First sale Italy**	2.15	0.34
		Wholesale Italy	6.63	**0.03****
Octopus	**First sale Italy**	**Wholesale Italy**	3.54	0.16
		Retail Italy	0.49	0.78
	Wholesale Italy	**First sale Italy**	8.54	**0.01****
		Retail Italy	0.70	0.70
	Retail Italy	**First sale Italy**	24.93	**0.00*****
		Wholesale Italy	4.17	0.12

Source: STATA program.