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Abstract

This paper analyzes the aggregate inflation dynamics based on the spatial model that allows the asymmetric regional spillover effects using Japanese prefectural panel data. We simulate how the shocks in regional inflation affect the aggregate inflation and evaluate which region should be targeted for achieving high aggregate inflation. Our finding suggests that policies targeting rural rather than urban areas are important for activating the aggregate economic activity reflected in the price level. Our findings further suggest that the monetary policy of "price stability target" should also set up the "rural price stability target" to achieve national "price stability target."

JEL classification: E31,R22,
Keywords: Regional inflation; Spillover effect; law of one price

1. Introduction

The law of one price (LOP) is a measure of market integration across regions. Research exploring the test of LOP between and within countries have found failure of LOP within countries.[3] The test of LOP is divided into (1) price dispersion across regions and (2) convergence to certain equilibrium prices. In Japan, Baba (2007) and Crucini, Shintani, and Tsuruga (2010) find the heterogeneity in local retail prices, whereas Nagayasu (2011) finds the heterogeneity in local consumer prices. Nagayasu

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[3] As an influential paper, see Engel and Rogers (1996).

(2011) and Ikeno (2014) find no evidence of convergence in regional price levels. The failure of LOP across regions within Japan indicates that the presence of segregated local markets in the country. However, Nagayasu (2017) finds that the existence of spillover effects of regional inflation among prefectures in Japan. If the regional inflationary spillovers exist and the effects are *asymmetric* among regions, then policy-targeted aggregate price level is determined by asymmetrically interdependent regional prices. Previous research on regional inflationary spillovers is approximately divided into global (international) and domestic regions. On the global inflationary spillovers, Ciccarelli and Mojon (2005) analyze the international co-movement of inflation and decompose the inflation shocks of the Group of Eight countries into common, cross-country spillover, and domestic shocks. They find the fraction of forecast error variance because cross-country spillover shocks are relatively small and reject the importance of inflationary spillovers across countries. On the contrary, Osorio and Unsal (2013) analyze the co-movement of inflation among Asian countries and find that inflation spillovers from China have significantly large impact on the inflation of other Asian countries.

The importance of spillovers in domestic regional inflation is highlighted in the regional inflation dynamics literature (Marques et al. 2014; Yesilyurt and Elhorst 2014; Winkelried and Gutierrez 2015). Winkelried and Gutierrez (2015) investigate how the shocks in regional inflation in Peru propagate across other regions and find that shock in Lima (capital city) has fast and strong effects on other regions. The effects of shock in regional inflation on aggregate inflation are important for the implementation of monetary policy of "price stability target" in connection with regional policy. From the evidence of global spillovers in inflation (Osorio and Unsal 2013) and domestic regional spillovers in inflation (Winkelried and Gutierrez 2015), inflation in a large economy (urban area) tends to have a substantial impact on inflation in small economies (rural area). If a similar mechanism holds for regional inflation in Japan, urban–targeted economic policy is desirable for inflation in Japan. Conversely, if the shock in rural inflation increases the aggregate inflation more than the shock in urban inflation does, regional development policy is desirable not only for local welfare but also for targeted inflation in Japan.

This study analyzes the aggregate inflation dynamics based on a spatial model that allows asymmetric regional spillover effects using Japanese prefectural panel data. Our study's original contribution is not only to test the LOP across regions in Japan but also to simulate how the shocks in regional inflation affect the aggregate inflation and evaluate which region should be targeted for achieving higher aggregate inflation.

This paper is organized as follows. Section 2 presents the derivation of estimation model from the price function with spatial elements. Section 3 presents an analysis of data, and Section 4 discusses the results of economic simulation for regional inflation. Finally, Section 5 presents the conclusion of our analysis.

2. Estimation model

We assume that three factors determine prices in each region. First, when the price of i-th region-specific factor is decided only by the price of i-th region, the consumer will face the price of $\ln P_{it}{}^{*}$. Second, the price fluctuates due to price difference with other regions. If the price of the adjacent area is high, then the price increases. Third, prices are affected by uniform shocks throughout the regions, such as changes in the system (referred to as θ_t). Adapting these three factors, the price function is given by the following:

$$\ln P_{it} = \ln P_{it}{}^{*} + \sum_{j=1}^{N} \delta_{ij}\left(\ln P_{jt}{}^{*} - \ln P_{it}{}^{*}\right) + \theta_t + u_{it}$$

$$\text{for } i = 1, \ldots, N, \;\; t = 1, \ldots T. \quad (1)$$

where P_{it} is the price at region i in period t, P_{it}^{*} is the price level determined by only the region i in period t, θ_t is the common variations across regions in period t, and u_{it} is the error term. The first term represents the price level in the specified region, and if no common fluctuation exists across the region and that region is not affected by other regions, then $\ln P_{it}{}^{*}$ and $\ln P_{it}$ coincides with each other except for the error term. The second term represents the difference in price level between the specified and other regions. For example, if $\delta_{ij} < 0$ and the price level is higher in other regions, then it means that the price in that region is smaller. In addition, δ_{ij} represents the magnitude of the influence on the price level in that region from the other regions. The larger this value, the stronger is the impact from the other regions. The third term indicates a regional uniform shock, and macro shocks are included in this term. $\ln P_{it}{}^{*}$represents the region-specific price level and is determined by region-specific shock. Because observing region-specific shocks is impossible, we assume that it follows a random walk. Therefore, $\ln P_{it}{}^{*}$ is expressed by:

$$\ln P_{it}{}^{*} = \ln P_{it-1} + \epsilon_{it} \quad (2)$$

As $\ln P_{it}^{*}$ and θ_t cannot be observed, we consider removing it. We substitute Eq. (2) into Eq. (1) to remove $\ln P_{it}^{*}$ from the model.

$$\ln P_{it} = \ln P_{it-1} - N\delta_i \ln P_{it-1} + \textstyle\sum_{j=1}^{N} \delta_{ij} \ln P_{jt-1} + \theta_t + v_{it} \quad (3)$$

where $\delta_i = \sum_{j=1}^{N} \delta_{ij} / N$.

As a result, the unobservable variable P_{it}^{*} is removed from the model. Next, we consider removing θ_t from Eq. (3). Taking the average in the cross-section direction, the following equation is obtained:

$$\overline{\ln P_t} = \overline{\ln P_{t-1}} - \textstyle\sum_{j=1}^{N} \ln P_{jt-1}\delta_i + \sum_{i=1}^{N} \ln P_{it-1}\delta_j' + \theta_t + \bar{v}_t, \quad (4)$$

where $\delta_j{}' = \sum_{i=1}^{N} \delta_{ij} / N$.

When Eq. (4) is subtracted from Eq. (3), the following equation is obtained:

$$\Delta \ln P_{it} - \Delta \overline{\ln P_t} = \textstyle\sum_{j=1}^{N} \delta_{ij}\left(\ln P_{jt-1} - \ln P_{it-1}\right) + \sum_{j=1}^{N}\left(\delta_j - \delta_j{}'\right) \ln P_{jt-1} + v_{it} - \bar{v}_t \quad (5)$$

By estimating this equation, verifying how prices change is possible when a difference in prices with other regions exists. In Eq. (5), the explanatory variable is the lagged variable, which is not correlated with the error term; thus, it can be estimated by the ordinary least squares (OLS). Furthermore, the OLS estimator is consistent. In this model, if the explanatory variable is a cointegration vector, then it becomes a vector error correction model (VECM).

Furthermore, Eq. (5) is a spatial model with spatial terms δ_{ij}, but it can be regarded as a VAR model. In addition, we include spatial elements in δ_{ij} such as adjacent effect, reciprocal of distance, and GDP. Although it is possible to estimate δ_{ij} without restriction, the estimation is not stable because estimating an enormous number of $N \times N$ parameters is necessary. Therefore, the following restrictions are imposed on δ_{ij} in the estimation:

$$\delta_{ij} = \alpha_1 \frac{1}{m} n_{ij} + \alpha_2 \frac{1}{m} \cdot \frac{1}{d_{ij}} n_{ij} + \alpha_3 \left(\frac{1}{m} \cdot \frac{1}{d_{ij}}\right)^2 n_{ij} + \alpha_4 \frac{Y_j}{Y_i} + \alpha_5 \frac{\frac{Y_j}{Y_i}}{d_{ij}} + \alpha_6 \frac{\frac{Y_j}{Y_i}}{\left(d_{ij}\right)^2}, \qquad (6)$$

where n_{ij} is a dummy variable that takes 0 if $i = j$ or i and j are not adjacent, m represents the number of adjacent regions to the i-th region, d_{ij} is the distance between i and j regions and takes 0 if $i = j$, and Y_j is the GDP of j regions. The first term of Eq. (6) represents the influence in the case where it is adjacent, and no influence exists in the case where it is not adjacent. The second term is the intersection of the first term and the effect of attenuation according to the distance, and the third is quadratic of the second term. The fourth term represents the gravity term, and if the GDP of the adjacent region is relatively larger than the region, then the effect is greater. The fifth term is the intersection of the second and fourth terms, and the sixth is quadratic of the fifth term. Moreover, δ_{ij} is a parameter that indicates how the price will be affected if there is a price difference from other regions. These terms are determined depending on the number of adjacent regions, the distance between i and j regions, and the economic scale. It usually takes a positive value and never exceeds 1. Also, in the case of a negative value, if the price in other regions is high, then the price in that region falls. We suppose that the influence from other regions is large when it is geographically close and small when it is far. By identifying δ_{ij} in advance, Eq. (5) can be estimated by the OLS.

3. Data

The dataset consists of a panel of 47 prefectures from 1980 to 2016. The price data are sourced from The Consumer Price Index (CPI) by the Statistics Bureau of Japan. d_{ij} uses the distance between the prefectural capitals. Furthermore, the GDP by prefectures is obtained from the Annual Report on Prefectural Accounts by the Cabinet Office and fixed by the value of 2010 in the estimation. In addition, Japan can classify 47 prefectures into nine regions, namely, Hokkaido, Tohoku, Kanto, Chubu, Kinki, Chugoku, Shikoku, Kyushu, and Okinawa. To clarify the argument in this paper, we will often describe results in units of the region.

Figure 1 shows the distribution map of average log prices in 47 prefectures. The darker the map, the higher are the log prices in the prefecture. In Japan, although the price difference between prefectures is not large, Saitama, Tokyo, and Kanagawa, which belong to the Kanto region, and Osaka and Hyogo, which belong to the Kinki region, have relatively high price differences. Most of the high-priced prefectures are along the Pacific Belt Zone. These regions include industrial areas in Tokyo, Kanagawa, Saitama, and Osaka, which are population-concentrated areas. On the contrary, Gunma and Tochigi, Mie and Nara, and Miyazaki and Kagoshima are prefectures where average prices are relatively low. These areas belong to the Kanto, Kinki, and Kyushu regions, respectively. Although they are adjacent to the prefectures that belong to the Pacific Belt Zone, the average price is relatively low and the population concentration is small.

The Pacific Belt Zone indicates that many populations and factories line up like belts from the Kanto region to the Kyushu region, passed through the two dotted lines in Figure 1. This area accounts for approximately two-thirds of Japan's industrial output. Keihin Industrial Zone with Tokyo and Kanagawa, Chukyo Industrial Zone with Aichi, and Hanshin Industrial Zone with Osaka and Hyogo are called the three major industrial areas. These industrial areas are convenient for the transportation of raw materials and products because of its maritime location. In addition, these spread around large cities such as Tokyo, Aichi, and Osaka, have a large population, and easily attract workers. Table 1 and Figure 2 also show that high GDP and population accumulation occur in the three major industrial areas, such as Tokyo, Osaka, and Aichi. On the contrary, prefectures having low GDP and small population are concentrated in the Chugoku and Shikoku regions, such as Tottori, Tokushima, and Kochi.

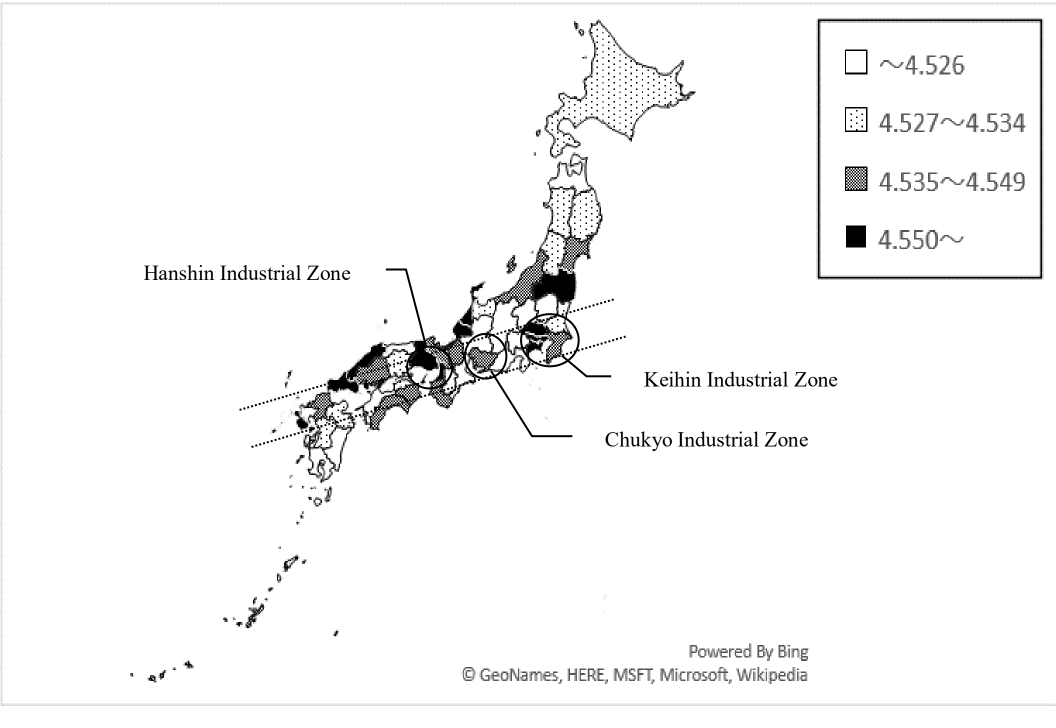

Fig. 1. Distribution map of average log prices in Japan.

Region	Prefectures	GDP	GDP per capita	Population
Hokkaido	Hokkaido	18,166	3.299	5506
Tohoku	Aomori	4423	3.221	1373
	Iwate	4054	3.048	1330
	Miyagi	7802	3.323	2348
	Akita	3423	3.152	1086
	Yamagata	3615	3.092	1169
	Fukushima	6937	3.419	2029
Kanto	Ibaraki	11,233	3.782	2970
	Tochigi	7939	3.954	2008
	Gunma	7497	3.734	2008
	Saitama	20,021	2.783	7195
	Chiba	19,377	3.117	6216
	Tokyo	91,926	6.986	13,159
	Kanagawa	30,244	3.343	9048
Chubu	Niigata	8586	3.617	2374
	Toyama	4352	3.982	1093
	Ishikawa	4416	3.774	1170
	Fukui	3341	4.145	806
	Yamanashi	3161	3.663	863
	Nagano	7641	3.551	2152
	Gifu	7085	3.405	2081
	Shizuoka	15,404	4.091	3765
	Aichi	32073	4.328	7411
Kinki	Mie	7389	3.983	1855
	Shiga	5968	4.230	1411
	Kyoto	9728	3.690	2636
	Osaka	36,727	4.143	8865
	Hyogo	19,335	3.460	5588
	Nara	3554	2.537	1401
	Wakayama	3503	3.496	1002
Chugoku	Tottori	1773	3.010	589
	Shimane	2327	3.245	717
	Okayama	7103	3.652	1945

	Hiroshima	10,519	3.677	2861
	Yamaguchi	5640	3.887	1451
Shikoku	Tokushima	2865	3.650	785
	Kagawa	3632	3.647	996
	Ehime	4783	3.342	1431
	Kochi	2232	2.921	764
Kyushu	Fukuoka	17,694	3.489	5072
	Saga	2776	3.266	850
	Nagasaki	4352	3.050	1427
	Kumamoto	5496	3.025	1817
	Oita	4176	3.489	1197
	Miyazaki	3481	3.067	1135
	Kagoshima	5448	3.193	1706
Okinawa	Okinawa	3704	2.659	1393

Note: The unit of GDP is one billion yen, and the population is in thousands of people.

Table 1. GDP, GDP per capita, and population of 47 prefectures in Japan.

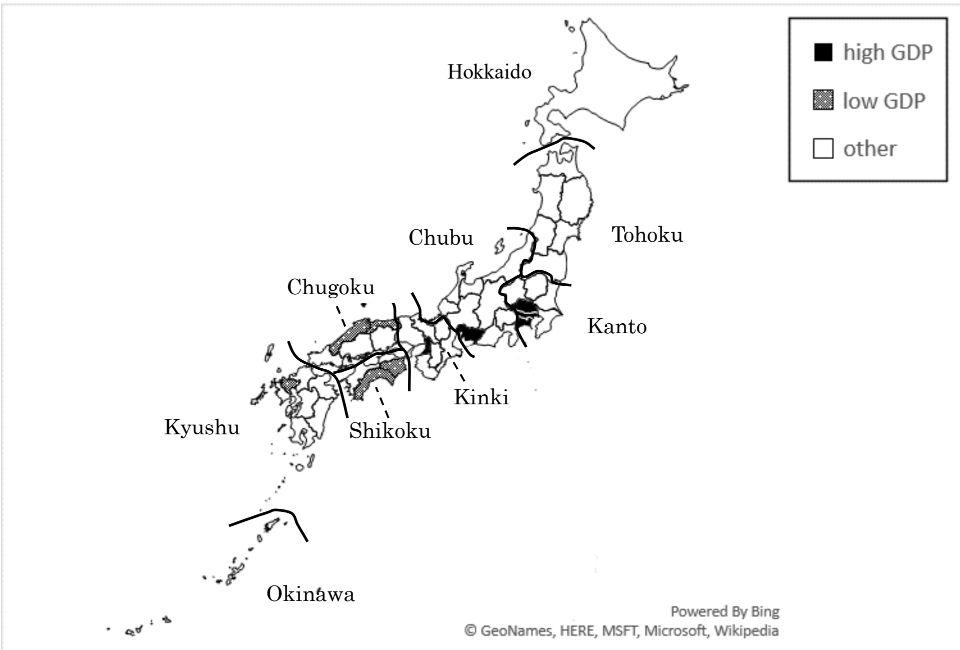

Fig. 2. Distribution map of the top and bottom five prefectures of GDP.

4. Empirical results

4.1 Panel unit root and cointegration test

Table 2 shows the result of the panel unit root test (Maddala and Wu 1999; Levin, Lin, and Chu 2002;

Im, Pesaran, and Shin 2003) for $\ln P_{it}$, we adopt individual unit root process for 47 cross-sections. When the equations in the unit root test include only the individual effects, the null hypothesis of no unit root will not be rejected at 5% in all test types. However, when the equations in the unit root test do not include individual effects and linear trends, the null hypothesis will be rejected at 5% level. We confirm that $\ln P_{it}$ can be a nonstationary variable I(1). Prices are generally non-stationary. Furthermore, Table 3 shows the panel cointegration test results. This test is executed as the panel unit root test for $\ln P_{it} - \overline{\ln P_t}$. In addition, excluding one prefecture data from the test is necessary to impose a constraint that the sum of all prefecture values is 1. Therefore, panel unit root tests were conducted on 46 prefecture data, excluding Okinawa. If these cointegration relationships are established, then the linear combinations are stationary. The null hypothesis of no unit root in all test types is not rejected at 5% level, and the construction of cointegration relationships is confirmed.[4] That is, we confirm that the price difference with other regions has a long-term stability relationship. Therefore, LOP has been established between Japan's regions over the long term. In international transactions, arbitrage often does not work due to various factors. Arbitrage transactions are likely to occur in Japan due to the development of logistics, which is consistent with the results of many previous studies.

Test type	Level		First difference	
	Test statistics	p-value	Test statistics	p-value
(a) none				
Levin, Lin, and Chu t	7.870	1.000	-25.127	0.000
ADF-Fisher chi-square	7.008	1.000	723.270	0.000
(b) individual effects				
Levin, Lin, and Chu t	-8.881	0.000	-19.708	0.000
Im, Pesaran, and Shin W-stat	-5.5116	0.000	-18.173	0.000
ADF-Fisher chi-square	161.833	0.000	490.584	0.000
(c) individual effects, linear trend				
Levin, Lin, and Chu t	-3.901	0.000	-20.868	0.000
Im, Pesaran, and Shin W-stat	2.094	0.982	-14.691	0.000
ADF-Fisher chi-square	46.833	1.000	365.440	0.000

Table 2. Panel unit root tests.

Test type	Test statistics	p-value

[4] We do not verify the cointegration test including the linear trend because the price difference with other regions increasingly spreads by including trends.

(a) none		
Levin, Lin, and Chu t	-4.557	0.000
ADF-Fisher chi-square	167.303	0.000
(b) individual effects		
Levin, Lin, and Chu t	-6.272	0.000
Im, Pesaran, and Shin W-stat	-3.962	0.000
ADF-Fisher chi-square	148.561	0.000

Table 3. Panel cointegration tests.

4.2 Economic simulation to price rises

Table 4 shows the estimated coefficients of Eq. (5). The estimated values except for α_1 are statistically significant at 5% level. In addition, the bottom line of Table 1 shows the Wald test result of the significance for all parameters. This result indicates the rejection of the null hypothesis, and parameters are statistically significant at 5% level. Moreover, it shows that prices are not only determined by macro shocks but also influenced by prices in other regions. The impact from other regions depends on the distance and size of GDP. By contrast, interpreting the estimated coefficient values intuitively is difficult. In Eq. (3), all explanatory variables are lagged variables and can be regarded as VAR model with 47 variables. The economic simulation measures how the price in a specific region spreads to other regions if it increases by 1%. In this analysis, with the region as one unit, when the price of a certain region rises by 1%, it is will clarify the extent of the influence on the price of the remaining region. That is, we predict the effect of innovation giving a price increase of 1% in a certain region as its application. Additionally, the economic simulation was represented by multiplying the GDP representing the economic scale of each region by the ratio. As a result, the effect of the region's price increase on other regions will depend on the economic scale of the region.

Figures 3–5 show the impact on Japan's average price level in the next 30 years when the shock of increasing the price of a specific region is set at 1%. The horizontal axis of the graph represents the number of years in which inflation increases. The vertical axis represents the degree of impact. The higher the value, the higher is the price increase. If the innovation where the price in the specific regions rises by 1% is uniformly given, a price increase of 1% is seen in the prefectures belonging to the specific regions at the initial time point. If the convergence destination of the simulation exceeds 1, it can be interpreted that a 1% price increase in the specific region leads to price increase in other regions. Figure 3 can be divided into Figures 3.1 and 3.2 because the quantitative scale of the response varies depending on the region. Figure 3.1 shows that the quantitative scale of the response exceeds 1 in the regions, excluding Kanto. Kanto is the region with the highest GDP and large economic scale in Japan. From this result, regardless if a price increase of 1% occurs in the region with a large economic scale, it will not raise inflation to other regions.

On the contrary, Figure 3.2 shows that the movement of prediction in Shikoku is remarkable. When the price increases in this region, the influence on other regions will be great. The convergence speed is relatively slow in most regions, and it takes 30 years to converge. However, the movement in Kanto becomes smaller in 10 years and thus converges. This finding indicates that the influence on other regions with large economic scale such as the Kanto is small from the viewpoint of convergence speed. Furthermore, compared with the two figures, the three regions in Figure 3.1 have relatively large economic scale in Japan, including the three major industrial areas. The four regions in Figure 3.2 are other small economies. In other words, the spillover of prices has a greater impact on other regions in smaller economies than on developed regions.

A similar trend can be seen in Figures 4 and 5. Figure 4 shows the differences between five prefectures with high and low GDP, respectively. As described in Table 1, prefectures with high GDP include Tokyo, Osaka, Aichi, Kanagawa, and Saitama, and prefectures with low GDP include Tokushima, Saga, Shimane, Kochi, and Tottori. This categorization is also almost the same as dividing into three major industrial areas. Although results of the five prefectures with high GDP do not exceed 1, results of the five prefectures with low GDP are higher than 1. That is, the influence of price spillover from the region with small economic scale is larger than the influence from region with large economic scale.

Figure 5 shows the simulation result when the price of the population-concentrated area rises by 1%. The population-concentrated areas here refer to nine prefectures, namely, Hokkaido, Saitama, Chiba, Tokyo, Kanagawa, Aichi, Osaka, Hyogo, and Fukuoka. We also confirm that although the result of other areas exceeds 1, the effect of the price increase of 1% in the population-concentrated areas on a nationwide price rise is less. The convergence speed is relatively high in both cases, which takes approximately 20 years. The effect decreases by half in the population-concentrated areas in 20 years. Furthermore, it is assumed that prices will decline on the contrary, given the shock that prices will increase due to intense price competition in the population-concentrated areas.

	Coefficient	t-stat	p-value
α_1	-0.0052	-0.300	0.765
α_2	6.97E-05	4.098	0.000
α_3	-1.94E-07	-3.123	0.002
α_4	0.0011	4.757	0.000
α_5	-3.07E-05	-3.616	0.000
α_6	1.02E-07	2.575	0.010
Null hypothesis		χ^2 stat	p-value
$\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = \alpha_6 = 0$		139.027	0.000

Table 4. Estimated results.

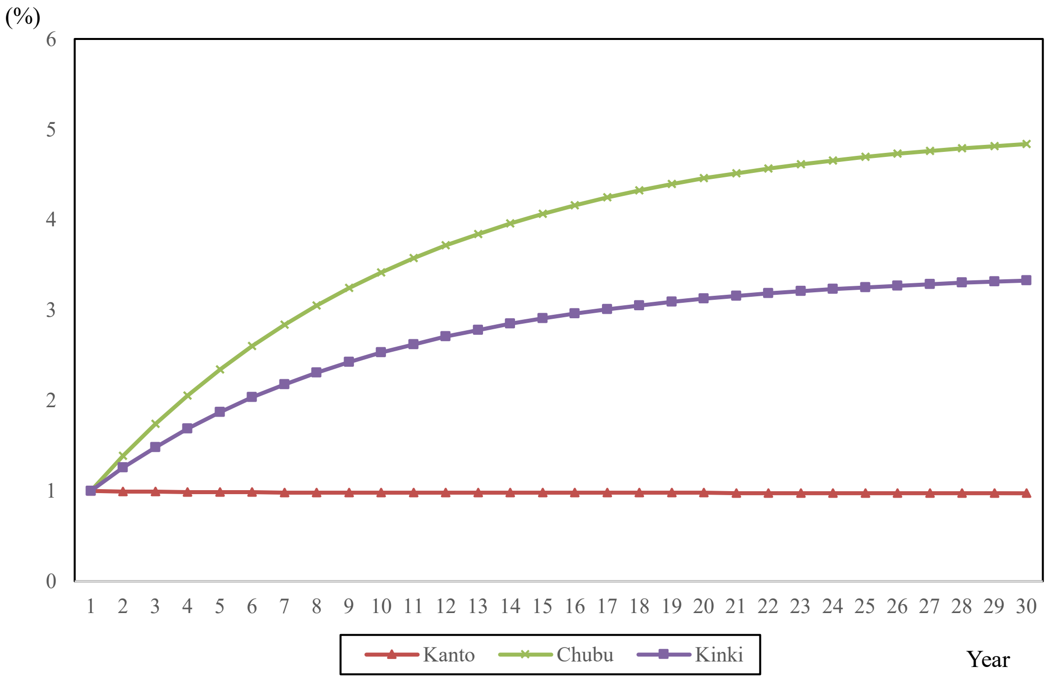

Fig. 3.1. Simulation results of the national average by region.

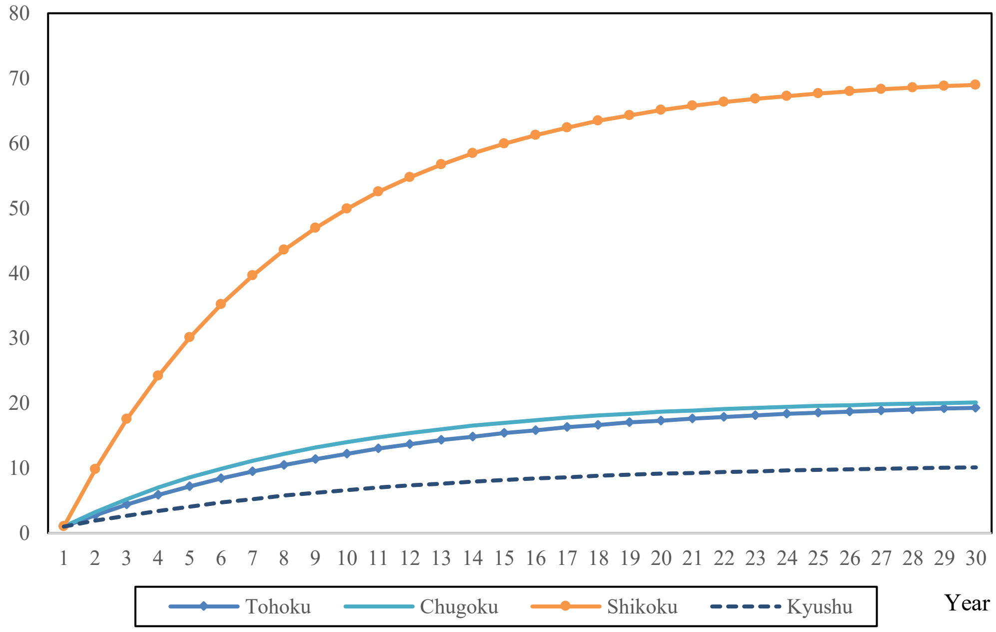

Fig. 3.2. Simulation results of the national average by region.

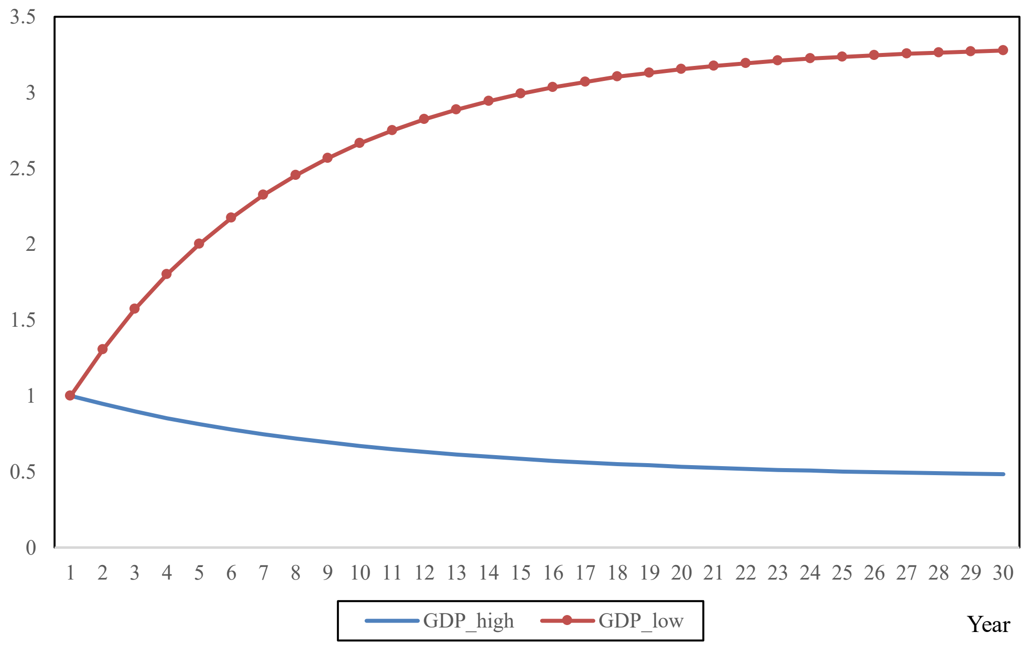

Fig. 4. Simulation results of high-GDP and low-GDP regions.

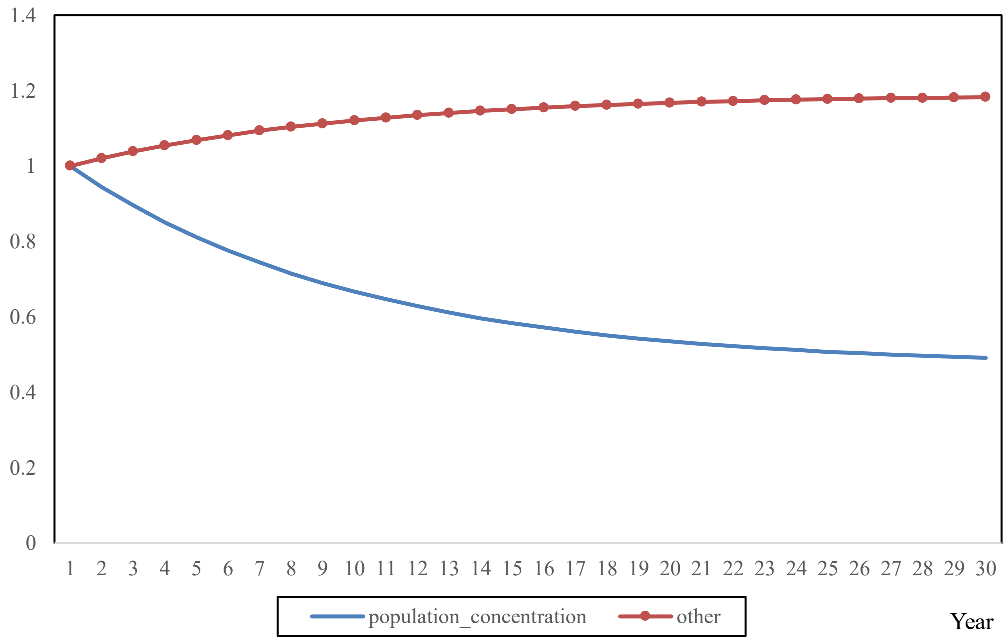

Fig. 5. Simulation results of the population-concentrated regions.

4.3 Spillover route to other regions of price increases

In this section, we confirm the spillover route to other regions when prices increase in each region.

Figures 6.1–12.2 show the regions that have strong spillover effects when there is an exogenous shock in a certain region, which then divides the degree of the influence on other regions into quartiles. It should be noted that this influence is not only an absolute degree but also a relative degree. Moreover, these results measure the spillover process 10 and 20 years after the exogenous shock was given to a certain region.

Figures 6.1 and 6.2 show the degree of spillover to other regions when price increases in the Tohoku region. After 10 years, the impact is limited to some prefectures such as Tokyo, Kanagawa, Aichi, and Osaka. However, in the next 20 years, the influence is growing for many prefectures such as Hokkaido, Tokyo, Kanagawa, Chiba, Shizuoka, Aichi, Osaka, and Hyogo. Compared with Figures 7.1 and 7.2 in the Kanto region, the impacts on Aichi, Hyogo, and Fukuoka are large in the next 10 and 20 years. In other words, the influence of price rise does not spread to other regions regardless if the number of years has passed. Compared with Figures 8.1 and 8.2 in the Chubu region, the spillover effects on Tokyo, Kanagawa, Chiba, Osaka, and Hyogo are large in the next 10 years. The spillover effects on Fukuoka are also large in addition to these prefectures in the next 20 years. In Figures 9.1 and 9.2 in the Kinki region, the spillover effects in Tokyo, Kanagawa, Shizuoka, and Aichi are large in the next 10 years. The spillover effects on Chiba and Fukuoka are also large in addition to these prefectures in the next 20 years. In Figures 10.1 and 10.2 in the Chugoku region, the spillover effects on Tokyo, Kanagawa, Shizuoka, Aichi, Osaka, and Hyogo are large in the next 10 years, and the spillover effects on Fukuoka are also large in addition to these prefectures in the next 20 years. Additionally, in Figures 11.1 and 11.2 in the Shikoku region, the impact on Kanagawa, Aichi, Osaka, Hyogo, Hiroshima, and Fukuoka is large in the next 10 years, and the influence is further in Tokyo, Chiba, and Shizuoka in addition to these prefectures in next 20 years. As the years go by, the number of regions with spillover increases and the effect of price increase can also be spread. Furthermore, in Figures 12.1 and 12.2 in the Kyushu region, the impact on Kanagawa, Aichi, Osaka, and Hyogo is large in the next 10 years, and the influence spreads in Tokyo, Chiba, Shizuoka, and Hiroshima in addition to these prefectures in the next 20 years. As in the case of the Shikoku region, the number of regions on spillover increases as the years go by.

From these results, the region affected by the price increase in a specific region is limited to prefectures with a large economic scale. In particular, the price increase in the Kanto region has limited effects only on some prefectures. Conversely, regions with large economies such as Tokyo, Kanagawa, Aichi, Osaka, and Hyogo located along the Pacific Belt Zone are largely affected by other regions and have relatively brought high spillover effects from others. On the contrary, the impact of rising prices of other regions is small on regions with small economies of scale. Furthermore, price increases in small economies such as the Shikoku, Chugoku, and Kyushu regions influence regions with large economy.

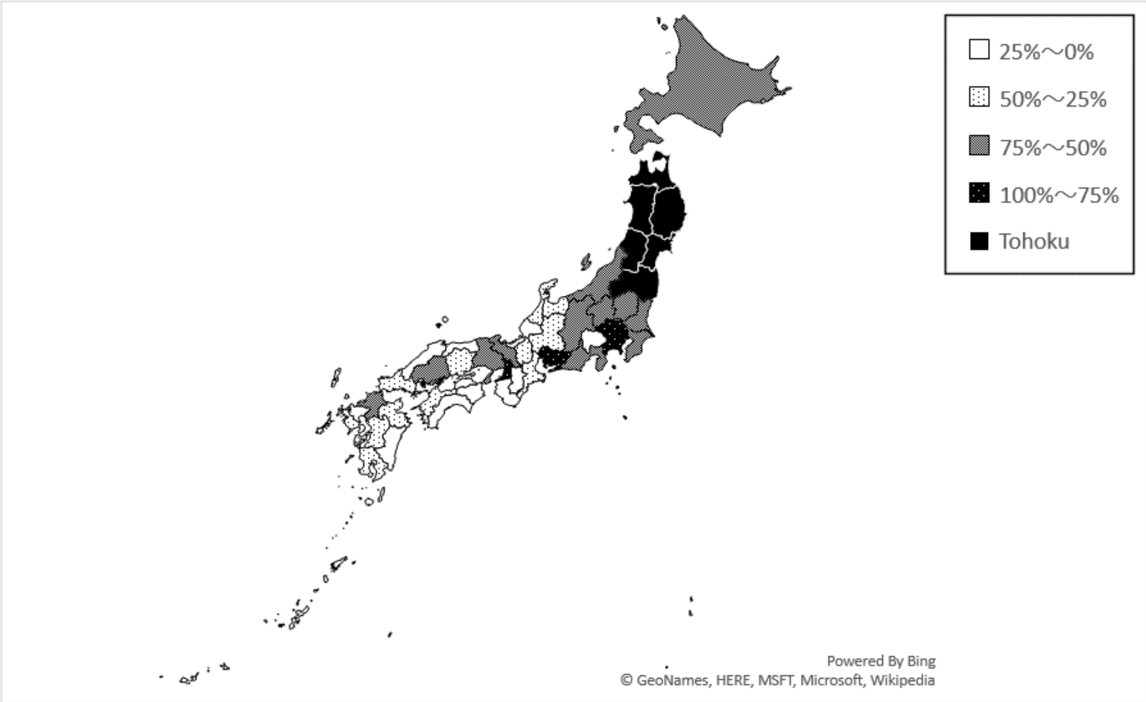

Fig. 6.1. Spillover from the Tohoku region to other regions in the next 10 years.

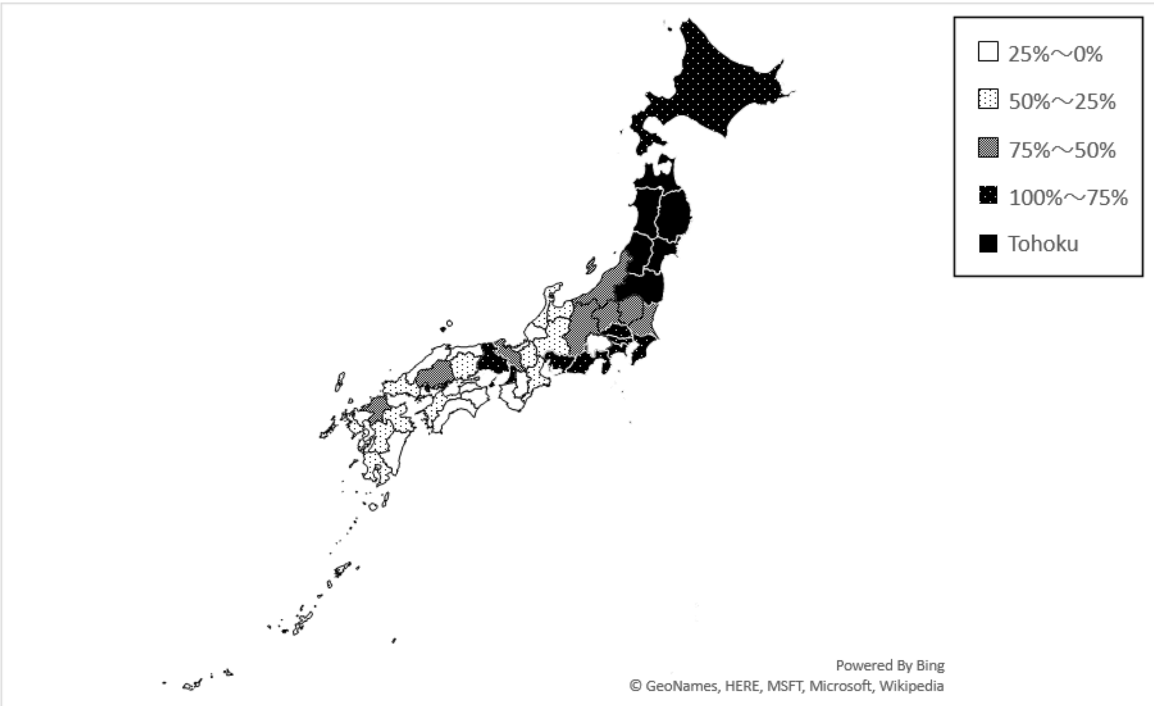

Fig. 6.2. Spillover from the Tohoku region to other regions in the next 20 years.

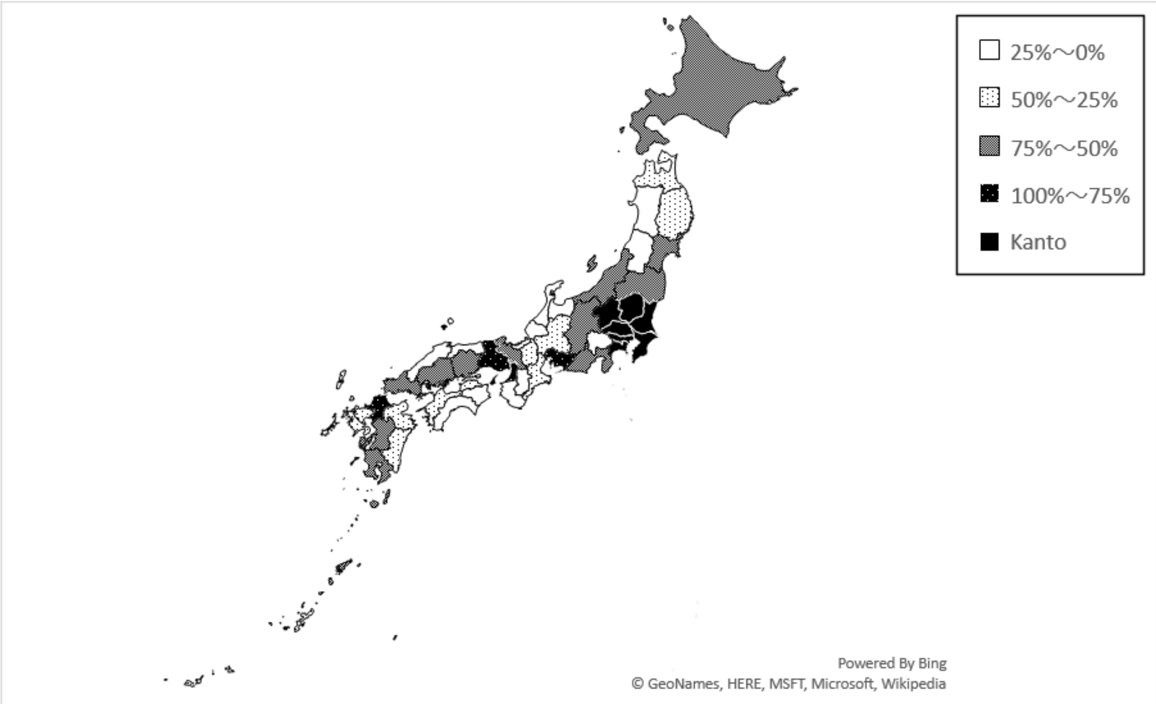

Fig. 7.1. Spillover from the Kanto region to other regions in the next 10 years.

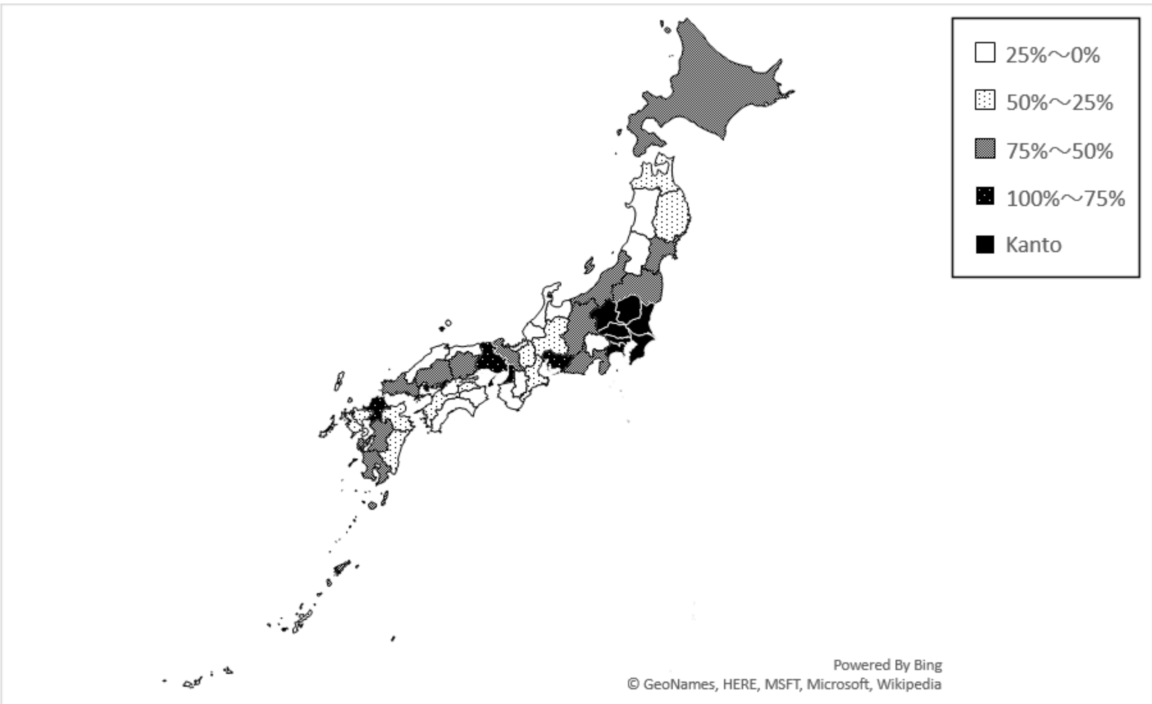

Fig. 7.2. Spillover from the Kanto region to other regions in the next 20 years.

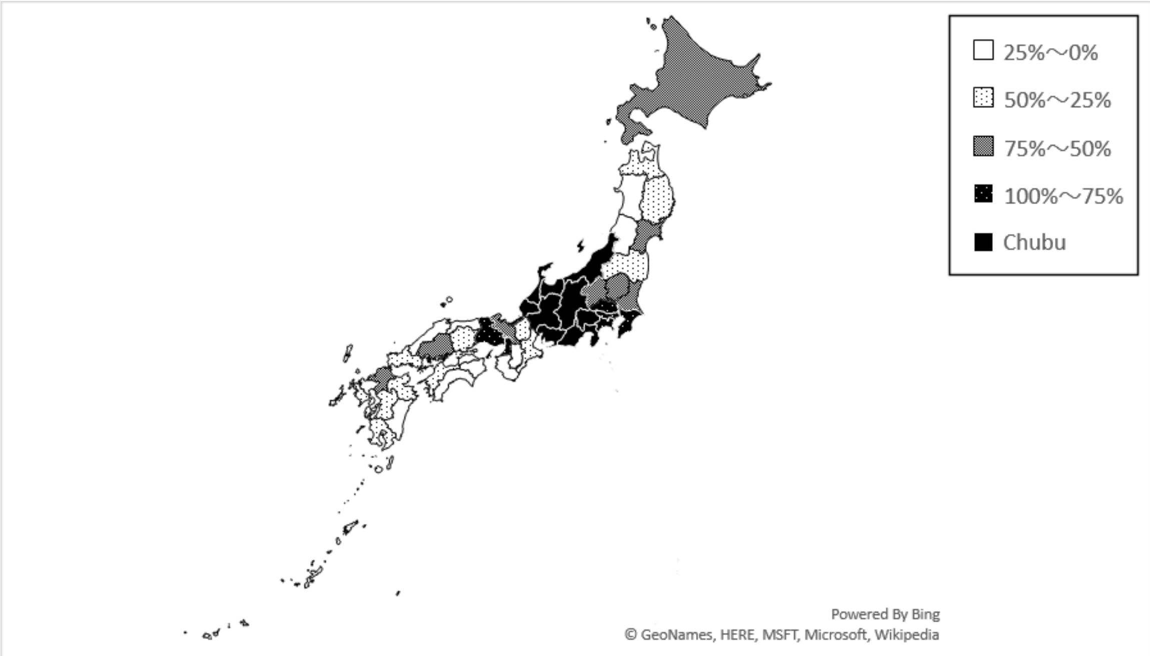

Fig. 8.1. Spillover from the Chubu region to other regions in the next 10 years.

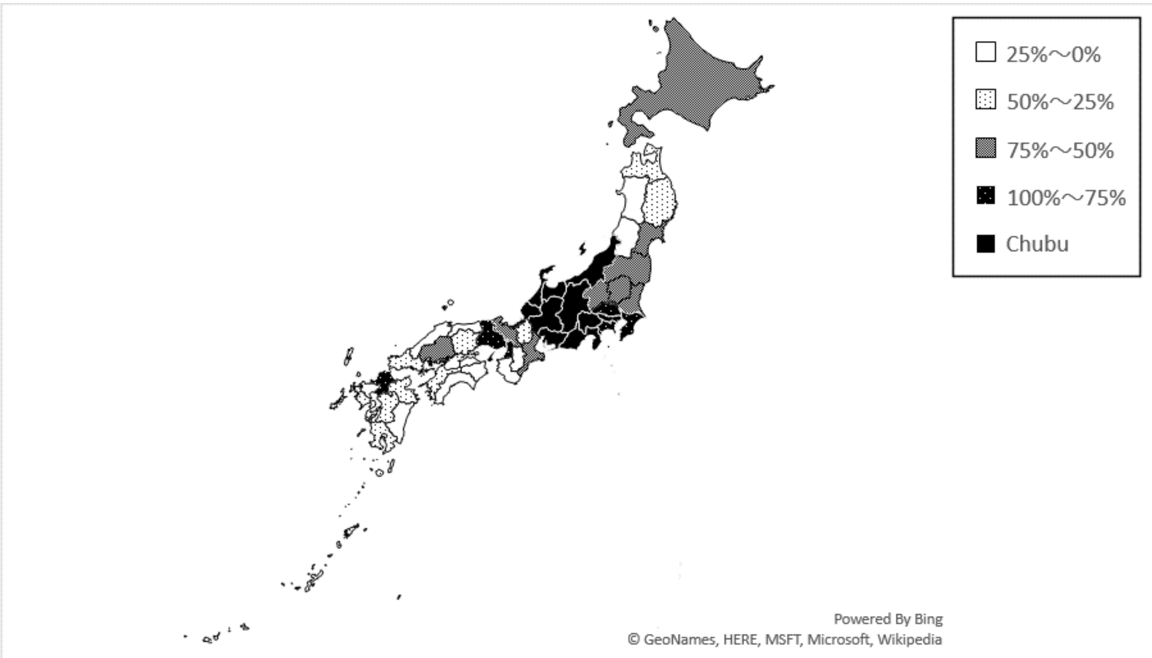

Fig. 8.2. Spillover from the Chubu region to other regions in the next 20 years.

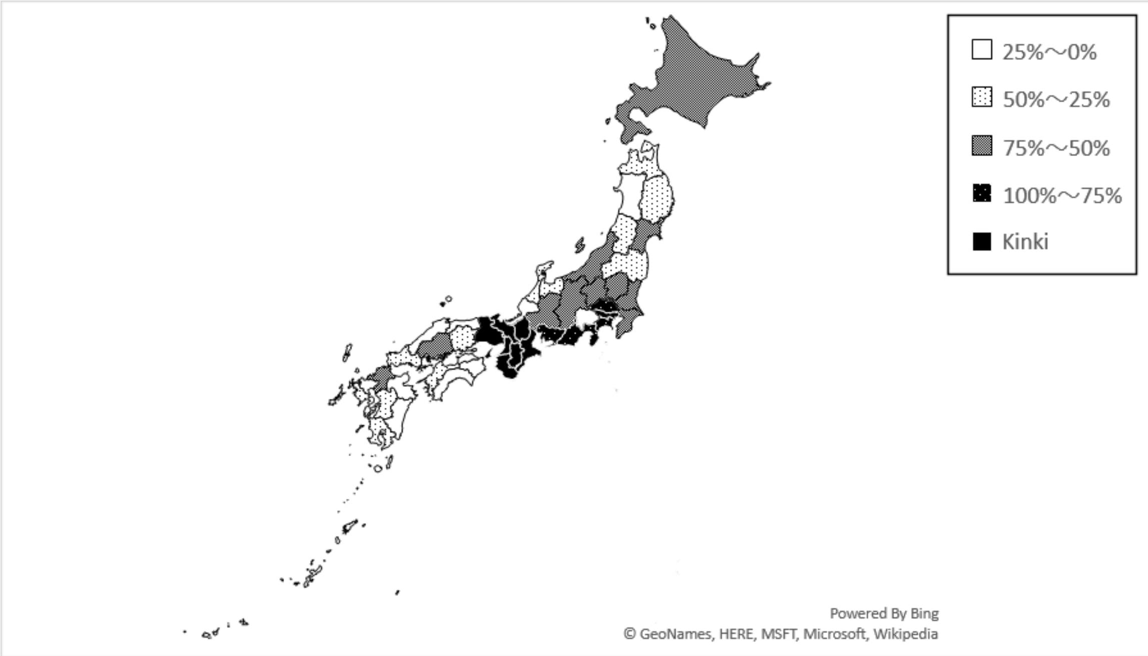

Fig. 9.1. Spillover from the Kinki region to other regions in the next 10 years.

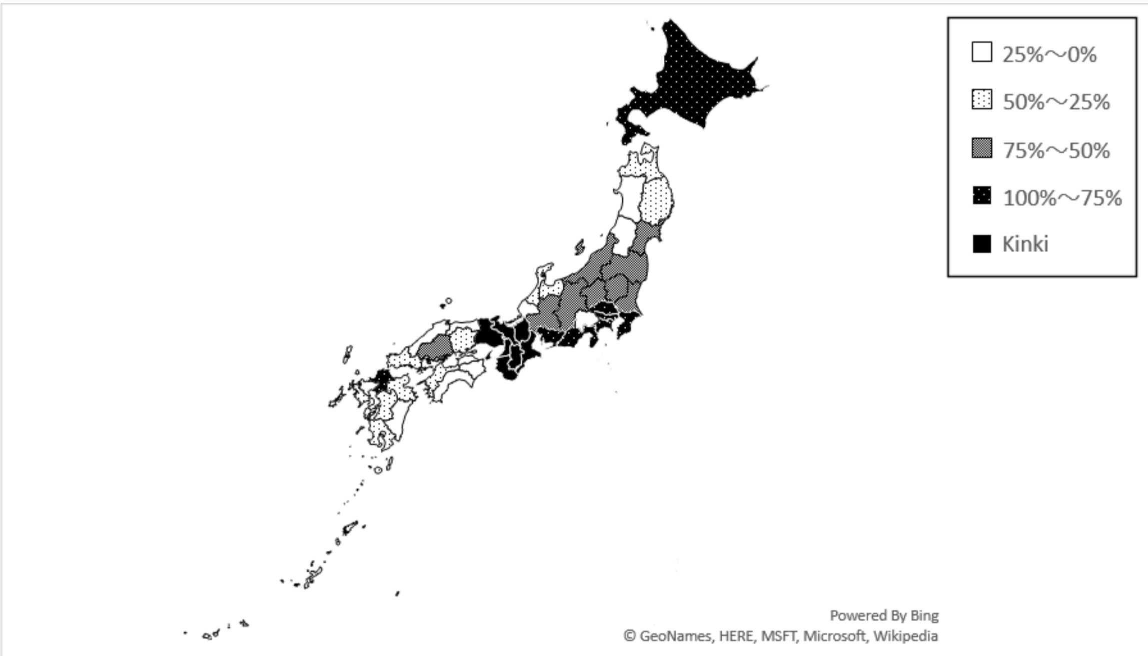

Fig. 9.2. Spillover from the Kinki region to other regions in the next 20 years.

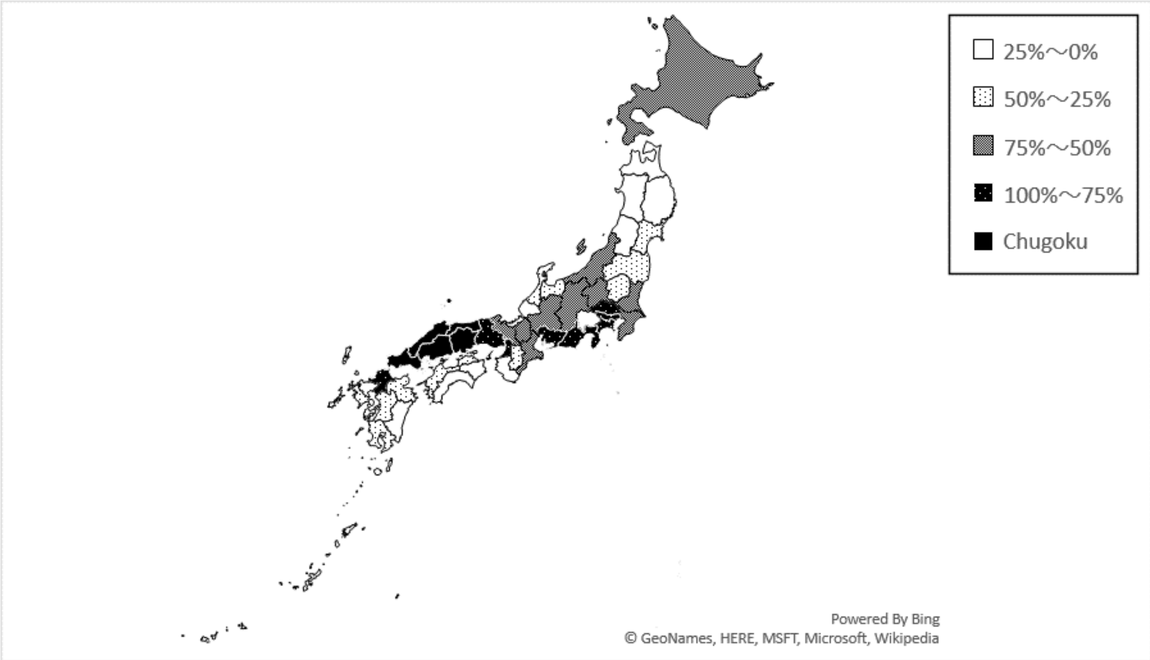

Fig. 10.1. Spillover from the Chugoku region to other regions in the next 10 years.

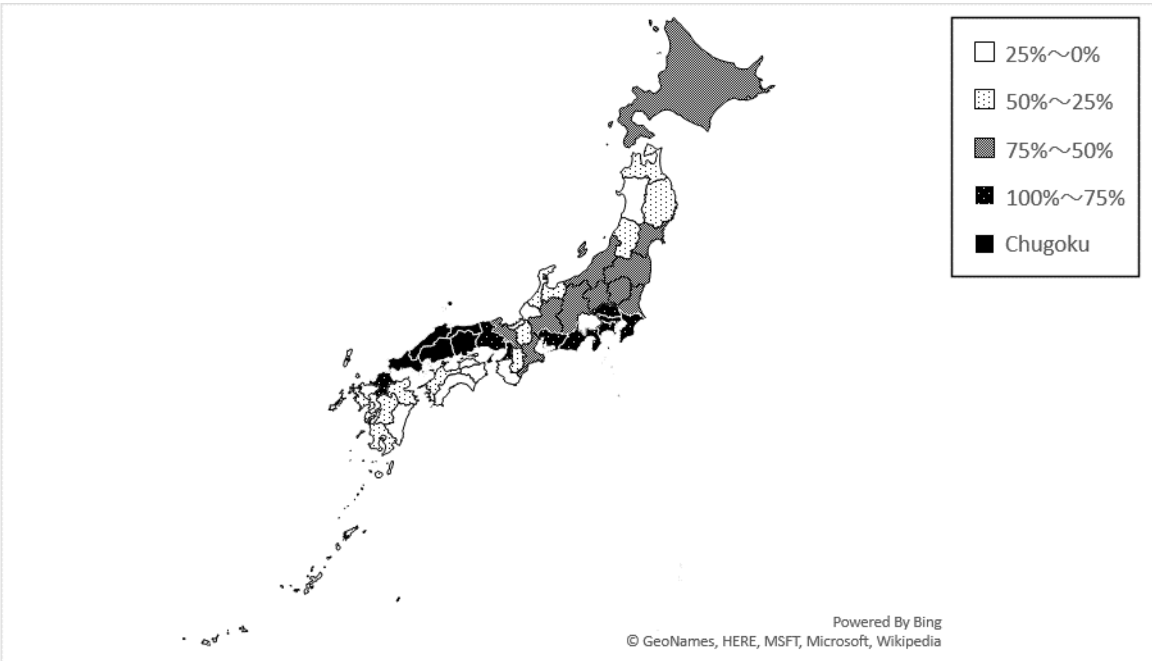

Fig. 10.2. Spillover from the Chugoku region to other regions in the next 20 years.

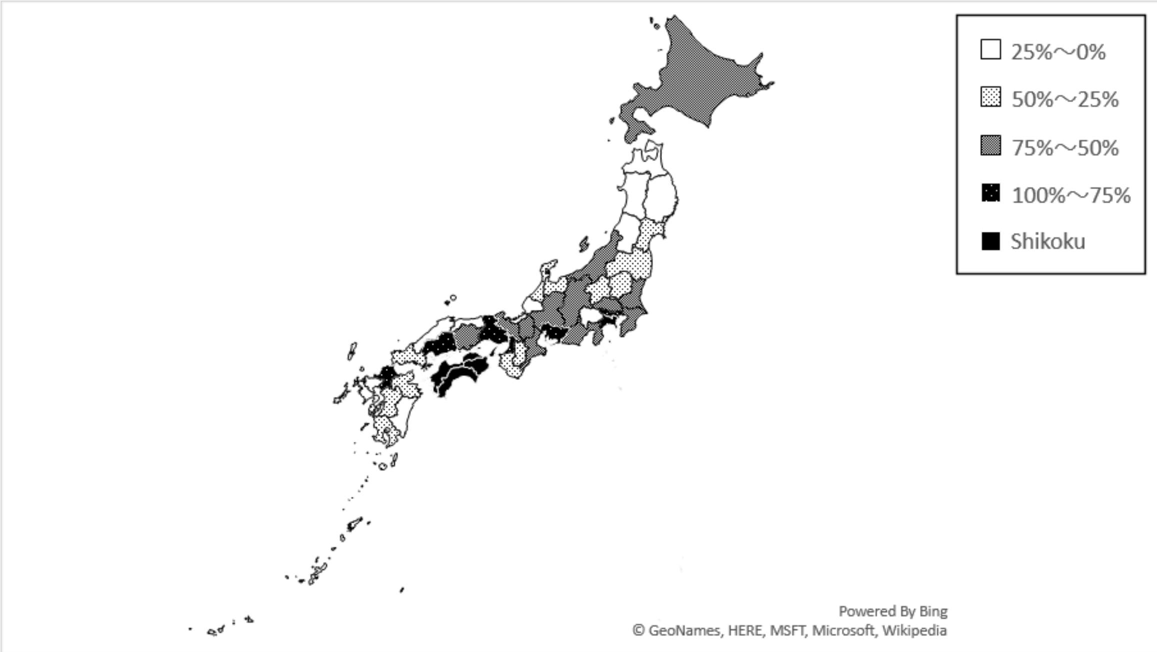

Fig 11.1. Spillover from the Shikoku region to other regions in the next 10 years.

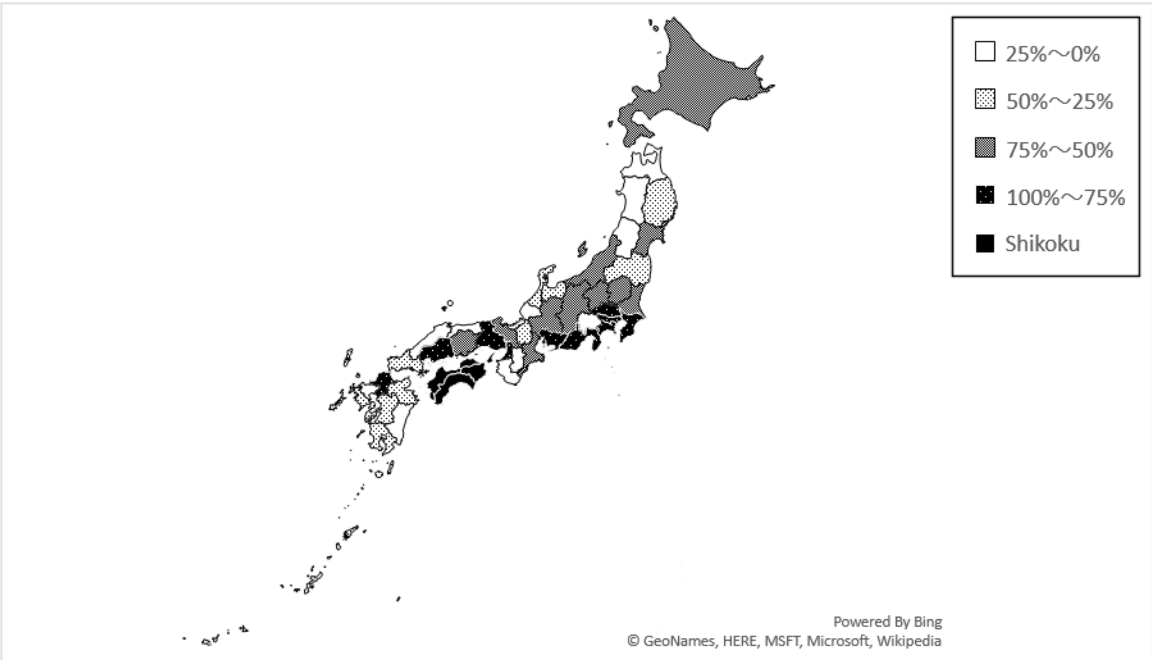

Fig. 11.2. Spillover from the Shikoku region to other regions in the next 20 years.

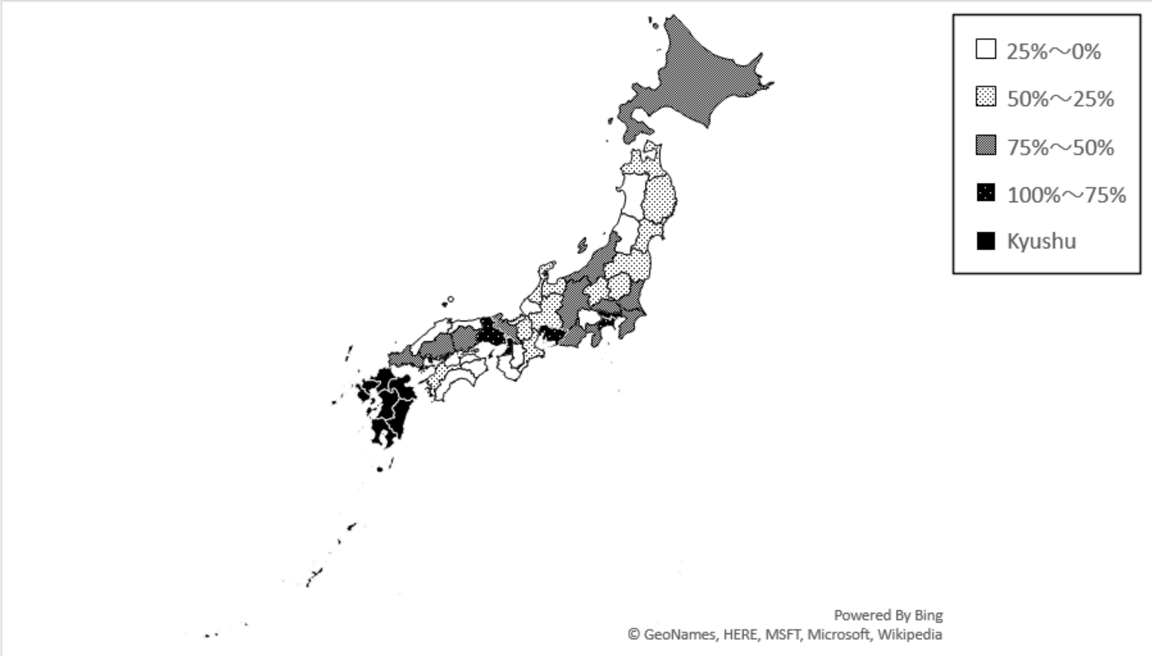

Fig. 12.1. Spillover from the Kyushu region to other regions in the next 10 years.

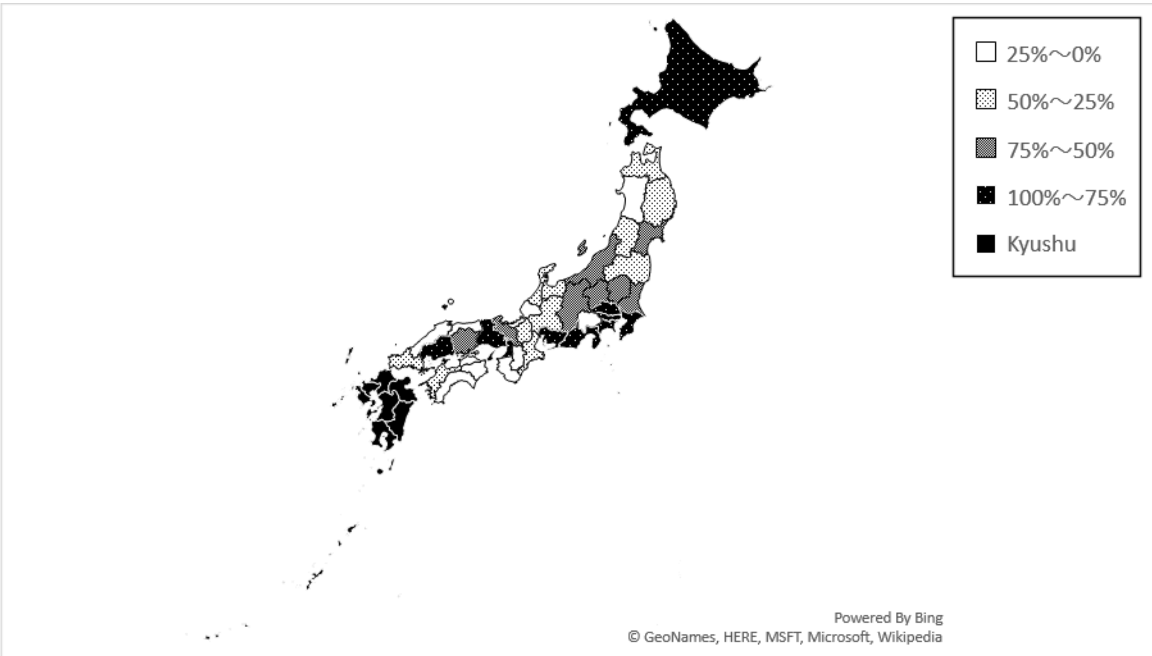

Fig. 12.2. Spillover from the Kyushu region to other regions in the next 20 years.

5. Conclusion

This paper analyzes the aggregate inflation dynamics based on the spatial model that allows the asymmetric regional spillover effects using Japanese prefectural panel data. We simulate how the shocks in regional inflation affect the aggregate inflation and evaluate which region should be targeted for achieving high aggregate inflation.

We find that the effects of 1% increase in region-specific inflation on the sum of other regions' inflation rate exceed 1, except for the Kanto region. This result suggests that the spillover effect from urban areas such as the Kanto region to other regions is not sufficiently large. Similarly, the price spillovers from high-GDP prefectures to other prefectures and from population-concentrated areas to other areas are also not sufficiently large. On the contrary, the price spillover from local areas such as Shikoku, Chugoku, and Kyushu regions to other regions and from low-GDP prefectures to other prefectures are expected to have large effects on the price level of Japan. Furthermore, although the Kanto region limited influences on other regions, the Shikoku, Chugoku, and Kyushu regions have a large influence on many regions.

In summary, the effects of region-specific price shock on aggregate inflation are larger in local areas than in rural area. First, this result confirms that LOP does not hold in the regional product market in Japan. Our finding suggests that policies targeting rural rather than urban areas are important for activating the aggregate economic activity reflected in the price level. Our findings further suggest that the monetary policy of "price stability target" should also set up the "rural price stability target" to achieve national "price stability target."

References

Baba, Chikako., 2007. Price Dispersion Across and Within Countries: The Case of Japan and Korea. Journal of the Japanese and International Economies. 21, 237-259.

Ciccarelli, Matteo., Mojon, Benoit., 2005. Global Inflation. ECB Working Paper Series. No. 537.

Crucini, Mario J., Shintani, Mototsugu., Tsuruga Takayuki., 2010. The Law of One Price Without the Border: The Role of Distance Versus Sticky Prices. The Economic Journal. 120, May: 462-480.

Engel, Charles., Rogers, John H., 1996. How Wide Is the Border? American Economic Review. 86(5), December: 1112-1125.

Ikeno, Hidehiro., 2014. Long-run Analysis on Convergence of Japanese Local Price Levels: A Pairwise Approach. Economic Modelling. 42, 390-397.

Im, Kyung So., Pesaran, M. Hashem., Shin, Yongcheol., 2003. Testing for Unit Roots in Heterogenous Panels. Journal of Econometrics. 115(1), July: 53-74.

Levin, Andrew., Lin, Chien-Fu., Chu, Chia-Shang., 2002. Unit Root Tests in Panel Data: Asymptotic and Finite-Sample Properties. Journal of Econometrics. 108(1), May: 1-24.

Maddala, G.S., Wu, Shaowen., 1999. A Comparative Study of Unit Root Tests with Panel Data and a New Simple Test. Oxford Bulletin of Economics and Statistics. 61(S1), December: 631-652.

Marques, Helena, Pino, Gabriel., de Dios Tena Horrillo, Juan., 2014. Regional Inflation Dynamics using Space-Time Models. Empirical Economics. 47, 1147-1172.

Nagayasu, Jun. 2011. Heterogeneity and Convergence of Regional Inflation (Prices). Journal of Macroeconomics. 33, 711-723.

Nagayasu, Jun. 2017. Inflation and Consumption of Nontradable Goods: Global Implications from Regional Analyses. International Review of Economics and Finance. 48, 478-491.

Osorio, Carolina., Unsal, D. Filiz., 2013. Inflation Dynamics in Asia: Causes, Changes, and Spillovers from China. Journal of Asian Economics. 24, 26-40.

Winkelried, Diego., Gutierrez, Jose Enrique., 2015. Regional Inflation Dynamics and Inflation Targeting: The Case of Peru. Journal of Applied Economics. 18(2), November: 199-224.

Yesilyurt, Filiz., Elhorst, J. Paul., 2014. A Regional Analysis of Inflation Dynamics in Turkey. The Annals of Regional Science. 52, 1-17.