# Economic Aspects of the Japanese Kamaboko Industry

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## Introduction

The newest and most promising seafood technology impacting U.S. markets in recent years is an ancient Japanese fish paste process which yields a final product called kamaboko, a fish protein gel which is flavored and formed to suit the tastes and preferences of consumers. Many varieties of kamaboko have been developed for the Japanese market (Table 1), and since 1976, several forms of kamaboko have been exported from Japan to the United States including: A lobster tail analog, scallop analog, shrimp analog, and crab analog. In this paper we discuss various economic aspects of trade, marketing, and production which affect the kamaboko industry of Japan and impact the U.S. market for Japanese kamaboko.

## Kamaboko Manufacture

Kamaboko is manufactured from minced/washed fish which is ground with sugar and other flavorings, shaped, heated, and cooled to form a final product. To produce minced/washed fish from fresh fish, the fish is headed and gutted, deboned, and washed. The minced/washed fish may go directly into kamaboko production (fresh-fish method) or it may be frozen and used later. To prevent deterioration of the flesh in frozen form, cryoprotectants (sugars) are added to the minced fish. This process yields an intermediate product called surimi, the history and manufacture of which are discussed in the following section.

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To produce kamaboko from surimi (surimi method), the surimi must first be thawed. After thawing, the surimi is really no different than the minced/washed fish used in the fresh fish method except that it already contains cryoprotectants which are required to manufacture kamaboko. The decision to use either surimi or fresh fish as a base raw material for the manufacture of kamaboko is solely dependent upon geographic and economic considerations. The quality of the final product is not altered by the method employed. The resilient texture of kamaboko, referred to as "ashi" by the Japanese, is a major factor in determining product quality. The ashi is determined by the species, freshness, and size of the fish used, fishing method, and fishing season (Suzuki, 1981).

The fresh-fish method is limited to a scale of production directly associated with raw fish availability, while the surimi method enables large-scale production associated with the ability to store large quantities of frozen surimi. Where the fresh-fish method is job-oriented, the surimi method is process- and flow-oriented which, in most cases, translates to a more efficient use of capital through larger outputs using similar capital requirements, i.e., cost of plant, cost of machinery, and fixed overhead costs. The surimi method, however, has additional costs associated with the freezing, holding, and handling of the intermediate product. If these additional costs are greater than the efficiency gains of the process- and flow-operation, it may be economical to forego the surimi process in favor of producing kamaboko directly from fresh fish. In 1984, about 38 percent of Japanese kamaboko was produced from fresh fish[1].

Table 1.—Variations of kamaboko (Suzuki, 1981).

| Item | Variation[1] |
|---|---|
| By heating method: | Steamed<br>Steamed and broiled<br>Broiled<br>Broiled (hampen)<br>Fried (tempura, satsuma age) |
| By shape: | Piled on a thin wooden slab (itatsuki)<br>Tubular (chikuwa)<br>Ball, bar, or square (age)<br>Leaf (susa)<br>Needle (soba)<br>Rolled (datemaki)<br>Chipped (kezuri) |

[1]Japanese name in parentheses.

Japanese domestic production of kamaboko totaled 1,020,028 metric tons (t) in 1984 (Table 2). Total production increased 11.7 percent from the 1980 level. Exports of kamaboko increased fifteenfold, growing from 0.25 percent of total production in 1980 to 3.5 percent in 1984. U.S. imports, as a percentage of total Japanese exports, grew from 44.7 percent in 1981 to 82.1 percent in 1984.

## Surimi Manufacture

The Japanese have fished for walleye pollock, *Theragra chalcogramma*, in the waters between Japan and Alaska for many years. The primary value of the fish had traditionally been attributed to its roe, considered a delicacy in Japan. Although the flesh is also valued, the quality of fillets processed from the fish-

[1]Assumptions are surimi produced in year *t* was processed into kamaboko in year *t*, and the average surimi-based kamaboko product contained 60 percent surimi and had a yield of 1.67, kamaboko to surimi.

ery was low due to deterioration of the flesh even after freezing.

To prevent deterioration, the fish were washed, minced, and mixed with sugar and polyphosphate to produce mu-en (salt free) surimi. Ka-en (salted) surimi was also produced by adding salt to the mixture, replacing the polyphosphate. K. Nishiya has been credited with the discovery of the process and preliminary research regarding methodology (Nishiya et al., 1961), and by 1964 large-scale onshore production of pollock surimi was realized[2].

Surimi has developed its own market as an input for the production of kamaboko, and a number of firms have appeared in the industry that produce only surimi which is sold on the open market and further produced into kamaboko by another set of firms. If the cost per unit of surimi is less than the cost of procuring and mincing a unit of fish, it would be favorable to purchase surimi and forego the mincing and washing operations.

A fairly strong analogy can be drawn between surimi and frozen fish blocks. Both participate in factor markets in that these goods are not directly consumed; surimi and fish blocks are the major cost and quantity components of kamaboko and "fish sticks and portions," respectively; the demand for surimi and frozen blocks is derived directly from the demand for their final products; and the supply of each input factor is a function of the biological abundance of species utilized and fishing effort directed toward those species.

In 1964 there were 39 surimi factories located in Japan which produced a relatively low-grade surimi. The low quality was attributable to the length of time required between catch (offshore) and process (onshore). To increase the quality of pollock surimi, factory vessels were introduced in 1965. The number of factory vessels as a percentage of total factories grew from 4.7 in 1965 to 26.5

**Table 2.—Kamaboko production and export from Japan in metric tons[1], 1980-84.**

| Nation and year | Exports (t) | Percent change from 1980 | Percent of total export | Percent change per annum |
|---|---|---|---|---|
| United States | | | | |
| 1980 | 1,482 | | 65.8 | |
| 1981 | 2,603 | +75.6 | 44.7 | +75.6 |
| 1982 | 7,320 | +393.9 | 59.2 | +181.2 |
| 1983 | 14,982 | +910.9 | 63.8 | +104.7 |
| 1984 | 29,387 | +1882.9 | 82.1 | +96.1 |
| England | | | | |
| 1980 | 9 | | 0.3 | |
| 1981 | 15 | +66.7 | 0.3 | +66.7 |
| 1982 | 376 | +3177.8 | 3.0 | +2406.7 |
| 1983 | 2,246 | +23955.5 | 9.6 | +497.3 |
| 1984 | 1,769 | +18655.5 | 4.9 | −21.2 |
| Australia | | | | |
| 1980 | 67 | | 3.0 | |
| 1981 | 2,191 | +3170.1 | 37.6 | +3170.1 |
| 1982 | 2,915 | +4250.7 | 23.6 | +33.0 |
| 1983 | 2,846 | +4147.8 | 12.1 | −2.4 |
| 1984 | 1,883 | +2710.4 | 5.3 | −33.8 |
| Others | | | | |
| 1980 | 695 | | 30.8 | |
| 1981 | 1,016 | +46.2 | 17.4 | +46.2 |
| 1982 | 1,753 | +152.2 | 14.2 | +72.5 |
| 1983 | 3,398 | +388.9 | 14.5 | +93.8 |
| 1984 | 4,933 | +609.8 | 13.8 | +45.2 |
| Total | | | | |
| 1980 | 2,253 | | | |
| 1981 | 5,825 | +158.5 | | +158.5 |
| 1982 | 12,364 | +448.8 | | +112.3 |
| 1983 | 23,472 | +941.8 | | +89.8 |
| 1984 | 35,791 | +1488.6 | | +52.5 |
| | Kamaboko production | | | |
| Japan | | | | |
| 1980 | 913,186 | | | |
| 1981 | 948,882 | +3.9 | | +3.9 |
| 1982 | 960,900 | +5.2 | | +1.3 |
| 1983 | 996,171 | +9.1 | | +3.6 |
| 1984 | 1,020,028 | +11.7 | | +2.3 |

[1]Data furnished by Hirochika Katayama, Japan-U.S. Trade Office, Washington, D.C.

**Table 3.—Surimi production, in metric tons, from walleye pollock in Japan[1].**

| Year | Onshore production | No. of plants (n=24) | Offshore production | Factory ships (n=19) | Total production |
|---|---|---|---|---|---|
| 1960 | 250 | 4 | | | 250 |
| 1961 | 2,500 | 9 | | | 2,500 |
| 1962 | 4,500 | 14 | | | 4,500 |
| 1963 | 9,282 | 28 | | | 9,282 |
| 1964 | 18,060 | 39 | | | 18,060 |
| 1965 | 23,639 | 41 | 8,184 | 2 | 31,823 |
| 1966 | 29,913 | 54 | 13,034 | 5 | 42,947 |
| 1967 | 44,869 | 58 | 39,220 | 7 | 84,089 |
| 1968 | 69,635 | 121 | 75,837 | 9 | 145,472 |
| 1969 | 92,718 | 110 | 103,610 | 14 | 196,328 |
| 1970 | 118,522 | 108 | 142,802 | 16 | 261,324 |
| 1971 | 137,848 | 110 | 183,534 | 20 | 321,382 |
| 1972 | 161,308 | 105 | 193,548 | 21 | 354,856 |
| 1973 | 159,146 | 103 | 223,598 | 23 | 382,744 |
| 1974 | 152,829 | 100 | 195,297 | 23 | 348,126 |
| 1975 | 169,036 | 97 | 191,730 | 22 | 360,766 |
| 1976 | 197,559 | 125 | 187,807 | 22 | 385,366 |
| 1977 | 193,123 | 111 | 168,823 | 22 | 361,946 |
| 1978 | 132,432 | 89 | 183,012 | 19 | 315,444 |
| 1979 | 114,426 | 85 | 180,402 | 20 | 294,828 |
| 1980 | 105,669 | 76 | 183,232 | 20 | 288,901 |
| 1981 | 114,393 | 66 | 192,264 | 22 | 306,657 |
| 1982 | 142,000 | 61 | 198,534 | 22 | 340,535 |
| 1983 | 160,000 | 61 | 180,000 | 22 | 340,000 |
| Avg. 1971-83[2] | 149,213 | | 189,368 | | |

[1]From a report to the Overseas Fishery Cooperative of Japan by the Deep Sea Trawlers Association, 1983, 103 p., unpubl., copy on file at SEFC Charleston Laboratory, Charleston, S.C.
[2]These averages are significantly different at the 0.01 probability level with $t = -4.61$ and d.f. = 16.8.

in 1982 (Table 3). Much of this increase resulted from the decline in the number of onshore facilities and not from the growth in the number of offshore factory ships.

Average annual production of factory vessels from 1971 to 1983 was much larger than that of onshore facilities, 189,368 t/year and 149,213 t/year, respectively. Supply from onshore facilities for the same period totaled 1,939,769 t while the supply from factory vessels totaled 2,461,781 t.

Although the number of onshore facilities had generally declined over the period, the average annual production per plant had grown dramatically. In 1972, there were 105 plants producing an average of 1,536 t of surimi, compared with 61 plants in 1983 producing an average of 2,623 t. This reflects an increase in production per plant of 71 percent. About 90 percent of all surimi is processed from walleye pollock, but Atka mackerel, *Pleurogrammus monopterygius*; croaker (Sciaenidae); jack mackerel, *Trachurus symmetricus*; and lizardfish, *Synodus lucioceps*, are also used (Hotta, 1982).

Japanese domestic production of surimi totaled 384,275 t in 1984 (Table 4), an increase of 5.5 percent from the 1980 level. Domestic firms utilized 99.3 percent of the 1984 production. The Japanese exported 2,580 t in 1984, about 3.5 times the 1980 level. The United States was the major importer of surimi from 1980 through 1984.

## Surimi and Kamaboko Production Ouside of Japan

The limited production of surimi and kamaboko outside Japan through 1984

[2]From a report to the Overseas Fishery Cooperative of Japan by the Japan Deep Sea Trawlers Association, 1983, 103 p., unpubl. A copy of this report is on file at the SEFC Charleston Laboratory, NMFS, NOAA, P.O. Box 12607, Charleston, SC, 29412-0607.

came, for the most part, from joint ventures established by Japanese companies. The fish used for surimi production are those that produce a high-value product for the Japanese market. Croaker has been the most popular species used due to its high quality ashi. Participating countries include, but are not limited to, Thailand, Taiwan, and the United States. Kamaboko production in these countries relies for the most part on pollock surimi imported from Japan. To achieve economic benefits from this method of trade in surimi, i.e., croaker surimi imported to Japan and pollock surimi exported from Japan, the Japanese must have a comparative advantage in the production of pollock surimi and a comparative disadvantage in the production of croaker surimi.

A simplistic estimate of comparative advantage/disadvantage may be made by examining relative prices. In this case, the following condition must hold:

$$\frac{\text{Pollock surimi}_{JP}}{\text{Croaker surimi}_{JP}} < \frac{\text{Pollock surimi}_{TPP}}{\text{Croaker surimi}_{TPP}}$$

where:
$JP$ = Japanese price and
$TPP$ = Trading partner's price.

These price ratios are referred to as the terms of trade and are one factor in determining both the levels and the direction that trade occurs.

A New Zealand company manufactured surimi from barracouta, *Thyrsites atun*, on an experimental basis, and found that the process was not economically feasible due to a yield from round barracouta of 17-18 percent for surimi compared with a yield of 33 percent for fish blocks. The U.S.S.R. has unsuccessfully attempted to produce surimi from walleye pollock for the Japanese market. The reason most commonly given for their failure is "poor quality product" (Hotta, 1982).

**Table 4.—Surimi production and export from Japan in metric tons[1], 1980-84.**

| Nation and year | Exports (t) | Percent change from 1980 | Percent of total export | Percent change per annum |
|---|---|---|---|---|
| United States | | | | |
| 1980 | 703 | | 99.2 | |
| 1981 | 819 | +16.5 | 88.6 | +16.5 |
| 1982 | 1,114 | +58.5 | 87.3 | +36.0 |
| 1983 | 1,708 | +143.0 | 87.0 | +53.3 |
| 1984 | 2,306 | +228.0 | 89.4 | +35.0 |
| Europe | | | | |
| 1980 | 6 | | 0.8 | |
| 1981 | 7 | +16.7 | 1.0 | +16.7 |
| 1982 | 5 | −16.7 | 0.7 | −28.6 |
| 1983 | 4 | −33.0 | 0.6 | −20.0 |
| 1984 | 6 | 0 | 0.8 | +50.0 |
| Australia | | | | |
| 1980 | 0 | | 0.0 | |
| 1981 | 5 | | 0.7 | |
| 1982 | 0 | | 0.0 | |
| 1983 | 0 | | 0.0 | |
| 1984 | 212 | | 8.4 | |
| Others | | | | |
| 1980 | 0 | | 0.0 | |
| 1981 | 97 | | 10.5 | |
| 1982 | 157 | +61.8 | 12.3 | +61.8 |
| 1983 | 251 | +340.4 | 12.9 | +59.9 |
| 1984 | 56 | −42.3 | 2.2 | −77.7 |
| Total | | | | |
| 1980 | 709 | | | |
| 1981 | 928 | +30.9 | | +30.9 |
| 1982 | 1,276 | +80.0 | | +37.5 |
| 1983 | 1,963 | +176.9 | | +53.8 |
| 1984 | 2,580 | +263.9 | | +31.4 |
| | Surimi production | | | |
| Japan | | | | |
| 1980 | 364,246 | | | |
| 1981 | 354,922 | −2.6 | | −2.6 |
| 1982 | 373,049 | 2.4 | | 5.4 |
| 1983 | 379,873 | 4.3 | | 1.8 |
| 1984 | 384,275 | 5.5 | | 1.2 |

[1]Data were furnished by Hirochika Katayama, Japan-U.S. Trade Office, Washington, D.C.

## Industry Structure

The Japanese offshore surimi industry is controlled by five firms, three of which produce 90 percent of the total product (Hotta, 1982). These firms sell top-grade surimi to a large number of kamaboko producers in Japan and a limited number of kamaboko producers outside of Japan. The majority of firms outside Japan are subsidiaries of Japanese firms; therefore, a limited amount of money in the form of labor cost, overhead cost, taxes, and cost of plant actually leaves Japan. This is especially true since these plants use Japanese machinery and equipment in their operations.

## The Economic Impact of EEZ Legislation

The Japanese have lost access to a major portion of Alaska's walleye pollock fishery in the Bering Sea with the advent of the 200-mile U.S. Exclusive Economic Zone (EEZ), but the resource is still available through joint ventures with U.S. fishermen. It is likely that these arrangements have translated into higher fish raw material costs for Japanese offshore producers. It is not clear, however, as to the extent the United States benefits from the EEZ legislation. Given the structure of the Japanese offshore industry, few firms supplying a large number of buyers, it is likely that surimi producers are passing these higher costs on to kamaboko producers, who, in turn, may pass at least a portion on to consumers both in Japan and in the United States. Therefore, in a strict welfare context, the American consumer may be forced to pay a higher price for Japanese kamaboko, reducing the sum of the benefits of the EEZ to the United States, i.e., American fishermen gain and American consumers of Japanese-produced kamaboko lose, but since the major market for kamaboko is Japan, U.S. society, as a whole, should gain from these arrangements.

## Substitution of Crab Analog for King Crab Meat

The crab analog form of kamaboko has gained wide acceptance in the United States. It first appeared on the market in 1978 in small quantities in the form of imitation[3] crablegs, and more recently lump and chunk forms of imitation crabmeat have been introduced.

The export of crab analog as a percentage of total Japanese kamaboko export increased from 64.1 percent in 1980 to 98.9 percent in 1984. In 1984 the United States imported 29,188 t which accounted for 82.4 percent of Japanese exports (Table 5). Although it is apparent that the Japanese have been very successful in marketing crab analog, it is not clear why. Many people postulate that an increase in king crab, *Paralithodes camtschatika*, prices, due to drastically reduced landings, encouraged consumers to purchase the crab analog as a lower priced replacement.

To investigate this assumption, a price function to estimate the demand for king crab meat at the wholesale level was specified. In the absence of price data (due to the newness of imported crab analog), a dummy variable was incor-

[3]The term "imitation" is descriptive of the product. The exact nomenclature as specified by the FDA has not been resolved.

porated into the regression which reflects the effect on king crab prices that was not predicted by historical demand and supply patterns in the years 1981-84.

A structural change in the marketing of crab meat which concentrated on the restaurant trade was coincidental with the large increases in demand for crab analog in the period 1981-84 (Table 5). Therefore, we assume that the dummy variable is capturing the price effect of the summation of the new marketing initiatives for king crab and the increased demand for the Japanese kamaboko product. The marketing initiatives have a positive effect on price through increased demand for crab meat which causes the dummy variable to have a positive sign. Conversely, the replacement factor of crab analog for crab causes a decreased demand for crab meat causing the dummy variable to have a negative sign.

It is assumed that crab meat supplies are a function of abundance and thereby are assumed to be predetermined. It is also assumed that yields of crab meat from the whole crab have remained unchanged over the period. Prices and income are deflated by the GNP-implicit price deflator to preclude inflationary effects. The equation utilizes 14 years of annualized data, 1971-84, inclusive, and is estimated using the ordinary least squares technique.

**Table 5.—Crab analog export from Japan in metric tons[1], 1980-84.**

| Nation and year | Exports (t) | Percent change from 1980 | Percent of total export | Percent change per annum |
|---|---|---|---|---|
| United States | | | | |
| 1980 | 1,254 | | 86.8 | |
| 1981 | 2,228 | +77.7 | 55.2 | +77.7 |
| 1982 | 6,749 | +438.2 | 72.3 | +202.9 |
| 1983 | 13,823 | +1102.3 | 73.4 | +104.8 |
| 1984 | 29,188 | +2327.6 | 82.4 | +111.2 |
| Europe | | | | |
| 1980 | 0 | | 0.0 | |
| 1981 | 27 | | 0.6 | |
| 1982 | 597 | +2211.1 | 6.4 | +2211.1 |
| 1983 | 2,752 | +10092.5 | 14.6 | +361.0 |
| 1984 | 2,632 | +9648.1 | 7.4 | −4.4 |
| Australia | | | | |
| 1980 | 120 | | 8.3 | |
| 1981 | 1,734 | +1445.0 | 43.0 | +1445.0 |
| 1982 | 1,750 | +1458.3 | 18.8 | +0.9 |
| 1983 | 1,581 | +1317.5 | 8.4 | −9.7 |
| 1984 | 1,791 | +1492.5 | 5.1 | +13.2 |
| Others | | | | |
| 1980 | 70 | | 4.8 | |
| 1981 | 44 | −37.1 | 1.1 | −37.1 |
| 1982 | 234 | +234.3 | 2.5 | +431.8 |
| 1983 | 673 | +861.4 | 3.6 | +187.5 |
| 1984 | 1,562 | +2131.0 | 4.4 | +132.1 |
| Total | | | | |
| 1980 | 1,444 | | 64.1 | |
| 1981 | 4,033 | +179.3 | 69.2 | +179.3 |
| 1982 | 9,330 | +546.1 | 75.5 | +131.3 |
| 1983 | 18,829 | +1203.9 | 80.2 | +101.8 |
| 1984 | 35,413 | +2352.4 | 98.9 | +88.1 |

[1]Data were furnished by Hirochika Katayama, Japan-U.S. Trade Office, Washington, D.C.

## Functional Form Equation

$$PK = f(-Q, +PSN, +Y, \pm D)$$

where

- $PK$ = average annual wholesale price of king crab meat in real cents per pound at Fulton Fish Market, N.Y., in year $t$ (1972 = 1.0),
- $Q$ = quantity demanded in millions of pounds in year $t$,
- $PSN$ = average annual wholesale price of snow crab, *Chionocetes* sp., meat in real cents per pound at Fulton Market, N.Y., in year $t$ (1972 = 1.0),
- $Y$ = per capita income in year $t$, and
- $D$ = dummy variable, where 1971-80 = 0 and 1981-84 = 1.

## Estimated Equation[4]

$$PK = -427 - \overset{*}{1.40}\, Q + \overset{*}{0.738}\, PSN$$
$$\qquad (-1.94) \qquad (1.55)$$

$$+\ \overset{*}{0.189}\, Y + \overset{*}{183}\, D$$
$$(2.11) \qquad (2.65)$$

$$R^2 = 82.6 \quad F_{(4,9)} = \overset{*}{16.39} \quad d = 1.97$$

### Interpretation

The price flexibility of demand for king crab meat is measured at −0.215, which means a 1 percent increase in quantity demand will decrease price by 0.215 percent. The cross-price flexibility of snow crab meat for king crab meat is measured at 0.410, meaning a 1 percent increase in the price of snow crab meat will cause an increase in the price of king crab meat of 0.410 percent. The price flexibility of income for king crab meat is measured at 1.560, meaning that a 1 percent increase in per capita income will cause the price of king crab meat to increase 1.560 percent. All measurements were taken at the centroid, or center point of the demand curve.

The deflated price of king crab meat rose from $5.40 to $8.06 from 1981 to 1984, inclusive. The coefficient of the dummy variable (183) means that the deflated price rose 183 cents more than we would expect. In other words, there was an additional real price increase of 68.8 percent that occurred outside of historical demand.

The positive dummy coefficient leads us to conclude that there has been no substantial replacement of crab analog for king crab. Had a substantial replacement occurred, we would observe a negative dummy coefficient. It appears that the assumption of an increased demand for the kamaboko product due to high king crab prices may not be well founded. While this analysis adds credence to the supposition that crab analog is not a substitute or "imitation" for king crab, the results are not conclusive for other species of crab. Vondruska (1985) suggests that competition from other products, as measured by market shares, affects snow crab prices much more than king crab or blue crab, *Callinectes sapidus*, prices.

### Discussion

The (0,1) dummy coefficient is certainly not the most efficient method to measure substitution effect. Had price data been available for crab analog imports, we could have measured direct price cross-flexibility where analog prices would appear as a parameter in our equation similar to snow crab prices. The inherent problem in using the dummy parameter is that it is most likely capturing more than our two assumed causal factors, a new marketing strategy, and competition from a new product. After all, there is an indeterminate number of factors which may affect market demand in any given period. Also, the estimation of a positive coefficient for the dummy variable does not preclude that substitution has occurred. We are merely concluding that the amount of substitution has not

[4]An asterisk indicates significance at the 0.10 level.

been substantial enough to outweigh the sum of other factors that have caused an additional increase in predicted demand for crab meat over the period.

Notwithstanding, the results of the equation do question conclusions reached by those people in the public and private sectors who believe that consumers en masse are substituting crab analog for crab meat. We feel that potential entrepreneurs in the United States should recognize that kamaboko may be prepared from fresh fish, and if the fish is available in large quantities continuously, it may be more profitable to forego the surimi process. There is a real need for further and continuing economic analyses of these dynamic product markets by government institutions and the private sector. With adequate preinvestment planning, there may be a bright future for a U.S.-based kamaboko industry.


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