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Testing market integration for Japanese retail seafood markets

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Although Japan is one of the largest seafood-consuming countries, with various types of seafood products traded throughout the nation, few studies have explored how this market is integrated from the aspect of market price. Because Japanese consumers in different regions have different preferences for seafood, we focused our study to see how the regional seafood retail markets (Tokyo, Osaka, Nagoya, Sapporo, and Fukuoka) are integrated for 10 major seafood products (horse mackerel, short-necked clams, yellowtail, scallops, cuttlefish/squid, flounder, tuna, mackerel, saury, and octopus) consumed in Japan. We applied the relatively new Phillips–Sul convergence test for our analysis. For most of the seafood products investigated in this study, our results indicate that the Japanese regional seafood markets cannot be integrated as a whole and that marketing strategies need to consider the peculiar characteristics of the regional seafood markets.

Key words: convergence test, Granger causality, Japanese retail seafood market, market integration.

1. Introduction

Japanese seafood markets are highly differentiated in terms of the species sold in the markets, and preferences for particular species differ widely among regions. It is believed that such differences reflect historical distinctions in consumer preferences among the regions (Wessells and Wilen 1994). For example, the *Kanto* region located in the eastern part of Japan consumes more red-fleshed fish than the *Kansai* region located in the west of Japan, where white-fleshed fish is preferred to red-fleshed fish. Hayashi (2011) found that there are regional differences in the types of seafood consumed among different cities in the 2000s using data on the percentages of types of seafood consumed among the 47 prefectural capitals.

However, recent improvements in freezing and storing technologies, transportation networks, and so on make it possible to transport seafood products from landing harbours to distant areas. As a result, some seafood products are traded across regional borders and are available in broader geographical market areas. Hayashi (2011) suggests that although regional differences in consumer preferences still exist for some seafood products in

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Japan, such distinctions are becoming smaller for products that are commonly sold in large supermarket chains.

Figure 1 shows the plots of the nominal prices for 10 highly consumed seafood products in the Tokyo (TK), Osaka (OS), Nagoya (NG), Sapporo (SP), and Fukuoka (FK) regions for the 1996–2009 period. In the short-necked clam, yellowtail, and octopus markets, prices in the five regions

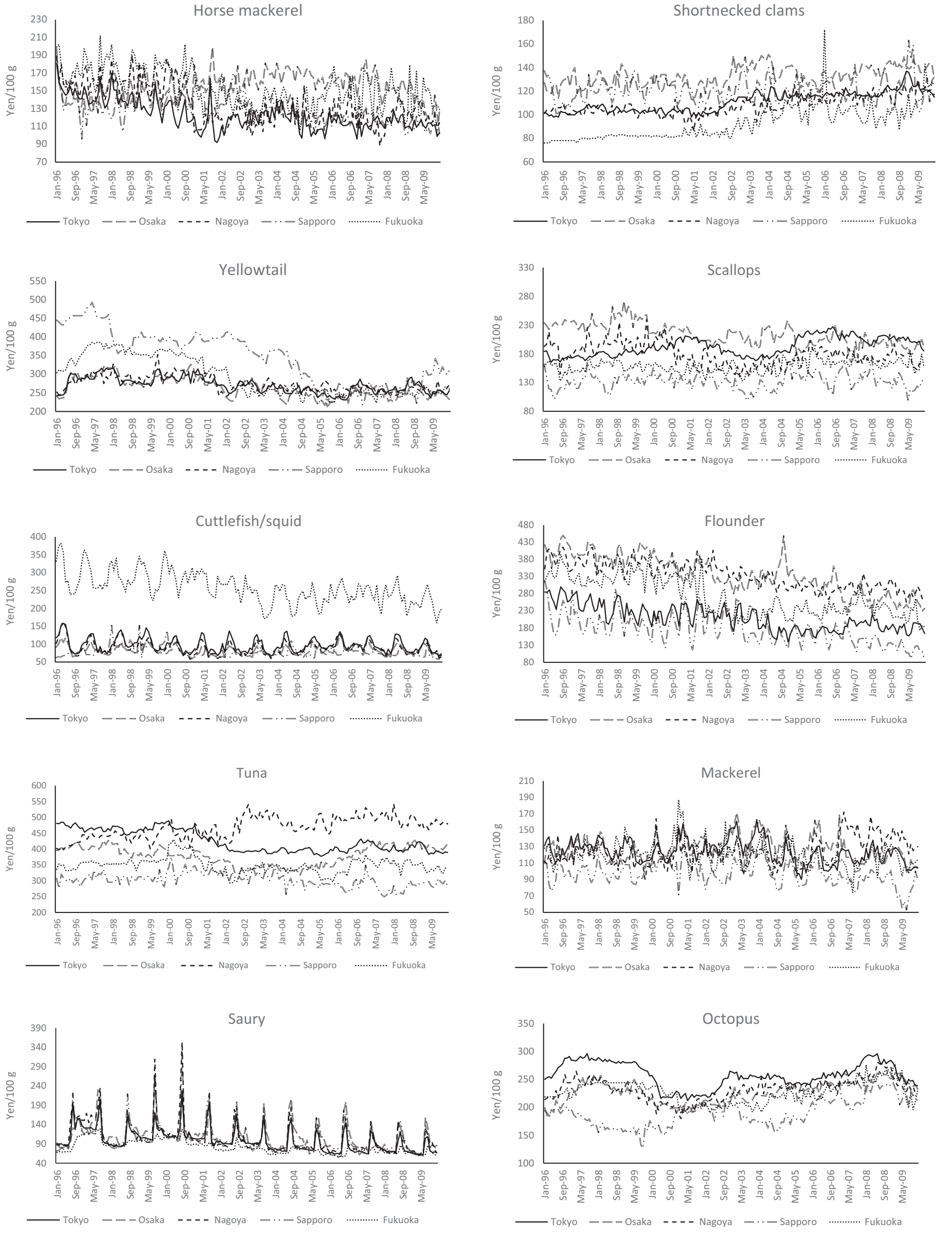

Figure 1 Prices of the Japanese regional seafood markets.

appeared to diverge at the beginning of the study period, but converged towards the end of the study period.

There are several previous studies analysing the regional differences in seafood consumption in Japan (Horii 1996; Ariji 2006; Hayashi 2011). However, these studies only focus on the differences in the types of seafood and the degree of consumption among different regions and have not investigated whether the regional markets are integrated using price data. Furthermore, these studies have not tested how regional markets are inter-related through market prices.

In studies investigating regional seafood market integration, Norman-López *et al*. (2014) analyse the Australian rock lobster industry; Shinoj *et al*. (2008) test the market integration for mackerel, sardine, pomfret, and shrimp among the major coastal states of India; Gordon and Hannesson (1996) examine the European and U.S. cod markets; and Asche *et al*. (2012) investigate the U.S. shrimp market. However, compared with Australian, South Asian, U.S., and European seafood markets, there are few studies examining regional seafood market integration in Japanese markets.

The purpose of this study is to fill this gap and identify how the Japanese regional seafood markets are inter-related by testing for the existence of common price trends among five populated regional cities in Japan for 10 highly consumed seafood products. Our study will be helpful for market participants in the Japanese seafood market who wish to see which regional markets follow similar price trends. If the result of the study reveals that some regions are integrated, market participants in these regional markets can use each other's price information for their price discovery process. If it becomes evident that regional markets are integrated, the seafood price of one region can be used as a reference price for other regional markets when buyers and sellers determine the market price. The study results will also provide valuable information for seafood distributers or policymakers seeking to build effective distribution channels, because if they know which regional markets are integrated, they can identify which regional markets can be dealt with using similar marketing strategies. Regional markets that are integrated can be targeted using common marketing strategies, but regional markets that are independent will need to be treated differently.

Our study is one of the first studies to investigate market integration for agricultural markets where price series are a mixture of stationary and nonstationary series so that it is difficult to apply the conventional cointegration method. We use the Phillips–Sul (2007) convergence test to overcome the problems applying a cointegration test for market data that are difficult to integrate into the same order by taking first or second differences of the price series. Hence, our study provides a valuable source for conducting market integration tests for various markets that are difficult to analyse using the conventional cointegration method.

In the next section, we describe the data we used in the study. In the third section, we explain the methods used in this study. In the fourth section, we show the empirical results of the data analysis. Finally, in the last section, we discuss our conclusions.

2. Data description

Our data for Japanese retail seafood prices were obtained from the Japanese retail price survey conducted by the Japanese Statistics Bureau.[1] Monthly observations from January 1996 to December 2009 are used for every price series, giving us 168 observations. Data were obtained for 70 cities which either have a population greater than 150,000 or are capitals of the 47 subnational jurisdictions. The survey was conducted using the most commonly sold seafood products throughout Japan. The specifications of the products are based on the average products sold regularly at randomly chosen grocery stores among the 70 cities. The survey data did not contain information on whether the seafood products are fresh or frozen. Among these 70 cities, we used the retail prices of the following five highly populated regional cities in Japan: TK, OS, NG, SP, and FK.

Figure 1 plots the price series, and Figure 2 illustrates the locations of the five chosen cities within Japan. These cities were chosen because of their geographical spread and their high population – all are among the 10 most highly populated cities in Japan. The 10 seafood products we cover in this study are horse mackerel (*aji*), short-necked clams (*asari*), yellowtail (*buri*), scallops (*hotate*), cuttlefish/squid (*ika*), flounder (*karei*), tuna (maguro), mackerel (*saba*), saury (*sanma*), and octopus (*tako*). These seafood products are among the 33 most highly and commonly consumed seafood products in Japan. These 10 products were chosen for this study because they are the only ones that have consistent data without missing observations for the full study period. These products are also ones that did not have much change in their product specifications.

For horse mackerel, the prices are for whole fish measuring more than 15 cm. The price of short-necked clams is for 100 g of short-necked clams with shell. The price of yellowtail is for 100 g of sliced (fillet) yellowtail. The scallop price is for 100 g of boiled and shelled scallops. The price of cuttlefish/squid is for 100 g of Japanese Flying Squid. For flounder, mackerel, and saury, the prices are for whole fish measuring between 25 and 35 cm, between 25 and 40 cm, and more than 25 cm long, respectively. The price for tuna is the price of 100 g of either yellowfin or bigeye tuna, sliced for sashimi use.[2] Finally, the octopus price is for 100 g of boiled octopus.

[1] The reason we used the retail price is because recently both the volume and value of wholesale trades for Japanese seafood are decreasing (Shimanuki 2009) and more fish are traded directly between producers and retailers.

[2] The Japanese retail price survey only provided tuna data for these mixed types of tuna and assumed that yellowfin tuna is a substitute for bigeye tuna. Indeed, Bose and McIlgorm (1996) suggest that their degree of substitutability is relatively high.

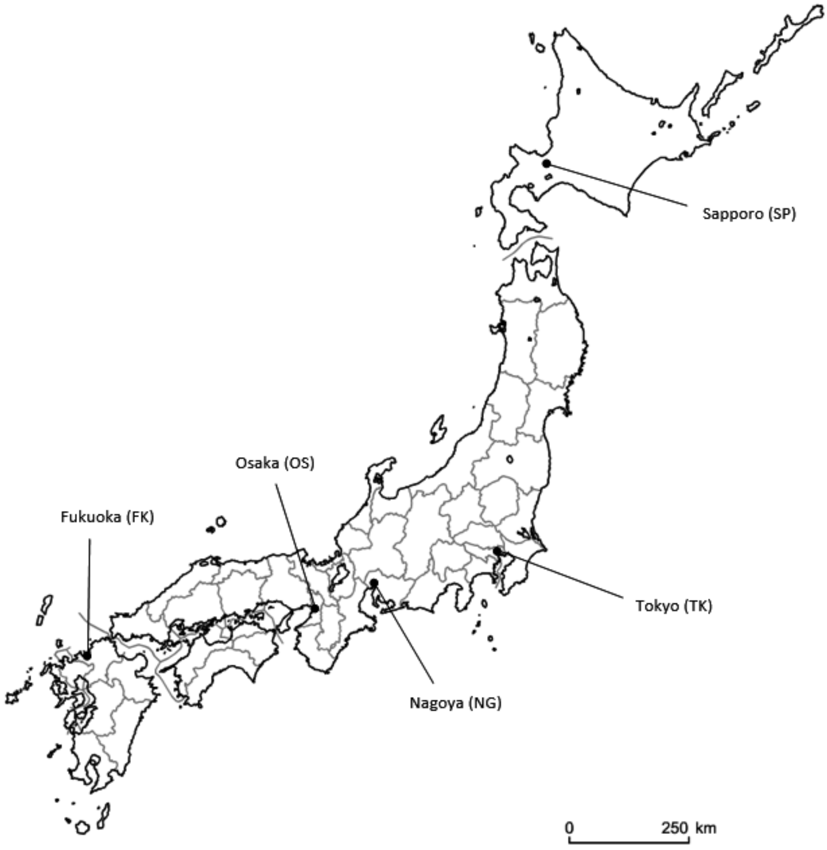

Figure 2 Locations of the five highly populated cities in Japan.

3. Methods

Before determining which tests should be used for identifying the existence of regional market integration among the 10 seafood products, we conducted the Augmented Dickey–Fuller and Phillips–Perron stationarity tests. Table 1 shows the results of these unit root tests. As seen in the table, most of the price series for the regional seafood markets had different order of integration: they were mostly integrated of order zero (I(0)) and some price series were integrated of order one (I(1)). This suggests that conventional cointegration tests such as the Johansen and Juselius (1990) test cannot be used for testing market integration for our price series. An additional shortcoming of the conventional cointegration tests is that they will have low power in detecting market integration when the markets are integrating slowly (Phillips and Sul 2007).

To overcome these shortcomings in the conventional cointegration method and because we are interested in examining how Japanese regional seafood markets are inter-related by identifying the regional clusters, we apply the Phillips–Sul (PS) (2007) convergence test in our study.

The PS test is an alternative approach to test for market integration based on the law of one price (LOP) and the notion of price convergence. In a similar study that applied the PS test to find out whether the LOP held among different markets, Li *et al.* (2010) investigated the market integration for international steam coal products. Unlike the cointegration analysis, which requires the data series to be nonstationary, the PS test does not rely on any particular assumptions of trend stationarity or stochastic nonstationarity. Thus, the test is useful in measuring transition towards a long-run growth path or individual transitions over time relative to some common trend or some representative variable. Another advantage of the PS method is that it also allows us to identify subconvergent groups of regional markets that converge to different equilibriums for every seafood market investigated in the study.

The basic model of the PS test has the following form:

$$P_{it} = g_{it} + a_{it}, \tag{1}$$

where P_{it} is the fish price of a region i in time period t, g_{it} is the systematic component that captures the effect of economic fundamentals on the price of a seafood product in a city, and a_{it} represents a transitory component. a_{it} measures how P_{it} adjusts towards its steady-state level. Phillips and Sul (2007) transform (1) to separate common and idiosyncratic components. Specifically,

$$p_{it} = \left(\frac{g_{it} + a_{it}}{\mu_t}\right)\mu_t = \delta_{it}\mu_t, \text{ for all } i \text{ and } t, \tag{2}$$

where μ_t is a common component that affects the price of a seafood product in all the cities, such as overall (country) demand. δ_{it} is a time-varying idiosyncratic component that measures individual transition effects specific to city i. δ_{it} can be any city-specific variable that might influence the price of a seafood product in city i. It can also be interpreted as a city-specific economic distance between the common variables μ_t and P_{it}.

Following Phillips and Sul (2007), we define convergence (or long-run equilibrium) between two price series as:

$$\lim_{s\to\infty} \frac{p_{it+s}}{p_{jt+s}} = 1, \text{ for all } i \text{ and } j. \tag{3}$$

Considering the convergence among more than two price series, Equation (3) is equivalent to convergence of each individual δ_{it} to a common coefficient:

$$\lim_{s\to\infty} \delta_{it+s} = \delta, \text{ for all } i. \tag{4}$$

Phillips and Sul (2007) model the time-varying factor loadings of Equation (2) in a semi-parametric form as

$$\delta_{it} = \delta_i + \frac{\sigma_i}{L(t)t^{\theta}}\xi_{it},\ t \geq 1,\ \sigma_i > 0\,\text{for all}\,i = 1, \ldots N. \quad (5)$$

where ξ_{it} is assumed to be i.i.d. $N(0, 1)$ across i but weakly dependent over t, and θ is the decay rate, which measures the speed of convergence of δ_{it} to δ_i. The function $L(t)$ is slowly varying and increasing, for example $L(t) = \log(t + 1)$, so that $L(t) \rightarrow \infty$ as $t \rightarrow \infty$.[3] The presence of this function ensures that δ_{it} converges in probability to δ_i as $t \rightarrow \infty$ even when $\theta = 0$. However, if θ is negative, δ_{it} will not converge. As a result, when $\delta_i = \delta$ for all i, the null hypothesis of convergence is the weak inequality constraint $\theta \geq 0$.

Phillips and Sul (2007) propose a procedure to test the null hypothesis of convergence:

$$H_0 : \delta_i = \delta\,\text{and}\,\ \theta \geq 0,$$

against the alternative H_A: $\delta_i \neq \delta$ for all i or $\theta < 0$. To focus on long-term market behaviour, we apply the Hodrick–Prescott filter to the price series to remove any possible business cycle components before performing this convergence test.

In the event that the null of convergence is rejected for the full panel, Phillips and Sul (2007) suggest an algorithm based on repeated regression tests for the identification of convergence subgroups in the full panel. According to Phillips and Sul (2007), when there are convergence subgroups in the panel, the evidence is usually most apparent in the final time-series observations. Therefore, the first step of the algorithm involves the ordering of individuals (cities) in the panel according to the last observation or some time-series average of the last fraction of the sample when there is substantial time-series volatility.

Step two attempts to form a core convergence subgroup. A core group is formed by running the convergence test on the first $k(N > k \geq 2)$ highest individuals. The optimum size of the core group, k^*, is chosen by maximising the t-statistic over k, provided that the null of convergence is not rejected. If the null of convergence is rejected for $k = 2$, then the highest individual can be dropped from each subgroup. This step will be repeated until a core group is formed. If no core group can be formed for all the sequential pairs, then there is no convergence subgroup in the panel.

Step three selects members of the convergence club, which is comprised of the core group and some other individuals in the panel. After the core group is formed, the remaining individuals in the panel are added to the core group one at a time and a convergence t-test is performed. The individual will be included in the club if the t-statistic is larger than a chosen critical value. After

[3] 'Slowly varying and increasing' means the value of the function increases much slower than t.

Table 1 Unit root tests

	TK		OS		NG		SP		FK	
	ADF	PP	ADF	PP	ADF	PP	ADF	PP	ADF	PP
Level										
Horse mackerel	−4.2514***	−7.2962***	−0.8165	−5.5515***	−4.4481***	−7.0908***	−7.8921***	−7.9207***	−8.1922***	−8.1720***
Shortnecked clams	−4.2710***	−4.2180***	−5.6618***	−5.5903***	−3.6982**	−7.5497***	−7.0002***	−7.2115***	−5.2184***	−7.2359***
Yellowtail	−4.2934***	−4.5332***	−4.1753***	−4.2935***	−5.7840***	−5.7089***	−2.7320	−2.4420	−2.5139	−3.0884
Scallops	−1.9805	−2.2938	−6.5269***	−6.5012***	−3.3138	−5.3755***	−6.2882***	−6.3861***	−7.8916***	−7.8977***
Cuttlefish/squid	−1.7777	−5.6124***	−1.9400	−5.6505***	−6.4615***	−5.6329***	−6.2890***	−8.2080***	−6.2472***	−5.9273***
Flounder	−2.1733	−6.8672***	−5.7856***	−5.8640***	−2.5578	−7.6979***	−1.9763	−7.3895***	−5.7609***	−5.6224***
Tuna	−2.4421	−2.3823	−1.4597	−1.7447	−5.5981***	−5.4906***	−6.6621***	−6.5010***	−3.6738**	−3.5195**
Mackerel	−1.9896	−5.0835***	−5.7123***	−5.6960***	−6.1396***	−6.2363***	−5.8857***	−5.9804***	−6.8466***	−7.9694***
Saury	−7.8308***	−7.2934***	−4.7641***	−6.9758***	−7.4253***	−7.4795***	−7.1652***	−6.9668***	−4.5897***	−4.5283***
Octopus	−1.9428	−1.5545	−2.9016	−2.5836	−1.9058	−2.9502	−3.9468**	−3.6328**	−1.8624	−2.8525
1st difference										
Horse mackerel	−9.1176***	−17.692***	−5.5264***	−17.2606***	−9.9099***	−22.79***	−13.169***	−19.76***	−7.1442***	−20.353***
Shortnecked clams	−10.2340***	−15.5009***	−7.4285***	−16.3963***	−7.3237***	−23.27***	−4.807***	−14.937***	−9.6191***	−20.728***
Yellowtail	−4.4302***	−12.5989***	−7.6220***	−13.2780***	−10.4658***	−15.5038***	−11.7929***	−14.9544***	−11.6935***	−15.2609***
Scallops	−16.4743***	−16.8288***	−7.0145***	−18.6820***	−13.836***	−19.8001***	−17.1990***	−17.4871***	−9.1349***	−19.615***
Cuttlefish/squid	−6.9112***	−10.5159***	−4.6803***	−12.9896***	−11.105***	−12.674***	−5.243***	−20.496***	−10.957***	−13.1***
Flounder	−4.2547***	−14.625***	−7.8489***	−15.91***	−6.3537***	−15.585***	−3.6479**	−11.713***	−4.8331***	−16.938***
Tuna	−13.903***	−14.057***	−17.36***	−17.593***	−12.426***	−16.19***	−13.559***	−20.237***	−14.93***	−15.254***
Mackerel	−8.8444***	−15.998***	−7.8817***	−17.824***	−8.7555***	−16.587***	−7.7305***	−15.838***	−8.6343***	−17.897***
Saury	−13.404***	−14.213***	−4.858***	−14.154***	−4.2259***	−15.279***	−5.2431***	−14.647***	−13.867***	−14.139***
Octopus	−5.5807***	−14.728***	−17.049***	−17.39**	−13.772***	−18.673***	−16.405***	−17.048***	−12.675***	−19.058***

Note: ADF = Augmented Dickey–Fuller; PP = Phillips–Perron. TK, OS, NG, SP, and FK denote Tokyo, Osaka, Nagoya, Sapporo, and Fukuoka. The tests are conducted with constant and trends. *** and ** denote rejection of the convergence hypothesis at 1% and 5% significance levels.

the club membership is determined, a convergence t-test should be performed for the club to ensure that it is a convergence subgroup.

In the final step, a convergence t-test can be performed for the individuals who do not belong to the above convergence subgroup to see whether this cluster converges. If convergence is found, there are two convergence subgroups in the panel. Otherwise, steps two and three can be repeated to determine whether there is a smaller convergence subgroup in this cluster.

After conducting the PS test, we also performed the Toda and Yamamoto (1995) modified Granger causality test to identify the short-run price relationships among the 10 regional markets. Sims *et al.* (1990) suggest that the results of causality tests become spurious when the variables used in the causality test are nonstationary, but the Toda and Yamamoto's method overcomes this problem. According to Toda and Yamamoto (1995), differencing of the price series to make the series stationary is not necessary for the estimation of the vector autoregressive (VAR) model in their causality test. Causality is tested using $k + d$ lags in the VAR model, where k is the statistically optimal lag order in the VAR model and d is the maximal order of integration that is suspected to exist in the price series. The optimal lag order is identified by the Schwartz information criteria.

4. Empirical results

4.1. Convergence t-test

Table 2 shows the results of the overall convergence test. The table reports the test statistics for the log t-test calculated with heteroscedasticity-and-autocorrelation-consistent standard error with $r = 0.3$. The 1 per cent and 5 per cent critical values for the left-tail t-test are approximately -2.326 and -1.645, respectively. The null hypothesis of overall convergence is not

Table 2 Overall convergence

Species	t-stat
Short-necked clams	15.557
Yellowtail	14.365
Octopus	2.749
Horse mackerel	−3.718***
Scallops	−3.888***
Cuttlefish/squid	−1.833**
Flounder	−85.193***
Tuna	−13.740***
Mackerel	−29.245***
Saury	−11.093***

*** and ** denote rejection of the convergence hypothesis at 1% and 5% significance levels.

rejected for short-necked clams, yellowtail, and octopus. Therefore, there is evidence of market integration for these three seafood products across Japan. This implies that there is a nationwide integrated market for these species and that these products likely share price information among different regions of Japan. Short-necked clams, yellowtail, and octopus are all products measured per 100 g and are comparatively standardised throughout Japan. The specification of the price unit for these products is similar among different regions. It is plausible that this high level of standardisation is why these markets showed overall convergence.

In contrast, the null hypothesis is rejected for horse mackerel, scallops, flounder, tuna, mackerel, and saury at 1 per cent significance and for cuttlefish/squid at 5 per cent significance. The rejection of overall convergence does not imply that there is no convergence among the Japanese regional seafood markets, and there are still possibilities for these regional seafood markets to be separated into subconvergent groups. However, the results for the overall convergence test imply that for the above-mentioned seven seafood products, the Japanese regional seafood markets are not integrated as a whole and that nationwide marketing policy is not possible for these seafood products. This implies that any policy or marketing strategy to affect or control regional seafood markets needs to consider the peculiar characteristics of the region, such as regional economic growth, distance to the major production regions, consumer preferences of the region, and so on.

Next, we investigate the existence of subconvergent groups in the panel employing the convergence subgroup identification algorithm outlined in the previous section. Table 3 displays the results of the club convergence tests. Up to two convergence subgroups are found for each species. For scallops and cuttlefish/squid, TK, OS, NG, and FK form a convergence group, while the prices of SP appear to be driven by a different system or mechanism. TK, OS, and NG are the three most populated cities among the five cities examined in this study, so convergence for the scallops and cuttlefish/squid prices among these three cities means that scallops and cuttlefish/squid markets are relatively integrated. For horse mackerel and saury, OS, NG,

Table 3 Club convergence test

Species	Subgroup 1	Subgroup 2	Not converge
Horse mackerel	OS, NG, FK	TK, SP	na
Scallops	TK, OS, NG, FK	na	SP
Cuttlefish/squid	TK, OS, NG, FK	na	SP
Flounder	TK, OS, FK	na	NG, SP
Tuna	TK, SP	na	NG, OS, FK
Mackerel	OS, NG	TK, SP	FK
Saury	OS, NG, FK	TK, SP	na

Note: TK, OS, NG, SP, and FK denote Tokyo, Osaka, Nagoya, Sapporo, and Fukuoka.

and FK form the first convergence subgroup, while TK and SP form the other. The results for mackerel are similar to those of horse mackerel and saury. The only difference is that Fukuoka does not belong to any convergence subgroup. Among the five regions examined in this study, OS, NG, and Fukuoka are in western Japan, while TK and SP are located in the east, so it could be that this geographical spread has separated the markets for these fish species into two subgroups shown in Table 3. For flounder, only TK, OS, and FK converge, with no other subconvergence group, and prices for NG and SP each follow a different price trend. Because there was only one convergence group for flounder, the flounder market is relatively independent among different regions and price information for this market is more affected by regional supply and demand factors.

Finally, for tuna, only TK and SP converge, which suggests that the regional prices move independently and the tuna market has a lower level of regional market integration. This result might be due to the limitations of the survey data. The tuna prices in the survey data contained both the prices of yellowfin and bigeye tuna, assuming that the substitution level between these tuna is high. However, it could be that this mixture of the two tuna species in one tuna price series lowered the level of market integration among the five regional tuna markets.

4.2. Granger causality tests

As shown in Table 1, there is a mix of I(0) and I(1) prices in our data set. Therefore, the Granger causality tests are all conducted with the maximum order of integration of one (I(1)). The null hypothesis of the tests is that there is no Granger causality from one variable to another. The multivariate Granger causality results for the species in which overall price convergence is found are presented in Table 4. The numbers reported in the table are the *P*-values.

From Table 4, it is apparent that for all three seafood markets, there is a Granger causality from TK to either OS or NG. This suggests that price signals flow from Japan's largest market, the TK market, to either OS or NG for these seafood products. However, for all three seafood products, there are also price leaderships from other markets. NG leads TK in the short-necked clams and octopus markets, and OS leads TK in the yellowtail and octopus markets. It is likely that these differences in the price leaderships among different seafood products reflect differences in consumption behaviour among the regional markets. There are causalities in both directions between TK and NG for short-necked clams and octopus. The causality test between TK and OS for yellowtail also reveals price relationships in both directions. This implies that for these seafood products, price information is not entirely centralised in the TK market and other regional markets also have the power to lead other markets for transmitting price information. Hence, during the price discovery process for these seafood markets, the TK market is not the

Table 4 Granger causality test for seafood market where overall convergence is found

From/to	TK	OS	NG	SP	FK
Short-necked clams					
TK	na	0.0016***	0.0476**	0.0163***	0.0024***
OS	0.2191	na	0.9160	0.3029	0.5731
NG	0.0498**	0.0078***	na	0.3866	0.7101
SP	0.3584	0.1509	0.2504	na	0.0672*
FK	0.3315	0.1956	0.2967	0.5893	na
Yellowtail					
TK	na	0.0014***	0.1402	0.1788	0.5675
OS	0.0012***	na	0.0161**	0.1962	0.4793
NG	0.0943*	0.0595*	na	0.9917	0.7978
SP	0.7225	0.0336**	0.9843	na	0.3977
FK	0.5133	0.0568*	0.0157**	0.2336	na
Octopus					
TK	na	0.5418	0.0004***	0.0001***	0.2368
OS	0.0283**	na	0.1878	0.4353	0.7085
NG	0.0129**	0.0472**	na	0.1625	0.6668
SP	0.7620	0.0696*	0.0036***	na	0.7936
FK	0.5872	0.3644	0.0352**	0.1212	na

Notes: TK, OS, NG, SP, and FK denote Tokyo, Osaka, Nagoya, Sapporo, and Fukuoka. The values in the table represent the *P*-values. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

only reliable source for a reference price, and market participants in these markets need to also pay attention to prices of other regional markets.

For the species with subgroup convergence, one set of Granger causality tests are conducted for each subgroup. The results are presented in Table 5. For scallops and cuttlefish/squid markets, we find price information flow from all five cities. This indicates that although TK, OS, and NG are the three largest cities among the five examined in this study, they are not the only markets to transmit price information. For the horse mackerel, saury, and mackerel markets, we performed multivariate Granger causality tests for each subgroup, because our result of the club convergence test indicated that there are two subconvergence groups for these seafood products. As seen in Table 5, for the horse mackerel and saury markets, all three cities in the first subgroup have price leaderships, while no price leaderships sustain from TK to SP for the second subgroup. For the mackerel market, NG leads OS and SP leads TK for transmitting price information. These results also imply that price information flow is not centralised in the three large cities TK, OS, and NG. From the result of the Granger causality test for flounder, no causalities were found between the two large cities, TK and OS, and we found only price leaderships from Fukuoka to these two cities. This result again suggests that the large cities of the mainland (Honshu) do not exhibit price leadership for the flounder market. Finally, for the tuna market, we find an information flow from TK to SP, which indicates that TK leads SP for its information processing. Thus, for the tuna market, TK does have the central role in transmitting price information.

Table 5 Granger causality tests among the subgroups identified by the convergence test

Horse mackerel

From/to	TK	OS	NG	SP	FK
TK	na	na	na	0.4183	na
OS	na	na	0.0356**	na	0.0534*
NG	na	0.2822	na	na	0.0043***
SP	0.5228	na	na	na	na
FK	na	0.0473**	0.5595	na	na

Scallops

From/to	TK	OS	NG	FK
TK	na	0.0386**	0.8513	0.0293**
OS	0.2641	na	0.0999*	0.8879
NG	0.8521	0.0189**	na	0.3369
FK	0.6953	0.5579	0.0383**	na

Saury

From/to	TK	OS	NG	SP	FK
TK	na	na	na	0.1192	na
OS	na	na	0.0320**	na	0.6507
NG	na	0.0088***	na	na	0.0004***
SP	0.0325**	na	na	na	na
FK	na	0.149	0.0017***	na	na

Mackerel

From/to	TK	OS	NG	SP
TK	na	na	na	0.5685
OS	na	na	0.2094	na
NG	na	0.0178**	na	na
SP	0.005***	na	na	na

Cuttlefish/squid

From/to	TK	OS	NG	FK
TK	na	0.5044	0.2842	0.0152**
OS	0.0285**	na	0.051*	0.7677
NG	0.0094***	0.0247**	na	0.1072
FK	0.0001***	0.3597	0.0098***	na

Flounder

From/to	TK	OS	FK
TK	na	0.7238	0.2726
OS	0.6207	na	0.3371
FK	0.0385**	0.0072***	na

Tuna

From/to	TK	SP
TK	na	0.0441**
SP	0.2897	na

Note: TK, OS, NG, SP, and FK denote Tokyo, Osaka, Nagoya, Sapporo, and Fukuoka. The values in the table represent the *P*-values. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

5. Conclusions

In this paper, we investigated the convergence and integration of five Japanese regional retail seafood markets for 10 different seafood products to find out whether the Japanese regional seafood markets are integrated. We also tested whether regional seafood markets have inter-relationships. We found from the convergence test that the short-necked clam, yellowtail, and octopus markets have higher levels of market integration. The test also showed that the scallop and cuttlefish/squid markets are relatively integrated. From the results for the horse mackerel, mackerel, and saury markets, we showed that although these markets are not integrated at the national level, these markets can be separated into two subgroups by their geographical locations. Finally, we found a lower level of market integration for the flounder and tuna markets. From the causality tests, except for the tuna market, we find that in most seafood markets, regional markets other than the TK, OS, and NG also exhibit price leadership. This indicates that for most of the seafood markets investigated in this study, price information flow is not centralised in TK, OS, and NG and that regional markets have their own power to transmit price information.

Our study suggests that some seafood markets are relatively integrated but that there are still seafood markets that have lower level of market integration, such as the flounder and tuna markets. Thus, although it is becoming easier to transport seafood products to distant areas because of improvements in freezing and storing technology, differences among the regional markets still remain for some of the most commonly consumed seafood products in Japan. Hayashi (2011) found that in the 2000s, there were differences in consumer preferences for seafood products among different regions in Japan, based on consumption data. We believe that the results of our study reflect different characteristics of consumption among different regions in Japan and revealed the existence of regional differences for certain seafood products. Hence, seafood distributers or policymakers that are involved in seafood markets with lower levels of market integration need to consider the peculiar characteristics of the regional seafood markets when building effective marketing strategies.

For practical purposes, our study will help suppliers involved in the Japanese seafood markets understand which seafood products will likely move differently among different regions and which regional prices inter-relate to other regional markets. It also provides valuable information for policymakers seeking to create effective distribution policies to amplify the market area for seafood products that are only consumed in regional markets.

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