



Impact of Nuclear Wastewater Discharge on Consumption in Japan (based on HKTVMALL data)

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Abstract. Nuclear wastewater discharge has been a controversial and focused topic since the Japanese government officially decided to discharge nuclear wastewater into the sea in 2021, especially in the agenda of environmental protection, food safety, and global consumer concerns, triggering extensive discussions and worries. The policy of discharging nuclear wastewater into the sea for the Fukushima accident was officially initiated on 24 August 2023, which was a decision that drew strong condemnation from various countries around the globe, with various economic, social, and environmental consequences for the various economic, social and environmental impacts on consumption within Japan and in the international market. Due to the ocean's characteristics of large size, high mobility and wide range of influence, the negative impacts of nuclear pollution hazards caused by the discharging are greater than those of general disasters. Japan's decision to discharge Fukushima nuclear wastewater, which is harmful to the marine environment, into the ocean is the first of its kind in history, leading to a series of negative effects, including environmental degradation, food safety concerns and international reputational issues. These are all influences that expose the nuclear wastewater discharges have had a profound impact on consumer markets in Japan and globally.

Keywords: Seafood; Nuclear Wastewater Discharge; Consumption.

1 Introduction

On 24 August 2023, the Japanese Government decided to discharge the wastewater into the sea, which, although temporarily relieving the urgent needs of the Japanese Government, has greatly endangered the safety of the entire Pacific region and the world, and will have a significant impact not only on the environment, economy and people's livelihoods in Japan, but also on the areas of food, fisheries, tourism and international trade. This decision not only involves inter-regional environmental impacts, but also has a direct bearing on the daily lives of consumers around the globe.

This study aims to provide insight into the potential impacts of nuclear wastewater discharges to the sea on consumption in Japan by focusing on the potential impacts of nuclear wastewater on seafood, particularly in relation to Japanese seafood and its sales, in order to better understand the possible impacts of the decision on people's

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T. Ramayah et al. (eds.), *Proceedings of the 2024 International Conference on Applied Economics, Management Science and Social Development (AEMSS 2024)*,

Advances in Economics, Business and Management Research 284,

https://doi.org/10.2991/978-2-38476-257-6_38

lives, health and consumption habits. This is not only directly related to the quality of life of people living in Japan, but also involves the global supply chain. Understanding these impacts will help us better anticipate possible commodity shortages and price fluctuations, thereby guiding consumers to make more informed shopping choices. At the same time, it will help the government and the international community to better communicate and respond to similar environmental issues in order to achieve more sustainable development goals.

At present, domestic scholars are mainly concerned with the impact of nuclear wastewater on marine ecosystems and organisms along with food safety, with fewer articles targeting the impact on seafood consumption. Domestic scholars such as ^[1] Chen Haiyan et al. indicated that radioactive substances in nuclear wastewater may affect the environment with the action of ocean circulation, groundwater or carbon cycle. ^[2] Wu Qing et al. indicated that after the Fukushima nuclear accident in Japan, radioactive substances were diluted into the ocean, and even though there will be no obvious harm in the short term, the mortality rate of fish and mammal organisms in the ocean will increase dramatically as they accumulate in the food chain. ^[3] Li Tianqi pointed out that once the wastewater is discharged, its pollutants are also inevitably transmitted into human bodies through the bodies of fish, shrimp and crabs. Therefore, the marine industry will inevitably be impacted, which will certainly affect the cultivation and sale of Japanese seafood.

At the international level, several countries and international organizations have expressed concern about Japan's plans to discharge nuclear wastewater into the sea.^[4] Sternsdorff Cisterna et al. stated that consumers can cope with food safety risks on their own terms.^[5] Toshihiro Wada et al. stated that the accumulation of radioactivity in wild fish is higher than that in farmed fish in general.^[6] According to McKendree et al.'s empirical study, 30 percent of respondents indicated that they had reduced their seafood consumption following the Fukushima nuclear power plant accident, and more than 50 percent believed that Asian seafood posed a risk to consumer health as a result of the nuclear disaster in Japan.^[7] Aruga and Wakamatsu et al. noted that the impact of contamination events resulting from the discharge of nuclear wastewater on the marine food supply may range from a direct reduction in quantity to microbiological, chemical and radiological contamination resulting in consumer panic.

2 Pre-processing of HKTVMALL data

After analyzing the CSV data files of HKTVMALL which is Hong Kong's largest e-commerce website, the authors obtained the data by analyzing the type of each piece of data, distinguishing between string data and numeric data, and then counting the amount of data in all the files.

Table 1. Data map of HKTV mall in Hong Kong

information	quantitative	Percentage	qualitative	Percentage
		24	21.43%	98
Data volume	Number of CSV files	Each CSV data volume	add up the total	
	90	1.8×10^5	1.62×10^7	

There are a total of 90 files of CSV data. These files separately record the order information of the products sold by HKTV MALL on each day from 1 December 2022 to 28 February 2023. One CSV file includes about 180,000 pieces of data, and the total data volume is about 1.62×10^7 pieces. A piece of data includes 112 pieces of information such as product ID, order amount, membership level, order time, payment method and delivery address, etc., of which there are a total of 98 qualitative features accounting for 78.57% and a total of 24 quantitative features accounting for 21.43%, as shown in Table 1 above.

The CSV files are converted into 90 data frames by pandas, and the relevant data in the 90 files are extracted by column names respectively to synthesize multiple datasets. Then classify the datasets and assign a new date value. On 13 January 2023, the Japanese government formally decided that the nuclear wastewater from the Fukushima Daiichi nuclear power plant of the Tokyo Electric Power Co. will be discharged into the sea in the spring or summer of this year. Therefore, the data before 13 January is assigned a value of 0 to the *Date* column, and the data after that is assigned a *Date* value of 1. The analysis and processing of the relevant data gives the following partial information, which is shown in Table 2 below.

Table 2. Graph of CSV file data analysis

	Data category				
	MAX	MIN	MEAN	MEDIAN	VAR
Order amount	2300.00	0.125	105.23	75.00	8436.86
Discount amount	2500.00	0.25	29.57	0.25	111139.61
freight fee	496.00	0.00	0.37	0.00	0.26
Offset amount with dis- count .coupon	13900.00	20.00	365.58	250.00	963.65
sales volume	1500.00	1.00	1.69	1.00	7.04

Quantitative features are analyzed, where the maximum order amount is \$2300 (HKD), the minimum amount is 0.125, the mean is 105.23, the median is 75, and the

variance is 8436.86 while the maximum discount is \$2500 (HKD), the minimum is 0.25, the mean is 29.57, the median is 0.25, and the variance is 11139.6. The rest of the data in the table 1 is not described here.

3 Analysis of seafood sales

3.1 data analysis

The discharge of nuclear wastewater from Japan into the sea has caused widespread concern about seafood quality and consumer safety on a global scale. This incident has had a direct impact on the sales and consumer market of Japanese seafood. In order to gain a deeper understanding of this impact, we will focus on the Hong Kong e-commerce company HKTVMALL and analyze its seafood sales data in an attempt to reveal the substantial impact of the nuclear wastewater discharge on consumption.

From Figure 1, it can be seen that the sales of seafood products in HKTVMALL tend to be normal in general during these 90 days, with no significant decline or increase. However, on 23 January 2023, the sales of seafood products suffered a precipitous drop and the sales dropped to the bottom, i.e. 252 units. It was found that on 13 January 2023, the Japanese government indicated that the discharge of nuclear contaminated water from the Fukushima Daiichi nuclear power plant into the sea was tentatively scheduled for the spring/summer timeframe of 2023, while the International Atomic Energy Agency (IAEA) concluded a second validation exercise on 20 January 2023 to confirm the appropriateness of the review by Japan's Atomic Power Regulation Commission (APRC). Sales of seafood products began to decline on the 13th and fell to a lowest value of 252 on the 23rd, indicating that consumers' willingness to purchase seafood products was significantly reduced by the impact of the discharge of nuclear wastewater into the sea, which in turn suggests that the impact of the discharge of nuclear wastewater into the sea in Japan on consumption is significant.

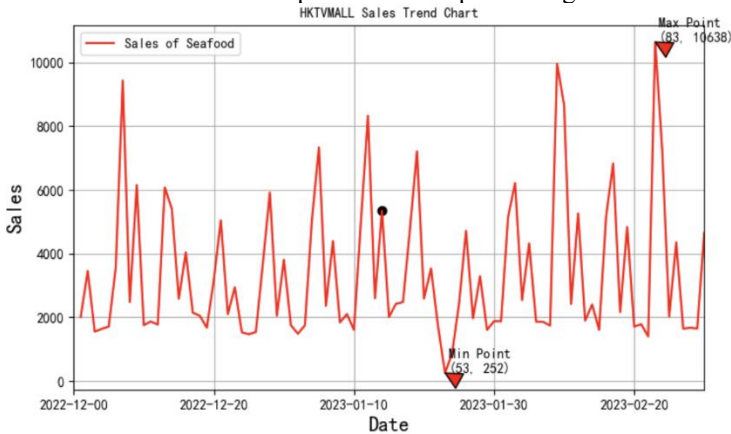


Fig. 1. HKTVM mall seafood sales in Hong Kong

Further analysis into the change of sales before and after the announcement of Japan's sea discharge, it can be seen from Figure 2 that the average sales of European seafood rose. While comparing with Figure 1, it is obvious that the decision of nuclear wastewater discharge seriously affects the consumer's purchasing mentality. Firstly, it reduced the willingness to buy Japanese seafood. Then it stimulated the consumer to buy European seafood, leading to the rise in sales of European seafood. The slow decrease in sales of Japanese seafood products showed that the consumers are ambivalent.

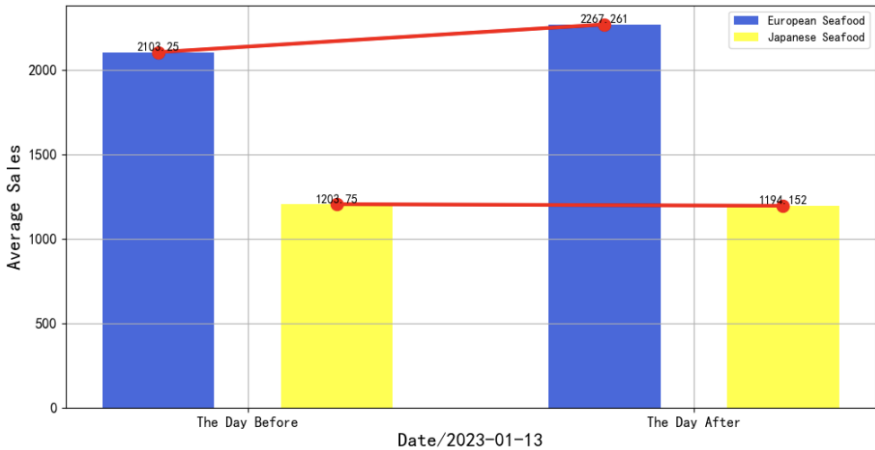


Fig. 2. Comparison of average sales of seafood before and after Japan's announcement of nuclear wastewater discharge to the sea

3.2 OLS analysis

The data related to seafood from five countries, Japan, Denmark, Norway, Iceland and Spain,¹ were extracted to synthesize a new dataset. The missing data of price of seafood was supplemented by the average of the seafood price for 90 days, and the rest of the missing quantitative features were filled with 0. The seafood products that had not been sold on one day were supplemented by the data from the previous day, while the quantity volume was filled with 0. The rest of the missing qualitative features were supplemented by the data the day before. Linear regression of the dataset using the OLS model with seafood sales as the dependent variable yielded an adjusted R-squared of 0.197 which shows a good fit of the model, as shown in Table 3 below.

¹ In the Food and Agriculture Organization of the United Nations (FAO) ranking of fishing producers, the top four fishing shares of European countries were Norway, Iceland, Spain and Denmark.

Table 3. OLS regression analysis of sales volume

Sales of seafood		
	coef	P
Date (by 13 January 2023/after 13 January 2023)	-0.0233	0.011
prices	-0.0115	<0.001
freight fee	0.0005	0.674
Cargo preparation time	-0.0173	0.930
Refundable orders	0.0004	0.042
Place of origin (Japan)	0.0435	0.070
Place of origin (Denmark/Japan)	-0.0467	-0.245
Place of origin (Norway/Japan)	-0.0139	-0.305
Place of origin (Iceland/Japan)	-0.0485	-0.204
Place of origin (Spain/Japan)	-0.0042	-0.279
Discounts on orders	<0.0001	<0.001
chilled fish	-0.9009	<0.001
Frozen prawns and crabs	-0.2052	0.032
F		22.81
R-square		0.206
Adjusted R-squared		0.197

The results of regression analyses for sales volume indicate that the higher the seafood price, the smaller the corresponding market sales volume. In addition, the sales volume of chilled fish and frozen prawns and crab decreased significantly (p less than 0.05), indicating that the sales volume of seafood products decreased after nuclear wastewater discharge. The negative coefficient of *Date* indicates that Japanese seafood products were significantly affected after the announcement of nuclear wastewater discharge from the sea, with a significant decrease (p less than 0.05) in market sales. In addition, some other factors may affect consumers' purchasing attitude, such as discounts on orders will attract customers to make purchases, and refundable orders are more acceptable to some consumers. However, there is no significant relationship between the sales of seafood products for the place of origin, whether it is from Japan as the country that discharges nuclear wastewater, or Denmark, Norway, Iceland and Spain. This may be due to the fact that the discharge of nuclear wastewater hadn't started yet, and the consumers were not very strict about the place of origin.

4 Conclusions

Through in-depth analysis of the data from HKTVMALL and the application of an OLS model for regression, we conclude that sales in the seafood market declined significantly after the announcement of nuclear wastewater discharge from Japan on 13 January 2023. This finding indicates the worries about consumer trust, food safety awareness, and international trade. The significant decline in market sales not only reflects consumers' concerns about environmental safety, but also highlights their high level of concern about the source and quality of food.

This study is more than just an observation of consumer behavior; it is a testimony to the profound impact of global environmental changes on the market. Japan's decision to discharge nuclear wastewater into the sea has not only caused strong controversy in its

own country but has also created turmoil in the seafood industry in the international market. We should recognize that consumers have a keen interest in the quality and safety of products, and that the public is becoming more sensitive to food safety and environmental issues, which is no longer just an economic issue about the sale of products, but a call for sustainable development and global environmental health.

With this study, we send an important signal to consumers. Businesses and policy makers, ecological environment and sustainable development have become important factors in shaping the market pattern. Governments and enterprises should take the issues of environmental protection and food safety seriously and take effective measures to safeguard product quality. In the globalized market, decisions made in one country often spill over to other countries, so cross-border cooperation and information transparency are crucial. In the future, different organizations must work together to find greener, sustainable ways of production and consumption to ensure that our behavior not only has a positive impact on the economy but is also environmentally and socially responsible.

In summary, despite the series of problems caused by the discharge of nuclear wastewater into the sea, it is expected that, through a scientific and pragmatic approach, the governments and the international community will work together to meet this challenge and create a new situation for the sustainable development of Japanese seafood.

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