# Global integration of European tuna markets

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**Abstract:**

This paper evaluates the degree of integration between the world market and the major European marketplaces of frozen and canned tuna through both vertical and horizontal price relationships. Spatial linkages are investigated horizontally in order to estimate the connection between the European market and the world-wide market on the primary stage of the value chain. One of the key results is the high level of market integration at the ex-vessel stage, and the price leadership of yellowfin tuna over skipjack tuna. The same approach is applied at the ex-factory level. Basically, the European market for final goods appears to be segmented between the Northern countries consuming low-priced canned skipjack tuna imported from Asia (mainly Thailand) and the Southern countries (Italy, Spain) processing and importing yellowfin-based products sold at higher prices. France appears to be an intermediate market where both products are consumed. The former market is found to be well integrated to the world market and can be considered to be competitive, but there is a suspicion of market power being exercised on the latter. Price relationships are therefore tested vertically between the price of frozen tuna paid by the canneries and the price of canned fish in both Italy and France. The two species show an opposite pattern in prices transmission along the value chain: price changes along the chain are far better transmitted for the "global" skipjack tuna than for the more "European" yellowfin tuna. The results are discussed, along with their implications for the fishing industry.

## 1. Introduction

Of the 4 million tonnes of tuna caught all over the world, 65% come from the Pacific Ocean, 20% from the Indian Ocean and the remaining 15% from the Atlantic Ocean (Oceanic Developpement *et al.* 2005). Half of the catch is made up of one species, skipjack, (*Katsuwonus pelamis*) and 30% is yellowfin (*Thunnus albacares*). The canning industry has the lion's share of raw tuna with its processing sites located in South East Asia (Thailand, Philippines, and Indonesia) up to the South West Pacific (American Samoa, and Fiji), Europe (Spain, Italy and France), Latin America (Ecuador, Mexico, Venezuela), Indian Ocean islands (Seychelles, Mauritius, and Madagascar) and West Africa (Côte d'Ivoire, and Senegal). Increasingly, tuna is consumed directly by end-consumers as fresh tuna steaks or sashimi as one fourth of the world production (yellowfin, but also bigeye –*Thunnus obesus*- and bluefin –*Thunnus maccoyi, Thunnus orientalis, Thunnus thynnus*-).

When markets are well integrated, they can be considered as competitive, and conversely a weak integration can be caused by market power and may result in price distortions. The level of market integration generates various and sometimes opposite effects depending on the stage of the value chain.

The market of tropical tuna has been found to be globally integrated through the system of prices, at least for the cannery-grade skipjack tuna (Jeon *et al.,* 2007). In a comprehensive study covering all major tuna markets throughout the world, it has been clearly demonstrated that all the six skipjack markets included in the study (Japan, Thailand, American Samoa, Americas, Côte d'Ivoire and Spain) were linked together in the long run and therefore form a single market, with prices moving jointly in the long run. At both extremes of this integrated market chain, Japan has showed a more independent behaviour, presumably because of higher prices due to the influential presence of the Sashimi market[1] (Bose and McIlgorm, 1996), but Abidjan is clearly a price follower, responding to Bangkok or American Samoa despite having lower prices. Market leadership can even be identified either in either the Americas or Thailand, two major processing sites, driving other prices throughout Europe, the south West Pacific islands, the Indian Ocean islands and Africa (Jeon *et al.,* 2007; Squires *et al.,* 2006).

When it comes to yellowfin, the results are less clear and this species cannot be found to fully connect to the world tuna market (Squires *et al.,* 2006). The two series of skipjack and yellowfin prices, although both present in Pago-Pago (American Samoa) where yellowfin contributes 25% of the raw tuna used by the canneries, were not found to be cointegrated. Neither was it found, between the Italian and Thailandese markets of yellowfin tuna (the Japanese one being excluded from the test because of stationary prices). This was despite the series being perceived to have a good apparent correlation (Jeon *et al.,* 2007). Consequently, it seems of interest to extend previous research in order to include the significant European markets so as to estimate the spatial market integration between the two main tuna species, and also to take into consideration the canned fish markets.

This issue of market integration has significant consequences for tuna fisheries management for considerable reasons. The worldwide integration of tuna markets means that some interactions between different production areas and between different target species may occur through market incentives. Market driven interactions between fisheries take place because tuna products are easily transportable and spatially substitutable. Such interactions would indicate that the stock-based approach, adopted by all the tuna Regional Fisheries Management Organisations (RFMO), may not be sufficient to properly encompass the economic incentives in the fisheries.

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[1] Japan is also the sole significant market place where canned tuna is not the leading product: in 2003, 52% of the Japanese tuna consumption was sashimi, 24% was katsuobushi, and only 10% was canned tuna (Shima and Kawamoto 2006).

When considered horizontally at the ex-vessel stage of the value chain, the high degree of price transmission is likely to increase competition between producers. Under such conditions, a period of resource scarcity at local level could have no effect on global supply, and as fishermen´s revenue may decrease because of continual low prices, those operating in such depleting areas would receive no incentive toward reducing their catches. On the demand side, an oligopsonistic processing sector, which would be blind to the extremely low raw material prices induced by its own market power, may also contribute to perverse incentives over several integrated markets. The probability of market imperfections on the downstream side of the supply chains is evident in the low levels of horizontal integration between final product markets, or by the low levels of vertical market integration between raw material and final products. In the case of such market imperfections, the signal of tuna resource scarcity might not be fully transmitted through higher prices to the retailers or consumers who would otherwise turn their procurement to other products or species. Finally, market integration may have important consequences on the rent-sharing rules adopted within the new generation of fishing agreements (South Pacific tuna treaty, EU fishing partnership agreements, etc.). Such rules are designed to reduce the fishing effort through the use of market incentives. For instance, some authors questioned the adequate reference price used for the revenue-sharing arrangement under the South Pacific Tuna Treaty (Squires *et al.,* 2006). If prices are set in Bangkok and transmitted to other places, local prices only respond weakly to local changes in landings. Such interactions have to be taken into consideration in the fishing agreements.

The objective of this paper is to estimate the extent to which the European tuna markets are integrated with worldwide tuna markets. The analysis attempts to determine where integration ends and where market imperfections may occur; this article will examine why and how such market imperfections could impact tuna exploitation systems. The methodology is based on the recognised cointegration analysis of price series (section 2). Different levels of market integration are considered according to the long-run co-movements of prices, first in a bivariate strategy, and then in a multivariate framework, testing for the law of one price (LOP). The Granger long-run causality is then investigated through a VECM to identify the leadership of some marketplaces (Granger, 1988). Market linkages are evaluated first at the primary stage of the value chain between the European and the world-wide markets for both skipjack and yellowfin species (3.1). The same methodology is then applied horizontally at the ex-factory or retail level between various European markets (3.2). For the latter, the hypothesis lies in a possible segmentation of the European market for final goods between the Northern European countries (UK, and Germany) consuming low-priced skipjack-based products imported from Asia (mainly Thailand and also the Philippines) and the Southern European countries (Italy, and Spain) processing and importing yellowfin-based products sold in their domestic markets at higher prices. France presents an intermediate situation in which both markets provide a significant part of the national canned tuna consumption.

Regarding canned tuna products, the results show a high level of market integration for skipjack but not so much for yellowfin. Such a disparity has two main causes. First, the European processing companies have adopted product differentiation strategies based on their well-established national brands. Secondly, they benefit from a preferential trade regime which favours both the re-importation of canned tuna processed by their subsidiary plants in Africa, Latin America or in some small island countries (Pacific and Indian oceans) and the use of raw material supplied by the European fleets with which they have investment agreements. Therefore, in a last set of estimations, price relationships are tested vertically between the price of frozen tuna paid by the canneries, the price of canned fish at the processing level in Italy, and at the retailing level in France (section 4). A weak or bad transmission of price signals along the value chain will be interpreted as first evidence of market power exercised either by the processors or the supermarket chains. In a last section, all results are discussed with

respect to their implications for fisheries management, in particular, if market power is likely to be exercised upon the upstream levels of the value chain.

## 2. Cointegration methodology to look at price linkages

Market integration tests are an increasingly common approach to investigate the behaviour of seafood markets (Bose and McIlgorm, 1996; Gordon and Hannesson, 1996, Asche *et al.*, 1999; Jaffry *et al.*, 2000; Asche *et al.*, 2002, 2004; Nielsen, 2005). Looking at the degree of price transmission using cointegration analysis is a fairly new approach with only a few applications to seafood markets (Jaffry, 2004; Guillotreau *et al.*, 2005; Jiménez-Toribio and García-del-Hoyo, 2006; Asche *et al.* 2007)

The quality of price transmission has been analysed for several decades now in the context of the law of one price, for the purpose of market integration studies or in order to look at price-cost margins within a value chain (for a recent survey on these issues see Rapsomanikis *et al.* 2004). Price signals can be distorted by market power, pricing-to-market behaviours, exchange rates, trade or price-support policies and isolated regional markets from the global economy. When regional markets are integrated, any change in supply and demand in any of the markets has equal effects on all of the connected areas.

The degree of price transmission can be studied either horizontally between different regional market places, or vertically along a supply chain. Two possible strategies could be established. In the first one, bivariate relationships between each pair of markets are modelled. The second one concerns the specification of multivariate models using more than two markets simultaneously. Both strategies have been used in this study. According to Asche *et al.* (2004), in relation to both strategies, it is unclear which could be the most appropriate one. Sanjuán López (1998) points out that in systems with many variables, possibly, the relationships between various variables may not be visible because of the combined interaction among all of them. Asche *et al.* (2004) mention that, initially, bivariate models are normally chosen because they provide all the important structural information, and in the majority of cases the information related to exogeneity as well. González-Rivera and Helfand (2001) pointed out in their paper on price transmission among spatially separated markets that in order to capture the dynamics of adjustments in prices, bivariate models are not the best choice. They prefer and recommend the use of multivariate models.

To determine the interaction between several levels in the value chain or several spatially separated markets, Sanjuán and Gil (2001b) establish the conditions that are necessary for perfect market integration: "in a set of k markets, two conditions should be satisfied: first, every pair of prices must be cointegrated, hence there must be k-1 cointegration vectors; and second, every pair of prices must fulfil the parity condition". In short, changes in prices should be proportional. Other authors also approve the first condition of k-1 cointegration vectors to conclude for full market integration (Asche, Bremnes and Wessells, 1999; Gonzales-Rivera and Helfand, 2001).

When studying market integration using time series data on prices, the basic relationship is:

$$\ln P_{1,t} = \mu + \beta \ln P_{2,t} + \varepsilon_t \qquad (1)$$

where $P_{1,t}$ and $P_{2,t}$ are prices, $\varepsilon_t$ is a white noise error term, $\mu$ represents an intercept which includes the differences between the prices expressed in levels (i.e., the logarithm of a proportionality coefficient), and $\beta$ is the price transmission elasticity, i.e., the percentage change in the price of a market (dependent variable) in response to a 1% change in the price of another market (independent variable). When $\beta$ is equal to 0, there is no relationship between the prices. In contrast, when $\beta$ is equal to 1 the prices are proportional (vertical linkages) or the law of one price (LOP) holds (horizontal

linkages). This also leads to the conclusion that there is a perfect price transmission between both market segments. Finally, if β is different from 0 but not equal to 1, even though the relative price is not constant, it can be said that there is a relationship between the prices.

Before performing the cointegration analysis, the order of integration of each price series has to be calculated. Several tests are now commonly used by econometricians. These include the Augmented Dickey-Fuller unit root test (Dickey and Fuller, 1981), the DF-GLS unit root test (Elliot *et al.*, 1996) and the KPSS stationarity test (Kwiatkowski *et al.*, 1992).[2]

If the series are integrated of order 1, I(1), then the cointegration analysis can be performed. The Engle-Granger two-stage procedure (Engle and Granger, 1987) and the Johansen maximum likelihood procedure (Johansen, 1988; Johansen and Juselius, 1990) are commonly used. The Engle-Granger two-stage procedure is relatively simple to put into practice but has some disadvantages, especially if a multivariate context is implemented. For Suriñach Caralt *et al.* (1995), there are two important problems: the impossibility of performing tests on the parameters estimated in the cointegration relationship and the determination of the exogeneity or endogeneity of the cointegration relationship variables.

After considering the Engle-Granger two-stage procedure, the Johansen procedure has been chosen, mainly because it allows tests on the cointegration relationship/s of the model to be performed. The basis of Johansen procedure is an error correction model (ECM). Assuming that $P_t$ is a vector which contains k prices, in order to check whether there are one or several cointegration relationships, the model could be written as:

$$\Delta P_t = \mu + \Phi D_t + \sum_{i=1}^{n-1} \Gamma_i \Delta P_{t-i} + \Pi P_{t-n} + \varepsilon_t, \quad t = 1, 2, ..., T$$

(2)

where $\Gamma_i = -I + \Pi_1 + ... + \Pi_i$, for i = 1,..., n-1, $\Pi = -I + \Pi_1 + ... + \Pi_n$, I is a (k x k) identity matrix, $D_t$ is a vector of dummy variables (seasonal, etc.) and, finally, μ is a vector of intercepts. Therefore, Π contains the possible long-run equilibrium relationship/s of the equation (2). The number of cointegration relationships is provided by the rank of the matrix Π (r) and it is determined by two asymptotically equivalent tests: the trace test and the maximum Eigenvalue test.

As mentioned previously, the Johansen procedure allows tests on the coefficients α and β, by the use of likelihood ratio (LR) tests (Johansen and Juselius, 1990, 1992, 1994). In particular, for the bivariate case there would be two price time series in the vector $P_t$. If both price series are cointegrated, the rank of $\Pi = \alpha\beta'$ is equal to 1 and α and β are (2x1) vectors. β contains the r cointegration relationships and α includes the adjustment speed parameters of the dependent variables towards the long-run equilibrium, which is represented by $\beta'P_{t-n}$. In this case, if the constraint β'=(1,-1)' is tested, a proportionality test between the prices of two value chain levels (the second condition for a perfect integration between two markets) is performed. This constraint is also used to test for the law of one price (LOP) in spatially separated markets.

For the multivariate strategy, the LOP is a test to determine if the columns in the β matrix sum to zero, leading to the conclusion that the price series are pair-wise co-integrated. To run this test, assuming the β matrix has a rank which is equal to the number of variables minus one (i.e., k-1), the β matrix could be expressed as:

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[2] Likewise, seasonal unit root tests have been undertaken (Franses, 1991 and Hylleberg *et al.*, 1990).

$$\beta = \begin{bmatrix} 1 & 1 & \Lambda & 1 \\ -1 & 0 & \Lambda & 0 \\ 0 & -1 & \Lambda & 0 \\ M & M & M & M \\ 0 & 0 & \Lambda & -1 \end{bmatrix} \tag{3}$$

Granger causality is analysed in a vector error correction model (VECM) following Tiffin and Dawson (2000)[3], who use the concept of long-run causality as defined by Hall and Milne (1994). The causality tests consist of checking whether the adjustment speed parameters of the dependent variables towards the long-run equilibrium ($\alpha$) are significantly different from zero. Concerning how the results are interpreted, Sanjuán and Gil (2001a) point out, if each market uses information from the other one during the price setting procedure, there is a bi-directional causality. However if causality is found unidirectional, it shows the leadership of one market over the others.

## 3. Horizontal (spatial) linkages between European tuna prices and the world market

### 3.1. Ex-vessel price level (frozen tuna)

Price series were selected from among different national and international sources. They have been carefully selected among a great deal of trade series in order to account for quantity flows supporting reliable series of prices.

**Table 1 Data used for spatial integration of frozen tuna**

| Product | Origin | Data source | Period |
|---|---|---|---|
| Frozen yellowfin 20 lbs (CIF) | France | Orthongel | 1995-1-2006-12 |
| Frozen yellowfin > 10 kg | Italy extra-EU import | Eurostat | 1995-1-2006-12 |
| Frozen yellowfin > 20 lbs | Spanish import price | Ministerio | 1995-1-2006-12 |
| Frozen yellowfin < 20 lbs | Spanish import price | Ministerio | 1995-1-2006-12 |
| Frozen skipjack | Spanish import price | Ministerio | 1995-1-2006-12 |
| Frozen yellowfin > 10 kg | Spain extra-EU import | Eurostat | 1995-1-2006-12 |
| Frozen yellowfin < 10 kg | Spain extra-EU import | Eurostat | 1995-1-2006-12 |
| Frozen skipjack | Spain extra-EU import | Eurostat | 1995-1-2006-12 |
| Frozen yellowfin 20 lbs (C&F) | Bangkok (Thailand) | SPC-FFA* | 1995-1 ; 2005-12 |
| Frozen yellowfin 20 lbs | Yaizu (Japan) | SPC-FFA | 1995-1 ; 2005-10 |
| Frozen skipjack 4-7.5lbs | Yaizu (Japan) | SPC-FFA | 1995-1 ; 2005-10 |
| Frozen skipjack 4-7.5lbs (CIF) | Bangkok (Thailand) | SPC-FFA | 1995-1 ; 2005-12 |
| Frozen skipjack  4-7.5lbs | Puerto-Rico+Ecuador | FFA-Infofish | 1995-1-2002-8 |

SPC-FFA = South Pacific Commission – Fisheries Forum Agency
All prices were converted in US dollars per kilo, using national banks and IMF exchange rates.

All series of frozen tuna could not be used simultaneously because the American price series includes a lot of missing values and can only be reasonably tested for the period 1995-1 : 2002-8. Regarding the properties of the series and for the time span funning

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[3] Regarding the causality analysis, it is worth noting that if two I(1) variables are cointegrated, there is Granger causality in at least one direction (Granger, 1988).

from February, 1995 to August, 2002 all the skipjack time series (America, Bangkok, Japan, Spain) can be considered I(1,0) according to the seasonal unit root test. According to the DF-GLS unit root test, the KPSS stationarity test and the sequential ADF test, all the frozen skipjack tuna prices are I(1) and therefore can be further tested for cointegration relationships.

The bivariate causality tests were completed for both skipjack and yellowfin. The first sample, using all skipjack series, covered the period from 1995-1 to 2002-8. All series were found to be cointegrated at the 5% level of significance, except Japan with Thailand and America. Long-run Granger causality proved to be bi-directional between Thailand and Spain and between Japan and Spain (Fig. 1). The American price clearly influences skipjack prices both in Thailand and Spain. This result confirms those obtained in previous studies (Jeon *et al.,* 2007), although they may seem counter-intuitive because of the very high quantity traded in Bangkok. But uncertainty should not necessarily be expected on the supply side due to the variability of catches: in the present case, an explanation may be found on the demand side, since the US market is the biggest single-country market for canned tuna in the world. Whatever the market leader is, multivariate cointegration tests bring strong evidence of one single market between the three places (two cointegration relationships were found between the three series), Yaizu (Japan) being not too far away as the law of one price holds at the 5% level with Spain in a dual causality.
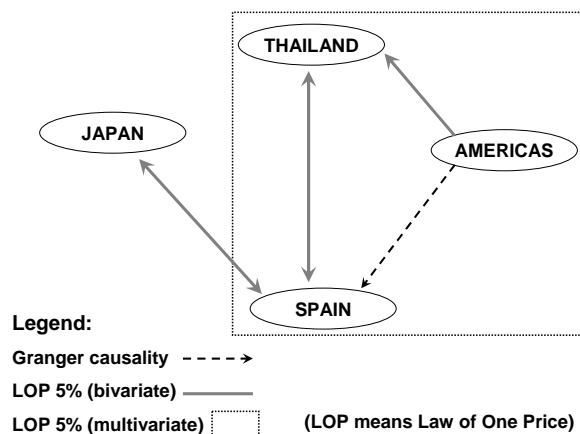


**Figure 1 Relationships between frozen skipjack prices 1995-2002**

Regarding yellowfin, six series were used and the existence of a full market system was demonstrated in a multivariate framework for four of the places (Thailand, France, Italy and Spain) (3 cointegration vectors and the LOP holds) (Fig. 2). Presumably, Japan is under the influence of other market forces (such as the bigeye or the sashimi market) and is only indirectly touched by the other markets. The law of one price holds at the 5% level of significance for many relationships and causality is often observed in a bi-directional way.
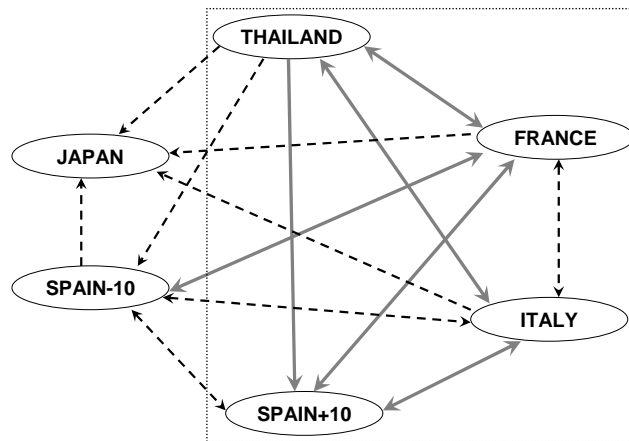
**Figure 2 Spatial price linkages of frozen yellowfin 1995-2005**

Japan is certainly a price follower because it is Granger-caused by all other European and Asian market places. There is more evidence that Bangkok drives the other yellowfin markets, although some information can be fedback by the French or Italian markets, which are great consumers of yellowfin products. This is not so surprising because Italian imports of yellowfin have sharply decreased from 80,000 tonnes in 1992 to 30,000t in 2003, while Thailandese imports remained between 80 and 100,000t during the same time period. Another explanation lies in a common major supplier (Taiwan) for both countries.

There is a far more interesting relationship between the prices of both species (yellowfin and skipjack) (Fig. 3).
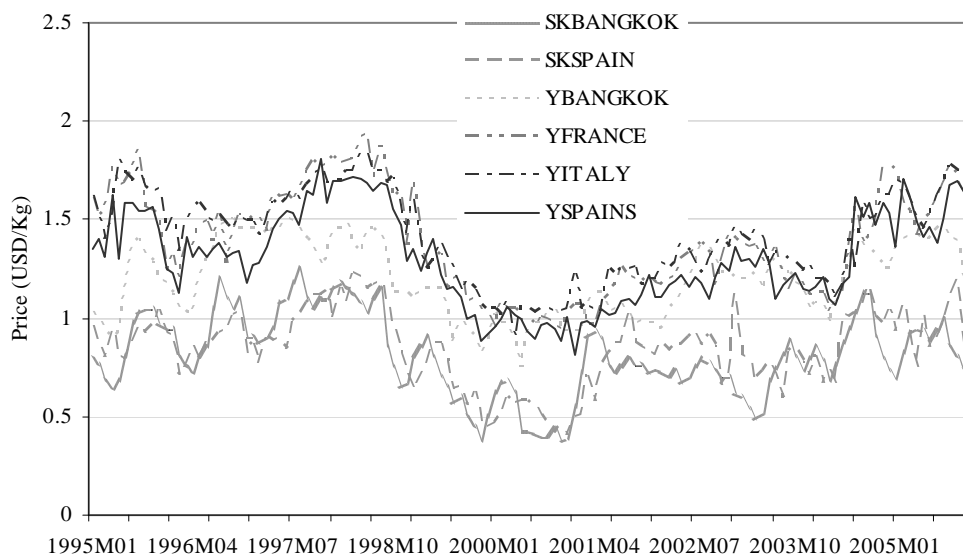


**Figure 3 Evolution of frozen yellowfin and skipjack prices (1995:1-2005:12)**

The six price series in four different market places (Spain and Thailand bear a strong market for the two species) were all found to be cointegrated at the 5% level (Fig. 4). In the Jeon *et al* study, no cointegration model was able to detect any long-term relationship between the two species.
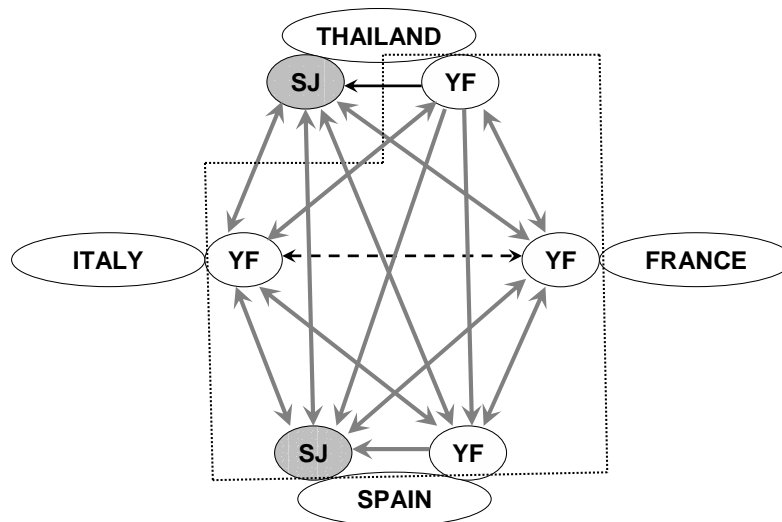
**Figure 4 Price relationships between yellowfin and skipjack 1995-2005**

By considering a model including four yellowfin prices (Thailand, Spain, France, and Italy) and one skipjack price (Spain), the trace test and the maximum Eigenvalue test demonstrated that there are 4 cointegration relationships at the 5% significance level and the LOP holds at the 5% significance level. When the Bangkok price of skipjack is added to this multivariate system and the Thai yellowfin price is removed, it still exhibits a good level of market integration (4 cointegration relationships), but not so perfect (the LOP does not hold). Therefore, with (k-1) cointegration relationships, one might conclude there is a single market mixing both species. This first outcome is strengthened by the dual causality and the successful LOP test between the Thailandese yellowfin and skipjack markets and the two Spanish markets of yellowfin and skipjack at the 5% level. In many bivariate models, including the Thailandese market (France YF, Italian YF, Spanish YF, and Spanish SJ), the LOP holds at this significance level and the causality is bi-directional. Lastly, a simple Granger causality showed at the 5% significance level a clear influence of yellowfin on skipjack; firstly where both species are traded, secondly between yellowfin in Bangkok and skipjack in Spain, the law of one price holding at the 5% level for the bivariate relationships, and thirdly between the French yellowfin market and the Spanish skipjack market. This is quite unexpected due to the worldwide domination of skipjack over yellowfin in terms of quantity (respectively 50% against 30% of global catches). Due to the higher prices and higher returns on raw fish for loins, yellowfin is probably prioritised by the European fleet, and by some of the European markets where this product is differentiated and demanded by consumers (Italy, Spain, and France).

### 3.2. Canned tuna at the ex-factory or retail price level

The same methodology was applied to the next stage of the chain, either through the market prices between the processing industry and the retailing sector, or between the latter and the European end consumers. There is difficulty when considering the selection of the series, due to the lack of information about the species contained in the can. This problem can be partly solved with some assumptions about the origin of products and the end-consumers habits (for instance, when imported from Thailand or the Philippines and consumed in Northern European countries, canned tuna is more likely to be skipjack than yellowfin, and conversely for the Spanish products sold on the Italian market) (Table 2).

**Table 2 Data used for spatial integration of canned tuna**

| Product | Origin | Data source | Period |
|---|---|---|---|
| Canned tuna in brine (yellowfin) | France retail | Ofimer (quarter) | 1995-1 ; 2006-4 |
| Canned minced tuna (Skipjack) | France retail | Ofimer (quarter) | 1995-1 ; 2006-4 |
| Canned oil skipjack Côte d'Ivoire | French imports | Eurostat (month) | 1995-1 ; 2006-12 |
| Canned skipjack in brine Thailand | UK imports | Eurostat (month) | 1995-1 ; 2006-12 |
| Canned oil skipjack Philippines | German imports | Eurostat (month) | 1995-1 ; 2006-12 |
| Canned oil yellowfin Spain | Italy (imports) | Eurostat (month) | 1995-1 ; 2006-12 |
| Canned oil skipjack Philippines | US imports | USDA (month) | 1995-1 ; 2006-12 |
| Canned skipjack in brine Thailand | US imports | USDA (month) | 1995-1 ; 2006-12 |

As far as skipjack is concerned, the existence of one market is a realistic hypothesis because both bivariate and multivariate cointegration was found between the three canning prices (France imports from Côte d'Ivoire, German imports from the Philippines and UK imports from Thailand). The law of one price holds only at the bivariate level between Côte d'Ivoire and Germany on the one hand, and between Côte d'Ivoire and the United Kingdom on the other. The exogenous price is the German one in the first case and causality is found to be bi-directional in the second one. The French retail price proved to be cointegrated only with one other series (UK imports from Thailand), but without perfect integration. If a bi-directional causality of prices is found, it is perhaps because the influence has to be discovered somewhere else. Indeed, looking at import prices of US canned tuna from Asia (Thailand, and Philippines) shows the significant US market leadership upon the European markets (Fig. 5). This result is quite interesting because a previous study based on 1983-1986 figures found that the Thai canned tuna market operated independently of price conditions in the US and the Philippine markets, although the Thai and the Philippine markets were found integrated in the long run (Herrick and Squires, 1989). Nowadays, global integration of canned tuna markets between Asia, America and Europe has become more evident than ever.
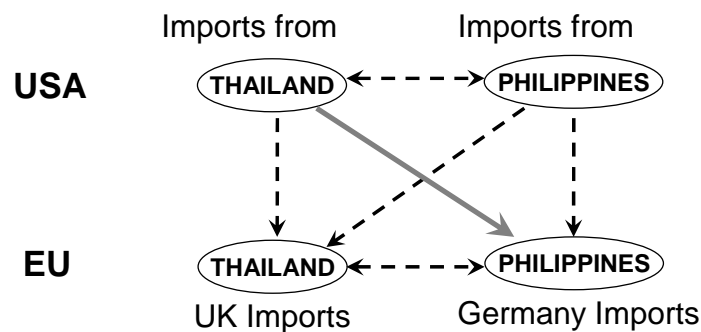


**Figure 5 US and European import prices of canned skipjack from Asian countries**

Granger causality is traditionally interpreted to suggest that the market side facing the greatest level of uncertainty is likely to produce the exogenous price (Schroeter and Azzam, 1991). In the fishing industry, supply is the natural candidate for such uncertainty but in the case of tuna, the variability of demand, subject to many substitute products and other external shocks could fulfil the role. For instance, the media coverage of the dolphin mortality associated with tuna fishing and the trade restrictions which followed made the US canned tuna consumption fall from 1990, but then the

American market recovered after the implementation of dolphin-safe labelling initiatives (Teisl *et al.*, 2002).

Results are much simpler in the yellowfin study: the two series are not linked together in the long run. This can be taken as evidence that markets are perhaps not fully competitive for this species, although a conclusion cannot be so straightforward with only two series, of which one includes the additional margin of retailers. The vertical analysis provides a better view of the situation.

## 4. Vertical pass-through between frozen and canned tuna prices

Ex-vessel and ex-factory price series were tested altogether to look at the degree of price transmission. A simple glance at price-cost margins shows the outstanding stability of cannery-grade skipjack gross margins over the past decade (Fig. 6). Conversely, for yellowfin both the processing margin in Italy and the double margin of canning and retailing in France experienced a significant increase during the second half of the period (respectively from 2.5 to 4 €/kg and from 5 to 8 €/kg).

Taking the two series of frozen skipjack in Asia (Thailand) and Europe (Spain) and the two series of canned skipjack in the UK (in brine) and Germany (in oil), all pairwise relationships were found to be cointegrated at the 5% significance level with dual Granger causality. The German canned fish price was even found to be proportional to the price of frozen tuna in Spain or Thailand, which is equivalent to the law of one price for spatial integration (perfect price transmission). In other words, the elasticity parameter of price transmission is not significantly different from 1 in the following equation:

$$\text{LCSJ-GERMANY}_t - 0.88*\text{LSJ-SPAIN}_t - 0.86 = \varepsilon_t \qquad (4)$$

However, although cointegrated and demonstrating bi-directional causality, the relationship between canned skipjack imported in the UK and frozen skipjack in Thailand was not found to be proportional:

$$\text{LCSJ-UK}_t - 0.52*\text{LSJ-THAILAND}_t - 0.99 = \varepsilon_t \qquad (5)$$
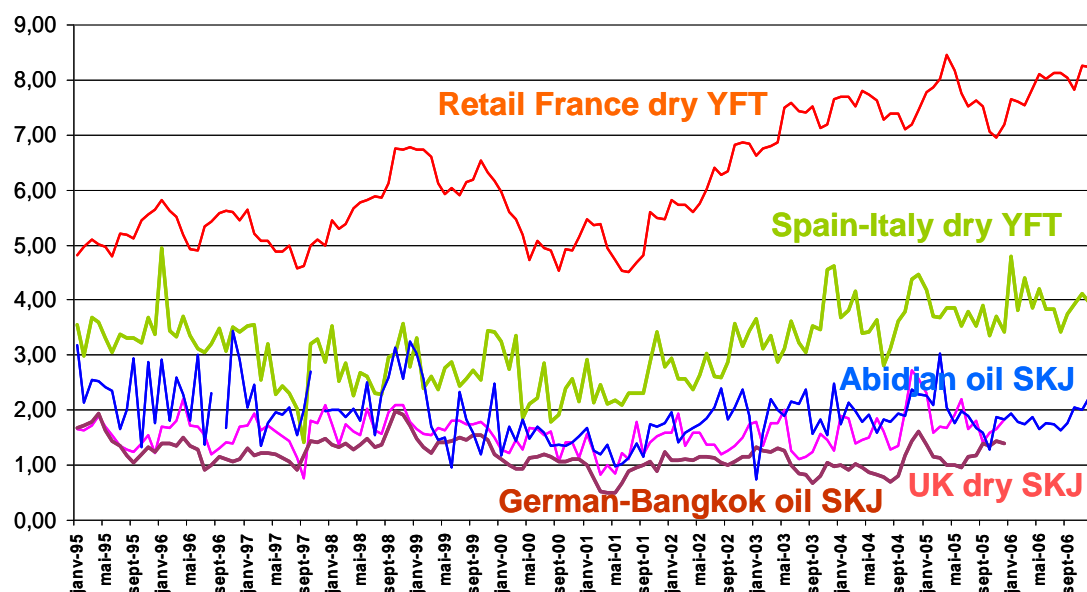
**Figure 6 Price-cost margins of canned tuna sold in Europe 1995-2005**
Sources in tables 1 and 2

The results for yellowfin are totally opposite: the two price series of canned yellowfin in France or Italy (introduced in the previous section) tested along with three different ex-vessel prices gave no cointegration at all, nor Granger causality, hence no proportionality. Like the previous section for canned tuna horizontal market integration, there is potentially some distortion within the yellowfin value chain for an unknown reason. Only a properly specified structural model could bring clearer evidence of market power as long as a comparable series (same level of the marketing chain) could be made available.


# 5. Implications for the tuna fishery

In this research paper, price relationships between the European and the world markets were tested both horizontally (spatial linkages at the ex-vessel and the ex-cannery levels) and vertically (degree of price transmission). First of all, a very high degree of market integration was found at the worldwide level for the two major species (skipjack and yellowfin) used by the processing firms. This is consistent with the structure of the industry as some of the processors are big multinational companies comparing in real time ex-vessel prices from a limited number of market places (Thailand, Ecuador, American Samoa, Japan, Italy, Côte d'Ivoire, and Spain) (Oceanic Development *et al.*, 2005), and the trading sector is also very concentrated with, for instance, three leaders cumulating 75-80% of the supply to the Thailandese canneries (Campling *et al.*, 2007).

The European canned fish market is dual. The Skipjack in oil or brine, conventionally consumed in the North European countries, offers a clear picture of a competitive market ruled by imports from Thailand that are able to jump over the 24% custom tariff. This result is consistent with other studies, having shown through an AIDS, on canned tuna in the UK, the good (and negative) response of expenditure to prices between different product mediums (brine, sauce, oil) (Jaffry and Brown, 2008; Josupeit 1993). In addition, the US demand probably has the greatest influence on global markets, thus creating linkage with the European market through their huge imports from Asian

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countries. As far as the canned yellowfin is concerned, all horizontal and vertical price relationships estimated at the final stages of the marketing chain gave opposite conclusions: no co-movements in the long run, no causality and a rather low degree of price transmission, except on the ex-vessel market segment.

The EU tuna fleet as well as the Latin American and ACP countries take advantage of an array of preferential regulations and subsidies to supply the South European market for high-valued products. The compensatory allowance for tuna (CAT) guarantees a minimum price to European fishing companies supplying the European-based canning industry whatever the international raw-tuna prices are. The EU applies a 24% tariff rate on canned products, which is suspended for the developing countries according to the Generalised System of Preferences, thus facilitating the re-importation of canned tuna processed by subsidiary companies of the European firms in Africa, Latin America and in the Pacific Island countries (Mongruel, 2002; Kaczynski and Fluharty, 2002). This tariff barrier is perhaps the most effective means of protecting the more expensive canned yellowfin in brine from global competition. This is evident in that, the reduced tariff quota (12%) granted by the EU to Asian countries (mostly Thailand and Philippines) since July 2003 has resulted in a sharp increase in imports of canned tuna in brine from these countries. This has been detrimental for West African countries whose exports have gone down by approximately 50%. Non-tariff barriers are also playing a significant role in protecting EU producers: the application of tariff preferences on canned products is subject to a rule of origin imposed on the use of raw materials supplied either by the beneficiary countries or by European producers. Nevertheless, all these rules are being challenged, and increasingly being withdrawn from the new Economic Partnership Agreements (Campling *et al.*, 2007). This could lead to some significant re-allocation consequences for the trade and production of tuna products in the years to come.

The risk of a dominant position by the global canning oligopsony is the potentially low price paid for raw tuna. In such a case, producers might be tempted to increase their fishing effort in order to compensate higher quantities against the fairly low prices obtained. If the price is significantly low, they could conversely be discouraged. During past couple of decades, US fleets stopped fishing because they considered that the price paid by canneries was not fair (Le Roy and Guillotreau, 2002). More recently in the late 1990s, tuna prices plummeted because of high catches of skipjack in the Western Pacific, thus pulling the global tuna market downwards. Manufacturers´ demand is considered price elastic (Chiang *et al.,* 2001; Bertignac *et al.,* 2000). Because of this relatively high demand elasticity from the processing industry (reported as 1.55 for raw tuna supplied to the canning market by purse-seine and pole-and-line fleets of the WCPO, in Bertignac *et al.,* 2000), any decline in catches due to over-exploitation would result in decreasing revenue for the producers.

This does not represent good news for the fishing industry, nor for tuna conservationists. Fishery economic theory forecasts that there should be a safer level of biomass and economic rent with monopoly and property rights, instead of competitive open access. But in the real world, the fishing industry typically consists of highly competitive harvesting sectors facing oligopsonistic processing sectors (Clark and Munro, 1980), the latter capturing whole or part of the fishery surplus by depressing the prices paid to fishermen (Stollery, 1986; Weninger, 1999). If prices remain too low, scarcity signals due to mismanagement are not passed on to the consumer and fishermen are likely to fish more for the same amount of income and in turn increase pressure on stocks. "The effects of changes in harvest levels on tuna prices are difficult to predict" (Bertignac *et al.,* 2000, p. 175), presumably because of stored stock which allows a certain power on prices for processors who can buy primary fish and store it when the market price is low, and then wait while there are peaks in market prices due to a bad harvest (Chiang *et al.,* 2001). If the derived demand of the canning industry is so elastic, any decrease in harvest due to overexploitation would also reduce the revenue of fishing companies. The rent sharing

between resource owners (for instance, ACP or Pacific Islands countries whose benefits come mainly from access licences to their EEZs), fishing companies and canneries clearly shows the advantage that the canning industry has over the market (Mongruel, 2002).

Whatever the market power at the canning or retailing level, the most outstanding result of the study lies in the remarkable linkage between the two major tuna species (skipjack and yellowfin) on the Asia-European market. This is an important result because previous attempts have failed to demonstrate the integration of the two markets despite the perception that both prices are linked together in the long run (Jeon *et al.,* 2007). Even more unexpected was the leadership of the yellowfin market over the larger skipjack market. Indeed, in the two markets where both species were present (Thailand and Spain), the yellowfin price leads the other market by two. In terms of implications for fisheries, this result means that any change in yellowfin supply in the world market will affect prices in the skipjack markets, and that the subsequent responses of fishermen in order to adapt, may occur in any area. This species is less abundant and more difficult to catch, as a result purse-seiners prefer to target it because of its higher prices. Likewise canneries prefer to buy it because of a higher yield in the filleting process associated with its loins and possibly also because of better pricing due to market imperfections in some final consumption places. Although yellowfin has a smaller market and a lower stock level, the race to obtain it is more time-consuming and unpredictable. This has resulted in its influence on the skipjack market. In order to confirm this result, it would be interesting to have access to an American series of yellowfin prices (either in Samoa or in Ecuador) because the market leader could reasonably be found somewhere in the Pacific.

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## ANNEX

Nota Bene: Because the same methodology is repeated for all cointegration models, it would be tedious to display all related statistics in the appendix. The sole example of horizontal (spatial) linkages between frozen yellowfin and skipjack prices is given as methodological example of Fig. 4. All other statistical results can be obtained on simple request to authors, as well as the unit root tests.

## Tables

**Table A1. Bivariate cointegration and LOP tests on the horizontal linkages between European tuna prices and the world market for frozen yellowfin and skipjack prices.**

| Price relationships | Null hypothesis for the cointegration tests | | | | LOP |
|---|---|---|---|---|---|
| | Rank = 0 | | Rank = 1 | | |
| | Max | Trace | Max | Trace | |
| LYTHAILAND-LYFRANCE | 17.6641 * | 20.6660 * | 3.0020 | 3.0020 | 0.863452 |
| LYTHAILAND-LYITALY | 22.9086 * | 24.7718 * | 1.8632 | 1.8632 | 0.323520 |
| LYTHAILAND-LYSPAINS | 19.9780 * | 23.4523 * | 3.4743 | 3.4743 | 0.638523 |
| LYTHAILAND-LSKTHAILAND | 15.2296 * | 22.3317 * | 7.1020 | 7.1020 | 0.503777 |
| LYTHAILAND-LSKSPAIN | 25.2480 * | 29.6557 * | 4.4076 | 4.4076 | 1.750991 |
| LYFRANCE-LYITALY | 75.8287 * | 79.1085 * | 3.2798 | 3.2798 | 9.585383* |
| LYFRANCE-LYSPAINS | 56.7375 * | 60.5228 * | 3.7853 | 3.7853 | 0.780921 |
| LYFRANCE-LSKTHAILAND | 26.3710 * | 28.9820 * | 2.6110 | 2.6110 | 0.550797 |
| LYFRANCE-LSKSPAIN | 33.3798 * | 37.5595 * | 4.1797 | 4.1797 | 1.081481 |
| LYITALY-LYSPAINS | 82.1265 * | 84.4862 * | 2.3597 | 2.3597 | 3.387994 |
| LYITALY-LSKTHAILAND | 27.3812 * | 29.6221 * | 2.2409 | 2.2409 | 1.294780 |
| LYITALY-LSKSPAIN | 34.7221 * | 38.7977 * | 4.0755 | 4.0755 | 3.104625 |
| LYSPAINS-LSKTHAILAND | 22.5997 * | 25.3129 * | 2.7131 | 2.7131 | 0.048574 |
| LYSPAINS-LSKSPAIN | 16.7400 * | 19.5595 * | 2.8196 | 2.8196 | 0.304756 |
| LSKTHAILAND-LSKSPAIN | 42.0756 * | 48.2478 * | 6.1722 | 6.1722 | 0.114057 |

Notes: aNull hypothesis: the number of cointegrating vectors is equal to zero or one. b Maximum eigenvalue test. c Trace test.
Critical values are provided by Pesaran et al. (2000). Critical values for the maximum eigenvalue test are 14.8800 (for rank=0) and 8.0700 (for rank=1) at the 5% significance level. Critical values for the trace test are 17.8600 (for rank=0) and 8.0700 (for rank=1) at the 5% significance level.

**A2. Causality tests on the horizontal linkages between European tuna prices and the world market for frozen yellowfin and skipjack prices**

| Price relationships | ECM[ε]t-1 / LR statistics | | | | | |
|---|---|---|---|---|---|---|
| | LYTHAILAND | LYFRANCE | LYITALY | LYSPAINS | LSKTHAILAND | LSKSPAIN |
| LYTHAI-LYFRANCE | 4.789308* | 8.045315* | | | | |
| LYTHAI-LYITALY | 9.897746* | | 14.63112* | | | |
| LYTHAI-LYSPAINS | 2.776460 | | | 11.09457* | | |
| LYTHAI-LSKTHAI | 0.006839 | | | | 6.186890* | |
| LYTHAI-LSKSPAIN | 0.946214 | | | | | 18.35075* |
| LYFRANCE-LYITALY | | 12.57869* | 32.57303* | | | |
| LYFRANCE-LYSPAINS | | 7.110289* | | 23.64291* | | |
| LYFRANCE-LSKTHAI | | 8.522659* | | | 15.18273* | |
| LYFRANCE-LSKSPAIN | | 9.661320* | | | | 15.11885* |
| LYITALY-LYSPAINS | | | 30.73949* | 32.46924* | | |
| LYITALY-LSKTHAI | | | 7.224007* | | 17.42998* | |
| LYITALY-LSKSPAIN | | | 13.03464* | | | 12.62560* |
| LYSPAINS-LSKTHAI | | | | 5.060577* | 10.61093* | |
| LYSPAINS-LSKSPAIN | | | | 3.679381 | | 5.136773* |
| LSKTHAI-LSKSPAIN | | | | | 4.043033* | 26.18933* |

Note: * Signficant at the 5% level.

Finally, Table A3 presents the results related to the multivariate cointegration analysis on the horizontal (spatial) linkages between European tuna prices and the world market for frozen yellowfin and skipjack prices. Furthermore, test statistics for the LOP (Law of One Price) are shown.

**Table A3. Multivariate cointegration and LOP tests on the horizontal linkages between European tuna prices and the world market for frozen yellowfin and skipjack prices**

| Price relationships | Null hypotheses for the cointegration tests[a] | | | | | | | | | | | | LOP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rank = 0 | | Rank = 1 | | Rank = 2 | | Rank = 3 | | Rank = 4 | | Rank = 5 | | |
| | Max[b] | Trace[c] | Max | Trace | Max | Trace | Max | Trace | Max | Trace | Max | Trace | |
| LYTHAILAND-LYFRANCE-LYITALY-LYSPAINS-LSKTHAILAND-LSKSPAIN | 96.6515* | 247.5318* | 60.2042* | 150.8803* | 54.6095* | 90.6761* | 20.8711 | 36.0666* | 13.4723 | 15.1955 | 1.7232 | 1.7232 | --- |
| LYTHAILAND-LYITALY-LYSPAINS-LSKTHAILAND-LSKSPAIN | 91.0555* | 183.8406* | 56.8907* | 92.785* | 20.9526 | 35.8943* | 13.3267 | 14.9417 | 1.615 | 1.615 | --- | --- | --- |
| LYTHAILAND-LYFRANCE-LYSPAINS-LSKTHAILAND-LSKSPAIN | 62.7245* | 153.8759* | 53.8185* | 91.1513* | 21.2765* | 37.3329* | 13.1617 | 16.0564 | 2.8947 | 2.8947 | --- | --- | --- |
| LYTHAILAND-LYFRANCE-LYITALY-LYSPAINS-LSKTHAILAND | 93.332* | 182.5989* | 57.3431* | 89.2669* | 19.635 | 31.9238* | 10.56 | 12.2888 | 1.7288 | 1.7288 | --- | --- | --- |
| LYTHAILAND-LYFRANCE-LYITALY-LYSPAINS-LSKSPAIN | 91.1704* | 200.5733* | 56.931* | 109.4029* | 32.4409* | 52.4719* | 18.3194* | 20.031* | 1.7116 | 1.7116 | --- | --- | 7.22298 |
| LYTHAILAND-LYFRANCE-LYITALY-LSKTHAILAND-LSKSPAIN | 82.6217* | 179.3525* | 58.7664* | 96.7308* | 22.5863* | 37.9644* | 13.6553 | 15.3781 | 1.7228 | 1.7228 | --- | --- | --- |
| LYFRANCE-LYITALY-LYSPAINS-LSKTHAILAND-LSKSPAIN | 96.3361* | 228.3502* | 59.5076* | 132.0141* | 52.1527* | 72.5065* | 18.0607* | 20.3539* | 2.2932 | 2.2932 | --- | --- | 10.83947* |

Notes:

a Null hypothesis: the number of cointegrating vectors is equal to zero, one, two, three, four or five.

b Maximum eigenvalue test.

c Trace test.

Critical values for the cointegration tests are provided by Pesaran et al. (2000). When including 6 variables, the critical values for the maximum eigenvalue test are 39.8300 (for rank=0), 33.6400 (for rank=1), 27.4200 (for rank=2), 21.1200 (for rank=3), 14.8800 (for rank=4) and 8.0700 (for rank=5) at the 5% significance level. When including 5 variables, the critical values for the maximum eigenvalue test are 33.6400 (for rank=0), 27.4200 (for rank=1), 21.1200 (for rank=2), 14.8800 (for rank=3) and 8.0700 (for rank=4) at the 5% significance level. When including 6 variables in the model, the critical values for the trace test are 95.8700 (for rank=0), 70.4900 (for rank=1), 48.8800 (for rank=2), 31.5400 (for rank=3), 17.8600 (for rank=4) and 8.0700 (for rank=5) at the 5% significance level. When including 5 variables in the model, the critical values for the trace test are 70.4900 (for rank=0), 48.8800 (for rank=1), 31.5400 (for rank=2), 17.8600 (for rank=3) and 8.0700 (for rank=4) at the 5% significance level.

*