Japanese Fish Demand and Price Linkage with Foreign Markets

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Summary

Japan has about 10% and 15% share for the consumption and trade of marine products respectively, and the trend has significant impacts on world markets. Thus the purpose of this article is to estimate the income elasticity of the demand, that includes all kinds of fish usage such as eating out and cooked foods as well as fresh materials for cooking in the household, and to analyze price linkages between domestic and foreign markets.

As a result of estimating demand function by commodity, it was found that a) the income elasticity of demand for all usage is higher than that for household material, for many commodities, and b) tuna, bonito, salmon, left-eye flounder, sea bream, shrimp and crab show positive income elasticity.

The analysis of price linkage for tuna, salmon, mackerel and shrimp showed that a) Japanese CIF price correlates with world average FOB price for salmon, implying that the prices are determined simultaneously, and b) there exist a time-lag for domestic price to be transmitted to foreign markets for tuna and frozen shrimp, though the lag is for some months.

Therefore, Japanese recovery from economic recession will give rise to price hike in world markets for tuna and shrimp, for which supply potentials are worried due to the resources limitation and environmental contamination.

1. Introduction

Japan is one of the main importers of marine products, and domestic prices of some commodities such as tuna, salmon and shrimp are interdependent with the FOB and CIF prices in foreign markets.

Thus the purpose of this article is to analyze the long-term trends of Japanese demand for marine products by commodity, especially focusing on the income elasticity of demand, thereby to get information necessary for forecasting price changes of the world markets under the situation of limited fisheries resources. Therefore, analysis of the seasonal pattern and locality of demand are out of the scope of this study. These are given in Wessells and Wilen (1994) and Johnson *et al*. (1998).

Japanese fish demand was studied in Taya (1991) and Eales *et al*. (1997), where the analysis was focused on household demand for fresh fish. However, significant proportion of fish is consumed in restaurants as eating out and in households as cooked foods. Therefore, the demand for fresh fish in household and the demand that includes all kinds of products shows different trends as mentioned below. Thus, a comprehensive demand analysis that includes such usage is necessary for Japan.

In the following sections, the increase/decrease in demand means the shift of demand curve indicating a change in quantity demanded under a constant price, and the increase/decrease in consumption means the realized quantity determined by the interaction of demand and supply.

2. General trend of fish consumption

1) Household consumption of marine products

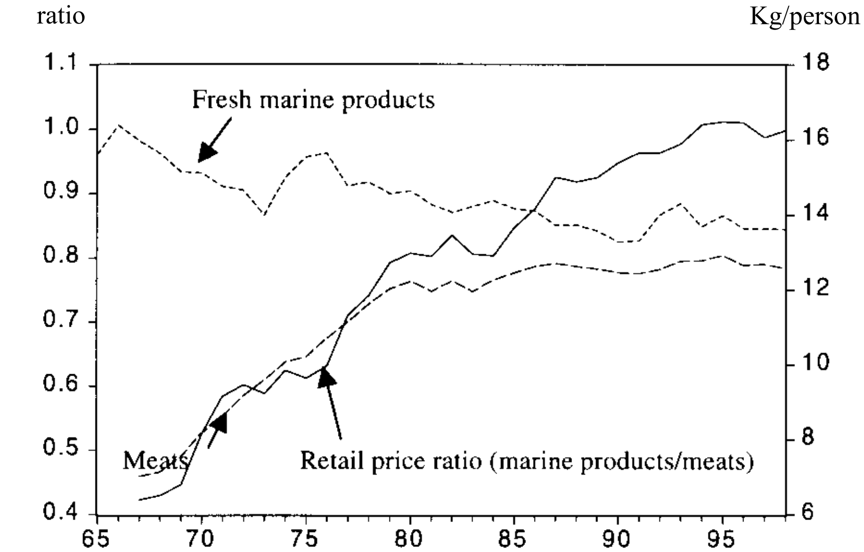
Household consumption per capita of fresh marine products has been decreasing, and fell to 14kg in 1995. In 1996, it fell to 13.6kg due to the occurrence of food poisonings. The consumption has not recovered since 1997 and remains at the same level as the previous year.

The reasons for this trend are some of the following; a) consumption of marine products shifted from household to eating out, b) the usage of processed and cooked foods increased in household meals, and c) the price of fresh marine products became expensive compared to livestock meats as seen in Fig. 1.

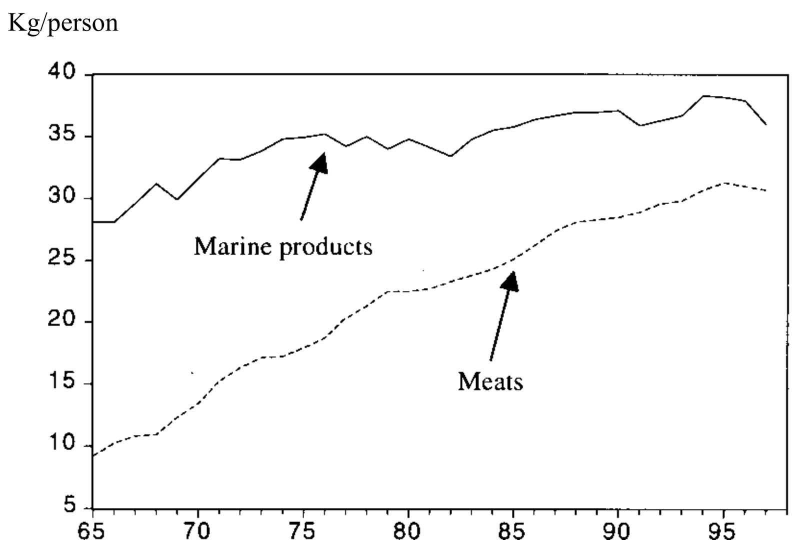
Factors affecting the price rise in fishes against meats are a) the limitation of marine resources, b) increase in the demand for marine products caused by health awareness issues, c) productivity improvement in livestock production and long-term stagnation of grain prices, while the price level of fresh marine products deflated by CPI (Consumer Price Index) remains almost constant after the 1980's.

Figure 1: Consumption of Marine Products and Meats per Year

Consumption in Household



Total Consumption (= live fish weight equivalent; edible part)



Data: Statistics bureau, Management and Coordination Agency, "Annual Report of the Family Income and Expenditure Survey", and Ministry of Agriculture, Forestry and Fisheries, "Food Demand-Supply Balance Sheet"

2) Trend of consumption by commodity

(1) Consumption of fresh marine products in households

The consumption of tuna, bonito and salmon has shown an upward trend, and the consumption of mackerel, sardine, cod, flounder (righteye flounder), flatfish (lefteye flounder) and cuttlefish has shown a downward trend for the 2 decades. In addition, the consumption of crab, shrimp and scallop has increased drastically in the last decade, though their long-term trends are not clear due to the lack of data. The trend of horse mackerel, saury, sea bream, yellowtail, octopus and shellfish remains almost constant. The commodity which has an upward trend in consumption has a feature of either "high price" or "easy to cook and eat".

In addition to commodities listed above, "other fresh fish", "sashimi mixed", "unclassified", and "salted and dried fish" have a significant share in the household consumption.

(2) Total consumption

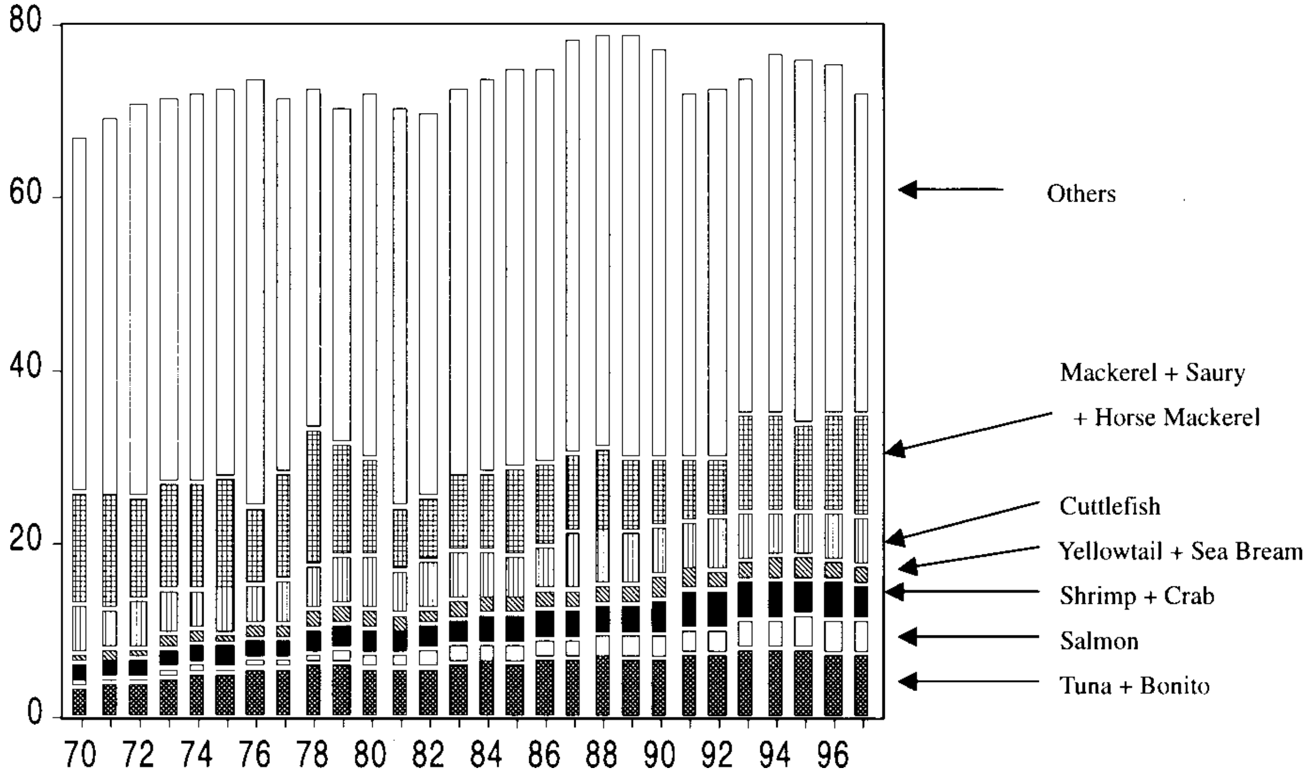
Here, the total consumption includes all kinds of consumption such as eating out, processed foods, cooked foods, etc. Thus, per capita total consumption is estimated as (domestic landing + import – export • inventory change)/population, where the exported or imported canned fishes are converted to the equivalent weight of live fishes.

Based on the food demand-supply balance table published from The Ministry of Agriculture, Forestry and Fisheries, per capita consumption for all kinds of marine products has been stable around 37kg (edible part) for the decade, and the amount is 5kg more than meats. Therefore, William (1995) and Ye (1999) present a slight decreasing and a constant demand respectively for the Japanese fish demand projection in the publications from FAO.

However, the consumption of individual items is different by commodity. Per capita total consumption shows an upward trend for tuna, bonito, flat fish, sea bream, and a downward trend for swordfish. Flat fish and sea bream show an upward trend in the total consumption in spite of a downward and even trend in household consumption.

In order to identify factors that determine the upward/downward trend of consumption, we tried to estimate the demand functions and separate the effect of income change implying the shift of demand curve and the effect of price change caused by fluctuation and productivity change of supply.

Figure 2 Trend of Consumption by Commodity (kg/person)



Note) live fish weight equivalent

3. Method to estimate income and price elasticity

1) Form of demand function

The following I, II, and III type demand functions are prepared for the total and the household demand.

The type I is a logarithmic linear function indicating that the demand responds monotonously to income and price changes.

The type II function indicates that the demand increases according to the income growth for the initial phase, but after that it turns to a decrease. When a>0 and b<0, the income elasticity is presented as $\varepsilon=(\Delta D/D)/(\Delta Y/Y) = -(a-2b/Y)/Y$, and the demand is maximized when $Y=-2b/a$.

The type III function indicates that the income elasticity is positive but decreasing according to the income growth under the condition of a<0.

[I] $\log D = a \log Y + b \log P + c$
[II] $\log D = a/Y + b/Y^2 + c \log P + d$
[III] $\log D = a/Y + b \log P + c$

where
D = per capita consumption of the commodity in a year,
Y = per capita household expenditure deflated by CPI,
P = wholesale or retail price of the commodity deflated by CPI,
a, b, c, d = coefficients to be estimated.

2) Method of regression

Ordinary least squares (OLS) or generalized least squares (GLS) were applied to estimate the demand functions. Simultaneous estimation or a demand systems approach is not appropriate, because the supply function of marine products is not established yet and the demand substitution between commodities through price changes is very unclear due to the small share of each commodity in household expenditure.

In estimating demand functions, GLS was frequently applied. When OLS was applied without the lagged variable, that is the per capita consumption of the commodity in the previous year, a serial correlation for the error term was often found due to the existence of demand inertia. When the lagged variable was introduced, the multicollinearity between the lagged variable and the other variables made the estimated coefficients unstable. Thus we coped with the serial correlation by using GLS. Estimated price and income elasticity is presented in Table 1.

4. Estimated results

1) Demand substitution with meats

A demand substitution of marine products with meats through their relative price was not found. This is because the cooking menu in households is generally determined between Japanese, Western and other style dishes prior to purchasing of food materials. Thus the relative price is not an important factor.

When we used data before 1990, we could observe the substitution of tuna with beef meat. In that period, a significant proportion of beef was consumed as *sukiyaki* and *shabushabu* (Japanese boiled meat dishes). But recently a larger proportion of beef meat is consumed as steak and hamburger (Monma, 1984).

2) Demand substitution between fish species

A demand substitution between marine products through their price changes was not found either. This is because a) it is difficult to identify the substitutive commodity due to the broad range of consumed varieties, and/or b) there are a tremendous amount of discarded parts of fish and there is a discrepancy between the bought and the eaten weight.

3) Price elasticity

In general, the absolute values of price elasticity for the total demand are lower than those for the household demand. This is why the price fluctuation in retail markets is more stable than that in wholesale markets. Retail prices include more wage costs than the wholesale prices, and this is the other reason for the stable retail price.

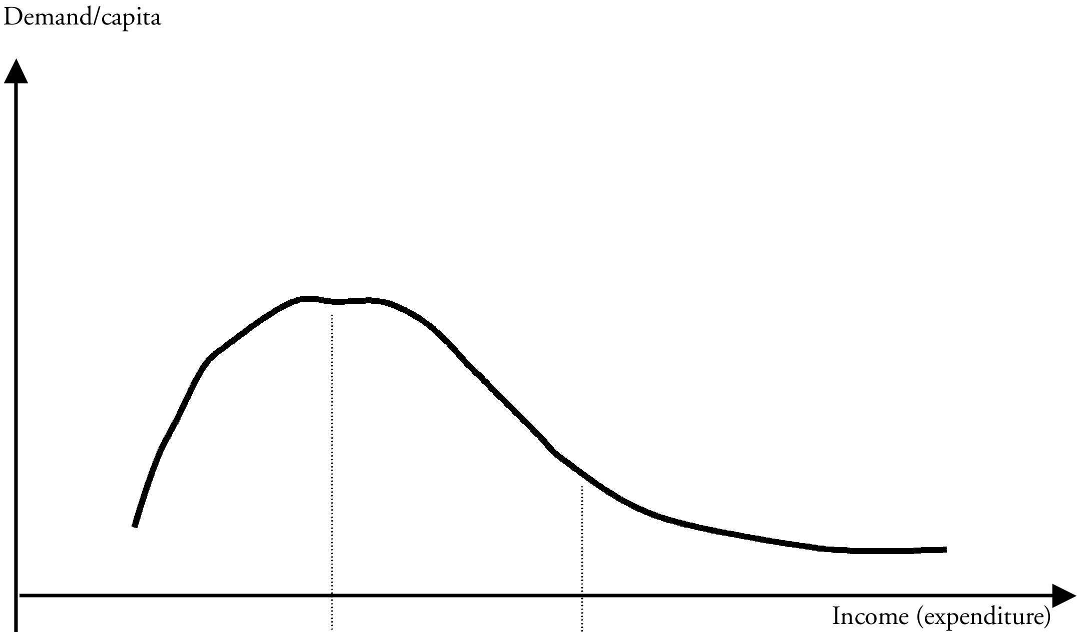
4) Income elasticity

In the household demand, bonito, salmon, shrimp, crab, and scallop have a positive income elasticity. Thus the recent increases in the consumption of tuna is considered to be caused by its price fall due to the increase in the catch. Another reason for the negative income elasticity of tuna is that it is consumed as a value added product such as *sushi* and *mixed sashimi* that are convenient for housewives to save time.

In the total demand, tuna, bonito, salmon, flatfish, sea bream, shrimp and crab showed positive income elasticity. These commodities are usually classified as “high grade”, and their retail prices are 2-3 times expensive than prices of traditionally popular fishes such as sardine, saury and mackerel. The prices of flatfish, tuna and crab are equivalent or more expensive than that of beef meat.

The income elasticity of these food items are summarized in the Fig. 3. For the latter half of the 1990’s, the demand for commodities that have positive income elasticity has been stagnant due to the continuous economic recession. If the Japanese economy recovers from recession, the demand for these commodities is expected to increase, depending on the income elasticity of the commodity and the expenditure growth that are determined mainly by GDP and saving ratio.

Fig. 3: Classification of fish by the demand phase



Total demand		
Fish total	Mackerel (1975)	
Tuna	Saury (1982)	
Bonito	Sardine (1982)	
Salmon	Cod (1979)	
Horse mackerel	Yellowtail (1985)	
Flatfish	Cuttlefish (1984)	
Sea bream		
Shrimp		
Crab	Swordfish	Flounder
Household demand		
Bonito	Tuna (1976)	Fresh fish total (1969)
Salmon	Saury (1979)	Horse Mackerel (1969)
Shrimp	Sardine (1982)	Cod (1969)
Crab	Flatfish (1978)	Flounder (1969)
Scallop	Cuttlefish (1968)	
	Mackerel	Yellowtail
	Sea bream	(constant)

( ) indicates the year when the demand was maximized.

5) Conversion ratio and inventory

In estimating the total demand, conversion ratios for canned fishes to live fish weight equivalents were not established. Therefore, we prepared some alternatives for the ratios. However, the changes of ratios had little effects on the coefficients estimated. The consideration of inventory changes made the estimated coefficients more elastic for some commodities such as saury and sea bream.

5. Price Linkages of Japanese Fish with Foreign Markets

As a result of demand analysis above, it became clear that the demand for individual commodity has different trend, while the aggregated demand shows a slight increasing trend. Under the situation of limited marine resources, the matter is that whether the Japanese demand increase will lead to the global price rise or not.

Therefore, we analyzed the linkages of Japanese domestic prices with foreign prices for four commodities such as tuna, salmon, mackerel and shrimp, for which international trade has enough volume and the price data is available.

Since the purpose here is not only to test a causality between domestic and world prices but also to estimate their correlation, we applied OLS regression that includes lagged prices in explanatory variables. Thus, the method carried out the "Granger's Causality Test" at the same time.

1) Tuna

As regard fresh tuna, there is a time-lag for the Japanese wholesale price to be transmitted to the CIF price, implying that the former determines the latter.

As regard frozen tuna, the Japanese CIF price is transmitted to the world average price, though the correlation is not so high and the elasticity is 0.59 (= 0.33 + 0.26). The Japanese CIF price correlates well with the FOB prices of Indonesia and Korea that are main exporters to Japan, and the CIF price of USA. On the contrary, the Japanese CIF price does not correlate with Italy FOB price.

According to the observations above, it was found that the world tuna markets are not integrated perfectly, and the world price responds to the Japanese domestic price with a time-lag.

2) Salmon

As regard fresh salmon, Japanese share in the international trade is little, and the Japanese CIF price has correlated with the world average price well since the year 1996 when Japanese import began to increase, meaning that Japan is a price taker.

As regard frozen salmon, the world average FOB, Japanese CIF and wholesale prices correlate well without a time-lag, and the Japanese CIF price correlates with USA FOB price first, and next with Canada and Chili prices, in particular. Therefore, the world markets are considered to be nearly integrated.

3) Mackerel

The Japanese wholesale and CIF prices does not correlate especially for frozen mackerel due to a domestic-global market separation by import quota. In addition, wide quality difference between domestic and imported mackerel is also considered to be a factor of low correlation of the prices.

4) Frozen shrimp

The Japanese CIF price correlates with the world average piece, but the correlation with an individual country is various. In addition, the Japanese wholesale price is transmitted to the CIF price with a time-lag.

As estimated from a time-lag required for a price transmission, the FOB price of India with a low production cost affects the Japanese CIF price, and then it affects the FOB price of Thailand whose quality control is excellent but the supply potential of shrimp is already limited.

6. Conclusions

In the world fish markets, Japan has more than a 10% share for both edible and non-edible fishes, and her import share is about 30% of the international trade. Therefore, the impact of Japanese fish demand on the global market is considered to be significant. For the first step to obtain information on the balance between fish demand and potential supply in the future, our demand analysis focused on the income elasticity of demand in Japan.

As a result of estimating demand functions of marine products, we found that income elasticity changes gradually for many commodities, and the elasticity of the total demand, that includes every kind of products of the fish, is higher than that of the household demand for many commodities. Especially the total demand for tuna, bonito, salmon, flatfish, sea bream, shrimp and crab has a positive income elasticity.

The Japanese economic recovery from recession, as is expected recently, will expand the demand for these commodities. The supply potential is widely worried for tuna and shrimp from the view point of resource limitation and environmental contamination as seen in FAO (1997). For these two commodities, the demand not only in Japan but also in other countries has been increasing (Campbell, 1996). Therefore, if the anxious for supply potential is adequate, prices of them are forecasted to rise.

The results of price linkage analysis supported the concern for price rise for tuna and shrimp, for which global markets are fairly integrated, although there exist a time-lag for the Japanese domestic price to be transmitted to foreign markets.

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Table 1. Price and Income Elasticity of Fish Demand

		Functional form	Price elasticity	Income Elasticity [1997]	Adjusted R2	Estimated period	Method	
Fresh fish total	H	II	-0.19	-0.26	0.82	1965-98	GLS	
Fish total	T	III	-0.29	0.13	0.87	1970-97	GLS	Edible part
Tuna	H	II	-0.82	-0.26	0.90	1965-98	GLS	
	T	III	-0.20	0.57	0.90	1972-97	GLS	Conv. Ratio=2.49, inventory change included
	T	III	-0.21	0.59	0.91	1972-97	GLS	Conv. Ratio=2.00, inventory change included
Bonito	H	III	-1.62	0.90	0.86	1965-98	GLS	
	T	III	-0.34	0.89	0.90	1970-97	OLS	Conv. Ratio=2.76, inventory change included
	T	III	-0.36	0.76	0.89	1970-97	OLS	Conv. Ratio=2.22, inventory change included
Swordfish	T	I	-0.14	-1.44	0.79	1976-97	OLS	Inventory change included
Salmon	H	I	-2.05	-3.42	0.98	1975-98	GLS	Salted salmon excluded
	H	I	-0.88	-0.28	0.95	1965-98	GLS	Salted salmon included
	T	III	-0.44	1.92	0.94	1980-97	OLS	Conv. Ratio=2.00, inventory change included
	T	III	-0.44	1.92	0.94	1980-97	OLS	Conv. Ratio=1.60, inventory change included
Mackerel	H	I	-1.12	-2.88	0.94	1965-98	GLS	
	T	II	-0.73	-1.14	0.60	1966-97	GLS	Conv. Ratio=1.72, inventory change included
	T	II	-0.72	-1.34	0.63	1966-97	GLS	Conv. Ratio=1.45, inventory change included
Saury	H	II	-1.33	-0.41	0.74	1965-98	GLS	
	T	II	-0.38	-1.97	0.55	1969-97	OLS	Inventory change included
	T	II	-0.29	-1.88	0.39	1969-97	OLS	Inventory change excluded
Sardine	H	II	-0.83	-0.33	0.81	1965-98	GLS	
	T	II	-0.23	-1.56	0.97	1971-97	GLS	Conv. Ratio=1.70, feed usage included, inventory change included
Horse Mackerel	H	II	-0.92	-0.87	0.95	1965-98	GLS	
	T	I	-1.03	0.12	0.83	1969-97	OLS	Inventory change included
Cod	H	II	…	-1.27	0.93	1965-98	GLS	
	T	II	-0.24	-2.60	0.96	1970-97	GLS	Trade of processed food excluded, inventory change included
Flatfish	H	II	-1.10	-0.41	0.93	1965-98	GLS	
(lefteye)	T	III	-0.22	3.46	0.90	1981-97	GLS	
Flounder	H	II	-0.27	-0.92	0.89	1965-98	GLS	
(righteye)	T	I	-0.22	-1.94	0.40	1987-97	OLS	Inventory change included
Yellowtail	H	I	-1.11	-1.57	0.47	1982-98	OLS	
	T	II	-0.46	-1.02	0.87	1970-97	GLS	
Sea Bream	H	I	-0.96	…	0.85	1965-98	GLS	
	T	III	-0.97	1.54	0.91	1970-97	OLS	Inventory change included
	T	III	-0.66	1.72	0.91	1970-97	OLS	Inventory change excluded
Cuttle Fish	H	II	-0.79	-1.75	0.76	1965-98	GLS	
	T	II	-0.35	-1.35	0.40	1970-97	GLS	Inventory change included
Shrimp	H	I	-1.32	0.51	0.95	1981-98	GLS	
	T	III	-0.25	1.22	0.96	1969-97	OLS	Inventory change included
Crab	H	I	-1.76	4.19	0.91	1981-98	GLS	
	T	III	-0.17	1.63	0.78	1970-97	OLS	
Scallop	H	I	-1.12	1.76	0.94	1987-98	OLS	

H=household demand, T=total demand
Coefficients with 5% significance are listed here.

Table 2. World -Japanese Price Linkage

	Elasticity				Elasticity		
	Price of the year	Price of the previous year	R2		Price of the year	Price of the previous year	R2
Tuna (Fresh & Chilled)							
Japan (wp) → Japan(CIF)	0.55	0.33	0.94	World Avarage(FOB) →Japan(CIF)	0.62		0.76
Japan(CIF) → World Average(FOB)	0.77		0.68	Japan(CIF) → Japan(wp)	1.07		0.92
Tuna (Frozen)							
Japan(wp) → Japan(CIF)	0.82		0.83	World Avarage(FOB) →Japan(CIF)	0.97		0.45
Japan(CIF) → World Average(FOB)	0.33	0.26	0.52	Japan(CIF) → Japan(wp)	1.02		
Japan(CIF) → USA(CIF)	0.54	0.28	0.90	USA(CIF) → Japan(CIF)	1.17		0.87
Japan(CIF) → Italy(CIF)		0.28	0.34	Italy(CIF) → Japan(CIF)	1.31		0.31
Japan(CIF) → Indonesia(FOB)	0.43	0.42	0.80	Indonesia(FOB) → Japan(CIF)	1.01		0.74
Japan(CIF) → Korea(FOB)	0.70	0.65	0.74	Korea(FOB) → Japan(CIF)	0.58		0.68
Salmon (Fresh & Chilled)							
Japan (wp) → Japan(CIF)	0.53		0.45	World Avarage(FOB) →Japan(CIF)	0.78		0.89
Japan(CIF) → World Average(FOB)	1.14 (1986 year-)		0.89	Japan(CIF) → Japan(wp)	0.30	0.52	0.59
Salmon (Frozen)							
Japan (wp) → Japan(CIF)	0.88		0.89	World Avarage(FOB) →Japan(CIF)	1.07		0.81
Japan(CIF) → World Average(FOB)	0.75		0.81	Japan(CIF) → Japan(wp)	1.01		0.89
Japan(CIF) → USA(FOB)	0.82		0.95	USA(FOB) → Japan(CIF)	1.15		0.95
Japan(CIF) → Canada(FOB)	0.57		0.64	Canada(FOB) → Japan(CIF)	1.12		0.64
Japan(CIF) → UK(FOB)	0.57		0.42	UK(FOB) → Japan(CIF)	0.74		0.42
Japan(CIF) → France(CIF)	0.39		0.10	France(CIF) → Japan(CIF)	0.26		0.10
Japan(CIF) → German(CIF)	0.42		0.60	German(CIF) → Japan(CIF)	1.43		0.60
Japan(CIF) → Chile(FOB) (Chile: 1984-)	0.75		0.51	Chile(FOB) → Japan(CIF)	0.68		0.51
Mackerel (Fresh & Chilled)							
Japan (wp) → Japan(CIF)	0.55		0.76	World Avarage(FOB) →Japan(CIF)	0.67	0.35	0.78
Japan(CIF) → World Average(FOB)	0.53	0.30	0.78	Japan(CIF) → Japan(wp)	1.40		0.76
Mackerel (Frozen)							
Japan (wp) → Japan(CIF)	0.14		0.21	World Avarage(FOB) →Japan(CIF)	0.41		0.62
Japan(CIF) → World Average(FOB)	1.52		0.62	Japan(CIF) → Japan(wp)	1.11		0.21
Shrimp (Frozen)							
Japan (wp) → Japan(CIF)	0.57	0.37	0.94	World Avarage(FOB) →Japan(CIF)	1.40		0.95
Japan(CIF) → World Average(FOB)	0.67		0.95	Japan(CIF) → Japan(wp)	1.04		0.88
Japan(CIF) → Thailand(FOB)		1.76	0.66	Thailand(FOB) → Japan(CIF)	0.33		0.53
Japan(CIF) → Indonesia(FOB)	0.98		0.89	Indonesia(FOB) → Japan(CIF)	0.90		0.89
Japan(CIF) → India(FOB)	0.72		0.60	India(FOB) → Japan(CIF)	0.66	0.31	0.65
Japan(CIF) → USA(CIF)	0.45		0.52	USA(CIF) → Japan(CIF)	1.16		0.52
Japan(CIF) → Denmark(FOB)	1.15		0.41	Denmark(FOB) → Japan(CIF)	0.36		0.41
Japan(CIF) → UK(CIF)	1.17		0.94	UK(CIF) → Japan(CIF)	0.80		0.94
Japan(CIF) → France(CIF)	1.15		0.63	France(CIF) → Japan(CIF)	0.55		0.63

note 1) elasticity = % change in the price of a destination country / % change in the price of a departure country
note 2) wp = wholesale price