ARTISANAL FISHERIES AND CONSEQUENCES OF THE INTERNATIONAL TRADE OF BLUEFIN TUNA

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ABSTRACT

There has been significant growth in the catches of bluefin tuna in the Atlantic Ocean and especially in the Mediterranean Sea for the last decade due to the expansion of fattening farms which export their production to Japan. There has been an increase in catches due to strong demand and, consequently, it has produced a degree of exploitation of the stock. According to ICCAT, this could cause the extinction of the resource, and as a result recommendations have been made. For this reason, the European Union has imposed drastic cuts in TACs, which have affected not only the purse-seining fishing fleet which was supplying tuna to farms, but also the artisanal fleet segments which continue ancient fishing activities such as the tuna traps in the South of Spain. In this paper the current situation of this sector is presented in detail. The existing interrelationships between the profitability of firms and catches and, above all, between the profitability of firms and the situation of the bluefin tuna demand in the Japanese market are analysed. This is because this market determines the price obtained by tuna trap firms. This price is established by Japanese wholesalers at the beginning of each fishing season.

Keywords: Atlantic Bluefin tuna, trap fishery, demand system.

INTRODUCTION

The catching of bluefin tuna has been carried out on the Spanish coast using tuna traps from the first century. Estrabon describes this activity about which there is plentiful archeological evidence in sites which are associated with salted fish factories. From the thirteenth century to the nineteenth century the Andalusian tuna traps were run as a monopoly due to the Royal dealership which had been given to the Dukedom of Medina Sidonia. These tuna traps were related to the salted fish industry and the trade of these kind of goods in the Spanish market and in the rest of the Mediterranean Sea. It is interesting to note that there are time series of catches of these traps which started in 1525[1]. The disappearance of the lordships and the deregulation of the fishing activity led to its expansion. As a result, there used to be 4-6 traps which were set annually between the Spanish-Portuguese border and the Straits of Gibraltar, however between 1844 and 1847 it expanded to 12. The number grew to more than 15 from 1880 to 1915, when they were devoted to the production of canned fish which were preferably exported to the Italian market. After the end of WW1, there was a significant crisis in the running of these traps. It was not caused by a reduction in catches but by the excess of fishing capacity. As a result the Government encouraged the setting up of a joint venture company called "Consorcio Nacional Almadrabero". It was set up in 1828 and ran all the tuna traps in the Gulf of Cadiz as a monopoly. It processed catches to be exported and sold in the Spanish market[2]. The "Consorcio" started its activity by running 11 traps. The number of traps gradually diminished. The least profitable were closed down or relocated. They operated best between 1950 and 1955. In that time span, there were 7 tuna traps working. They caught 60,000 tunas every year, which approximately represented a total weight between 8,000 MT. and 9,000 MT. However, this thriving situation started to change in the late 1950s, when the yields drastically diminished although bluefin tuna catches continued increasing due to the activity which was developed by the industrial fleets in the Atlantic Ocean. Therefore, margins diminished because the sale price of canned fish was also small in the traditional markets. For this reason, the situation of the "Consorcio" and its associated factories became unsustainable. There was a reduction in catches from 9,116 MT. in 1957 to 3,009 MT. in 1967 or 616.7 MT. in 1971. In this year, the company was dissolved[3].

Nonetheless, from 1973 new businessmen, who had run tuna traps in Morocco during the Protectorate, started to set tuna traps on the coast in the province of Cadiz. However, catches were sold fresh and exported instead of processing them as canned fish and exporting them to Italy. It made the unit price of catches increase and justified the maintenance of the activity despite a drastic reduction in catches. As a matter of fact, while the breakeven point of Consorcio tuna traps was situated around 600-700 MT. per tuna trap and year, from the trade reorientation onwards this point was situated around 200-300 MT. Therefore the activity could continue. From 1974 to 1986 the number of traps grew to 6 - 5 in Cadiz and 1 in Huelva - and subsequently it was reduced to the four current ones in

1993 (Zahara, Conil, Barbate and Tarifa). It is worth mentioning that there were some failed attempts to set up new traps in 2004 and 2008.

From 1995 there was an expansion in the activity of tuna fattening farms. This has caused the multiplication of juvenile fish catches in the Mediterranean Sea by Spanish, French and Italian purse seining fleets to supply tuna fattening farms. It has produced a significant overexploitation of the resource, which has resulted in a drastic reduction in catches from the traps. In particular, catches from these traps diminished 80% between 1999 and 2003.

Following ICCAT recommendations, the European Union has developed a special plan for bluefin tuna which has resulted in the establishment of TACs for each country and fishing gear. For Spanish tuna traps, this plan has resulted in the closure of the Ceuta tuna trap. Then, the TACs were distributed between the four Atlantic tuna traps. In 2008 the bluefin tuna TAC which was allocated to Spain was 5,678.5 MT. 1,417 MT. of this TAC were allocated to tuna traps. However, catches were lower than TAC in that year. By contrast, in 2009 and 2010 the TAC has been 1,211.8 MT. and 889.5 MT., respectively and they have been used completely by the traps. However the duration of the fishing season has been significantly reduced[4].

The reduction in TACs produces lower operating costs, but there are lower catches as well and, consequently, lower revenues provided that the reduction in catches does not have an influence on the final price. However, this final price is not subject to the laws of the market, given that the Japanese purchasing firms set the price by considering their expectations in the Japanese market before the start of the fishing season. They impose this price on tuna trap firms and, as a result, it represents a demand oligopoly. Whereas the supply of tuna traps accounted for 35% of total imports of bluefin tuna in the Japanese market at the late 1980s, it was around 20% between 1989 and 1993. Additionally, from that year onwards, the Andalusian traps provided less than 5% of the supply to the Japanese market due to the expansion of tuna fattening farms. This was despite the excellent quality of tunas which stem from traps as opposed to farm fattened ones[5]. Regarding the Spanish exports to the Japanese market, the traps accounted for 90% between 1985 and 1990 and this percentage diminished gradually up to 6% in 2004. In that year, the fattening farms which were located in Murcia or other areas in the Spanish Mediterranean Sea exported 6,000 MT. of bluefin tuna. But the limits using TACs, which have almost caused the disappearance of tuna fattening farms, have led to an improvement in the tuna trap activity, so that in 2009 tuna trap exports to the Japanese market accounted for 65% of the total exported amount by Spain and even much more over 2010. Nonetheless, in 2009 the price received by tuna trap firms has been in real terms 50% of what it had obtained in 2001.

DESCRIPTION OF THE MODEL

Almost all the production of Andalusian tuna traps – 95% between 1988 and 2009 – is exported to the Japanese market and only a small quantity is devoted to the domestic market as a luxury good. Exports to other destinations are practically nonexistent, despite efforts which are being made by the OPP-51 (i.e., the Tuna Trap Fish Producers Organisation). Production is logically limited by exogenous biological and environmental factors. For this reason, the only business decision regarding this matter is to set the tuna trap or not to set it. Once the decision to maintain the activity has been made, there is an enormous amount of necessary resources to optimize the facilities before the start of the fishing season. This makes firms maintain the activity until they have at least covered their operating costs. Unfortunately, the fishing season is also restricted by biological reasons because the catch of this resource using static fishing gear is limited to the period in which the tuna breeding migration occurs (i.e., the entrance of tunas in the Mediterranean Sea for its breeding and, in any case, the exit from the Mediterranean Sea towards the Atlantic Ocean once the breeding has ended). The traps in which the fishing season usually starts with full moon in April and ends in the middle of June are named "del derecho" or "de paso" (i.e., when tunas enter the Mediterranean Sea), whereas the tuna traps in which the fishing season starts in June and lasts until August at the latest are named "del revés" or "de retorno" (i.e., when tunas return from the Mediterranean Sea to the Atlantic Ocean). Therefore, when the traps are set, businessmen will try to catch the highest possible number of tunas over the short fishing season. As a matter of fact, only one out of the four current traps is "del derecho" and "del revés" (Barbate), while the rest ones are only "del derecho", in which tunas have better quality and price than "del revés" ones. For this reason, in exceptionally bad years only the trap in Barbate has tried to increase its catches by expanding the duration of the "del revés" fishing season. Then, they catch juvenile tunas and fatten them in cages until they reach a weight that allows their sale at a reasonable price. Currently, taking into account the current TACs, the "del revés" fishing season has almost disappeared.

The catches are sold directly to the Japanese boats which are moored in the port and, in some cases, they are sent to Japan by aeroplane. Only tunas which are discarded by Japanese buyers are sold to the domestic market and to restaurants and catering firms because the activity has become a fundamental touristic call in the region.

In the model we intend to relate the wholesale Japanese market with the tuna trap activity using a group of seven equations. The equations are as follows: (a) Wholesale demand in Japan, (b) Demand of frozen tuna inventories in cold stores, (c) Derived exvessel demand in Japan, (d) Relationship between the price of Japanese imports and the first-hand sale prices, (e) Exports of tuna traps to Japan, (f) Derived exvessel demand of tuna traps, (g) Profitability of tuna traps.

a) Wholesale demand in Japan

The equation for the wholesale bluefin tuna demand in Japan uses an inverse formulation in which the real wholesale price of frozen bluefin tuna (PWC_R) depends on the per capita level of frozen bluefin tuna inventories (INVPC), the real wholesale price of fresh bigeye tuna (PFBET_R) which can be considered as a substitute good of fresh and frozen bluefin tuna in the Japanese wholesale market (Chiang et al., 2001) (this is because it is the only tuna species with the exception of bluefin tuna which is consumed in sashimi), the real per capita household living expenditure in Japan (GPC_R), the per capita consumption of imported bluefin tuna (QICPC) and the price of fresh bluefin tuna imports in real terms (PIF_R), which can be also considered as a substitute good. The equation would be expressed as follows

$$PWC\_R_t = f_1\left(INVPC_t,\ PFBET\_R_t, GPC\_R_t, QICPC_t, PIF\_R_t\right) \tag{1}$$

In principle, it is assumed that the relationship between the real wholesale price of frozen bluefin tuna and the other variables should be as follows: it should have a negative sign with the consumed quantities and the inventories, while it should have a positive sign with the price of bigeye tuna, the imported fresh bluefin tuna and the real per capita household living expenditure in Japan.

b) Demand of frozen tuna inventories

To represent the demand of frozen tuna inventories, we have opted for adapting Nerlove's partial adjustment model (Nerlove, 1958). The variation of inventories depends on nominal prices and the expectations on them. These expectations are assumed to be built as an average of its current and lagged values (Herrmann and Criddle, 2006). Additionally, other exogenous variables have been included in this equation. Developing the partial adjustment model, the equation can be expressed as follows

$$INV_t = f_2\left(INV_{t-1}, PWC\_R_t, PWC\_R_{t-1}, CPC_t, IPSTRAT_t\right) \tag{2}$$

where the nominal inventory (INV) depends on the nominal wholesale price of frozen bluefin tuna (PWC_R$_t$) and its lag (PWC_R$_{t-1}$) -expectation- and two additional exogenous variables. These variables are the per capita consumption of tunas in Japan in terms of weight (CPC) and the road transportation price index in Japan (IPSTRAT). Logically, the expected signs of the coefficients should be negative for prices and they should be also negative for consumption and transportation costs.

c) Exvessel derived demand in Japan

In this case, we have also opted for an inverse formulation in which the real first-hand sale price of fresh bluefin tuna caught by the Japanese fleet (PLF_R) depends on its landed and auctioned quantity (QLF), the real wholesale price of frozen bluefin tuna (PWC_R), the total supply of frozen bluefin tuna in Japan (STC) and a proxy variable of transportation costs which is the maritime transportation price index in Japan in real terms (ITRAM_R):

$$PLF\_R_t = f_3\left(QLF_t, PWC\_R_t, STC_t, ITRAM\_R_t\right) \tag{3}$$

Logically, the coefficients of the quantity and the transportation costs should be negative, while the coefficient of the wholesale price should be positive.

d) Relationship between prices of imports and prices at the first-hand sale market

This relationship is introduced to show the fit between the real price paid for the Japanese imports of frozen bluefin tuna (PIC_R) and the real price of the Japanese production at the first-hand sale markets (PLF_R). Additionally, three other exogenous variables have been included such as the real exchange rate between yen and euro (TCYE_R), the real per capita household living expenditure in Japan (GPC_R), the total transportation price index in Japan (ITRA_R) and the total supply of fresh bluefin tuna (STF):

$$PIC\_R_t = f_4\left(PLF\_R_t, TCYE\_R_t, GPC\_R_t, ITRA\_R_t, STF_t\right) \qquad (4)$$

The coefficient of the price should be positive. The coefficient of the exchange rate should be negative. The coefficient of the household expenditure should be positive. Finally, the coefficient of the transportation cost should be negative because tuna imports arrive at Japan not only by sea but also increasingly by air.

e) Exports of tuna traps
It intends to represent the tendency of Andalusian tuna traps to export to the Japanese market. The exported quantity to Japan (QEXP) depends on the catches of tuna traps (QALM) and the average real price (PALM_R) of bluefin tuna received by Spanish tuna trap firms:

$$QEXP_t = f_5\left(QALM_t, PALM\_R_t\right) \qquad (5)$$

This price has been obtained as a weighted average of the price of exports to Japan, other exports and the sales in the Spanish first-hand sale market. It is expected that the sign of the coefficient of tuna trap catches should be positive. It is also expected a positive sign of the coefficient of the bluefin tuna price received by Spanish tuna traps.

f) Exvessel demand of tuna traps
This equation intends to show the price setting procedure in Andalusian tuna traps. It is formulated as an inverse demand which relates the real price obtained by traps (PAL_R) with the proportion that exports to Japan represent over the production (RQEXP), the maritime transportation cost, which is represented by the maritime transportation Japanese index in real terms (ITRAM_R) and the average real price paid by Japan for its bluefin tuna imports (PIC_R) expressed in euros:

$$PAL\_R_t = f_6\left(RQEXP_t, ITRAM\_R_t, PIC\_R_t\right) \qquad (6)$$

In this case, due to the monetary integration process in the European Union, the exchange rate peseta-yen until 2002 has been used, then re-calculated using the official euro-peseta exchange rate. The expected sign of the coefficients of the proportion that exports to Japan represent over the production and the transportation cost should be negative and the coefficient of the price of imports should be positive.

g) Profitability of tuna traps
Finally, there is an additional relationship to represent the effect that all the system has on the profitability of tuna traps. It relates the ratio between the Gross Value Added which is produced by tuna traps and the cost of employed staff (salary and social security) (R_EXBE) with the value of caught quantities or sales of bluefin tuna in real terms (VALM_R), the level of effort exerted by tuna traps (ESF) which is measured by the number of codend days. This is a proxy variable of the time period of tuna trap activity and, consequently, the period in which the number of employees are working. Finally, the consumer price index of fishing goods (IPCP) is also included. Additionally, we have included a dummy variable which intends to take into account the effect of an atypical fishing season in the tuna trap in Tarifa (DUM):

$$R\_EXBE = f_7\left(VALM\_R_t, IPCP_t, ESF_t, DUM_t\right) \qquad (7)$$

It is apparent that if catches were higher and price were better the profitability should grow. On the other hand, the coefficient of the fishing season duration should have a negative sign because the longer the fishing season is, the higher the costs are. Finally, the coefficient of the dummy[6] should also have a negative sign.

h) Identities
The following identities and definitions are introduced:

$PWC\_R_t = PWC_t / CPI\_PESCA_t$
$QICPC_t = QIC_t / POP_t$
$INVPC_t = INV_t / POP_t$
$PFBET\_R_t = PFBET_t / CPI\_FRESH_t$

$PIF\_R_t = PIF_t / CPI\_FRESH_t$

$GPC\_R_t = [(GPH_t * PPH_t) / POP_t] / CPI\_G_t$

$ITRAT\_R_t = IPSTRAT_t / CPI\_PFRESH_t$

$TCYE\_R = TCYE / CPI\_G_t$

$STC_t = INVt\text{-}1 - INVt + QIT_t + QLC_t$

$PLF\_R_t = PLF_t / CPI\_PFRESH_t$

$PIC\_R_t = PIC_t / IPI\_FOOD_t$

$ITRA\_R_t = ITRA_t / CPI\_PFRESH_t$

$ITRAM\_R_t = ITRAM_t / CPI\_PFRESH_t$

$STF_t = QIF_t + QLF_t$

$PALM\_R_t = PALM_t / IPCP_t$

$RQEXP_t = QEXP_t / QALM_t$

$R\_EXBE_t = (VAB_t / REM_t)$

$VALM_t = PALM_t * QALM_t$

$QIAL_t = QEXP_t$

In Appendices the definition of the variables used and the sources of the data are presented in Tables A1 and A2.

ESTIMATE OF THE MODEL

The model has been estimated using annual data between 1990 and 2009. Data for the year 2010 could not be used despite the fact that the fishing season has ended due to obvious reasons. Additionally, monthly data could not be used because of the concentration of catches in 3 months of the year and, above all, the lack of time coherence between the Spanish export series and the Japanese import series[7]. The equations have been estimated using Three Stage Least Squares (3SLS). The estimates are reasonably acceptable and they are shown for each equation in Tables 1-6. All the equations have been estimated using the variables transformed in logarithms, so that the coefficients could be interpreted as elasticities and/or flexibilities.

Table 1. Wholesale derived demand in Japan

Variable	Estimated coefficient	Stand. Error	"t" statistic	p-value
Constant	-41.8671	8.9159	-4.6958	0.0000
Japan inventory per-capita	-0.2796	0.0978	-2.8602	0.0051
Real fresh BET wholesale price	1.3385	0.0898	14.9013	0.0000
Real per capita living expenditure	3.4008	0.7570	4.4925	0.0000
Japanese per capita imports of frozen BFT	0.0876	0.0260	3.3702	0.0010
Real price of BFT fresh imports	0.2364	0.0855	2.7650	0.0067

Dependent variable: Real wholesale price of frozen BFT
in Japan
$R^2 = 0.96$, DW = 2.38

Table 1 shows the results of the estimates of equation (1). All the coefficients are significant in an equation which shows a high goodness of fit. The presence of serial autocorrelation can be clearly rejected. The inventories have a very strong influence on the determination of the wholesale price of frozen tuna, so that a 1% increase in them could cause a 0.27% reduction in the wholesale price of this product. This is not negligible if we consider that between 1990 and 2009 the inventories of bluefin tuna have increased from 7,700 MT. to 23,500 MT. Considering the estimated cross flexibilities with the fresh bigeye tuna (1.34) and the imports of fresh bluefin tuna (0.24), it is worth highlighting the strong interaction with the latter with a cross elasticity which is equal to 4.23. Due to the fact that many imports from the fattening farms have been exported fresh by air to Japan, the conclusions are apparent. As other papers have proved, the bigeye tuna appears as a substitute good for bluefin tuna. Furthermore, an increase in income – or in household expenditure – would cause a three fold higher increase in the wholesale price of frozen bluefin tuna. The positive coefficient of imported quantities proves what has actually occurred in Japan. The wholesale price has plummeted because there has been a change in the market. In the past the market used to be

mainly supplied by the catches of its own fleet (62% in 1990) and the exvessel prices were relatively high. Over twenty years, the market has turned to a situation in which 90% of the consumed bluefin tuna comes from imports, whose nominal unit cost was four fold lower than the one of the Japanese fleet catches. However, the increase in imports has produced a 80% increase in the total supply, a 65% reduction in the exvessel price in Japan and a slight increase in the price paid for imports. Therefore, currently both prices have equalled.

Table 2 displays the estimates of the equation which represents the demand of inventories. Also, all the estimated coefficients are significantly different from zero and, additionally, there is no evidence of serial autocorrelation. The goodness of fit is very high. In particular, almost 97% of the fluctuations of the inventories are explained by the variables which are included in equation (2). Concerning the estimates of the coefficients, the level of inventories is logically sensitive to the per capita consumption of tuna in Japan, so that a 1% increase in this variable would cause a 1.66% decrease in the inventories. Also, the inventories decrease if transportation costs increase. Simultaneously, a 1% increase in the wholesale price of frozen bluefin tuna could cause a 1.65% reduction in the average level of inventories. Additionally, a 1% increase in the lagged price, which involves a change in the expectations, could cause a 0.12% decrease in the level of inventories. However, this estimate is not significant.

Table 2. Demand of stocks in Japan

Variable	Estimated coefficient	Stand. Error	"t" statistic	p-value
Constant	33.0425	2.6801	12.3287	0.0000
Real frozen BFT wholesale price	-1.6509	0.1591	-10.379	0.0000
Lagged real frozen BFT wholesale price	-0.1169	0.1260	-0.9275	0.3557
Total per capita consumption of tuna in Japan	-1.6646	0.1510	-11.026	0.0000
Overland freight transportation cost index	-2.9798	0.6208	-4.7999	0.0000

Dependent variable: Inventory of frozen BFT in Japan
$R^2 = 0.97$, DW = 2.23

The equation (3), which describes the derived exvessel demand of bluefin tuna caught by the Japanese fleet, also presents a high goodness of fit ($R^2 = 0.94$), as shown in Table 3. All the coefficients are significant at the 1% significance level. The real exvessel price of fresh bluefin tuna is clearly affected by the landed quantities - a 1% increase in the landed quantities would cause a 0.27% decrease in the price. Likewise, the real exvessel price of fresh bluefin tuna shows a strong interrelationship with the wholesale price, so that a 1% reduction in this real wholesale price of frozen bluefin tuna would cause a 0.43% reduction in the first-hand sale price. Therefore, wholesalers are able to transfer to fishermen on average 43% of the changes in the wholesale market price (Wang and Kellog, 1988). It is worth highlighting the relationship with the exchange rate between yen and USA dollar, which represents the power of the Japanese currency. Therefore, if the exchange rate grows 1% - more yens are paid for each dollar and the Japanese currency is weaker – the exvessel price grows. This is logically caused by the higher price of imports.

Table 3. Derived exvessel demand in Japan

Variable	Estimated coefficient	Stand. Error	"t" statistic	p-value
Constant	6.0939	0.5283	11.5353	0.0000
Domestic landings of fresh BFT in Japan	-0.2763	0.0225	-12.279	0.0000
Real frozen BFT wholesale price	0.4341	0.0642	6.7633	0.0000
Real exchange rate yen–dollar	0.6774	0.0930	7.2843	0.0000

Dependent variable: Real exvessel price of fresh BFT in Japan
$R^2 = 0.94$, DW = 2.44

The relationship between the price of Japanese imports and the price at the first-hand sale market of domestic catches is represented by equation (4). As displayed in Table 4, the results of the estimate of the model are coherent, despite the fact that in this case the goodness of fit is lower than in the previous models ($R^2 = 0.85$). The real price of

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imports is influenced by the exchange rate between yen and euro, which can represent the strength of the Japanese currency in relation to the countries of the Mediterranean basin where these imports come from. Therefore, a 1% reduction in the exchange rate – more yens are paid for each euro – would logically cause a 1.86% increase in the price of imports. Likewise, there is some interaction with real exvessel price of domestic catches. It entails a substitution relationship and the cross elasticity is high (1.54). Transportation costs play an important role because most purchased tuna is sent to Japan by freezer boats or by air. A 1% increase in transportation costs would cause a more than proportional increase in the price of imports (2.96%). Finally, there is a strong relationship with income (expenditure) of consumers, so that slight increases in income would cause a much higher increase in price. If there were a 1% increase in income, there would be a 5.14% increase in the willingness to pay higher prices for imports.

Table 4. Relationship between the prices of imports and exvessel prices

Variable	Estimated coefficient	Stand. Error	"t" statistic	p-value
Constant	-32.0814	10.6210	-3.0206	0.0031
Real exchange rate yen–euro	-1.8631	0.1732	-10.753	0.0000
Transportation cost index	2.9663	0.4534	6.5421	0.0000
Real exvessel price of fresh BFT in Japan	0.6462	0.1409	4.5861	0.0000
Real per capita living expenditure	5.1442	1.4660	3.5091	0.0007

Dependent variable: Real import price of frozen BFT in Japan
$R^2 = 0.85$, DW = 2.10

Focusing on the tuna trap, equation (5) represents the tendency to export their production to the Japanese market. These results are shown in Table 5. It is worth noting the high goodness of fit of the model ($R^2=0.93$). However, the intercept is not significant. Due to the fact that almost all the supply is exported to Japan, a 1% increase in tuna trap catches would cause a 0.94% increase in exports. This result is consistent with the historical evolution of the series. Therefore, only in very specific years in which a large number of catches have been obtained or the conditions of the demand have not been satisfactory, significant quantities have been devoted to the domestic market. These quantities are never higher than 28% of catches. In 2009 less than 3% of the total number of tunas caught by tuna traps was devoted to the domestic consumption.

Table 5. Exports of tuna traps

Variable	Estimated coefficient	Stand. Error	"t" statistic	p-value
Constant	-0.4151	0.3863	-1.0745	0.2850
BFT tuna catches in Spanish tuna traps	0.9392	0.0467	20.1317	0.0000
Real exvessel BFT price of tuna traps	0.3458	0.1031	3.3549	0.0011

Dependent variable: Exported BFT quantity of Spanish tuna traps
$R^2 = 0.93$, DW = 1.96

Perhaps, Table 6 shows the most negative aspect of the tuna trap activity. The price of each fishing season is a priori established by the few Japanese firms which buy this production. Therefore, this is almost independent of the catches obtained in each fishing season. Logically, if the buyers' expectations allow them to negotiate a high price and the fishing season is successful, the economic results of tuna trap firms can be favourable. By contrast, in a bad fishing season an average price can create a situation in which they operate at a loss[8]. As a matter of fact, when equation (6) is estimated, the results show that all the variables are significant at the 5% significance level. Furthermore, the equation has a lower goodness of fit than the previous equations ($R^2 = 0.85$). Concerning the parameter estimates, a 1% increase of the average price paid by Japan for its imports to all the producing countries would only cause a 0.49% increase in the price received by tuna traps, while transportation costs also make the exvessel price of Spanish tuna traps become higher. The proportion of catches devoted to the Japanese market logically explains the final price received by the tuna trap firms. Therefore, a 1% increase in this proportion – which

has changed between 71% in 1998 in the midst of a Japanese financial crisis and almost 100% in 2005, and has had 89% on average –, would cause a 0.4% increase in the final price received.

Table 6. Exvessel demand of tuna traps

Variable	Estimated coefficient	Stand. Error	"t" statistic	p-value
Constant	0.8683	0.1499	5.7932	0.0000
Real import price of frozen BFT in Japan in euros	0.4872	0.0510	9.5565	0.0000
Real maritime freight transportation cost index	0.5940	0.1667	3.5627	0.0005
Export / Landings ratio for tuna traps	0.4000	0.1752	2.2828	0.0244

Dependent variable: Real BFT exvessel price of Spanish tuna traps
$R^2 = 0.85$, DW = 1.20

Finally, Table 7 presents the results of equation (7). It intends to explain the beheaviour of the ratio Gross Value Added / Staff costs. This ratio is affected positively by the real price received by the tuna trap firms and the amount of catches. These two variables are considered in the bluefin tuna sales. Also, this ratio is influenced by the level of effort – the number of cobden days – because the staff cost is proportional to the number of working days. Moreover, this cost is very high and in bad fishing years it can be even higher than sales.

Table 7. Profitability of tuna traps

Variable	Estimated coefficient	Stand. Error	"t" statistic	p-value
Constant	-8.4212	0.8894	-9.4685	0.0000
BFT tuna catch value of Spanish tuna traps	0.9186	0.0295	31.1436	0.0000
Effort (cobden days) of Spanish tuna traps	-0.2056	0.1109	-1.8541	0.0665
Dummy 1995	-0.2121	0.0554	-3.8297	0.0002
Fish consumer price index in Spain	0.3144	0.0725	4.3396	0.0000

Dependent variable: Ratio Gross Value Added / Staff costs of Spanish tuna traps
$R^2 = 0.98$, DW = 2.65

Each tuna trap employs on average between 60 and 80 employees from the moment in which traps begin to be set – at the end of February or the beginning of March – until, once catches have ended, and the fishing gear is removed completely. It can take between fifteen and twenty days from the end of the fishing season. Logically, in years of low catches tuna trap firms expand the duration of the fishing season as much as possible. This is specially done by tuna trap in Barbate. However, the establishment of TACs and the forced reduction in the fishing season duration prevents them from adapting their cost structure to the new situation. Therefore, a 1% increase in the fishing season duration would entail a 0.21% reduction in the ratio Gross Value Added/Staff costs on average. Nevertheless, as the model includes three explanatory variables – catches, price and effort – the fact that the ratio increases or decreases depends on the combination of the three variables. Therefore, if the fishing season duration is reduced without affecting the price or the level of catches, there would be an increase in profitability. Nonetheless, if this reduction produces a fall in TACs and a price received which does not depend on the level of catches, there would be a significant reduction in profitability.
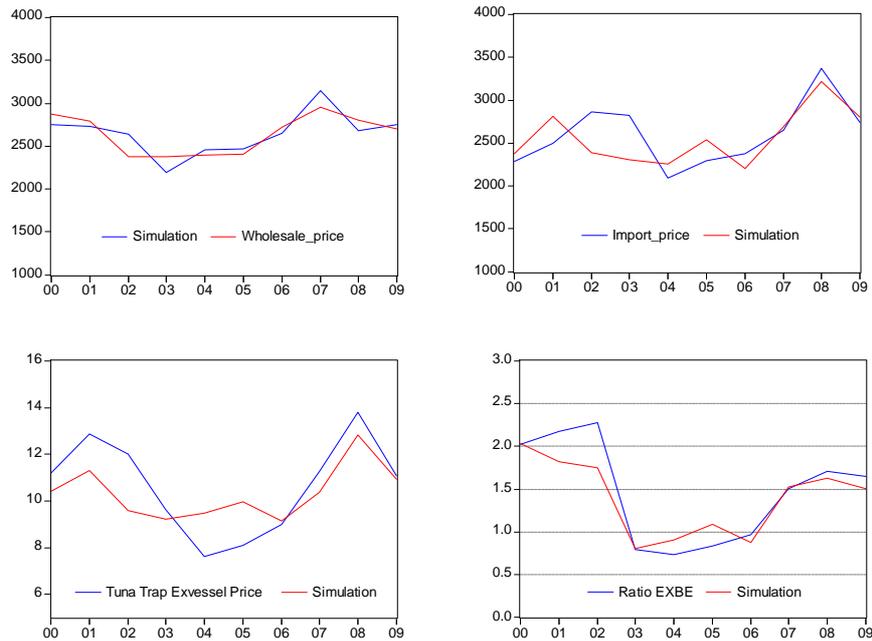
Figure 1. Simulated series for some endogenous variables

SIMULATION

Once the model is estimated, a historical simulation has been carried out for the time span 2000-2009 using an iterative algorithm as suggested by Gauss-Seidel which is implemented in Eviews (QMS, 2004). It is based on the Fair-Taylor method. The simulated series for some endogenous variables are shown in Figure 1. The goodness measures of the simulation are displayed in Table 8. All the simulated series for the endogenous variables have correlation coefficients with their respective actual series which are between 0.67 for the price of frozen bluefin tuna imports and 0.97 for the quantity of tuna trap exports.

Table 8. Historical simulations 2000-2009

Variable	Correl. Coef.	MAPE	RMSE
Wholesale price of frozen BFT in Japan	0.82	4.43%	5.16%
Inventory of frozen BFT in Japan	0.83	9.40%	11.08%
Exvessel price of fresh BFT in Japan	0.91	8.72%	11.43%
Import price of frozen BFT in Japan	0.67	8.55%	10.46%
Exported BFT quantity of Spanish tuna traps	0.97	7.42%	8.19%
Exvessel BFT price of Spanish tuna traps	0.77	10.38%	12.53%
Ratio Gross Value Added/Staff costs of Spanish tuna traps	0.94	11.42%	15.77%

The Mean Absolute Percentage Error (MAPE) varies between 11.42% regarding the simulation of the ratio Gross Value Added/Staff costs of tuna traps and 4.43% of the wholesale price in Japan of frozen bluefin tuna. By contrast, the Root Mean Squared Error (RMSE) remains in the same proportions and ranges from 5.16% to 15.77% in the aforementioned variables.

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CONCLUSIONS

The interdependence between the Spanish tuna trap sector and the Japanese market of bluefin tuna is apparent. This is nearly the only destination market of these catches. From 1997, when the bluefin tuna fattening farms expanded in the Mediterranean Sea, there was a growth in Japanese imports which have substituted the catches of the Japanese domestic fleet in the market. There has been a gradual fall in the wholesale and retail prices and, consequently, an increase in the consumption of this product, which is currently highly valued in the Japanese market.

Nonetheless, the large imports have also caused an increase in the frozen inventories because the market has not been able to consume the supply at the pace that imports have grown. However, another consequence of the expansion of farms has been the overexploitation of the resource due to the catches of juvenile tunas to be fattened in these facilities. It has equally produced a fall in the catches of the resource. The ICCAT recommendations have been implemented in the European Union using a restrictive TAC plan which has caused a lot of fattening farms to disappear. Also, there has been a significant reduction in the production of other fattening farms. Finally, all this has produced a fall in European exports to Japan. Nevertheless, the supply has not diminished in the same proportion in this market because if some countries such as Spain have reduced half its catches and its exports, other non-EU countries have increased them. Therefore, they maintain the bluefin tuna fattening activity and they have spoilt the ICCAT recommendations. Despite the fact that the average price paid for imports in Japan has diminished 25%, imports have grown from 22,476 MT. in 2008 to 23,232 MT. in 2009. Likewise, it has increased its frozen inventories, which have gone from 20,700 MT. to 23,600 MT. in the same period of time.

As it is impossible that tuna traps can adapt its cost structure to the new situation, the strong interdependence between the wholesale price and the price paid for imports, which represents the price received by tuna trap firms, makes difficult to maintain them. The reduction in the TAC which is allocated to Spain from 4,177 MT. in 2009 to 2,526 MT. in 2010, means a drastic decrease for the tuna traps. Tuna trap TAC has diminished 34% and, as a result, it makes the activity unprofitable. Logically, given that the expectations of the bluefin tuna recovery are not optimistic in the medium term, it seems that the tuna trap activity has its days numbered.

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ENDNOTES

[1] We refer to the manuscript which was written by Sarmiento (1757) and was commissioned by the Duke of Medina Sidonia. In this manuscript, after analysing the production of tuna traps between 1525 and 1750, he suggests that the

activity should lead towards "fishing a little and for ever" – sustainability – because, considering the "false tinsel that incomes were advanced", businessmen who rented tuna traps "were collapsing the fishing grounds". In other words, Sarmiento anticipates H. S. Gordon analysis 200 years before.

[2] It is curious that this was the solution that Miravent i Soler (1838), who was from the Huelva province, had pointed out to solve the problem of the competitive race. It was being noticed as a clear capacity excess at that time. This solution consisted of setting up a firm which ran them as a monopoly.

[3] This situation had been anticipated by Roesti (1966) who related low productivity to deficiencies in the distribution channels.

[4] The unit of effort used was the number of codend days. In the time span 1997-2006 it was on average 295 days for the four tuna traps, but in 2009 it decreased 15% and in 2010 it diminished 33.2%, which caused a significant reduction in employment. As a matter of fact, the trap in Barbate, which usually extended its "revés" fishing season up to August, has finished it on 15/6/2010 because its TAC has been used up, while the rest have done it over June.

[5] See García del Hoyo and Jiménez Toribio (2007).

[6] In a good year of catches for the rest of the tuna traps, the tuna trap in Tarifa had a terrible fishing season in which catches diminished up to 565 tunas. By contrast, in the previous year its catches were double (1,042 tunas) and in the following one catches were more than triple (1,852 tunas).

[7] In some years these differences can be noticed in the fact that the catches "enter" Japan before "leaving" Spain. It can be explained by the different deadlines which are imposed to declare exports or imports in each country.

[8] As a matter of fact, truth is stranger than any hypothesis. In the time span 2003-2006 the average annual catches of the four tuna traps in the Cadiz province amounted to 811 MT. per year. This figure is not enough to guarantee their profitability. Therefore, they worked at a loss. It is worth pointing out that the staff cost in the tuna traps has been 54% of sales between 1988 and 2009, and it was 88% on average in the four aforementioned years (Jiménez Toribio et al., 2002).

APPENDICES

Table A1. Market model variable definitions

PW	Wholesale price of BFT in Japan (fresh and frozen) (Yen/Kg.)[a,b]
PFBET	Wholesale price of BET in Japan (Yen/Kg.)[a,b]
QLFRESH	Landings of fresh bluefin tuna in Japan (MT.)[a]
QLFROZEN	Landings of frozen bluefin tuna in Japan (MT.)[a]
PLF	Price of Landings of fresh bluefin tuna in Japan (Yen/Kg.)[a]
PLC	Price of Landings of frozen bluefin tuna in Japan (Yen/Kg.)[a]
INV	Quantity of inventories of frozen bluefin tuna (MT.) in Japan[a]
POP	Population (thousands) in Japan[c]
QIFRESH	Japanese imports of fresh bluefin tuna (MT.)[d]
QIFROZEN	Japanese imports of frozen bluefin tuna (MT.)[d]
PIF	Japanese import price of fresh bluefin tuna (Yen/Kg.)[d]
PIC	Japanese import price of frozen bluefin tuna (Yen/Kg.)[d]
GPH	Annual Average of Monthly Household Living Expenditure in Japan[c]
PPH	Number of People per household in Japan[c]
CPI_G	Consumer Price Index in Japan. General[c]
CPI_PFRESH	Consumer Price Index in Japan. Fresh fish and Shellfish[c]
IPI_FOOD	Japanese Import Price Index[e]
IPSTRAT	Japanese Corporate Service Price Index:Overland freight transportation[e]
IPSTRAM	Japanese Corporate Service Price Index:Marine freight transportation[e]
IPCP	Spanish Consumer Price Index. Fresh fish and Shellfish[f]
PEXP	Spanish bluefin tuna export price of Tuna Traps (€/Kg.)[g]
QEXP	Spanish bluefin tuna exports of Tuna Traps (MT.)[g]
VAB	Gross Value Added of the tuna trap sector (1000x€)[h]
REM	Remuneration in the tuna trap sector (1000x€)[h]
TCYE	Exchange rate between yen-euro[i]
QALM	Bluefin tuna Landings of Spanish tuna traps (MT.)[j,k,l]
ESF	Effort (codend days) in the Spanish tuna traps[j,k,l]

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Table A2. Market model variable sources

(a)	Ministry of Agriculture, Forestry and Fisheries of Japan
(b)	Tokyo Central Wholesale Market
(c)	Statistics Bureau, Ministry of Internal Affairs and Communications of Japan
(d)	Trade Statistics of Japan. Ministry of Finance
(e)	Research and Statistical Department, Bank of Japan
(f)	Spanish National Statistics Institute
(g)	Spanish Tax Agency
(h)	Spanish Business Registry
(i)	Bank of Spain
(j)	ICCAT
(k)	Andalusian regional Government
(l)	OPP51