Understanding Geopolitical Effects on Consumer Behavior based on Japan's Nuclear Wastewater Release Signal using Multiple Linear Regression Analysis

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Abstract. This study employs behavioral economics theory and statistical analysis methods, using big data from HKTVMall, a well-known Hong Kong shopping platform, to analyze targeted consumer boycott patterns following geopolitical events, with a particular focus on food products. The study focuses on consumer reactions to the Japanese government's decision to release wastewater from the Fukushima nuclear power plant into the ocean. The research provides a detailed assessment of the impact of the Japanese government's statement on Hong Kong consumers' purchasing decisions, thus offering insights into broader global consumer attitudes. By clarifying the interaction between government policy decisions and market behavior, it helps to gain a deeper understanding of the dynamic changes in consumers' decision-making processes when facing environmental issues. Furthermore, this paper emphasizes the significant potential of consumer behavior analysis to provide reference for policy discussions and business ethics practices in a global economy increasingly focused on environmental protection.

Keywords: Geopolitical Event, Nuclear Wastewater, Online Purchase

1 Introduction

Geopolitics, a field of studying and measuring the relationship between foreign country policy and certain international behaviors such as consumer behavior in a specific region that serves as the main research topic of this paper. For certain types of geopolitical events such as wars and sanctions, prices of relevant types of products are considerably lifted by them and can cause alterations in purchase tendencies and consumer behavior [1]. Accordingly, driven by the war between Russia and Ukraine, European natural gas price began to skyrocket and resulted in a 300% surge [1]. Besides, US-China Trade Friction caused a 25% boost in Chinese import prices, people under those circumstances changes their preferences of products and brands so that the consumer behavior changes [1]. In addition, based on regression analysis, geopolitical conflicts such as Middle East conflict can statistically lead to significant discourages in consumers' du-

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rable, non-durable spending and big-ticket item purchase [2]. It is obvious that geopolitical conflicts especially in the aspect of military conflicts indeed prompt noticeable decline in purchasing willingness and consumer behavior. Such geopolitical conflicts and risks can be measured via various algorithms including Linear Regression, Random Forest and XG-Boost [3].

However, beyond these conventional and well-known geopolitical events (military conflicts and trade friction cases), there is another field that needs to be studied: can geopolitical events in the form of health risk impose certain impacts on consumer behavior? For instance, despite SARS was originally a type of naturally occurring virus, its spread promoted geopolitical reactions and events such as the travel ban in China for active virus defense purposes which unavoidably restricts domestic consumer consumption in domestic traveling externally and restrains the willingness to consume domestic traveling related goods and services internally, such situation fosters consumer behavior changes [4]. Similarly, during COVID-19 pandemic, due to the severity of this virus and the widely adopted lockdown measures, consumers in a plethora of countries switch to online platforms for purchasing [5], panic purchasing takes place [6] and people tend to purchase more medical, health and safety products for preparatory purposes than normal cases [7].

Driven by the information obtained above and the focus on health risk related geopolitical events, I noticed the announcement from Japan about its nuclear wastewater release confirmation on January 13, 2023 [8]. Hence, this paper is determined to discuss Japan's nuclear wastewater release announcement consequence on consumer purchase within a fixed region, Hong Kong SAR, China is selected in this paper. Before conducting the research, it is appropriate to make an initial assumption towards the result, that is, if the selected type of product is ordered after the announcement date January 13, 2023 and manufactured in Japan as well. The sales (quantity) of it will incur a drop to some extent. According to the previous research, maternity and baby products purchase shows a noticeable drop in Hong Kong due to the announcement [9].

In brief, this research utilizes Multiple Linear Regression powered by Ordinary Least Square (OLS) estimator, which generates statistically significant results that matches the initial hypothesis. It also proves that geopolitical events especially those related to health risk can influence and alter consumer behavior.

2 Data and Methodology

For data, HKTV mall consumer purchase data, the one used in later research procedures is downloaded directly from HKTV official website. The dataset obtains a time range from December 1st, 2022 to February 28th, 2023 and holds 18972896 observations as well as 112 variables.

Located in the southern part of northeastern Japan, Fukushima is surrounded by numerous fishing ports of varying sizes near the Fukushima nuclear power plant. The closest is Ukedo Fishing Port, where the local seafood has shown radiation levels many times higher than normal. The seafood industry was expected to be the most directly

impacted by the release of nuclear-contaminated water, and the Japanese government's discharge plan is likely to extend this pollution to a broader area in the future.

Figure 1 illustrates the sales volume of Japanese frozen seafood prior to and following the announcement of Japan's nuclear wastewater discharge policy (depicted by the yellow line). The blue line signifies daily sales. Due to the cyclical influence of weekdays and weekends, we plotted a 7-day moving average (MA). It can be seen that after Japan issued the announcement, sales of this type of Japanese product experienced a significant decline. Subsequently, sales rebounded somewhat.

Figure 2 shows the sales figures for Japanese canned and dried food before and after the announcement of Japan's nuclear wastewater discharge policy. It can be seen that after the announcement in Japan, the sales of this type of Japanese product experienced a more significant decline, and this downturn continued until late February.

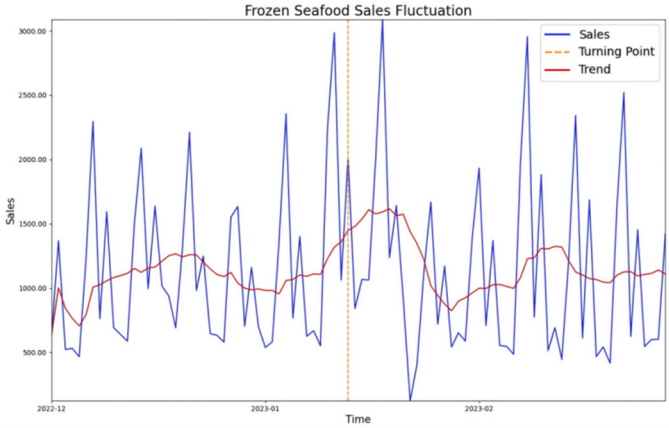

Fig. 1. The sales change chart for Japanese-produced frozen seafood.

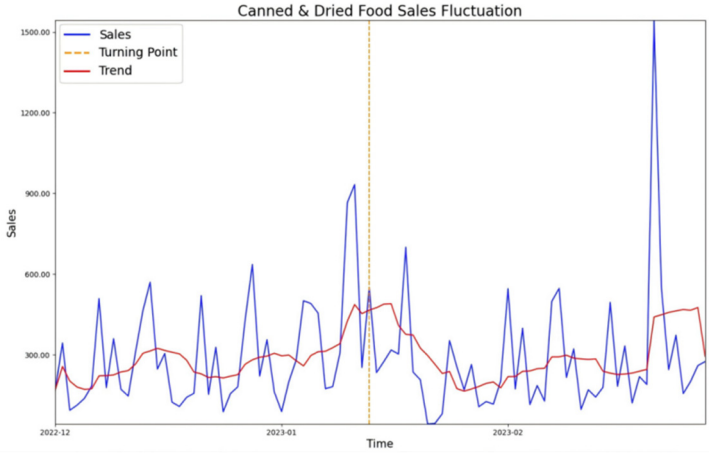

Fig. 2. The sales change chart for Japanese-produced canned & dried food.

As can be clearly seen from the comparison in Figure 3, the sales quantity of both canned and dried food products and frozen seafood products produced in Japan declined significantly after January 13, 2023. The average daily sales quantity of canned and dried food products dropped from 303.34 to 280.5, and that of frozen seafood products dropped from 1152.45 to 1125.26.

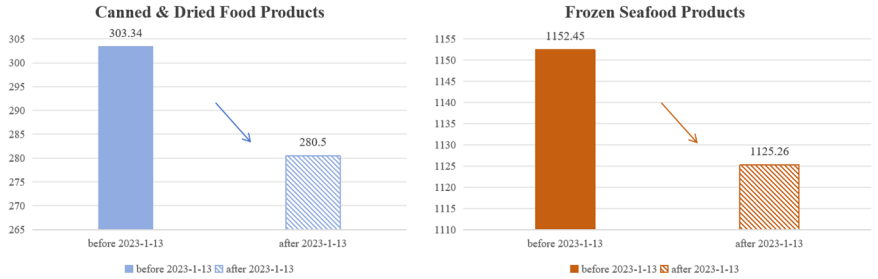

Fig. 3. Comparison of average daily sales quantity of canned & dried food products and frozen seafood products before and after January 13, 2023.

To ensure a more comprehensive and rigorous comparison, and considering the influence of other possible macroeconomic factors, we also used market share as a standard, selecting major food exporting countries such as the United States, Canada, and Australia as references to compare the changes in market share of these two types of products in Japan before and after January 13th. The results shown in Figure 4 & 5 indicate that the market share of Japanese products experienced a decline across both canned and dried food categories as well as frozen seafood. Specifically, the market share for canned and dried food products decreased by 0.3%, and for frozen seafood, the reduction was 1.5%.

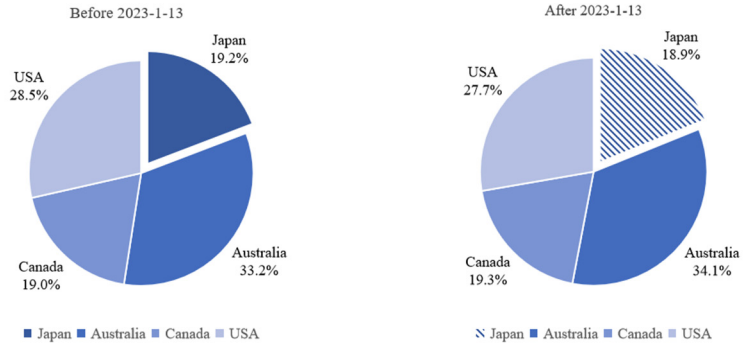

Fig. 4. Market share comparison of canned & dried food products in Japan around January 13th.

In contrast, products from Australia, located in the Southern Hemisphere, saw growth, especially frozen seafood, with its market share increasing by approximately 4.1%.

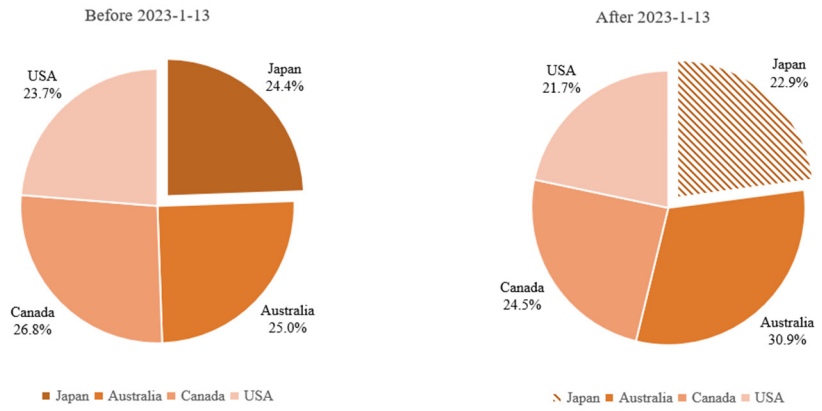

Fig. 5. Market share comparison of frozen seafood products in Japan around January 13th.

Following the intention of this research, in order to apply Multiple Linear Regression methodology, it is necessary to settle firstly the dependent variable which represents the indicator of this research topic and then multiple independent variables including the interaction terms mentioned in Section 1 with other dummy variable that impose certain influences on the dependent variable. Furthermore, some variables in the dataset are utilized for specific grouping and filtering purposes, so they should be listed as well. Detailed descriptions and interpretations of all variables can be viewed in the table listed below:

Table 1. List of Variables

Variable	Type	Definition
Grouping and Filtering Variable:		
sub_cat_1_name_en	String	The product first-level subcategory in English.
sub_cat_2_name_en	String	The product second-level subcategory in English.
manufacturer_country_en	String	The country of the manufacturer in English.
order_date	Timestamp	Creation date of the order.
before_after	Boolean	Equals 1 if order_date > 2023-01-13, and 0 otherwise.
from_japan	Boolean	Equals 1 if manufacturer_country_en = "Japan", and 0 otherwise.
Dependent variables:		
ln(quantity)	Float	The natural logarithm value of Quantity of SKU ordered.
Independent variables:		
ln(price)	Float	$\ln(\text{price}) = \ln(\frac{\text{total\_price}_{\min} + \text{total\_price}_{\max}}{2 \times \text{quantity}})$
interaction	Boolean	$\text{interaction} = \text{before\_after} \times \text{from\_japan}$
ln(discount)	Float	$\ln(\text{discount}) = \ln(\frac{\text{total\_discount}_{\min} + \text{total\_discount}_{\max}}{2})$
weekend	Boolean	Equals 1 if order_date is on weekends, and 0 otherwise.

Hence, according to the variables in Table 1 and the theoretical basis of Difference in Differences that creates a specific interaction term to distinguish various cases [10],

the Multiple Linear Regression test will be conducted later based on the following formula:

$$\ln(\text{quantity}_{i,t}) = \beta_0 + \beta_1 \ln(\text{price}_{i,t}) + \beta_2 \text{interaction}_{i,t} + \beta_3 \ln(\text{discount}_{i,t}) + \beta_4 \text{weekend}_{i,t} + u_{i,t} \quad (1)$$

β_2 is the coefficient of $\text{interaction}_{i,t}$. A negative value of it indicates that if the product is ordered after January 13, 2023 and produced in Japan, it will incur a negative consequence in the field of its sale. And if the value of β_2 is positive, the conclusion is the opposite.

3 Research Process and Results

This section will further explore and analyze the sales data of Japanese products before and after Japan's announcement of the discharge of nuclear wastewater on January 13, 2023, aiming to investigate whether the Japanese government's announcement, which is inconsistent with the spirit of ESG, caused Japanese products to encounter obstacles in the international market, ultimately leading to a "real" decline in sales.

In order to maximize the validity of the result of such research, various grouping and filtering should be performed and the relevant data is properly preprocessed. Generally, the researcher should claim the range of data applied via picking data of limited countries. In this research, it is necessary to filter and keep the data in which manufacturer_country_en mentioned in Table 1 equals Japan and some other countries that are geographically distant from Japan for enhanced precision and deeper universality of the research results. Accordingly, Japan, Australia, United States of America and Canada are selected at last.

In addition, driven by the incentive of Japan's nuclear wastewater release, the consequences on consumer behavior would most likely to occur in the field of food, especially seafood. To find suitable product types for this research while having a brief understanding towards the nuclear wastewater release incentive, data plotting under sub_cat_1_name_en and sub_cat_2_name_en mentioned in Table 1 is performed as such subcategory level contains sufficient category collections related to food and seafood. In the end, “Canned & Dried Food” in sub_cat_1_name_en and “Frozen Seafood” in sub_cat_2_name_en are preserved as the target product types because of their feasibility and sufficient daily sales (quantity) amount which can eliminate the unwanted uncertainty and randomness of regression results brought by the deficiency of daily sales. Furthermore, the data should only contain the part that manufacturer_country_en is Japan to align with this paper's research target.

Afterwards, regression tests with respect to both product types are conducted, which indicate the following results displayed in Table 2 and Table 3.

Table 2. Regression Result for type: Canned & Dried Food.

Dep. Variable: ln(quantity)				
Model:	OLS	R-squared:	0.145	
Method:	Least Squares	Adj. R-squared:	0.145	
Date:	Thu, 30 Oct 2025	F-statistic:	1405	
Time:	0.124328704	Prob (F-statistic):	0	
No. Observations:	33 151	Log-Likelihood:	–22 020.	
Df Residuals:	33 146	AIC:	4.405×10^{4}	
Df Model:	4	BIC:	4.409×10^{4}	
Covariance Type:	nonrobust			
	coef	std err	t	P>|t|
const	0.896	0.009	105.37	<0.001
ln(price)	–0.131	0.002	–59.24	<0.001
interaction	–0.221	0.006	–38.51	<0.001
ln(discount)	0.014	0.001	13.86	<0.001
weekend	0.031	0.007	4.17	<0.001

According to the results in Table 2, the statistics reveals a significant negative relationship between interaction term and quantity among Japan, Australia, United States of America and Canada under Canned & Dried Food first-level subcategory. The coefficient of $\text{interaction}_{i,t}$ is -0.2214 with a 0.000 p-value that is smaller than 0.01. As a result, statistically, it is appropriate to claim that Japan's nuclear wastewater release signal imposes a negative incentive towards consumers so that they tend to purchase less Canned & Dried Food products. Furthermore, in the aspect of percentage change, the interaction term or the case that such product is both ordered after January 13th, 2023 and manufactured in Japan can cause approximately 22.14% drop in quantity for each trade. For other independent variables, price can lead to a nearly 0.1311% drop in quantity for each trade, discount can offer a 0.0141% increase in quantity for each trade.

Table 3. Regression Result for type: Frozen Seafood.

Dep. Variable: ln(quantity)				
Model:	OLS	R-squared:	0.002	
Method:	Least Squares	Adj. R-squared:	0.002	
Date:	Thu, 30 Oct 2025	F-statistic:	57.93	
Time:	0.131724537	Prob (F-statistic):	6.34×10^{-49}	
No. Observations:	114 140	Log-Likelihood:	–31 342.	
Df Residuals:	114 135	AIC:	6.269×10^{4}	
Df Model:	4	BIC:	6.274×10^{4}	
Covariance Type:	nonrobust			
	coef	std err	t	P>|t|
const	0.211	0.005	40.15	<0.001
ln(price)	–0.015	0.001	–13.25	<0.001
interaction	–0.011	0.002	–5.54	<0.001
ln(discount)	0.001	0	3.23	0.001
weekend	0.003	0.003	0.93	0.354

In Table 3, the statistics also reveals a significant negative relationship between interaction term and quantity among Japan, Australia, United States of America and Canada under Frozen Seafood second-level subcategory. The coefficient of $interaction_{i,t}$ is -0.0242 with a 0.000 p-value that is smaller than 0.01. As a result, statistically, it is also appropriate to claim that Japan's nuclear wastewater release signal imposes a negative incentive towards consumers so that they tend to purchase less Frozen Seafood products. In a nutshell, both regression results match the initial guess that Japan's nuclear wastewater release signal will negatively influence consumers' purchases of food products especially seafood products. Moreover, if the product is ordered after January 13th, 2023 and manufactured in Japan, there will be a 1.08% drop in Frozen Seafood in quantity for each trade. And price offers a 0.0153% drop in quantity for each trade, discount shows a 0.0012% increase in quantity for each trade.

4 Conclusion, Policy Recommendations and Future Directions

In conclusion, Canned & Dried Food and Frozen Seafood category products indicates statistically significant negative relationship with quantity if the product is both ordered after January 13, 2023 and manufactured in Japan. Comparatively, such relationship is more intense in Canned & Dried Food category than Frozen Seafood category.

Accordingly, such behavior of nuclear wastewater release turns out to be not only harmful to the sale of certain types of products but also damages the global environment which obviously violates the standard and spirit of ESG. To ensure the unaffected sale of the products, it is necessary and important to guarantee the obedience of ESG standards for those types of products that can be addressed via several probably effective policy approaches.

On the one hand, internally, applying ESG standards, management and ideas to domestic society and corporations could contribute to generating better solutions when facing such geopolitical events. From the Environmental perspective, extra detections of product could probably minimize imports associated with negative geopolitical events such as seafood produced in Japan mentioned in this paper. From the Social perspective, relevant law terms of raw material quality verification and toxic chemical monitoring procedures can be set up so that the public will be less worried [11]. Finally, from the perspective of Governance, clear and noticeable labeling on all types of products satisfies the requirement of reporting in ESG. Also, business ethics could also help offset the negative impacts brought by those geopolitical events, measurements such as regulated proportional transparency of corporation operation records in the field of food, import as well as health and safety products. In spite of the advantages offered by ESG, real world implementation of such requires more efforts including mitigating financial risks stemming from global instability while expressing a desire to invest in the financial assets of companies dedicated to ESG principles [12].

On the other hand, externally, diplomatic relationships may help avoid the occurrence of unnecessary consumer behavior changes under geopolitical events, for instance, geopolitical teleconnection [13].

At last, in the field of future directions, as geopolitical events can not only impose changes on consumer behavior mentioned in Section 3, but also intensify the volatility of future prices of some natural resources or products [14]. As a result, promoting a more cooperative and less comparative global ambiance [15] could enhance international cooperation, communication and diplomacy. Such approach may reduce the negative influences of geopolitical events to a better degree and could be treated as an appropriate future direction in the aspect of governments.

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