An Analytical Model of Panel Data on Inland Prefectures of Japan

Shoichi KANEKO^{a*}, Takaaki KAWANAKA^b, Nyunho Jung^c
Hiroshi YAMASHITA^d, Masanobu MATSUMARU^e

^aFaculty of Business Administration, Yamanashi Gakuin University, 2-4-5 Sakaori, Yamanashi 400-8575, Japan

^bGraduate School of Engineering, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo, 113-8654 Japan

^cFaculty of Business, The University of Fukuchiyama, 3370 Hori, Fukuchiyama, Kyoto, 620-0886 Japan

^dDepartment of Commerce, Meiji University, 1-1 Kanda-Surugadai, Chiyoda-ku, Tokyo, 101-8301 Japan

^eMechanical and Industrial Engineering Department, 3-27-1 Rokkakubashi, Kanagawa-ku, Yokohama-shi, Kanagawa, 221-8686 Japan

Abstract

In Japan, administrative divisions are classified in 47 prefectures. Among them, eight that do not face the sea are designated as “inland prefectures.” These inland prefectures are considered to have different properties than “coastal prefectures”—those that face the sea. Therefore, in this study, we quantitatively analyze the influence of several factors on the value of manufactured goods shipments from inland and coastal prefectures, based on our previous studies. These factors include population, area, value of forestry goods shipments, value of fishery goods shipments, presence of ordinance-designated city, before and after the collapse of the bubble economy, before and after the Lehman shock, and so on. This analysis model is characterized by handling time series quantitative and qualitative data. We validate the model by conducting an empirical analysis using panel data. Furthermore, we attempt to quantitatively grasp the common points and differences between the industrial structures of inland and coastal prefectures, based on estimates of parameters obtained from the empirical analysis.

Keywords: *Inland prefecture, Coastal prefecture, Statistical data by prefectures, Panel data for an analysis model, Industrial structure*

1. Introduction

Japan is composed four main islands—Hokkaido, Honshu, Shikoku, and Kyushu (**Figure 1**). Further, Japan is an elongated island country, and because the distance between its bordering waters (i.e., the Pacific Ocean and Sea of Japan) is short, most prefectures are “coastal prefectures” that face the sea. However, in the Honshu regions where the Pacific Ocean and Sea of Japan are relatively far apart—that is, in the Kanto, Chubu, and Kinki districts—“inland prefectures” that do not face the ocean exist. Such are the Tochigi, Gunma, and Saitama prefectures in the Kanto district; Nagano, Yamanashi, and Gifu prefectures in the Chubu region; and Shiga and Nara prefectures in the Kinki district—a total of eight prefectures (**Figure 1**).

As a matter of course, the above-mentioned inland prefectures have common traits (special characteristics different from other prefectures—for example, very small “catch height”) that arise from not facing the ocean. However, the eight inland prefectures also have specific differences. The authors [1] pointed out the specialty and diversity of these inland prefectures and noted that the Nakasendo and Koshu Kaido were developed in the Edo period as a historical factor that established inland Japan. Along with the area and presence or absence of a plain, the eight inland prefectures with diverse characteristics

are presented with a framework (Japanese Inland Prefecture Classification Framework [1]) that classifies them into four categories.

As a result, the inland prefectures with a large area (Nagano and Gifu) naturally have a large population and large agricultural and industrial shipment values. Among inland prefectures with a small area, those in the Kanto plains have a large population and large agricultural and industrial shipment values. In comparison, inland prefectures in which plains are replaced by basins are few.

Based on the above-mentioned prior study, the industrial shipment values for coastal and inland Prefectures in Japan are affected by factors such as population, area, presence or absence of designated cities, before and after the collapse of the bubble economy, and before and after Lehman shock. The collapse of the bubble economy and the Lehman shock had a great impact on the economy [2]. Therefore, we propose a “panel data analysis model” to quantitatively analyze the influence of these factors [3,4]. In this study, the validity of the proposed model is verified by conducting an empirical analysis using panel data. Furthermore, we attempt to understand the common points and differences between the industrial structures of coastal and inland prefectures using the parameter estimates obtained from this empirical analysis.

*Corresponding author: shoichi@ygu.ac.jp

Figure 1 Map of Japan and 8 inland prefectures

2. Specialty and diversity of inland prefectures in Japan

Japan is surrounded by the oceans and has the characteristic of slender national land. Most prefectures in Japan, therefore, face the ocean. However, eight prefectures that do not face the ocean—inland prefectures—have different characteristics from the others. The remarkable specialty of inland prefectures is that the number of fishery workers is very small and there are few large cities. Specifically, inland prefectures have no cities with a population of 500,000 or more—except for Saitama city in Saitama prefecture. Furthermore, the only prefectures having cities with a population of 400,000 or more are Tochigi (Utsunomiya city) and Gifu (Gifu city). It is self-evident that the number of fishermen in inland prefectures is very small, but the fact that there are few populous cities is because large Japanese cities are formed along the coast.

However, the population of five inland prefectures—excluding Yamanashi, Shiga, and Nara Prefecture—reaches more than 1.5 million people, and the population of Saitama Prefecture is more than 7 million people (the fifth in Japan). Therefore, it cannot be said that the population of inland prefectures is small. For this reason, the authors [1] point out the following factors: ① Saitama, Tochigi, and Gunma prefectures are located in the Kanto plain, which is more populous than the mountainous areas. ② Nagano prefecture is located in the mountains, but the area is large. Gifu prefecture has both the plain of ① and the population of ②. On the other hand, the populations of Yamanashi, Shiga, and Nara prefectures are small, as they do not fall under either ① or ②.

In prefectures that face the ocean, agriculture and manufacturing industry are generally a trade-off, but in the inland prefectures, the following unique characteristic is observed. Those with large amounts of agricultural shipments also have large industrial shipment values (product shipment amounts, etc.). As contributing factors, the authors see aspects of both ① and ② above. That is, prefectures corresponding to ① have plains suitable for both ag-

riculture (especially vegetables) and industry. Additionally, agriculture and manufacturing industry are developing simultaneously because they are near to the consumption areas of the big cities. In Nagano prefecture—which corresponds to ②—there are many businesses operators that develop agriculture and industry simply because the land is so vast.

However, it can be pointed out that in addition to ②, the development of the precision machine industry aiming at the “Switzerland of Japan” greatly contributes to manufacturing industry in Nagano prefecture. On the other hand, in Yamanashi, Shiga, and Nara prefectures, both ① and ② are not satisfied, and both agriculture and manufacturing industry are not well developed. Therefore, even with the same designation of inland prefecture, the eight prefectures have different diversity as well as common points in terms of population, topography, and industry.

3. Inland prefectures in Japan and the five main roads of the Edo period of Japan

As many large cities in Japan have been formed and developed in coastal areas—such as Tokyo, Osaka, Nagoya, Yokohama, Kobe, Fukuoka, Hiroshima, and Sendai—the inland prefectures tend to be overlooked in terms of such development by all means is there. However, for an inland prefecture to be established as an independent prefecture, it must have a suitable industrial scale and populous city (for example, the prefectural capital).

As described above, the inland prefecture, which tends to be left behind in the development of cities and industries, as a historical factor leading to the establishment as an independent prefecture, has been developed in the five roads [1]. These roads were called Tokaido, Nakasendo, Koshu Kaido, Oshu Kaido, and Nikko Kaido. These five roads were called “Gokaido” in Japanese (Figure 2). All of the above 5 roads pass through the current inland prefecture, and five inland roads were in communication with seven inland prefectures other than Nara prefecture. Among other things, Nakasendo passed through five prefectures (Saitama, Gunma, Nagano, Gifu and Shiga prefectures) out of the eight inland prefectures. The old road was significant in the development of central Honshu (inland). Meanwhile, there is a historical factor that the capital of Japan (Heijokyo) was located also in Nara Prefecture, the only inland part where five old roads do not pass.

The five roads of the Edo period were the main roads at the time, around which cultural spheres and industrial zones were formed [1]. As such, cultural and industrial areas worthy of the current prefectures were formed. From the contrary viewpoint, had the five roads not been developed in the Edo period, cultural and industrial areas would likely not have been formed in the mountains of central Honshu, and it can be argued that the current inland prefectures would not have been established [1]. Put differently, the presence of the inland prefectures of Japan depends greatly on the historical factors mentioned above.

Figure 2 Map of the 5 main roads during the Edo period

4. Classification framework of inland prefecture

To describe the characteristics of the inland prefectures of Japan as briefly as possible, the authors [1] propose the inland prefectures classification framework shown in **Figure 3**. With the proposed framework, the characteristics of the inland prefectures of Japan can be classified into four categories by combining the axes of “area” and “presence or absence of plain.”

First, types S-2 and B-2 in **Figure 3** describe inland prefectures in which plains do not exist and a basin replaces the plain [1]. For example, only Nagano prefecture is classified as type B-2, in which there is no plain, but the area is large such that the population and industrial shipment values are large. Types S-1 and B-1 each describe prefectures in which plains exist. In this case, the following characteristics are observed: Saitama, Tochigi, and Gunma prefectures—located in the Kanto plain—are classified as type S-1, but only Gifu prefecture—located in the Nobi plain—is classified as type B-1. And the inland 3 prefectures in the metropolitan area are classified in type S-1, and Gifu prefecture in the Chukyo area is classified in type B-1. It finds out that the two types have a common character of inland prefecture in the metropolitan area. The inland prefectures belonging to these two types are more strongly characterized as prefecture located in the metropolitan area than prefecture in the mountain. Saitama prefecture has a population of more than 7 million people—the fifth largest in Japan—and primarily covers the Kanto plain, and it is a perfect urban type prefecture. Additionally, it has the only ordinance-designated city (Saitama City) of the inland prefectures.

Meanwhile, Gifu prefecture of type B-1 has mountains of 3,000 meters in height. As such, it has characteristics close to those of both Nagano (type B-2) and Yamanashi (type S-2) prefectures. For this reason, Gifu prefecture is an inland prefecture which has the character of both “prefecture located in metropolitan area” and “prefecture located in mountain.”

5. Model

With this analysis model [3,4], we attempted to quantitatively analyze the impact of industrial shipment values on

		S-1	B-1
Presence		Saitama, Tochigi, Gunma	Gifu
Plains			
Absence		S-2	B-2
		Yamanashi, Siga, Nara	Nagano
		Less than 10,000 km ²	10,000 km ² or more
		Area	

Figure 3 Classification framework of inland prefecture

the coastal and inland prefectures of Japan based on the following factors: population, area, existence of ordinance-designated city, before and after the collapse of the bubble economy, and before and after the Lehman shock [2].

First, panel data of industrial shipment values by prefecture were set as the dependent variable, y_{ijt} . Additionally, the common independent variables of all prefectures were set as x_{ijkt} , where

- $i=1$: inland prefecture
- $i=2$: coastal prefecture
- j : prefecture number
- t : fiscal year
- $k=1$: population
- $k=2$: area
- $k=3$: ordinance-designated city
- $k=4$: before the collapse of the bubble economy
- $k=5$: before the Lehman shock

The common independent variables of x_{ij3t} , x_{ij4t} and x_{ij5t} are categorical data [5,6].

The independent variables for inland and coastal prefectures were set as z_{ijkt} , where

- $k=6$: agricultural shipment value
- $k=7$: forestry shipment amount

Subsequently, partial regression coefficients for the independent variables x_{ijkt} common to all prefectures were set to a_k (a_1 to a_5); and those for the independent variables z_{ijkt} for inland or coastal prefectures were set to b_{ki} (b_{6i} , b_{7i}); the constant term was set to a_0 . On this basis, we proposed the following panel data analysis model of industrial shipment value by prefecture:

$$y_{ijt} = a_0 + \sum_{k=1}^5 a_k \cdot x_{ijkt} + \sum_{k=6}^7 \sum_{i=1}^2 b_{ki} \cdot z_{ijkt} + e_{ijt} \quad (1)$$

where e_{ijt} is the residual term.

Therefore, the estimate of the parameter vector $\mathbf{a}' = (a_0, a_1, a_2, a_3, a_4, a_5, b_{61}, b_{62}, b_{71}, b_{72})$ that minimizes the residual sum of squares, e_{ijt} , (the least squares estimator) of Equation (1) is given by the normal equation, Equation (2):

$$\mathbf{a} = (\mathbf{X}' \cdot \mathbf{X})^{-1} \mathbf{X}' \mathbf{y} \quad (2)$$

$$\mathbf{a}' = (a_0, a_1, a_2, a_3, a_4, a_5, b_{61}, b_{62}, b_{71}, b_{72})$$

X : $(47 \cdot T)$ rows and 10 columns of independent variables matrix

X' : transpose of matrix X

T : period

$i = 1$

$x = (1, x_{11t}, x_{12t}, x_{13t}, x_{14t}, x_{15t}, z_{16t}, 0, z_{27t}, 0)$

$i = 2$

$x = (1, x_{21t}, x_{22t}, x_{23t}, x_{24t}, x_{25t}, 0, z_{26t}, 0, z_{27t})$

y : $(47 \cdot T)$ dimension of dependent variables vector

$y = (y_{ijt})$

6. Empirical analysis

The validity of the proposed model [3,4] is verified by conducting an empirical analysis using panel data [7,8,9] collected a 47-year period from 1986 to 2012 (Table1).

Table 1. A sample from panel data

Fiscal year	1986		1987		2012	
Prefectures	Hokkaido	Aomori	Hokkaido	Aomori	Hokkaido	Aomori
Value of Manufactured goods shipments	5,021,310	1,014,033	4,950,863	1,000,409	6,139,425	1,492,347
Population	5,673	1,517	5,660	1,511		
Area	83,457	9,645	83,457	9,645		
Presence of ordinance designated city	1	0	1	0	1	0
Before and after the bubble economy	1	1	1	1	0	0
Before and after the Lehman shock	0	0	0	0	1	1
Value of agricultural goods shipments in inland prefecture	0	0	0	0	0	0
Value of agricultural goods shipments in coastal prefecture	11,094	3,115	10,373	2,503	10,536	2,759
Value of forestry goods shipments in inland prefecture	0	0	0	0	0	0
Value of forestry goods shipments in coastal prefecture	12,508	2,503	10,930	2,828	4,387	811

As a result of the empirical analysis of the proposed model [3,4], the multiple correlation coefficient (with a high degree of $R = 0.8090$) was obtained.

We rechecked the panel data and thus corrected the incorrect data. It was analyzed again. As a result of the analysis the multiple correlation coefficient (with a high degree of $R = 0.8096$) was obtained, as shown in Table 2. From the results of Table 2, it can be seen that parameters a_1 (population) and a_3 (ordinance-designated city) greatly affected the industrial shipment values in the common independent variables of all prefectures. Tokyo, Osaka, Kanagawa, and Aichi prefectures all have large populations and ordinance-designated cities. As such, the parameter values of the proposed model are in conformity with reality.

Conversely, the area parameter a_2 had a negative influence on the industrial shipment value. In Japan, the largest prefectures by area—such as Iwate, Fukushima, Nagano, Niigata and Kagoshima—have a relatively high reliance on the primary industries—such as agriculture and forestry—compared to smaller prefectures. The proposed model appears to have reflected these points. Additionally,

the largest area—Hokkaido—has large industrial shipment value with primary industry. Put differently, Hokkaido is populous in Sapporo city—its ordinance-designated city—and secondary industries are also popular and have different characteristics from other prefectures with a large area parameters a_4 (before and after the collapse of the bubble economy) and a_5 (before and after the Lehman shock) were negative and positive values, respectively.

The proposed model [3,4] showed interesting results in that the price, stock price decline, and land price had a negative influence on the Japanese economy both before and after the collapse of the bubble economy. However, the fluctuation of the industrial shipment value is small (stock price collapsed approximately 50% decline was recorded one year after).

Parameters b_{61} and b_{62} —which are the values of agricultural goods shipments in inland and coastal prefectures, respectively—were positive values. This result suggests that agriculture is actively performed even in many coastal prefectures. However, both parameter b_{71} (the weight of forestry shipments in inland prefectures) and b_{72} (the same for coastal prefectures) were negative values. From this result, it can be seen that the forestry shipment value of coastal prefectures is negatively relative to the industrial shipment value. Likewise, the forestry shipment value of inland prefectures is negatively relative to the industrial shipment value. Put differently, the proposed model suggests a trade-off between forestry and industry in coastal prefectures—which is in line with reality.

Table 2. Analysis results

Independent variables		Estimated results
a_0	Intercept	53.6×10^5
a_1	Population	45.0×10^5
a_2	Area	-22.4×10^5
a_3	Presence of ordinance designated city	24.3×10^5
a_4	Before and after the collapse of the bubble economy	-0.99×10^5
a_5	Before and after the Lehman shock	5.51×10^5
b_{61}	Value of agricultural goods shipments in inland prefecture	13.0×10^5
b_{62}	Value of agricultural goods shipments in coastal prefecture	20.6×10^5
b_{71}	Value of forestry goods shipments in inland prefecture	-0.12×10^5
b_{72}	Value of forestry goods shipments in coastal prefecture	-4.81×10^5
Multiple correlation coefficient (R)		0.8096

In Japan, the Great East Japan Earthquake struck in March 2011, damaging the Japanese economy. We set the parameter a_6 of “before and after the Great East Japan Earthquake” in our model, and formulate a new analysis model of Equation (3).

$$y_{ijt} = a_0 + \sum_{k=1}^6 a_k \cdot x_{ijkt} + \sum_{k=7}^8 \sum_{i=1}^2 b_{ki} \cdot z_{ijkt} + e_{ijt} \quad (3)$$

The validity of the new model is verified by conducting an empirical analysis using panel data collected a 49-year period from 1986 to 2014. As a result of the analysis, the multiple correlation coefficient was $R = 0.800$. The long low growth after the collapse of the bubble economy has influenced this result.

We formulate another new model. For the categorical variables of this model, parameter a_3 and a_4 were set as shown in equation (4).

$$y_{ijt} = a_0 + \sum_{k=1}^4 a_k \cdot x_{ijkt} + \sum_{k=5}^6 \sum_{i=1}^2 b_{ki} \cdot z_{ijkt} + e_{ijt} \quad (4)$$

The validity of the new model is verified by conducting an empirical analysis using panel data collected a 14-year period from 1986 to 1999. As a result of the analysis, the multiple correlation coefficient was $R = 0.8719$. However, in the model excluding parameter a_4 , the multiple correlation coefficient is $R = 0.7200$. The model of Equation (4) is considered to be valid for large changes in time series.

7. Conclusion

In this study, based on the previous study, the industrial shipment values of coastal and inland prefectures in Japan were estimated based on factors such as population, area, existence of ordinance-designated city, before and after the collapse of the bubble economy, and before and after the Lehman shock. Furthermore, empirical analysis of the proposed model using panel data from 1986 to 2012 was conducted, and the multiple correlation coefficient $R = 0.8096$ was obtained. Additionally, the proposed model has common explanatory variables for all prefectures, as well as explanatory variables for inland and coastal prefectures. From the estimated parameter values obtained from empirical analysis, we were able to grasp the commonalities for industrial shipment values, and differences in industrial structure between coastal and inland prefectures.

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