【Articles】

β- and σ-Convergence of Regional Prices in Consumer Markets in Japan

日本における消費財地域価格の β 収束と σ 収束

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Contents

(Abstract)

This study examines β- and σ-convergence of prices in the regional Japanese consumer markets over the last two decades. While there have already been studies on convergence of regional prices within a single country, the approach widely adopted is the investigation of unit-root in the price differentials between regions. Instead, this study directly applies tests of β- and σ-convergence to the issue. More than forty consumer items, including both goods and services, were selected on the basis of the purchase frequency of households and the weights of the Consumer Price Index, and the analysis utilizes their retail prices in the forty-seven prefectural capitals in Japan. Tests are executed using rolling regressions to capture temporal evolution of the extent of convergence. Goods and services indicate differing results. Services are less likely to β-converge than goods. On the other hand, the results from σ-convergence tests are different. Goods are less likely to σ-converge than services over the substantial portion of the investigated period. With sample periods covering the COVID-19 pandemic, failures of β- and σ-convergence remained at high levels, but the failures decreased shortly thereafter. The effects were transient. Finally, while the idea that a high inflation rate is associated with a large relative price variability has been widely discussed, statistical works in this study do not support it.

β- and σ-Convergence of Regional Prices in Consumer Markets in Japan

Keywords: regional price, Law of One Price, β-convergence, σ-convergence, Japanese consumer markets

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1. Introduction

This study examines β- and σ-convergence of prices in the regional Japanese consumer markets over the last two decades. The long-run movement of the Consumer Price Index (CPI) indicates that the regional price levels have diverged during some periods even after 2000. This study aims to provide detailed views of convergence (or divergence) of the regional prices in the Japanese consumer markets, using retail prices rather than price indexes. The investigated items are classified into goods and services, and they are analyzed from the point of view of the distinction between goods and services as well as the distinction of β- and σ-convergence.

There have already been many studies on convergence of regional prices within a single country. The basic issue behind these studies is investigation of how strongly regional markets are integrated within a single country. If the regional markets are integrated, then the Law of One Price dictates that a price differential between regions eventually disappears. If a price differential between regions remains even in the long run, then it is interpreted that the regional markets are segmented. Parsley and Wei (1996) and Cecchetti et al. (2002) are the most prominent seminal studies in this area, both of which investigate the US case. There have also been studies on the Japanese case. Among them are Kano et al.(2013) and Ikeno (2014a, 2014b). While there are a few different approaches to the issue in this area, the one widely adopted is the investigation of unit-root in the price differentials. When a unit-root is found, it is concluded that the price differential between two regions does not converge. When a unit-root is not found, then it is concluded that the price differential shrinks over a long run and, eventually, disappears.

Over the past few decades, several concepts of convergence have been proposed in economics, and they are widely utilized in research of economics, producing prominent results. In particular, they are widely used in the analysis of international and inter-regional comparison of income.[1] β- and σ-convergence are among representative concepts of convergence. There are some previous studies which apply these concepts of convergence to investigation of inter-regional price differentials, but they are relatively few compared to those using the unit-root approach. For example, Halka and Leszczynska-Paczesna (2019) analyze the price convergence in the European Union, using concepts of β- and σ-convergence.

The current study applies the concepts of β- and σ-convergence to the inter-regional price differentials in Japan.[2] Utilizing these concepts is expected to yield insights that the unit-

root approach does not provide. First, as previously noted, "convergence" is characterized by multiple definitions, whereas the unit-root approach corresponds just to one of them. For greater robustness, it is highly desirable to examine the issue based on alternative definitions. Second, when combined with rolling regressions, β- and σ-convergence provide a detailed account of the temporal evolution of convergence.

The traditional notion of dichotomy between goods and services in regard to the integration of markets claims integration of regional markets of goods but segmentation in markets of services, although this notion is affected by the recent development of internet markets. Goods, which are typically regarded as being tradable between locations, form an integrated market, and services, which are typically regarded as being nontradable between locations, fail to do so. This study takes account of this point.

Figure 1 shows the variance of the "regional difference index of consumer prices" of the Japanese forty-seven prefectural capitals over the past seventy years.[3)] They are based on "general" and "foods" indexes. It indicates that dispersions of regional prices exhibit upward and downward movements even after 2000. Moreover, the general index and the foods index do not always share a similar movement. Their movements are worth being investigated in details.

This study uses the monthly data of retail prices of consumer goods and services in prefectural capital cities in Japan since 2000, which are from the *Retail Price Survey* of the Statistics Bureau. Based on the weights in the CPI and the frequencies of purchase of households, more than forty consumer items were selected. The tests are executed in order to examine β- and σ-convergence. The convergence tests are executed over various sub-sample periods by rolling regressions. They provide detailed views about periods of convergence and divergence. The results indicate that many items exhibit divergence over substantial periods,

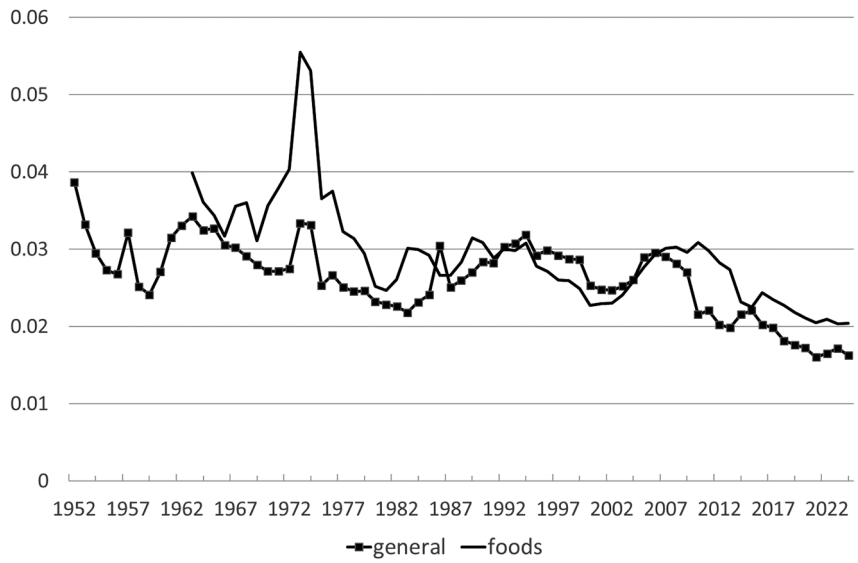

Figure 1. Variance of Regional Difference Index of Consumer Prices annual data

and goods and services exhibit different patterns of convergence.

The rest of this paper is organized as follows. Section 2 explains the methodology used in this study. Section 3 describes the data. Sections 4 and 5 perform tests of β- and σ-convergence, respectively. Section 6 investigates the relation between the convergence and the change rate of prices. Finally, concluding remarks are given in Section 7.

2. Methodology

This paper conducts empirical tests to examine two types of convergence: β-convergence and σ-convergence. Both concepts of convergence are widely used in economics, especially in research of income levels.

The current study examines absolute β-convergence, which is defined as a negative relation between the initial level and the change rate over the following period. In this study, it is tested by regression of the following equation over prefectural capitals;

$$\ln\left(\frac{p_{i,T}}{p_{i,t0}}\right)\frac{1}{T-t_0} = a + b\,\ln(p_{i,t_0}) + \varepsilon_i\,,\ i = 1,\cdots,I$$

where $p_{i,t0}$ is the price level in city i at the initial time t_0, $p_{i,T}$ is the price level in city i at the end of the sample period T, ε_i is an error term, and I is the number of cities under consideration. The parameter b is estimated, and the significance is tested using a one-sided t- test. If it is significantly negative, β-convergence of regional prices is concluded. The equation is tested for each of the investigated items.

In this study, the lengths of the period between t_0 and T are set to thirty-six and sixty months, i.e., three and five years, respectively.[4)] Rolling regressions are performed. The regressions are executed over the entire period during which data is available. That is, t_0 moves from the initial time of the data-available period to either thirty-six or sixty months prior to the end of the data-available period. This procedure reveals temporal evolution of convergence (or divergence), and it is also expected to mitigate the problem that results of the tests crucially depend on the start of the sample period.

σ-convergence represents the idea that the dispersion diminishes over time. This study uses the weak σ-convergence test, which was recently developed by Kong et al. (2019). The test is based on the following equation.

$$K_t = \hat{a}_T + \hat{\phi}_T t + \hat{u}_t\,,\ t = 1,\cdots,T$$

where $K_t = \frac{1}{I}\sum_{i=1}^{I}(p_{it} - \overline{p}_t)^2 / \overline{p}_t^2$, $p_{i,t}$ is the price level in city i at time t, $\overline{p}_t \equiv \frac{1}{I}\sum_{i=1}^{I} p_{i,t}$, I is the number of cities under consideration, and $\hat{u}_t$ is an error term.

A one-sided t-test is conducted to assess whether the slope coefficient $\hat{\phi}_T$ is significantly negative, using a Newey-West estimator of the variance. In the significantly negative case, weak σ-convergence is concluded. In the current study, weak σ-convergence is simply called

"σ-convergence" for brevity. With the Newey-West estimate, the lag truncation L is commonly set for estimation of the variance as follows.

$$L = [T^{1/3}]$$

One-sided critical values from the standard normal distribution $\mathcal{N}(0,1)$ are used in testing to detect the convergence.

In this study, when $\hat{\phi}_T$ is significantly negative, then it is interpreted that the regional prices σ-converge. The procedure of rolling regressions follows the one used in the β-convergence tests. The sample period is set to thirty-six and sixty months, and the test is executed by rolling regressions over the entire data-available period.

3. Data

The following statistical works use retail prices of goods and services, not price indexes. For the purpose of this study, it is necessary to compare absolute price levels in multiple cities. Price indexes that can be used for inter-regional comparison of absolute price levels are quite limited in Japan. The Statistics Bureau compiles the "regional difference index of consumer prices" for inter-regional comparison of price levels, but it is compiled only annually and contains only "general" and "foods" indexes.

For the statistical works, this study uses series from the *Retail Price Survey* of the Statistics Bureau. It contains monthly series of retail prices of more than five hundred items, from which the CPI is compiled. Price series in the 47 prefectural capitals are used. The items investigated here in the following statistical works are selected as follows:

(1) The items should be purchased frequently by households.
(2) The items should have a nonnegligible share in the composition of the CPI.
(3) The list of items should cover a wide range of items. All items covered by the CPI are broken down into fifteen groups, including "food products", "textiles", "petroleum products", "meals outside the home", and others. The list should cover as many groups as possible. It should also cover both goods and services.
(4) The items should not contain many missing observations.
(5) Prices of some items in the CPI list are the same nationwide or across several prefectures, such as postal fees and cell phone fees. The prices of some items are regulated by the government, such as medical fees. They are excluded.

The Statistics Bureau provides detailed information on items from which the CPI is compiled.[5] The following information is included: the share of individual items in the CPI, typical frequencies of purchases of individual items, and the classification of goods and services. If three consecutive observations are missing for any item, that series is not chosen. If only one or two observations are missing, they are complemented by a linear interpolation. Fortunately, the interpolation was rarely needed. The sample period is basically from January 2000 to March 2025. The start and end are adjusted in some cases because of missing or inadequate

observations.

Thirty items of goods and twelve items of service are eventually selected for statistical works in this study, and they are shown in the list in the Appendix, with the sample period and the number of covered cities. The items are also classified into goods and services.

4. Results of β-convergence

β-convergence tests are executed for each item over all periods during which data is available. The start of the first regression is the start of the data-available period, and the start of the last regression is either thirty-six or sixty months prior to the end of the data-available period since each β-convergence test is executed over thirty-six and sixty months.

Tables 1 and 2 indicate the proportions of failure to reject the null hypothesis that b is positive at the five-percent significance level, i.e., the proportions of failure of β-convergence, in all executed regressions for each item over the thirty-six and sixty months, respectively. For instance, in the case of "rice", the data is available from January 2000 to March 2025, and β-convergence over thirty-six months is tested over 267 subsample periods by the rolling

Table 1. Proportions of failure of β-convergence over thirty-six months

Goods

1. rice	2. white bread	3. cupnoodle	4. tuna	5. salmon	6. fish cake	7. pork
15.4%	31.5%	3.9%	11.6%	6.4%	4.9%	15.0%

8. chicken	9. sausage	10. milk	11. yogurt	12. eggs	13. cabbages	14. onions
13.9%	6.4%	37.1%	1.5%	3.4%	6.7%	8.6%

15. tomatoes	16. tofu	17. bananas	18. cooking oil	19. chocolate	20. ice cream	21. tea drink
5.6%	56.2%	2.6%	2.2%	7.4%	24.0%	3.9%

22. beer	23. kerosene	24. bathroom paper	25. detergent	26. men's shirts	27. ladies' underwear	28. ladies' shoes
1.5%	24.7%	2.6%	7.5%	27.3%	18.9%	33.7%

29. gasoline	30. notebook
22.8%	23.2%

Services

1. ramen	2. sushi	3. Japanese barbeque	4. rent	5. laundry of men's shirts	6. car maintenance fee	7. garage fee
47.2%	14.2%	55.6%	58.1%	29.6%	36.3%	52.1%

8. tutoring school fee	9. gym fee	10. veterinary fee	11. hair dressing	12. ladies' hair cut
24.3%	58.5%	44.6%	68.2%	59.2%

Table 2. Proportions of failure of β-convergence over sixty months

Goods

1. rice	2. white bread	3. cupnoodle	4. tuna	5. salmon	6. fish cake	7. pork
7.4%	23.9%	0.4%	4.9%	44.4%	0.0%	5.3%

8. chicken	9. sausage	10. milk	11. yogurt	12. eggs	13. cabbages	14. onions
5.8%	0.8%	18.1%	2.1%	0.8%	3.7%	5.3%

15. tomatoes	16. tofu	17. bananas	18. cooking oil	19. chocolate	20. ice cream	21. tea drink
2.1%	40.3%	0.4%	0.4%	3.7%	21.4%	4.9%

22. beer	23. kerosene	24. bathroom paper	25. detergent	26. men's shirts	27. ladies' underwear	28. ladies' shoes
0.0%	25.9%	0.0%	3.7%	26.3%	15.3%	33.7%

29. gasoline	30. notebook
23.5%	7.0%

Services

1. ramen	2. sushi	3. Japanese barbeque	4. rent	5. laundry of men's shirts	6. car maintenance fee	7. garage fee
32.9%	0.8%	35.0%	54.3%	19.8%	13.6%	15.6%

8. tutoring school fee	9. gym fee	10. veterinary fee	11. hair dressing	12. ladies' hair cut
10.7%	42.1%	33.3%	56.8%	44.4%

regressions. Since β-convergence fails to be rejected over 41 subsample periods, the proportion is 41/267, i.e., 15.4%.

Tables 3 and 4 summarize the results presented in Tables 1 and 2 on the basis of goods and services. Tables 1 and 2 show that the proportions of the failure are either zero or almost zero for many items. On the other hand, some items indicate a high proportion such as "tofu", "ramen" and "rent". They frequently fail to β-convergence during the data-available period. Tables 3 and 4 show that services indicate a higher proportion of the failure of *β*-convergence than goods do in both cases of thirty-six and sixty months. These results are compatible with the traditional notion of the dichotomy between goods and services; integration of regional markets of goods and segmentation in markets of services. Tables 3 and 4 also show that the proportions of failure are generally lower over sixty months than over thirty-six months, implying that β-convergence is more likely to be fulfilled as the period becomes longer.

Figures 2 and 3 illustrate temporal changes in the proportion of the items failing to exhibit β-convergence on the basis of all items, goods, and services for the windows of thirty-six and sixty months, respectively. The horizontal axis corresponds to the start of individual regressions. An overall view indicates that the proportion of services is higher than that of

Table 3. Number of items with a higher proportion of failure of β-convergence over thirty-six months

	goods	services	total
total items in the group	30	12	42
Larger than 10%	14	12	26
share in total items	46.7%	100.0%	61.9%
Larger than 20%	9	11	20
share in total items	30.0%	91.7%	47.6%

Table 4. Number of items with a higher proportion of failure of β-convergence over sixty months

	goods	services	total
total items in the group	30	12	42
Larger than 10%	9	11	20
share in total items	30.0%	91.7%	47.6%
Larger than 20%	7	7	14
share in total items	23.3%	58.3%	33.3%

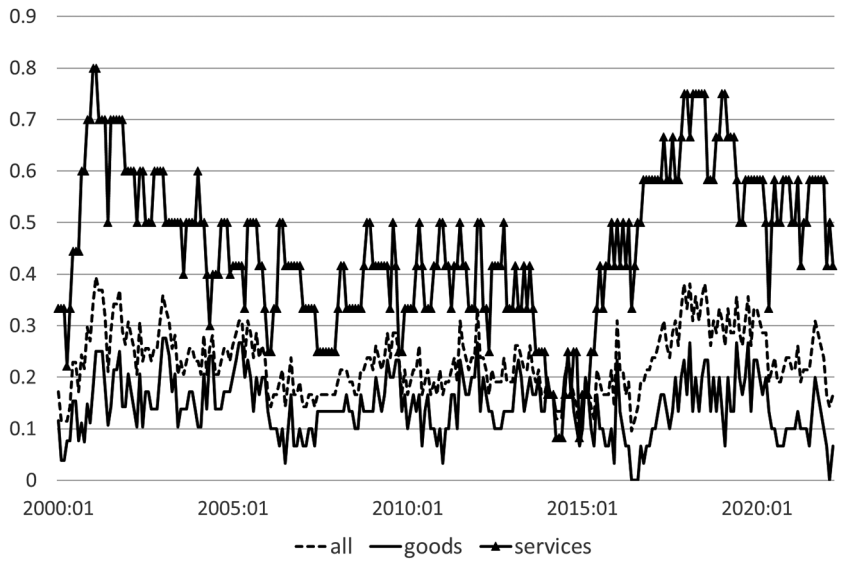

Figure 2. Proportion of failure of β-convergence of thirty-six months

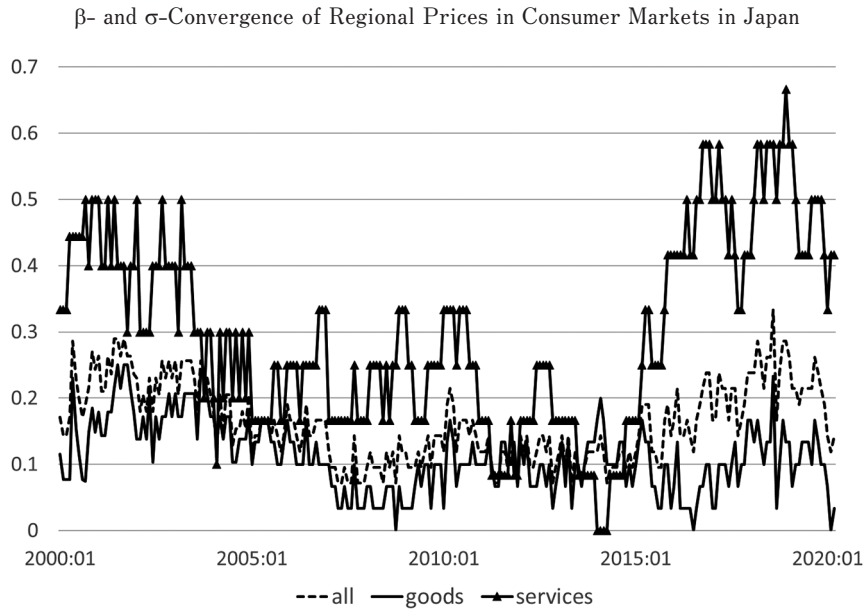

Figure 3. Proportion of failure of β-convergence of sixty months

goods over the most part of the period, which is consistent with what Tables 1 and 2 indicate. Figure 2 shows that the proportion of services started to rise shortly after 2015, and that of goods started in early 2017. Both peaked before 2020. Considering that each convergence test covers thirty-six months, i.e., three years, it is interpreted that the failure of the convergence of services started before the onset of the Covid-19 pandemic in Japan, i.e., early 2020, and it continued to rise after the pandemic started to affect the Japanese society. The failure of goods started to rise when the pandemic started to do so. On the other hand, the failure of goods and services declined rather quickly afterwards. Figure 3 shows that the failure of services started to rise in early 2015, and those of goods started to rise in the middle of 2016. Both peaked in 2018 and 2019. It is interpreted that the failures were at high levels over the periods covering the start of the pandemic, but they started to lower rather quickly when the pandemic once settled down.

5. Results of σ-convergence

The σ-convergence tests are executed following the procedure similar to that used for β-convergence tests. The weak σ- convergence tests are executed on each item over all periods during which data are available. The start of the first regression is the start of the data-available period, and the start of the last regression is either thirty-six or sixty months prior to the end of the data-available period.

Tables 5 and 6 indicate the proportions of failure to reject the null hypothesis that $\hat{\phi}_T$ is positive at the five-percent significance level, i.e., the proportion of failure of σ-convergence, in all executed regressions for each item for the period of thirty-six and sixty months, respec-

Table 5. Proportions of failure of σ-convergence over thirty-six months in the whole sample period

Goods

1. rice	2. white bread	3. cupnoodle	4. tuna	5. salmon	6. fish cake	7. pork
53.4%	71.7%	49.8%	53.9%	55.7%	45.7%	66.7%

8. chicken	9. sausage	10. milk	11. yogurt	12. eggs	13. cabbages	14. onions
63.5%	63.9%	82.2%	26.0%	82.6%	79.0%	66.2%

15. tomatoes	16. tofu	17. bananas	18. cooking oil	19. chocolate	20. ice cream	21. tea drink
77.2%	85.4%	53.4%	47.9%	74.9%	77.2%	44.0%

22. beer	23. kerosene	24. bathroom paper	25. detergent	26. men's shirts	27. ladies' underwear	28. ladies' shoes
34.2%	53.9%	38.8%	54.8%	73.1%	56.4%	79.9%

29. gasoline	30. notebook
65.8%	73.1%

Services

1. ramen	2. sushi	3. Japanese barbeque	4. rent	5. laundry of men's shirts	6. car maintenance fee	7. garage fee
59.8%	56.2%	65.4%	50.2%	54.8%	45.5%	40.6%

8. tutoring school fee	9. gym fee	10. veterinary fee	11. hair dressing	12. ladies' hair cut
38.4%	58.5%	53.0%	70.3%	55.3%

tively. The results demonstrate that the proportion of failure of σ-convergence is substantial for all items. They show that none of the items exhibits a proportion of zero or almost zero. Even goods indicate high proportions when compared to the case of β-convergence. Failure of σ-convergence is pervasive among both goods and services.

Figures 4 and 5 show temporal changes in the proportions of the items showing the failure of σ-convergence over thirty-six and sixty months on the basis of all items, goods, and services. The horizontal axis corresponds to the start of individual regressions. An overall view indicates that the proportion of services is often lower than that of goods. They also show that the proportions of both goods and services started to rise in 2015 and remained at high levels during the periods covering the start of the pandemic. They started to reduce in 2020. Again, the failure remained at a high level during the periods covering the onset of the pandemic, but it gradually declined afterwards.

Table 6. Proportion of failure of σ-convergence over sixty months in the whole sample period

Goods

1. rice	2. white bread	3. cupnoodle	4. tuna	5. salmon	6. fish cake	7. pork
48.9%	65.8%	31.4%	52.5%	42.9%	46.6%	69.4%

8. chicken	9. sausage	10. milk	11. yogurt	12. eggs	13. cabbages	14. onions
63.0%	51.1%	100.0%	30.6%	75.8%	74.0%	57.5%

15. tomatoes	16. tofu	17. bananas	18. cooking oil	19. chocolate	20. ice cream	21. tea drink
77.6%	80.8%	61.6%	50.2%	66.7%	71.2%	54.7%

22. beer	23. kerosene	24. bathroom paper	25. detergent	26. men's shirts	27. ladies' underwear	28. ladies' shoes
48.9%	48.9%	30.6%	60.7%	71.7%	47.4%	77.2%

29. gasoline	30. notebook
58.4%	82.6%

Services

1. ramen	2. sushi	3. Japanese barbeque	4. rent	5. laundry of men's shirts	6. car maintenance fee	7. garage fee
40.6%	55.7%	61.6%	53.0%	58.4%	38.4%	33.8%

8. tutoring school fee	9. gym fee	10. veterinary fee	11. hair dressing	12. ladies' hair cut
39.7%	76.7%	45.7%	64.8%	49.8%

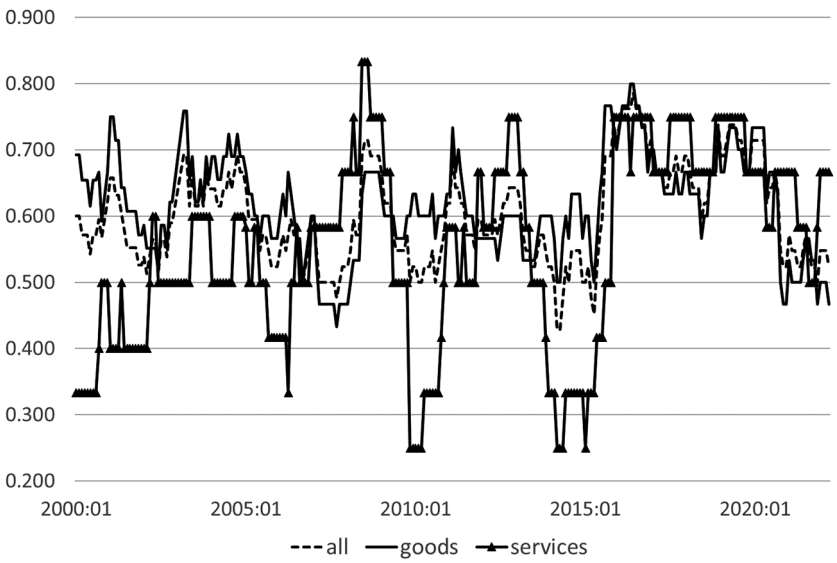

Figure 4. Proportion of failure of σ-convergence of thirty-six months

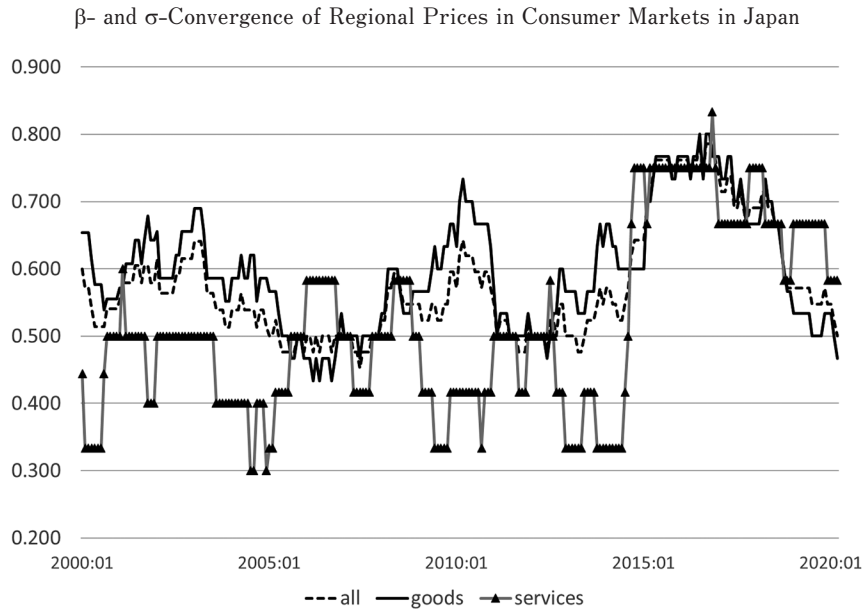

Figure 5. Proportion of failure of σ-convergence of sixty months

6. Relation between convergence and the change rates of prices

Sections 4 and 5 demonstrate that the acceptance or rejection of β- and σ-convergence fluctuate over time during the entire data-available period. This section investigates a possible cause of these results, i.e., inflation.

The relationship between inflation and price dispersion has long been studied as one of the most important issues in macroeconomics. For example, Vining and Elwertowski (1976) mention that eminent economists in the nineteenth and twentieth centuries, such as F. Edgeworth, W.S. Jevons, and M. Friedman, were interested in the issue. It is popularly presumed that a high inflation rate is associated with large price dispersion, and that idea has been discussed and analyzed in many studies. Sellers' menu costs and consumers' search costs often play important roles in the theoretical analysis of the relationship.[6] On the other hand, there are various methodologies and results in the area of empirical analysis. There are variations in interpretation and, also, in the measure of "price dispersion". Some studies investigate intra-market price dispersion, and others investigate intermarket dispersion. Some studies use, as the measure of price dispersion, the dispersion of price levels, and others use the variability of relative price changes.[7] The results are not unanimous. Some studies support the positive correlation between inflation and price dispersion, and some do not.

The current study investigates intra-market price dispersion, using the dispersion of price levels. The following two hypotheses are tested: one is that high rates of price changes make β-convergence more unlikely, and the other is that high rates of price change increase price dispersion.

The first hypothesis is tested based on the following Probit equation for each item:

$$Pr(FAIL\_CONV_t = 1) = \Phi(a + b \cdot INFL1_t + \varepsilon_t)$$

where $\Phi(\cdot)$ is the cumulative standard normal distribution function, $INFL1_t$ is the absolute value of the change rate of the national price index over the following thirty-six months, and $FAIL\_CONV_t$ is a dummy variable, taking value one if β-convergence fails over the following thirty-six months and zero otherwise. The source of the national price index of each item is the *Consumer Price Index*. If the absolute value of the price change rate is positively associated with the failure of β-convergence, b is positive. The Probit model is estimated only for the items whose proportion of the failure of β-convergence is greater than 10%. Taking account into overlapping samples and subsequent serial correlation in error terms, the t-statistics is

Table 7. Probit model of failure of β-convergence over thirty-six months

$Pr(FAIL\_CONV_t = 1) = \Phi(a + b \cdot INFL1_t + \varepsilon_t)$

	item	const.	(t-stat.)	*INFL*	(t-stat.)	pseudo R sq.	sign of b	sig. level of b
Goods								
	rice	−0.904	−2.335	−1.317	−0.846	0.008	minus	0.397
	white bread	−0.503	−1.098	0.352	0.076	0.000	plus	0.940
	tuna	−0.900	−3.526	−4.127	−1.764	0.015	minus	0.078
	pork	−0.400	−0.924	−14.551	−2.184	0.111	minus	0.029
	chicken	−0.579	−2.393	−12.107	−3.869	0.064	minus	0.000
	milk	−0.290	−0.869	−0.909	−0.187	0.001	minus	0.852
	tofu	0.277	0.845	−2.832	−0.906	0.365	minus	0.010
	ice cream	0.405	1.122	−30.818	−4.144	0.226	minus	0.000
	kerosene	−0.119	−0.294	−2.491	−1.649	0.093	minus	0.099
	men's shirts	0.150	0.339	−24.112	−3.257	0.219	minus	0.001
	ladies' underwear	−0.360	−2.592	−16.023	−4.111	0.110	minus	0.000
	ladies' shoes	−0.033	−0.082	−11.628	−1.589	0.042	minus	0.112
	gasoline	−0.281	−0.582	−3.274	−1.135	0.046	minus	0.256
Services								
	ramen	−0.389	−0.947	9.794	1.087	0.043	plus	0.277
	sushi	−1.085	−3.093	0.409	0.077	0.000	plus	0.939
	Japanese bbq	−0.275	−0.736	8.606	1.229	0.035	plus	0.219
	rent	0.430	0.574	−25.965	−0.351	0.009	minus	0.726
	laundry shirts	0.158	0.259	−23.095	−1.568	0.169	minus	0.117
	car maintenance	−0.397	−0.397	1.850	1.850	0.001	plus	0.905
	garage fee	0.713	1.781	−84.945	−2.568	0.147	minus	0.010
	tutoring school	−1.381	−3.815	24.397	24.397	0.108	plus	0.142
	gym fee	0.601	1.048	−15.058	−0.982	0.057	minus	0.326
	veterinary fee	0.148	0.270	−20.959	−0.853	0.034	minus	0.394
	hairdresser fee	0.889	2.205	−45.021	−1.677	0.106	minus	0.093
	ladies' haircut	0.217	0.556	0.937	0.064	0.000	plus	0.949

modified by the Newey-West window.[8] Table 7 indicates the results. They provide virtually no support to the hypothesis, where a support implies a significantly positive estimate of *b*.. The models of the sixty months were also estimated and the results were similar to those of the thirty-six months. The results are not presented here for brevity.

The second hypothesis is tested based on the following equation.

$$K_t = a + b \cdot K_{t-1} + c \cdot INFL2_t + \varepsilon_t$$

where $INFL2_t$ is the absolute value of the change rate of the national price index over the preceding twelve months. The use of the absolute value of inflation rates is discussed in Debell and Lamont (1997).

If the price change rate is positively associated with regional price dispersion, *c* should take a positive value. Again, due to overlapping samples and subsequent serial correlation in error terms, the t-statistics is modified by the Newey-West window. Table 8 indicates the results. They provide virtually no support to the hypothesis. More than half of the investigated items show a negative estimate of *c*, which is dissenting to the positive correlation. Reinsdorf (1994) and Sheremirov (2020) also find a negative correlation between the inflation rate and intra-market price dispersion.[9]

In summary, the statistical analyses in this section provide no evidence that the price change rate is associated with large price variability and, hence, the failure of convergence.

7. Conclusion

This study examined the convergence of regional retail prices in Japan over the past two decades. Goods and services indicate differing results. Services are less likely to β-converge than goods. On the other hand, it is not the same story with σ-convergence. Goods are less likely to σ-converge than services over the substantial part of the sample period.

It is known that β-convergence is theoretically a necessary condition for σ-convergence and, however, σ-convergence is only a sufficient condition for β-convergence.[10] It means that failure of β-convergence implies failure of σ-convergence, but failure of σ-convergence does not necessarily accompany failure of β-convergence. This is consistent with what the comparison of Figures 2 to 5 shows, that is, the proportion of failure of σ-convergence is generally higher than that of β-convergence.

It was shown that during the periods covering the start of the pandemic, i.e., early 2020, many items failed to β-convergence and σ-convergence, while this study did not examine the causality. It was also shown that the failure of the convergence declined rather quickly. An interpretation is that the outbreak of the pandemic affected the consumer markets through the troubles in the distribution system, but the problems settled down quickly. The effects were transient.

The results did not provide any support for the hypothesis that price changes increase regional price disparity. To identify the factors affecting convergence, further research is

Table 8. Standardized variance of price and change rate of price

$Kt = a + b \cdot K_{t-1} + c \cdot INFL2_t$

	item	const.	(t-stat.)	K_{t-1}	(t-stat.)	$INFL2_t$	(t-stat.)	$\bar{R}^2$	D.W.
1	rice	0.001	5.744	0.735	16.374	0.001	2.409	0.641	1.802
2	white bread	0.000	1.053	0.991	136.954	0.001	0.583	0.985	2.346
3	cup noodle	0.000	2.468	0.939	47.788	−0.002	−1.465	0.898	2.904
4	tuna	0.007	4.580	0.851	27.928	−0.013	−1.750	0.772	2.425
5	salmon	0.006	4.732	0.823	24.563	−0.006	−0.879	0.683	2.129
6	fish cake	0.002	1.845	0.951	57.462	−0.006	−0.425	0.920	2.064
7	pork	0.001	3.686	0.908	37.408	−0.002	−1.328	0.843	2.353
8	chicken	0.002	5.074	0.834	26.193	−0.007	−2.409	0.736	2.364
9	sausage	0.001	3.479	0.894	3.479	0.003	0.669	0.811	2.198
10	milk	0.000	2.702	0.952	55.384	0.002	1.028	0.923	2.256
11	yogurt	0.000	2.607	0.908	36.977	−0.002	−0.461	0.842	2.884
12	eggs	0.002	7.567	0.586	11.719	0.001	0.540	0.341	2.292
13	cabbages	0.018	9.934	0.396	7.026	−0.001	−0.744	0.154	2.018
14	onions	0.005	4.457	0.778	19.346	0.000	0.059	0.607	1.793
15	tomatoes	0.007	7.912	0.557	10.883	0.000	−0.048	0.305	2.082
16	tofu	0.003	2.656	0.949	46.874	−0.002	−0.248	0.892	2.456
17	bananas	0.003	4.914	0.814	23.091	−0.001	−0.204	0.667	2.005
18	cooking oil	0.002	4.446	0.844	26.303	0.000	−0.273	0.722	2.455
19	chocolate	0.001	7.076	0.580	11.062	0.004	3.948	0.487	2.348
20	ice cream	0.000	3.124	0.931	44.880	0.001	0.530	0.886	2.580
21	tea drink	0.000	3.254	0.843	23.559	0.005	1.798	0.784	2.583
22	beer	0.000	0.854	0.983	92.320	0.000	−0.280	0.972	2.483
23	kerosene	0.000	2.121	0.947	47.912	0.000	−0.589	0.896	1.487
24	bathroom paper	0.000	1.091	0.969	65.642	0.000	0.062	0.942	2.580
25	detergent	0.001	4.370	0.941	42.507	−0.026	−4.116	0.872	2.290
26	men's shirts	0.001	2.220	0.975	67.095	−0.010	−1.370	0.946	2.066
27	ladies' underwear	0.001	1.821	0.974	70.831	−0.007	−0.585	0.953	1.974
28	ladies' shoes	0.001	1.361	0.981	92.126	0.018	0.897	0.970	2.484
29	gasoline	0.000	3.687	0.862	27.865	0.000	−1.147	0.754	1.874
30	notebook	0.001	2.249	0.966	54.032	−0.003	−1.049	0.917	2.321
1	ramen	0.000	1.919	0.967	56.291	0.003	1.192	0.929	2.495
2	sushi	0.002	3.105	0.929	41.509	0.005	1.068	0.872	2.222
3	Japanese barbeque	0.002	2.165	0.963	54.137	−0.017	−1.258	0.939	2.149
4	rent	0.002	3.020	0.967	91.952	−0.023	−0.959	0.976	1.795
5	laundry of men's shirts	0.001	1.724	0.976	72.128	0.000	−0.083	0.951	2.191
6	car maintenance fee	0.001	1.828	0.978	80.459	−0.010	−1.951	0.964	1.976
7	garage fee	0.008	4.035	0.955	89.873	−0.095	−0.799	0.968	1.486
8	tutoring school fee	0.004	4.149	0.870	28.281	0.007	0.324	0.759	2.366
9	gym fee	0.001	1.162	0.967	33.501	−0.007	−1.657	0.845	1.953
10	veterinary fee	0.000	0.718	0.989	75.744	0.000	0.014	0.956	1.956
11	hair dressing fee	0.004	8.148	0.604	12.470	0.010	2.026	0.399	2.393
12	ladies' hair cut	0.000	1.704	0.978	82.099	0.009	2.305	0.962	2.065

needed.

Notes

1) Among the studies are Barro and Sala-i-Martin (1991, 1995).
2) Club convergence is also extensively explored in the area of international and inter-regional comparison of income. Ikeno (2016) uses club convergence to analyze the convergence of regional prices in Japan.
3) When the variances of those indexes are calculated, the averages are set to 100.
4) In relation to previous studies, the period of sixty months, i.e., five years, is in a comparable range. For example, Halka and Leszczynska-Paczesna (2019) examine β- and σ-convergence of prices in Europe over seven to nine years.
5) See "List of information for items of the 2020-Base Consumer Price Index". See https://www.stat.go.jp/english/data/cpi/pdf/2020base-list.pdf.
6) For example, see Reinsdorf (1994).
7) For example, Debelle and Lamont (1997) and Choi (2010) analyze intermarket price dispersion, using the variability of relative price changes, and Reinsdorf (1994) and Sheremirov (2020) analyze the intra-market price dispersion using the dispersion of price levels.
8) For the consistent estimator in the Probit model, see Estrella and Rodrigues (1998).
9) Sheremirov (2020) finds a negative correlation between the inflation rate and the dispersion of sale prices, but finds a positive relation between the inflation rate and the dispersion of regular prices.
10) For example, see Furceri (2005).

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（要旨）

本研究は、過去 20 年間の日本の地域消費者市場における価格のβ収束およびσ収束について検証する。一国内における地域間物価の収束に関する研究はすでに多く存在するが、広く採用されている手法は地域間の価格差における単位根の検定である。それに対して、本研究は、この問題にβ収束およびσ収束のテストを用いて分析する。まず、家計の購買頻度、消費者物価指数におけるウェイトなどに基づき財（モノ）とサービスの両方を含む 40 以上の品目を選び、統計分析には、日本の 47 都道府県庁所在地におけるその小売価格を使用する。テストはローリング・リグレッション（逐次回帰）によって実行され、収束の度合いが時間の経過とともにどのように変化したかを詳細に分析する。分析の結果、財とサービスでは異なる結果が示された。サービスは財に比べてβ収束しにくい傾向がある。一方で、σ収束については異なる結果となる。財はサービスよりもσ収束しにくい傾向にあった。新型コロナウイルスによるパンデミックを含むサンプル期間では、β収束およびσ収束が起きないケース（収束の失敗）が高い水準にとどまったが、それは長く続かずに直後に低下した。パンデミックの影響は一時的なものであったという結果であった。最後に、インフレ率と収束の失敗、地域間相対価格のばらつきについて仮説検定が行われるが、インフレ率と収束、インフレ率と地域間相対価格のばらつきには有意な統計的関係は見出されない。

Appendix

Items selected for statistical works in this study

	item	weight in CPI 2020 base (Per 10000)	start	end	number of covered cities
Goods					
1	rice	39	Jan.2000	Mar.2025	47
2	white bread	32	Jan.2000	Mar.2025	47
3	cup noodle	20	Jan.2000	Mar.2025	47
4	tuna	22	Jan.2000	Mar.2025	47
5	salmon	21	Feb.2000	Mar.2025	37
6	fish cake	10	Jan.2000	Mar.2025	43
7	pork	54	Jan.2000	Mar.2025	47
8	chicken	45	Jan.2000	Mar.2025	47
9	sausage	21	Jan.2000	Mar.2025	47
10	milk	41	Jan.2000	Mar.2025	47
11	yogurt	37	Jan.2000	Mar.2025	47
12	eggs	25	Jan.2000	Mar.2025	47
13	cabbages	10	Jan.2000	Mar.2025	47
14	onions	10	Jan.2000	Mar.2025	47
15	tomatoes	24	Jan.2000	Mar.2025	47
16	tofu	15	Jan.2000	Mar.2025	47
17	bananas	15	Jan.2000	Mar.2025	47
18	cooking oil	11	Jan.2000	Mar.2025	47
19	chocolate	30	Jan.2000	Mar.2025	46
20	ice cream	35	Jan.2002	Mar.2025	47
21	tea drink	22	Jan.2005	Mar.2025	47
22	beer	31	Jan.2000	Mar.2025	47
23	kerosene	38	Jan.2000	Mar.2025	47
24	bathroom paper	14	Jan.2000	Mar.2025	47
25	detergent	17	Jan.2000	Mar.2025	47
26	men's shirts	5	Jan.2000	Mar.2025	47
27	ladies' underwear	8	Sep.2000	Mar.2025	46
28	ladies' shoes	16	Jan.2000	Mar.2025	47
29	gasoline	182	Jan.2000	Mar.2025	47
30	notebook	11	Jan.2000	Mar.2025	46
Services					
1	ramen (eating out)	30	Jan.2000	Mar.2025	47
2	sushi (eating out)	37	Jan.2000	Mar.2025	46
3	Japanese barbeque (eating out)	48	Jan.2005	Mar.2025	46
4	rent	225	Jan.2000	Mar.2025	47
5	laundry of men's shirts	7	Jan.2000	Mar.2025	47
6	car maintenance fee	37	Sep.2000	Mar.2025	47
7	garage fee	45	Jan.2000	Mar.2025	47
8	tutoring school fee	36	Jan.2000	Mar.2025	46
9	gym fee	17	Jan.2005	Mar.2025	46
10	veterinary fee	24	Jan.2000	Mar.2025	47
11	hair dressing fee	26	Jan.2000	Mar.2025	47
12	ladies' hair cut	34	Jan.2000	Mar.2025	47