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The Impact of Prices on Seafood Trade: A Panel Data Analysis of the French Seafood Market

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Abstract *In the early 1990s, two major crises affected the French fish market. Low import prices were suspected to have affected import levels of fish. Therefore, this paper looks at the empirical economic factors of fish imports in France. Most economic papers related to this field use a demand function of imports for a single product and focus only on trade relations between two countries. In this research, a panel data trade model is used at the multilateral level with many trade partners and products over several years. Results are presented by product groups at both aggregated and disaggregated levels. French imports appear to be very sensitive to internal price competitiveness and nominal exchange rates, with a differentiated impact according to the degree of processing. From that model, simulations show the consequences of the implementation of a single European currency on seafood trade.*

Key words Exchange rates, France, import prices, panel data, seafood, trade modelling.

Introduction

In 1993 and 1994, French fishermen faced a market crisis. National producers blamed low import prices for the increase in France's fish imports. Indeed, French imports of fresh fish increased by 55% in volume between 1988 and 1992. Understanding the empirical causes of fish import level changes in France became an important issue to address. Very often, fish trade is affected by differences in natural resource endowments between countries. Other economic and noneconomic factors, such as changes in relative prices, trade barriers, or depreciation of currency may also improve national competitiveness. Moreover, some countries are developing a processing industry, sometimes importing and re-exporting seafood products.

The first part of this paper attempts to assess, through an economic model, what have been the determining factors of fish imports to France. The first section is devoted to the main features of seafood trade in France (tables 1, 2a, and 2b; figures 1, 2a, 2b, and 3). A tremendous trade deficit in seafood products *vis-à-vis* other countries was estimated to be more than 1.5 billion ECU in 1994. The main partner remains the European Union (EU), and France operates as an intermediate country be-

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Table 1
French Imports and Exports of Fish Products Between 1976 and 1994

	Volume (*t*)				Value ('000 ECU)			
	Exports	a.g.r.*	Imports	a.g.r.*	Exports	a.g.r.*	Imports	a.g.r.*
1976	103,789		317,804		114,653		456,414	
1982	141,483	+5.3%	445,509	+5.8%	301,219	+17.5%	1,047,975	+14.9%
1988	234,285	+8.8%	633,477	+6.0%	622,735	+12.9%	1,895,321	+10.4%
1994	364,852	+7.7%	748,322	+2.8%	747,381	+3.1%	2,316,503	+3.4%

Source: EUROSTAT-COMEXT.
*a.g.r. = average annual growth rate during the previous period.

tween northern and southern Europe, importing from northern countries (Denmark, the United Kingdom, and the Netherlands), and exporting to southern ones (Spain and Italy). However, some new trading partners have recently emerged, particularly South American countries. Another interesting aspect is the growing openness of the French seafood industry in the 1980s, which has been increasingly exposed to international competition. Both exports and imports of seafood increased steadily between 1976 and 1988 (more than 10% per year), before the average annual growth rate was reduced to +3% in value within the period 1988–94.

The second part of this paper is dedicated to presentation of the trade model, meant to capture the main factors of the French imports of seafood products. This model is of gravity type, based on the theoretical contribution of various authors, in particular Anderson (1979), Bergstrand (1989 and 1990), and Evenett and Keller (1998). The estimation of this model with Feasible Generalized Least Squares (FGLS) highlights the significance of prices and exchange rates as major factors of trade. Geographical distance also appears to strongly affect trade flows of seafood products, while trade barriers, although significant, have low elasticities. This indicates that the EU protection against imports is not really trade reducing in the French market, at least at an aggregated product level.

The model was run for several product groups (fresh, frozen, and prepared fish and shellfish), resulting in differentiated estimations for a few influential variables (domestic and import prices, exchange rates, trade barriers, distance). Interestingly, the degree of processing reduces the impact of distance on import levels. In other words, the market area is wider for processed than for fresh fish. Indeed, the trade of processed fish appears to be more vertically differentiated and not significantly sensitive to domestic price variations, unlike fresh fish.

The last section discusses the results in connection with the French crisis through analysis of actual and simulated trade figures related to changes in prices and exchange rates. In this respect, the implementation of the Euro since January 1, 1999 is a crucial event to consider as far as seafood imports are concerned.

Trade Patterns of the French Seafood Industry

The French seafood trade balance is characterized by an increasing deficit, reaching 1.5 billion ECU by the mid-1990s (figure 1).[1] A few products make up the bulk of France's international trade: frozen shrimps and prawns (imported from various

[1] All data in this section have been computed by the authors from the EU trade database EUROSTAT-COMEXT (1997, 1998). Trade data are presented in value, not quantity.

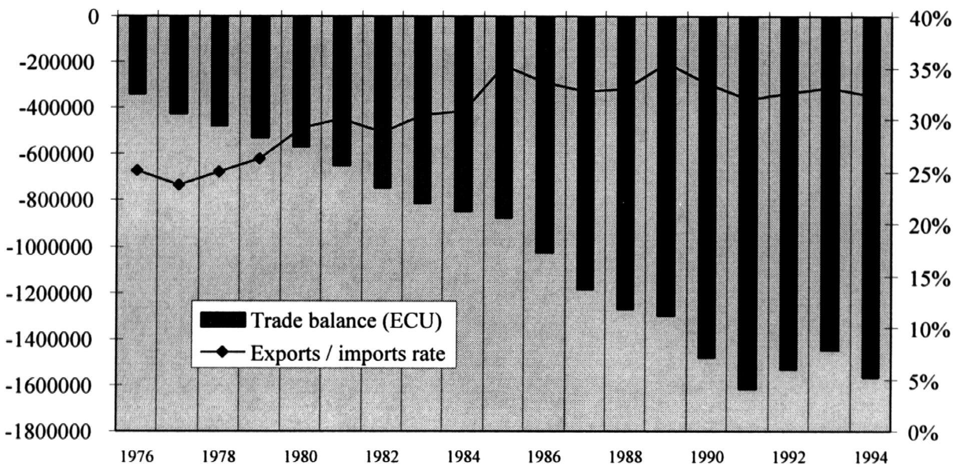

Figure 1. The Trade Balance and Export/Import Ratio from 1976 to 1994
Source: EUROSTAT-COMEXT.

tropical countries), fresh and frozen salmon (imported from various northern European countries, mainly Norway), and tropical tuna (both imported and exported according to the degree of processing).

Analysis by product group indicates that the French seafood industry is changing little by little towards more processing. The total share of fresh fish imports reached 23% in 1994 (535 million ECU), compared to 18% in 1988. The total share of frozen and processed product exports has increased (from 13% to 20% over the same period for frozen fish), accounting for 319 million ECU in 1994.

The regional pattern seems to be fairly stable with respect to some product categories, but demonstrating change for others. Table 2a and figure 2a show that several of France's traditional seafood trade partners (the EU, Norway, West African countries, *etc.*) still constitute the major share of trade. The EU remains the main partner, accounting for 73% of French exports and 58% of imports. It must be stressed that France operates as an intermediate country between northern and southern Europe, importing from northern countries (Denmark, the United Kingdom, and the Netherlands), and exporting to southern countries (Spain and Italy, figure 3).

However, as observed in table 2b and figure 2b, new partners are emerging; *e.g.*, South American countries, which represented 6% of total imports in 1994 (Ecuador, Chile, Argentina, *etc.*). These new partners mainly supply the French processing industry with frozen shrimp and frozen groundfish fillets.

Another feature of French seafood trade since 1988 has been increasing openness, especially for fresh fish. This may be shown by calculating an internationalization rate (Dagenais and Muet 1994) defined as:

$$I = \frac{X}{Q} + \left(1 - \frac{X}{Q}\right)\left(\frac{M}{Q + M - X}\right) \quad (1)$$

where Q, X, and M denote domestic production, exports and imports, respectively.

This rate measures the degree of exposure of a particular industry to international competition. The more an industry is open, the more it has to face international competition. This indicator is built up assuming that the exported share of the

Table 2a
Main Outlets of French Seafood Exports

Partners*	Value 1994 '000 ECU	1994	1988
1 SPAIN	210,198	28.0%	21.3%
2 ITALY	111,387	14.8%	32.3%
3 GERMANY	74,805	9.9%	9.4%
4 BELG.-LUXBG.	69,974	9.3%	9.0%
5 IVORY COAST	48,744	6.5%	2.3%
6 NETHERLANDS	27,436	3.6%	2.4%
7 USA	24,475	3.3%	2.9%
8 SWITZERLAND	23,830	3.2%	4.6%
9 UTD. KINGDOM	21,985	2.9%	3.5%
10 THAILAND	20,727	2.8%	1.3%
11 PORTUGAL	18,261	2.4%	1.7%
12 JAPAN	9,221	1.2%	1.2%
13 HONG KONG	8,130	1.1%	0.1%
14 DENMARK	7,848	1.0%	0.9%
Others	74,758	9.9%	6.7%
Total	751,779	100.0%	99.6%

Source: EUROSTAT-COMEXT.
* Accounting for more than 1% of total French exports of fish in 1994.

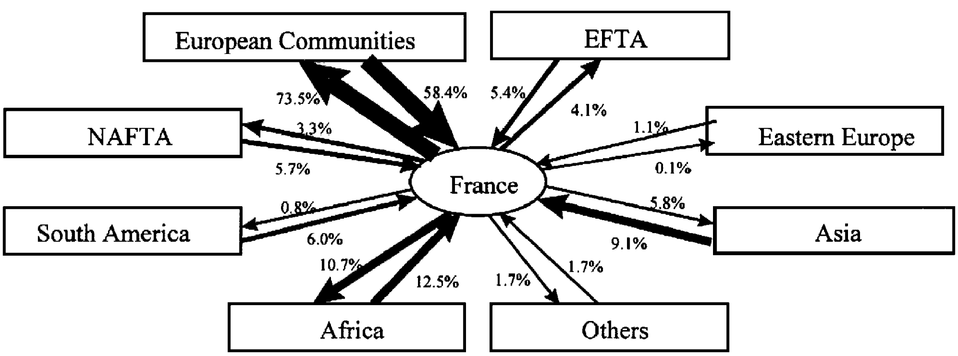

Figure 2a. Geographical Trade Patterns by Significant Areas

domestic production (X/Q) is fully exposed, whereas the nonexported share ($1 - X/Q$) is only exposed to the extent of the import rate ($M/[Q + M - X]$). In other words, the higher the import share within the domestic market (import rate), the more the domestic production that is devoted to the internal market faces international competition.

As compared with other indicators commonly used for measuring the openness of an industry—the export rate (X/Q), or the import rate (M/Q)—the present rate evaluates internationalization in a sole indicator.

This rate takes values between 0 to 1. It is equal to zero if there is no trade in the industry ($X = M = 0$), and, thus, this industry is not open. It is equal to 1 in two cases. The first implies that, whatever the import level, all domestic production is

Table 2b
Main Suppliers of French Seafood Imports

Partners*	Value 1994 '000 ECU	1994	1988
1 DENMARK	358,867	14.9%	9.4%
2 UTD. KINGDOM	352,115	14.7%	11.0%
3 NETHERLANDS	179,804	7.5%	6.2%
4 GERMANY	151,174	6.3%	3.9%
5 IVORY COAST	100,309	4.2%	4.1%
6 BELG.-LUXBG.	90,088	3.7%	2.7%
7 ICELAND	84,683	3.5%	2.5%
8 THAILAND	80,715	3.4%	2.5%
9 USA	80,223	3.3%	4.0%
10 SENEGAL	78,447	3.3%	5.7%
11 SPAIN	68,376	2.8%	1.5%
12 IRELAND	61,860	2.6%	2.4%
13 POLAND	57,105	2.4%	2.9%
14 ECUADOR	49,538	2.1%	0.4%
15 CANADA	47,711	2.0%	3.3%
16 MADAGASCAR	39,132	1.6%	0.8%
17 NORWAY	38,194	1.6%	9.7%
18 MOROCCO	35,666	1.5%	1.7%
19 RUSSIA	35,492	1.5%	–
20 PORTUGAL	33,185	1.4%	0.6%
21 ITALY	27,654	1.2%	1.5%
22 SOUTH KOREA	26,925	1.1%	2.5%
Others	325785	13.6%	20.5%
Total	2,403,048	100.0%	100.0%

Source: EUROSTAT-COMEXT.
* Accounting for more than 1% of total French imports of fish in 1994.

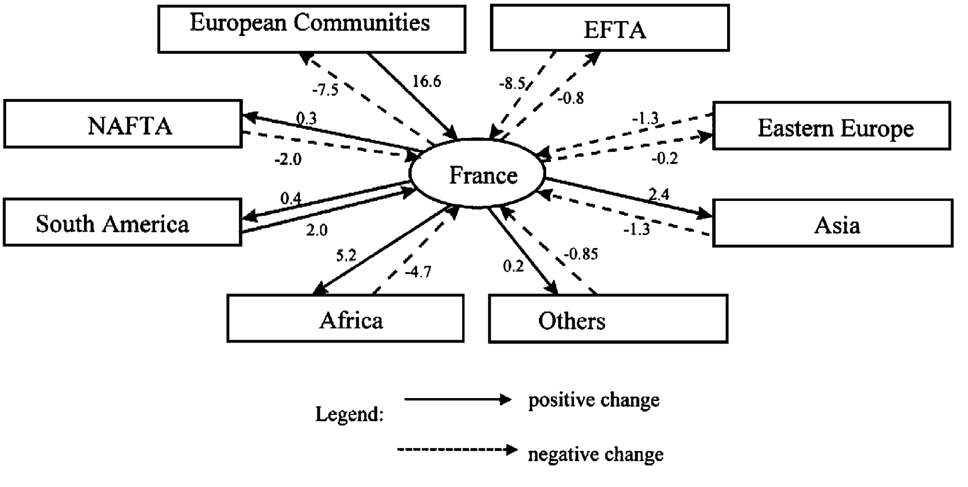

Figure 2b. Evolution of Geographical Trade Patterns Between 1988 and 1994 (in points)
Source: Own calculations from EUROSTAT-COMEXT.

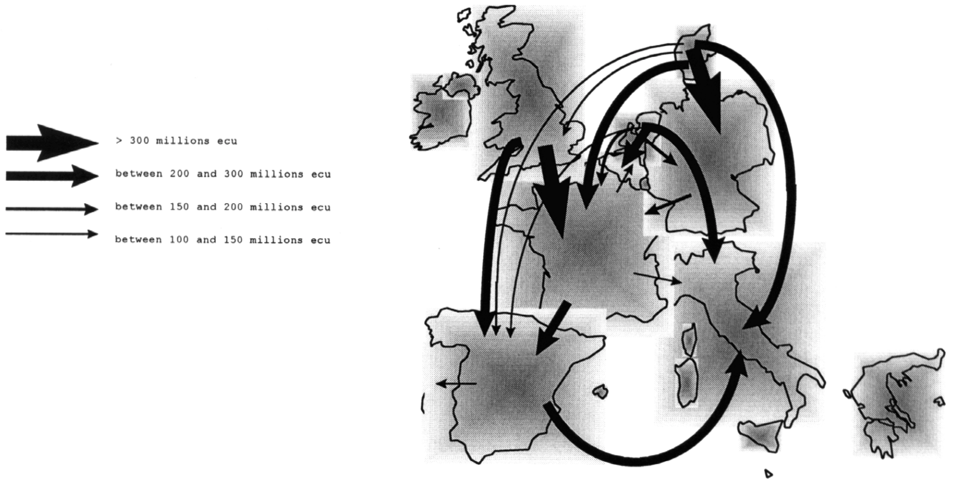

Figure 3. Major Intra-European Trade Flows of Seafood Products in 1994
Source: Own calculations from EUROSTAT-COMEXT.

exported ($X = Q \geq 0$). In this case, there is a no internal demand, and, consequently, the market is fully oriented to foreign countries. In the second case, there is no domestic production (hence, no exports: $Q = X = 0$). The national market is, therefore, fully supplied by imports. In both cases, a high level of the rate indicates a strong openness of the domestic industry, whatever the market orientation.

Calculations indicate a slight rise of this rate for all seafood (from 70% in 1988, to 75% in 1993). This means that the internationalization process goes on for seafood products. More important increases are observed for fresh fish (notably tuna, cod, whiting, and monkfish), which are now very open to international competition (figure 4). As a comparison, the overall French market has an internationalization rate of only 42%.

Although the seafood industry is now very open to international competition, there are significant differences among species (figure 4). A species like oysters is domestically produced and consumed, with very little foreign trade. In contrast, tuna products are largely framed by international investment. French-owned vessels are fishing in West African countries and off the Indian Ocean islands. They supply French or joint-venture canneries there, which then export canned fish to France. Consequently, an important two-way trade is observed. In addition, some species are caught by the national fishing industry, but not to the extent of the domestic market, the gap being filled by imports.

A last striking feature of French seafood trade may be further defined by splitting trade flows into inter- and intra-industry trade. If flows are of inter-industry type, it means that countries specialize in the production of goods for which they either have a comparative advantage, following Ricardo (1817), Heckscher (1919) and Ohlin (1933), or for which they enjoy economies of scale or agglomeration economies (according to the new economic geography).[2]

On the other hand, if trade flows are of intra-industry type, no specialization can be emphasized, and countries export and import identical or differentiated goods. The economic literature dealing with intra-industry trade is very rich and goes be-

[2] See Ethier (1982) for external scale economies and Krugman (1991) for the new economic geography.

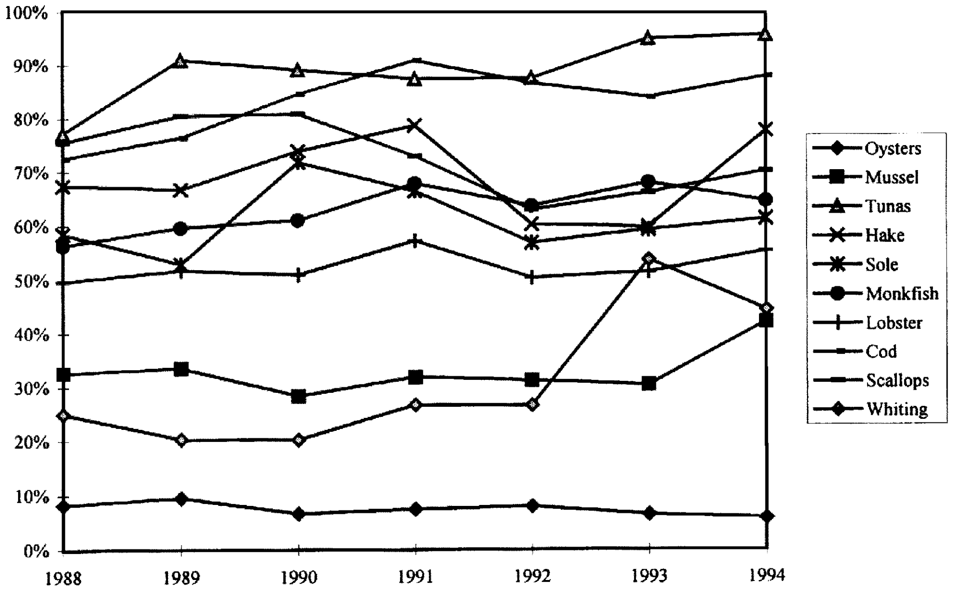

Figure 4. Rate of Internationalization for Some Major Species
Source: Own calculations from EUROSTAT-COMEXT and FIOM.

yond the scope of this study, but the reader will find a good summary of research progress concerning intra-industry trade in Greenaway and Torstensson (1997). Horizontal differentiation occurs whenever a country simultaneously exports and imports differentiated goods of similar qualities. In this case, the country exports some particular varieties of a good, and imports others.[3] Vertical differentiation concerns trade of goods of different qualities. In the latter case, a country produces and exports some particular qualities of a good, and imports other qualities of the same good.[4]

The estimation of inter- and intra-industry proportions of seafood trade is based on the approach developed by Abd-El-Rahman (1986), which is close to that found in Greenaway and Milner (1986). Basically, all the 372 seafood products of the EUROSTAT-COMEXT database (8-digit) have been selected. For each product, if the minor flow (*e.g.*, imports) represents at least 10% of the major flow (exports), this good is considered as significantly exported and imported, and, hence, included in intra-industry trade. However, if the overlap is below 10%, the good is assumed to be either exported or imported and included in inter-industry trade.

With respect to intra-industry trade, the distinction between horizontal and vertical differentiation relies on the measure of quality differences between export and import flows. Following Abd-el-Rahman and Greenaway and Milner, quality is evaluated by trade unit values. Quality is assumed to be similar as long as export and import unit values differ by less than 15% for the same product. In such a case, the good is seen as horizontally differentiated. Conversely, if the unit value differs by more than 15%, imports and exports would contain different qualities of the same product, and thus become vertically differentiated.

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[3] The underlying theoretical framework may be found in the Spence-Dixit-Stiglitz-Krugman model, or in the Helpman-Lancaster model.
[4] See Falvey and Kierzkowski (1987).

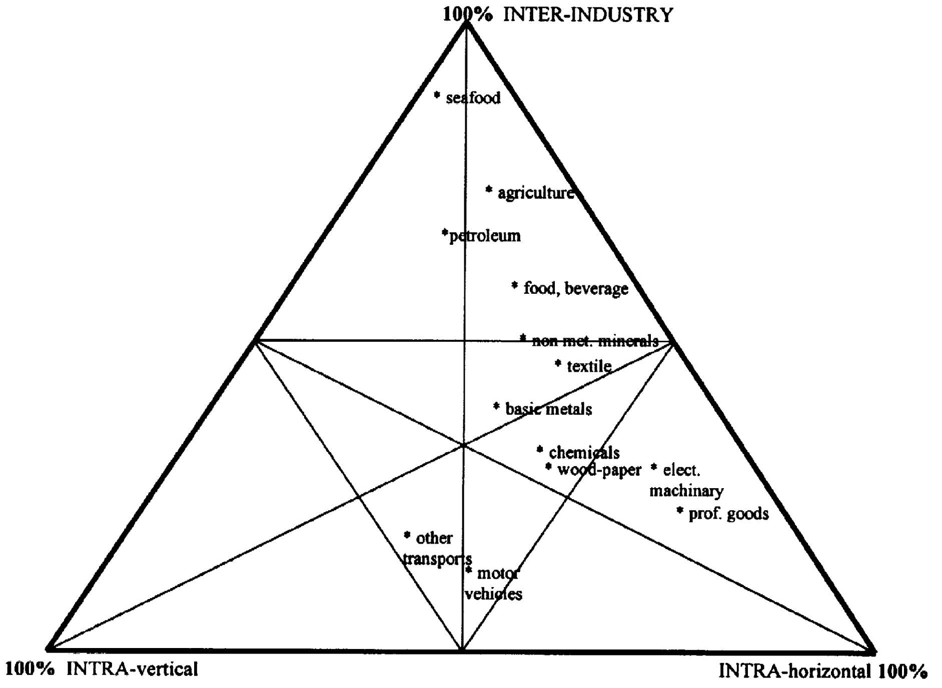

Figure 5. Inter- and Intra-industry Trade in Seafood Products and Other Industries in France (1994)
Source: Fontagné, Freudenberg, and Péridy (1998); own calculation for the seafood industry from EUROSTAT- COMEXT.

Once the 372 seafood products are classified into inter-industry trade, intra-industry trade with horizontal differentiation, or intra-industry trade with vertical differentiation, they may be reaggregated at different levels so as to calculate the share of each trade type as a percentage of total trade. In 1994, inter-industry trade accounted for 84% of total seafood trade, whereas intra-industry trade with vertically (horizontally) differentiated products represented only 11% (5% of total trade).

Compared to other industries in France, the highest share of inter-industry trade is found for seafood (figure 5) (Fontagné, Freudenberg and Péridy 1998). This reveals the nature of seafood trade, which is made up of poorly differentiated products. The other extreme is motor vehicles, for which inter-industry trade is only 18%. This industry contains highly differentiated goods, both horizontally (brand, color, shape, *etc.*) and vertically (power, dimension, options, *etc.*).

At lower aggregation levels (table 3), the share of inter-industry trade is particularly high for frozen fish (96%), fresh fish (91%), and fresh and frozen shellfish (85%); whereas, the share of intra-industry trade is more important for processed shellfish (25%), fish fillets (18%), and prepared fish (16%). Thus, the share of intra-industry trade increases with the level of processing, as processing provides firms with more possibilities for product differentiation.

Aggregation by species confirms the above result, since most of the nonprocessed goods fall into the inter-industry category. France imports salmon, scallops, saithe, and cod because of comparative disadvantages. On the other hand, intra-industry trade essentially concerns prepared and preserved tuna, as well as frozen shrimp.

Table 3
Inter- and Intra-industry Trade in the Seafood Industry

	Inter-industry	Intra-industry	
		Horizontal	Vertical
Live fish	78.1%	21.3%	0.6%
Fresh fish	84.6%	9.4%	6.0%
Frozen fish	95.9%	3.1%	1.0%
Fish fillets	82.2%	16.0%	1.8%
Fish, dried, salted, smoked	83.6%	6.6%	9.8%
Crustaceans	87.3%	11.8%	0.8%
Molluscs	84.7%	12.7%	2.5%
Prepared fish	87.4%	6.8%	5.8%
Prepared crust. and molluscs	75.4%	22.4%	2.2%
All seafood	85.5%	11.0%	3.6%

Source: Own calculations from EUROSTAT-COMEXT.

Since 1988, an increasing share of intra-industry trade has evolved (from 6.6% to 11% of total trade of seafood). This can be attributed to the reorganization of French seafood trade due to the growing processing sector. The theoretical implications are important. According to the Lancaster-Helpman approach, more intra-industry trade implies that competition increasingly depends on the industry's ability to create new products varieties and to realize economies of scale.[5] In this connection, the horizontal concentration of the processing industry, the extension of labelling (Wessells 1998), and the ongoing specialization process towards high-valued and elaborated commodities may push up the intra-industry tendency of French trade, as well as the rest of the French industry. Such an evolution could create jobs in the fishing industry, as a strong comparative disadvantage still affects the domestic harvesting sector.

Specification and Results of the Trade Model

The Model

In order to highlight the main factors of the French seafood industry trade, an econometric model was specified and tested. In most studies focusing on the econometric estimation of trade determinants (Tsoa, Schrank, and Roy 1982; Mazany, Roy, and Schrank 1994; Hannesson 1995; and Schrank and Roy 1991), the import function takes the following form:

$$\text{Log}Q_{i,t} = a_i + b_i \,\text{Log}Q_{i,t-1} + \Sigma c_{ij}\,\text{Log}P_{j,t} + d_i \,\text{Log}P_{i,t} + e_i \,\text{Log}I_{t-1} + \varepsilon_i \qquad (2)$$

where $Q_{i,t}$ is the quantity demanded of product i in time t; $Q_{i,t-1}$ is the production of product i lagged one period; $P_{j,t}$ is the price of product j ($j \neq i$); $P_{i,t}$ is the price of product i; I_{t-1} is the disposable income lagged one period; c_{ij} is the cross-price elasticity between product i and product j; d_i is the own price elasticity of product i; and e_i is the income elasticity of import demand lagged one period.

[5] Lancaster (1980), Helpman (1981).

The model is log-log specified so as to produce elasticities of the independent variables with the parameter estimates. Some extra information through dummy variables (seasonal patterns, structural changes in demand, *etc.*) can be found in Arnason and Felixson 1994; Jian 1995; Bjørndal, Salvanes, and Andreassen 1992. However, the model is often seen as bilateral between two particular trade partners (*i.e.*, the US and Canada or the US and the UK), and for specific products (such as frozen blocks of cod fillets).

In the present model, foreign trade is more broadly considered; *i.e.*, by considering bilateral flows between a country of reference and many trade partners,[6] and by taking into account a great number of products over several years. Therefore, the framework becomes multi-country, multi-product, and multi-year.

Such a framework requires specific estimation with reference to panel data econometrics. The crucial issue is that intercepts, parameter estimates, or error terms may *a priori* vary across countries, products, or time. This potential heterogeneity bias must be carefully investigated.

First, choosing a multi-index framework provides the opportunity to assess the impact of bilateral economic and policy variables, such as tariff and nontariff barriers, transport costs (proxied by the geographical distance between two partners), or exchange rates, which are of particular relevance to seafood trade. Second, by including a great number of observations, the dataset is comprised of several subsamples, containing various product groups. Consequently, structural differences between these groups can be captured by the parameter estimates of the disaggregated models. Finally, from an econometric point of view, several benefits are expected, as compared with time series analysis. They are: more significant parameter estimates, fewer estimation biases and multicollinearity problems, and greater control of unobservable individual effects (Hsiao 1985, 1986).

The model is thus a variant of the gravity equation, which fits fairly well with the explanation of trade flows. From a theoretical point of view, it has been increasingly recognized (since Anderson 1979) that the gravity equation can be derived from different models: Ricardo, Heckscher-Ohlin-Samuelson (HOS), or increasing return to scale models with imperfect competition (Helpman and Krugman 1985; Bikker 1987; Bergstrand 1989, 1990; Markusen and Wigle 1990; Evenett and Keller 1998). This equation may thus explain both inter- and intra-industry trade, in line with the new developments of international economics. Provided that the great bulk of seafood trade is of inter-industry type, Ricardo or HOS-based models are appropriate, but for the remaining intra-industry trade, the specialization process through economies of scale is also dealt with by the gravity equation (Evenett and Keller 1998).

Although the gravity equation has been estimated mostly for total trade, successful estimations at a disaggregated product level may be found in Frankel (1991), Leamer (1993), Péridy (1997), and Fontagné, Freudenberg, and Péridy (1998). The model takes the following form:

$$\begin{aligned} \text{Log}Q_{i,j,t} &= a + b.\ \text{Log}Q_{i,j,t-1} + c.\ \text{Log}PIMP_{i,j,t} + d.\ \text{Log}CONS_{i,t} \\ &+ e.\ \text{Log}PPROD_{i,t} + f.\ \text{Log}EQUI_{i,j,t} + g.\ \text{Log}DIST_j + h.\ \text{Log}CHG_t + \varepsilon_{i,j,t} \end{aligned} \tag{3}$$

Where: $Q_{i,j,t}$ is the imported quantity of product i from country j in year t (1,000 tons) (source: COMEXT-EUROSTAT); $Q_{i,j,t-1}$ is the imported quantity of product i

[6] The choice of the partner countries included in the model was made as follows: partner countries that accounted for at least 1% of France's total seafood imports were included. All the other countries were excluded from the model, unless they weighed at least 20% of French imports for a particular seafood product.

from country j lagged one period (1000 tons) (source: COMEXT-EUROSTAT); $PIMP_{i,j,t}$ is the import price from country j in year t (unit values, in ECU, 1993 = 100) (source: COMEXT-EUROSTAT); $CONS_{i,t}$ is the domestic consumption of product i in year t (1000 tons) (source: SECODIP); $PPROD_{i,t}$ is the domestic production price of product i in year t (in national currency, 1993 = 100) (source: FIOM); $EQUI_{i,j,t}$ measures trade barriers (tariff + NTBs in tariff equivalent) of product i imported from country j in year t (source: LEN-CORRAIL 1998); $DIST_j$ is the distance between France and country j (in kms between the two economic centers of the considered countries) (source: PC-GLOBE); CHG_t is the nominal currency exchange rate between French Franc (FF) and ECU (value of one ECU in terms of FF; 1993 = 100**)** [source: International Financial Statistics (IMF)].

With:

– $i = 1, \ldots, 146$ product categories
– $j = 1, \ldots, 40$ partner countries
– $t = 1, \ldots, 7$ years since 1988 to 1994
and $N = i \times j \times t = 40{,}880$ observations

The differences with the gravity equation commonly estimated in the literature are the introduction of prices and exchange rates (see Bergstrand 1989 and 1990 for theoretical justification) and the introduction of a consumption variable as a proxy of income. At the sectoral level, the expenditure for seafood products might represent a better proxy of income than the GDP. Indeed, seafood consumption represents a very low proportion of the national income; therefore, actual income effects might be more appropriately estimated at this level. Other *ad hoc* variables have been tested, such as fish production quotas or domestic production, without any success. The model also differs from standard gravity equations by introducing a lagged dependent variable in order to capture dynamic effects.

As compared to other empirical studies, some variables are not included here, such as the price of substitutes. This is theoretically and empirically justified because the model does not concern a particular product, but an aggregated seafood level. Furthermore, it would have been technically impossible to introduce the potential substitution effects between imported fish products for every year and from every country of origin, since the model follows a panel data pattern. Because country of origin of each imported quantity of a particular fish product is identified, the substitute would concern other products as well as other origins of these products, multiplying the number of information associated to each observation. For example, what could be the substitutes for French imports of canned tuna coming from Ecuador: canned tuna from Senegal (or Spain, Ivory Coast, …) or other fish-based commodities, if not meat products? Nonetheless, the substitution effect is not completely missing in the model, as the demand for imported goods faces a demand for substitutable domestic products captured by the domestic price.

Another particularity of this model is that the EQUI variable measures both tariff and nontariff barriers (NTBs). This seems relevant since the EU frequently used NTBs to protect farmers or fishermen. The instruments most applied to seafood imports are tariff quotas. For every product, EQUI has been calculated by converting both tariff and nontariff barriers into tariff equivalent. The conversion procedure is close to that used in Fontagné and Péridy (1994). For example, assuming a duty-free import quota of 5,000 tons for a particular product, the imported commodity is charged at the conventional rate (say 10%) beyond the quota. If the actual level of imports had been 6,000 tons, then:

$$EQUI = (5{,}000/6{,}000)*0\% + (1{,}000/6{,}000)*10\% = 1.6\% \quad (4)$$

Turning to econometric tests, as previously mentioned, the multidimensional data set potentially introduces heterogeneity biases. Consequently, special econometric methods are required to separate the various effects, and Feasible Generalised Least Squares (FGLS) techniques have been applied to a random effect model. This means that the heterogeneity of the parameters is transferred to the error term (a full description of the model is given in Greene 1991, pp. 313–18).

The choice of the estimation procedure is motivated by three factors. First, because of the presence of a lagged dependent variable, fixed effects models (with dummy variables) give inconsistent estimates (Chamberlain 1980, p. 227). Secondly, fixed effects models cannot be estimated with variables that are time and product invariant, such as geographical distance. Given the importance of this gravity variable in our model, random effects models are more appropriate. A final argument may be found in Maddala (1987, p. 312) where the number of individuals (countries and products in our model) is important as compared to the number of periods, many degrees of freedom are saved by using random effects models. Since our data covers only seven years for 146 products and 40 countries, the third argument seems particularly relevant.

More econometric tests (including multicollinearity and heteroskedasticity) are presented in detail in the appendix.

The model has been estimated both at an aggregated level (all seafood products), and at several disaggregated levels, such as product categories (fish, shellfish), processing types (fresh, frozen, prepared), and finally product categories across processing types (fresh fish, frozen fish, prepared fish, fresh shellfish, and frozen shellfish). The results for prepared shellfish are not presented, given the low number of observations and the important biases outlined by econometric tests (see the multicollinearity test in the appendix). The same applies to cured products.

Results: The Impact of Price Competitiveness on Trade

The results of the aggregate model are reported in table 4, with the calculation of long-run elasticities shown in table 5.[7] All parameter estimates have the expected sign. Results at a disaggregated level are presented in tables 6a, 6b, 6c, 6d. Basically, most of the parameters are significant and show the expected sign. The adjusted R^2 values remain expectedly high, whatever the product category (between 73.0% and 88.4%), because the model is autoregressive.

In the aggregate model, the distance variable is very significant with a negative sign, as expected. Thus, seafood trade is substantially reduced by geographical distance. This is traditionally explained by the fact that a longer distance increases transport costs, but in the case of seafood trade, another explanation may be found in the perishability of fresh products. However, some high-value species (*i.e.*, lobster and salmon), though fresh or even live, can travel by air for very long distances.

Further information about the impact of distance is produced by the disaggregated models (see tables 6a, 6b, 6c, 6d). Distance reduces imports of fresh products (the short-run elasticity is –0.13). Lower values are found for frozen products (–0.09), whereas imports of prepared products do not seem to be affected by dis-

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[7] The long run (LR) elasticities have been estimated from the short run (SR) elasticities (parameter estimates) through the equation $\alpha = \beta/(1 - b)$, where α is the LR elasticity, β is the SR elasticity, and b is the parameter of the lagged imported quantity.

Table 4
Parameter Estimates of the Trade Model for all Fish Products 1988–94
Through FGLS Regression Procedure: The French Import Function of Seafood Products

Variable	Parameter	T-ratio	Prob > T
Consumption	0.028	5.374	0.000
Import prices	–0.375	–19.797	0.000
Domestic prices	0.071	1.748	0.080
Trade barriers	–0.012	–2.178	0.029
Distance	–0.100	–11.805	0.000
Lagged imports	0.865	326.455	0.000
Exchange rate	–0.540	–3.173	0.002
Intercept	0.706	9.142	0.000
Number of obs.	40,880		
F-value	17,412.20	Prob > F:	0.00
Adjusted R^2	0.80		
White χ^2	1,621.74	Prob > X2:	0.00
Cond. number	33.97		
LM test	4,083.05	Prob value:	0.00
F-test for L.O.P.	52.71		0.00

Table 5
Short- and Long-run Elasticities

	Short-run Elasticity	Long-run Elasticity
Consumption	0.028	0.207
Import price	–0.375	–2.771
Domestic price	0.071	0.525
Trade barriers	–0.012	–0.092
Nominal exchange rates	–0.540	–3.990
Distance	–0.100	–0.742
Internal competitiveness	–0.334	–2.468

tance at all (parameter estimates are not significant). This result confirms that distance is a determining factor in fresh fish trade. Nonetheless, the reason is still unclear whether it is due to perishability or because of increased transport costs for less valuable products (fresh *vs.* processed fish).

Import demand is price sensitive in the aggregate model, and very much so in the long-run. The short-run price elasticity is –0.38, and the long-run elasticity is –2.77. Other empirical studies show that models using quantity as the regressand give much lower elasticities than those using prices (Tsoa, Schrank, and Roy 1982; Schrank and Roy 1991). Elasticities of –0.65 and –0.79 have been estimated in former studies on groundfish with quantity as the regressand (Tsoa, Schrank, and Roy 1982). The long-run elasticities in the present model are very close to those found in other studies analyzing dynamic effects (*e.g.*, Bjørndal, Salvanes, and Andreassen 1992).[8]

The domestic production price has a significant and positive parameter, just as

[8] In other studies using dynamic effects, high own-price elasticities are reported as well (*e.g.*, Bjorndal, Gordon, and Salvanes 1994; Asche 1996; Asche, Salvanes, and Steen 1997).

if the domestic consumer is comparing the world price and the domestic price before purchasing fish. Such a result would demonstrate that the French market is integrated with other markets at the industrial level. Other results tend to strengthen this conclusion (Len-Corrail 1998).

Basically, the fact that both import prices and production prices are significant indicates that internal competitiveness has a strong impact on import flows. This is confirmed by removing import prices and domestic prices from the model and add-

Table 6a
Elasticities of the Disaggregated Model (FGLS procedure)
Product Categories

	FISH		SHELLFISH	
	Short-run	Long-run	Short-run	Long-run
Import prices	–0.395***	–2.63	–0.285***	–3.287
Consumption	0.028***	0.189	0.024**	0.277
Domestic price	0.075*	0.504	ns	–
Trade barriers	ns	–	ns	–
Distance	–0.103***	–0.693	–0.086***	–0.996
Exchange rate	–0.405**	–2.720	–0.950***	–10.963
Internal compet.	–0.319***	–2.112	–0.266***	–3.128
Number of obs.	31,640		4,200	
F-value	12,213.8	prob = 0.000	3,456.0	prob = 0.000
Adjusted R^2	0.783		0.884	
White X2	1,228.7	prob = 0.000	230.0	prob = 0.000
Cond. number	34.3		30.4	
LM test	2,677.4	prob = 0.000	9.7	prob = 0.077
F-test for LOP	45.8	prob = 0.000	7.8	prob = 0.005

Table 6b
Elasticities of the Disaggregated Model (FGLS procedure)
Types of Processing

	FRESH SEAFOOD		FROZEN SEAFOOD		PREP. SEAFOOD	
	Short-run	Long-run	Short-run	Long-run	Short-run	Long-run
Import prices	–0.337***	–2.562	–0.420***	–2.608	–0.427***	–4.292
Consumption	0.020***	0.148	0.032***	0.200	0.092***	0.930
Domestic price	0.106**	0.801	ns	ns	ns	–
Trade barriers	ns	–	–0.027*	–0.169	ns	–
Distance	–0.133***	–1.009	–0.088***	–0.550	ns	–
Exchange rate	–1.558***	–11.831	ns	–	–1.415***	–14.203
Internal compet.	–0.247***	–2.258	–0.411***	–2.546	ns	–
Number of obs.	14,000		17,920		5,040	
F-value	7,770.1	prob = 0.000	4,840.8	prob = 0.000	2,877.1	prob = 0.000
Adjusted R^2	0.838		0.762		0.842	
White X2	589.8	prob = 0.000	937.7	prob = 0.000	226.2	prob = 0.000
Cond. number	40.7		31.3		71.3	
LM test	1,032.4	prob = 0.000	515.2	prob = 0.000	83.8	prob = 0.000
F-test for LOP	47.1	prob = 0.000	10.7	prob = 0.001	0.5	prob = 0.445

Notes: Short-run elasticities correspond to parameter estimates with:
*** significant at 1% level
** significant at 5% level
* significant at 10% level
ns: non-significant

ing a variable which accounts for internal competitiveness (import price over domestic price). Domestic price competitiveness appears to have a significant impact on imports, with short-run and long-run values of –0.33 and –2.47, respectively. In other words, a 10% reduction in price competitiveness would increase imports by nearly 25% in the long-run, other things being equal.

Domestic prices seem to play a less important role at the disaggregated level, with significant elasticities for fresh fish only. Import price elasticities are all significant, and the highest elasticity is found for prepared fish (–0.54). For other prod-

Table 6c

Elasticities of the Disaggregated Model (FGLS procedure)
Fish Products by Type of Processing

	FRESH FISH		FROZEN FISH		PREP. FISH	
	Short-run	Long-run	Short-run	Long-run	Short-run	Long-run
Import prices	–0.316***	–2.360	–0.485***	–2.591	–0.546***	–5.080
Consumption	0.031***	0.234	0.030***	0.225	0.090***	0.846
Domestic price	0.115**	0.855	ns	–	ns	–
Trade barriers	ns	–	–0.023*	–0.175	–0.020*	–0.150
Distance	–0.131***	–0.978	ns	–	ns	–
Exchange rate	–1.600***	–11.944	ns	–	–1.260***	–11.723
Internal compet.	–0.259***	–1.893	–0.521***	–2.775	ns	–
Number of obs.	10,640		14,280		3,640	
F-value	5,689.2	prob = 0.000	4,149.2	prob = 0.000	1,827.5	prob = 0.000
Adjusted R^2	0.832		0.730		0.824	
White C2	487.3	prob = 0.000	4,740.1	prob = 0.000	170.3	prob = 0.000
Cond. number	80.2		30.6		61.1	
LM test	756.8	prob = 0.000	268.9	prob = 0.000	58 .1	prob = 0.000
F-test for LOP	29.5	prob = 0.000	11.9	prob = 0.000	1.5	prob = 0.219

Table 6d

Elasticities of the Disaggregated Model (FGLS procedure)
Product Categories of Shellfish Crossed by Type of Processing

	FRESH SHELLFISH		FROZEN SHELLFISH	
	Short-run	Long-run	Short-run	Long-run
Import prices	–0.340***	–3.599	–0.271***	–3.310
Consumption	0.021**	0.224	ns	ns
Domestic price	ns	–	ns	ns
Trade barriers	ns	–	ns	ns
Distance	–0.096***	–1.014	–0.066*	–0.800
Exchange rate	–1.524**	–16.110	–1.330*	–16.246
Internal compet.	–0.302***	–3.129	ns	–
Number of obs.	1680		1680	
F-value	1,310.9	prob = 0.000	1,277.1	prob = 0.000
Adjusted R^2	0.880		0 .877	
White C2	113.2	prob = 0.000	144.5	prob = 0.000
Cond. number	31.8		50.0	
LM test	0.705	prob = 0.703	0.328	prob = 0.849
F-test for LOP	6.417	prob = 0.011	0.1	prob = 0.705

Notes: Short-run elasticities correspond to parameter estimates with:
*** significant at 1% level
** significant at 5% level
* significant at 10% level
ns: non-significant.

uct categories, import prices are also significant, but with lower elasticities.

More precisely, import demand for prepared fish is rather elastic to import price and inelastic to domestic price, and import demand for fresh fish is less elastic to import price but elastic to domestic price. To some extent, the comparison between domestic and foreign prices only applies to fresh fish because both parameters are significant and distance has a stronger impact on imports, thus restricting the competitive area. Presumably, the high import price elasticity of processed fish has more to do with international competition between suppliers of basic products such as canned tuna (Ecuador, USA, Thailand, and African countries).

In the aggregate model, the exchange rate parameter is the most significant variable at the 1% level and is consistent with theoretical expectations. An appreciation of the nominal exchange rate (French franc [FF] *vis-à-vis* ECU) reduces domestic competitiveness, thus increasing imports. Looking at exchange rate elasticities reveals that imports are very sensitive to exchange rate variations (LR elasticity of –4). Therefore, French imports have been undoubtedly affected by the appreciation of the FF *vis-à-vis* ECU. Between 1988 and 1994, the French currency appreciated by 6.5%. This would have pushed imports up by 26% in the long-run, other things being equal.

Of course, the simultaneous inclusion of domestic prices, import prices, and exchange rates raises the question of potential multicollinearity between these variables. An extended discussion of this problem is provided in the appendix.

Concerning product categories, elasticities are particularly high for shellfish (–11 in the long-run). By type of processing, high values are recorded for fresh products (–11.8), and prepared products (–14.2). However, they are not significant for frozen seafood, except shellfish. Within the fish category, a clear distinction must be made between fresh and prepared fish, on the one hand, characterized by high elasticities, and frozen fish on the other (not significant). In comparison, elasticities are high for all shellfish products, whatever the level of processing.

Therefore, similar to global results, disaggregated models emphasize the crucial role of exchange rate variations in import demand, although the effect is not identical for all product categories.

Because frozen fish appears as an exceptional category, it could be assumed that it is comprised, to a large extent, of groundfish supplied by a limited number of countries (Iceland, Norway, Canada, USA, *etc.*). The variations of the French currency *vis-à-vis* other European currencies would, therefore, poorly affect the quantity purchased by the domestic processing industry on this very integrated market at the worldwide level (Hannesson 1995).

Considering all seafood, trade barriers are significant with a negative sign. Although many trade flows do not face any barriers, the remaining barriers are efficient enough to restrict imports from non-EU countries. However, elasticities are rather low. This is not very surprising, since more than three-quarters of French imports are tariff free, and the weighted average barrier in the EU is around 7% over the period (Guillotreau, Péridy, and Bernard 1998; Len-Corrail 1998). As a result, further liberalization of seafood trade would not have a significant impact on French imports, even though the impact may be higher for a few specific products. Disaggregated results show a differentiated impact with regard to the processing level. Fresh products do not seem to be affected by trade barriers, whereas processed fish is slightly affected. Such a result is logically deduced from the higher protection level of elaborated goods implemented by the EU trade policy (Guillotreau, Péridy and Bernard 1998).

Logically, the consumption variable presents a positive sign—the greater the national demand for fish, the greater the demand for imports. However, elasticities are very low (+0.21 in the long-run). Changes in consumption volumes barely affect imported quantity. One may explain that consumption has hardly varied over the sample period (except a small increase between 1992 and 1994). At a disaggregated level, consumption shows very low, but significant, elasticities for most of the product categories, except frozen shellfish. Interestingly, in the case of fish, consumption elasticities increase with the processing level—imports of prepared fish are more sensitive to consumption than imports of fresh fish. This might be due to the increasing share of elaborate products for domestic consumption.

Discussion and Conclusion

Looking at the factors of French fish imports provides an insight into the economic phenomena at stake behind the increasing internationalization of the domestic fish market. In the early 1990s, France experienced simultaneously the decline of worldwide prices (import prices collapsed by 7% between 1991 and 92) and the appreciation of the national currency (+5% *vis-à-vis* ECU between 1992 and 1994). From the results of the model showing the influence of price competitiveness on imports, the shock on imports might be easily understood. Further research would be needed to assess the feedback impact of trade on domestic prices, thus possibly explaining the market crisis of 1993–94.

To a large extent, the simulations developed from the model support the results. On the basis of long-run elasticities, the actual 7% decrease in import prices in 1991–92 would have resulted in a 19% increase in imports, other things being equal. Similarly, the 5% appreciation of the FF would have increased seafood imports by 21%. Actual figures are below the simulations. As a matter of fact, the big shock on imports caused by the appreciation of the FF, together with the decrease of import prices, has been partly reduced by other variables of the model. In particular, the dramatic decrease in domestic prices between 1991 and 1994 (–20%) probably reduced the upward effect on imports through a slight improvement of competitiveness.[9]

Unlike France, two other countries (Spain and the UK) have not been affected by the market crisis, presumably because the decrease in world prices has been offset by depreciation of their currency. Similarly, the EU, when viewed as a whole, has experienced a decrease in import prices, but the value of the ECU *vis-à-vis* US$ has not significantly changed over the period 1988–94. This has somewhat limited the price competitiveness effect at the EU level.

An implication of the results is that the introduction of the Euro on January 1, 1999, definitely prevents intra-EU imports to change dramatically because of variations between EU currencies. The single currency should stabilize import variations inside the EU.

Significant differences have been found between the product categories at a disaggregated level, particularly with respect to relative prices. Imports of fresh fish would be more sensitive to domestic price variations and less to import price variations, with an opposite situation for processed fish. Hypothetically,

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[9] Other things being equal, a 20% decline in domestic price would have resulted in a 10.5% decrease in imports. The fall in domestic prices is probably due, in large part, to the decrease in import prices, as supported by some empirical studies. For example, Spagnolo (1996) demonstrates with a dynamic model that a 10% decrease in import prices implies a decline of up to 7% in French domestic prices, according to species.

competition between domestic and imported fresh fish is geographically more limited than for processed fish because of the distance between trade partners, in reference to the Hotelling hypothesis. The greater role of distance on fresh fish trade is demonstrated by the related parameter estimate of this variable in the model. Therefore, the specialization process might not be fully achieved for these products, as compared to more elaborate goods for which distance is less influential.

Concerning processed fish, it looks as though competition would occur among the foreign partners themselves—imports are likely to increase when import prices drop without a parallel move of the domestic price levels. The latter does not significantly affect import levels, as if the traded products were differentiated. Indeed, the higher proportion of intra-industry vertically differentiated trade found for processed fish would support such a hypothesis.

Further research should be undertaken to make a clear conclusion about this result. In particular, the problem of simultaneity has not been tackled in the present study—changes in import prices affect import levels, which, in turn, put pressure on domestic prices. Perhaps a pure time series model would provide additional information about the reciprocal relationship between seafood trade and prices.

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Appendix: Econometric Tests

Results of econometric tests are presented in tables 4, 5, 6a, 6b, 6c, and 6d. They concern heterogeneity, heteroskedasticity, and multicollinearity.

Heterogeneity

Given the particular nature of the data set (three index panel), OLS can be used only if parameters are homogeneous among countries, time and products (see Greene 1993, pp. 612–35). Otherwise, a choice must be made between fixed effects or random effects models.

The first difficulty lies in the three dimensions of the model. Usually, the theoretical econometric literature only deals with two dimensions. Most econometric software, therefore, can only compute two dimensions. To cope with the problem, behaviors are assumed time-invariant, given the limited period of time covered by the data set (1988–94). This assumption seems reasonable, since most econometric panel studies taking time into account present a much longer period of time. It is also reasonable to believe that in our sample, the 146 products and the 40 partners are much more heterogeneous than the 7 years taken into consideration. Finally, in the empirical literature, stable results over time for trade behaviors have been shown when compared to the heterogeneity of trade partners (Boude and Guillotreau 1992). Consequently, heterogeneity tests will only concern products and countries (two dimensions).

Specific tests have been performed so as to choose the appropriate model and estimation procedure. The Breusch and Pagan's Lagrange Multiplier (LM) test indicates the presence of heterogeneity of the parameters. Thus, OLS may not be properly used and must be replaced either by the LSDV (Least Squares Dummy Variables for fixed effect models) or FGLS (Feasible Generalised Least Squares for random effect models).

The choice of FGLS instead of LSDV has been explained in the section entitled, Specification and Results of the Trade Model. In addition, the model has also been estimated though LSDV (without the distance variable) and OLS. Comparison of the results indicates that whatever the estimation procedure, parameter estimates are very similar.

Multicollinearity

The problem of collinearity between the variables warrants several remarks. Concerning price-related variables, such as trade barriers, import unit values, domestic prices, and exchange rates, problems of collinearity may occur because the unit values of imported goods include, in part, the exchange rate between the national currency and ECU (import prices are expressed in ECU per kg), the transport cost (that might be correlated with the distance variable), and trade barriers. However, as far as exchange rates are concerned, many studies show that changes in nominal exchange rates are only partly reflected in import prices, due to markups being a function of the exchange rate (Dagenais and Muet 1992, p. 64; Goldberg and Knetter 1997). This should reduce multicollinearity problems.

Another question concerns the Law of One Price (LOP). If it holds, only two of the three variables (import price, domestic price, and nominal exchange rate) have to be used in the regression because of collinearity problems. To overcome this problem, we temporarily removed the exchange rate variable from the equation. Then, we tested for equality of the parameters corresponding to domestic and import prices (test for price equality). The F-test value leads to reject H_0 (equality of the parameters) at 0.1%. This means that the variables PIMP, PPROD, and CHG can be included in the model, and multicollinearity problems should be limited between these variables.

Multicollinearity tests have been performed systematically. The Belsley, Kuh, and Welsch test (1980) indicates that the condition number is 34 (for the aggregate model). This value is close to the upper limit usually given in any handbook of econometrics (30), below which there are no particular multicollinearity problems. Although a careful analysis of the VIF test (variance inflation factors) indicates the presence of some multicollinearity disturbances, they do not significantly affect the parameter estimates.[10] Indeed, a step-by-step regression procedure makes sure that whenever a variable is introduced in the model, the value and sign of the other parameters do not change significantly. Similarly, when the collinear variables are temporarily removed

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[10] See Belsley, Kuh, and Welsch (1980).

and the remaining coefficients estimated, the values and the sign of the latter remain the same. Based on these tests, it seems that multicollinearity problems are limited.

In the disaggregated models, condition numbers fluctuate between 30 and 80, thus indicating significant multicollinearity biases in some of the models. As for the global model, a careful analysis of the variance inflation matrix and a step-by-step estimation procedure tends to demonstrate that the biases do not significantly affect the sign and values of the parameters. Finally, the test for LOP shows that the LOP hypothesis is generally rejected.

Autocorrelation and Heteroskedasticity

The model takes into account autocorrelation and heteroskedasticity of the error structure though the estimation of ρ and the use of Generalized Least Squares [see general presentation in Kennedy (1985, pp. 98–103) and a presentation of panel data in Greene (1991, pp. 279–92, 319)].