Agglomeration Economies in Maritime Manufacturing Sector: A Case Study in Japan

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Abstract: This paper investigates agglomeration economies in maritime manufacturing sector at the prefectural level in Japan. After providing an overview of the Japanese regional and industrial policies since 1960s with a special focus on industrial cluster policy, the industrial diversity, the levels of regional specialization and regional competition in maritime manufacturing industry are measured by using the Hirschman-Herfindahl index and location quotient. It follows with the calibration of the production function for examining the effect of agglomeration economies in maritime manufacturing sector and with the exploration of three types of agglomeration: Marshall-Arrow-Romer, Porter and Jacobs. The empirical results reveal no strong evidence of agglomeration economies in maritime manufacturing sector in Japan, but judging from the signs of parameters, production amount in maritime manufacturing sector of some prefectures might be affected by the industrial diversity, the levels of regional specialization and regional competition in maritime manufacturing industry.

Keywords: Agglomeration economies, Maritime manufacturing sector, Maritime industrial cluster, Hirschman-Herfindahl index, Location quotient and Japan

1. INTRODUCTION

Over the last decades, Japan has lost its industrial competitiveness in Asia, where strong economic growth and economic integration have proceeded at both the global and regional levels. One of the typical examples includes its current lower status in the shipbuilding and related industries. The Japanese government intends to retrieve the competitive position Japan once had as an economic power in Asia by promoting several regional and industrial policies. Among them is industrial cluster policy, which aims to enhance the global competitiveness of Japanese industry and to invigorate local economy in the country by fostering the evolution of a concentration of industries.

The concept of industrial cluster has drawn considerable attention, particularly since the work of Porter (1998a). A lot of research has frequently discussed an industrial cluster and its theoretical background, agglomeration economies (Glaeser et al, 1992; Maruel and Sédillot, 1999; Fujita and Thisse, 2002; Barrios et al, 2003; Rosenthal and Strange, 2004; Bertinelli and Decrop, 2005; Alecke et al, 2006; Lafourcade and Mion, 2007; Basile and Ciccarelliy, 2015; Yamada and Kawakami, 2015; Yamada and Kawakami, 2016). A cluster allows each member to benefit as if it had greater scale or as if it had joined with others formally, without requiring it to sacrifice its flexibility (Porter, 1998b). In this context, the formation of maritime industrial clusters attracts much attention to vitalize the maritime sector in Japan.

Reflecting these backgrounds, the main purpose of this paper is to explore the presence of agglomeration economies in maritime manufacturing sector at the prefectural level in Japan. The remainder of this paper is organized as follows. The next section provides an overview of the regional and industrial policies adopted by the Japanese government since 1960s. In Section 3, the industrial diversity, the levels of regional specialization and regional competition in maritime manufacturing industry are measured on the prefectural level in Japan in 2014 by using the most popular measures: Hirschman-Herfindahl index and location quotient. In Section 4, production function is estimated to examine the effect of agglomeration economies in maritime manufacturing sector of the selected ten prefectures over the past twenty years and to explore three types of agglomeration (Marshall-Arrow-Romer, Porter and Jacobs), followed by discussion and conclusion with policy implication and future work in Section 5.

2. OVERVIEW OF REGIONAL AND INDUSTRIAL POLICIES AND CURRENT SITUATION OF SHIPBUILDING INDUSTRY IN JAPAN

2.1 Regional and Industrial Policies

Figure 1 describes the overview of the regional and industrial policies in Japan adopted since 1960s. The figure shows the national basic plan and its regional, industrial and economic policies over roughly five terms: the 1960s, the 1970s, from the 1980s to the early 1990s, the late 1990s and since the 2000s. Overall, the general trend in these policies is moving from “strong industrial relocation control” to “weak industrial relocation control” and from “not utilizing regional resources” to “utilizing regional resources”.

From 1960s to the mid-1990s, the policies had intended the industrial relocation and the development of regional core cities for the decentralization of growth industry fields by attracting enterprises outside of the area to create a driving force behind the regional economy and surrounding areas. From the mid-1990s, the policies have aimed at the prevention of the hollowing-out of Japanese industry and the support for development of new growth fields for the revitalization of the underlying cluster and the comprehensive support for development of new business.

Especially since 2001, the policies have focused on the comprehensive support for development of new competitive business in a global context, that is, industrial cluster policy. It’s extremely important to make an invisible trust network in the region to form industrial clusters, which will support the development of new business by small and medium-size enterprises (SMEs) and give rise to university-generated venture businesses. This policy has been promoted by the Ministry of Economy, Trade and Industry (METI) over the three stages. The first stage from 2001 to 2005 was Industrial Cluster Launch. Based on the existing clusters and policy needs, it launched some 20 projects nationwide in collaboration with local governments to construct the foundation for industrial clusters. The second stage from 2006 to 2010 was Industrial Cluster Development. The plan fostered network formation, developed specific businesses and promoted the corporate management reform and the creation of new businesses. The third stage from 2011 to 2020 is Industrial Cluster Autonomous Growth. The plan calls for industrial cluster activities to achieve financial independence and autonomous growth, with further promoting the formation of networks and the development of specific businesses. The activities are currently carried out as region-driven clusters mainly led by private organizations or local governments.

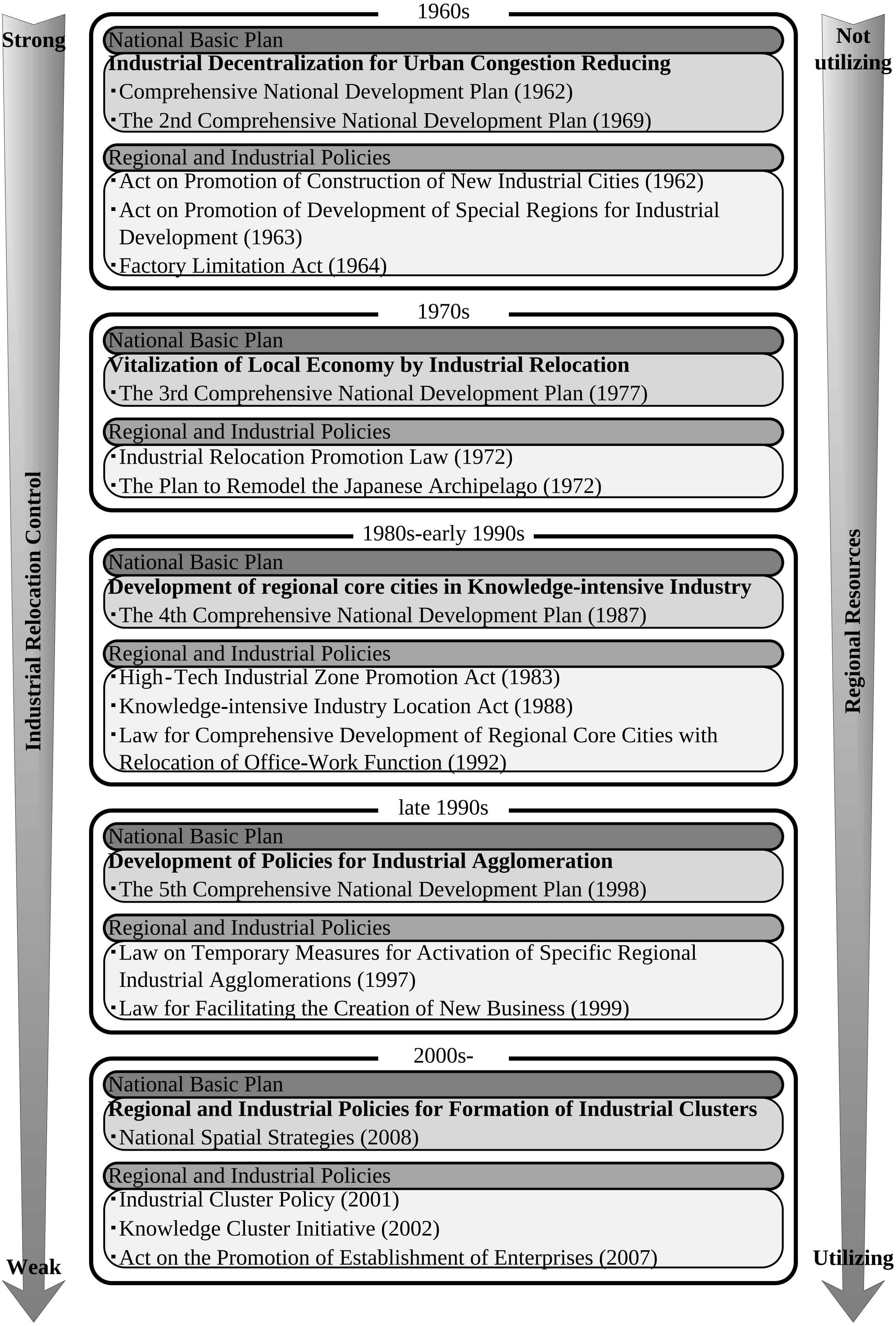

Figure 1. Trend of the regional economic and industrial policies in Japan

2.2 Geographical Location of Major Shipyards

Figure 2 and Table 1 indicate the 47 prefectures in Japan, which are the regional division analyzed below. These figure and table divide Japan into eight regions: Hokkaido, Tohoku, Kanto, Chubu, Kansai, Chugoku, Shikoku and Kyushu. These eight regions have been traditionally used as the regional division of Japan, which is also used in this paper.

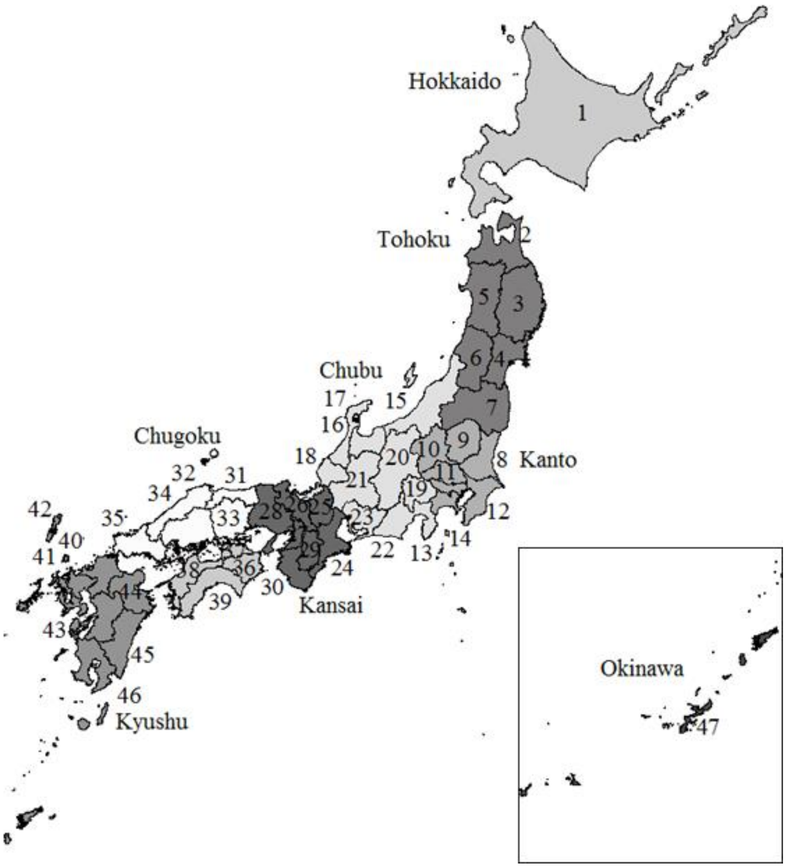

Figure 2. Forty-seven prefectures in Japan

Table 1. Forty-seven prefectures in Japan

No.	Prefecture	No.	Prefecture	No.	Prefecture	No.	Prefecture
Hokkaido		12	Chiba	Kansai		Shikoku	
1	Hokkaido	13	Tokyo	24	Mie	36	Tokushima
Tohoku		14	Kanagawa	25	Shiga	37	Kagawa
2	Aomori	Chubu		26	Kyoto	38	Ehime
3	Iwate	15	Niigata	27	Osaka	39	Kochi
4	Miyagi	16	Toyama	28	Hyogo	Kyushu	
5	Akita	17	Ishikawa	29	Nara	40	Fukuoka
6	Yamagata	18	Fukui	30	Wakayama	41	Saga
7	Fukushima	19	Yamanashi	Chugoku		42	Nagasaki
Kanto		20	Nagano	31	Tottori	43	Kumamoto
8	Ibaraki	21	Gifu	32	Shimane	44	Oita
9	Tochigi	22	Shizuoka	33	Okayama	45	Miyazaki
10	Gunma	23	Aichi	34	Hiroshima	46	Kagoshima
11	Saitama			35	Yamaguchi	47	Okinawa

Note: The numbers correspond to those in Figure 2.

Table 2 shows the major shipyards located in the 18 out of these 47 prefectures. There is geographical concentration of major shipyards especially in Hiroshima, Kagawa, Ehime and Nagasaki prefectures. They also concentrate in Kanagawa, Okayama, Yamaguchi and Oita prefectures. Many of these prefectures are located in the northern part of Kyushu region or surrounding Seto Inland Sea (Island Sea of Japan).

Table 2. Location of major shipyards in Japan

No.	Prefecture	Major shipyard
1	Hokkaido	Hakodate Dock
2	Aomori	Kitanihonship Building
12	Chiba	Mitsui Engineering & Shipbuilding
14	Kanagawa	Japan Marine United, Sumitomo Heavy Industries Marine & Engineering
23	Aichi	Shin Kurushima Toyohashi Shipbuilding
24	Mie	Japan Marine United
26	Kyoto	Japan Marine United
28	Hyogo	Kawasaki Heavy Industries
33	Okayama	Mitsui Engineering & Shipbuilding, Sanoyas Shipbuilding
34	Hiroshima	Japan Marine United, Imabari Shipbuilding, Kanda Shipbuilding, Naikai Zosen, Onomichi Dockyard, Tsuneishi Shipbuilding
35	Yamaguchi	Mitsubishi Heavy Industries, Shin Kasado Dockyard
37	Kagawa	Kawasaki Heavy Industries, Imabari Shipbuilding (2), Shikoku Dockyard
38	Ehime	Imabari Shipbuilding (2), Iwagi Zosen, I-S Shipyard, Shimanami Shipyard, Shin Kurushima Dockyard
39	Kochi	Shin Kochi Heavy Industry
41	Saga	Namura Shipbuilding
42	Nagasaki	Fukuoka Shipbuilding, Mitsubishi Heavy Industries, Namura Shipbuilding, Oshima Shipbuilding
43	Kumamoto	Japan Marine United
44	Oita	Minaminippon Shipbuilding (2), Saiki Heavy Industries

3. MEASURING MARITIME INDUSTRIAL AGGLOMERATION IN JAPAN

3.1 Data Used in the Analyses

We got the data related to maritime manufacturing industry from the Census of Manufacture 2014 conducted by the METI. This survey aims to clarify the actual conditions of the nation's manufacturing industry and obtain basic data for industrial policies. The reference period of the 2014 Census is as of December 31, 2014.

The analyses are based on the Report by Respective Industry, which is one of the statistic tables of the Census of Manufacture. This report covers establishments with four or more employees at the prefectural level and provides the data on the number of employees and establishments etc. in the industries that are classified by three-digits and four-digits of the Japan Standard Industrial Classification (JSIC). Among them, we focus on the industry of shipbuilding and repairing, and marine engines (JSIC code: 313), with a further breakdown by four-digits industry: shipbuilding and repairing (JSIC code: 3131), hull blocks (JSIC code: 3132), small watercraft building and repairing (JSIC code: 3133) and marine engines (JSIC code: 3134). We define this industry as maritime manufacturing industry in this study. The analyses below are conducted over the Japanese 47 urban and rural prefectures, as shown in Figure 2 and Table 1.

3.2 Industrial Diversity, Levels of Regional Specialization and Regional Competition in Maritime Manufacturing Industry

A range of global and quantitative methods have been employed to measure the spatial concentration and regional specialization of industrial activities. We focus here on the Herfindahl-Hirschman index and location quotient, which are the most widely used measures because of their ease of calculation and their limited data requirements.

3.2.1 Herfindahl-Hirschman index: industrial diversity

The Herfindahl-Hirschman index (HHI) is one of the measures to express the spatial concentration of industry. Originally, HHI is a commonly accepted measure of market concentration and an indicator of the amount of competition among firms. It is defined as the sum of the squares of the market share of each firm competing in a market, ranging from close to zero to one. The closer a market is to being a monopoly, the higher the market's concentration, and the lower its competition. The increase in HHI generally indicates a decrease in competition and an increase of market power, moving from a huge number of very small firms to a single large firm.

Here, the HHI for a measure of industry i across regions is expressed as follows:

$$HHI_i = \sum_j \left(\frac{x_{ij}}{\sum_j x_{ij}} \right)^2 \tag{1}$$

where,

xij : number of employees of industry i in region j, or
number of establishments of industry i in region j.

This is an index for spatial concentration of employees/establishments in industry i. In this paper, xij is the number of employees/establishments of maritime manufacturing industry in prefecture j (j=1, ・・・, 47).

The HHI of maritime manufacturing industry based on the number of employees in Japan was 0.07 and that based on the number of establishments was 0.06 in 2014, which means this sector is less concentrated and more dispersed across prefectures. The temporal change on HHI, however, indicates that the degree of spatial concentration of this industry in Japan has become larger over the period from 1995 to 2014, as shown in Figure 3. One of the reasons behind this is that Japanese shipbuilding companies have merged or some large diversified corporations merged their division of shipbuilding together during this period to raise their international competitiveness in the world shipbuilding industry. For example, IHI and Sumitomo Heavy Industries merged a warship business in 1995 and established Marine United. IHI moved a shipbuilding section to Marine United in 2002 and changed its name to IHI Marine United. Universal Shipbuilding was established in 2002 as the merger between the shipbuilding section of NKK and that of Hitachi Zosen. Japan Marine United was established in 2013 as the merger between IHI Marine United and Universal Shipbuilding. Other examples include the acquisition of Koyo Dockyard (2014) and Tadotsu Shipyard (2015) by Imabari Shipbuilding and that of Sasebo Heavy Industry by Namura Shipbuilding (2014).

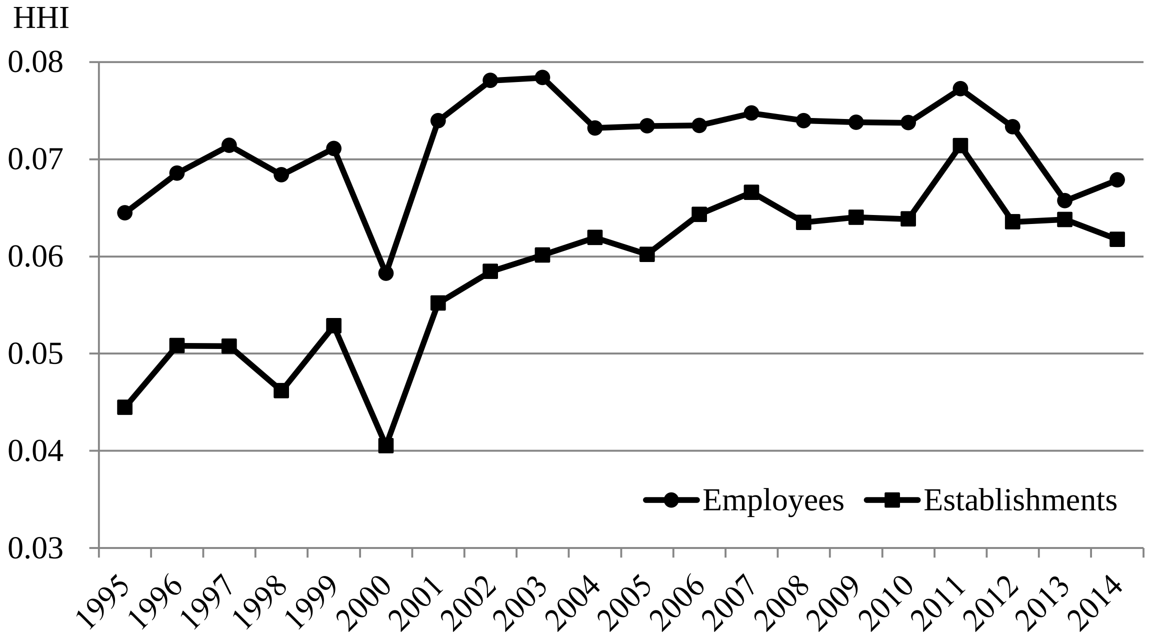

Figure 3. Herfindahl-Hirschman index of maritime manufacturing sector in Japan, 1995-2014
Source: Calculated by authors from the Census of Manufacture 2014.

Meanwhile, the HHI for a measure of industrial diversity in region j is expressed as follows:

$$HHI_j = \sum_i \left(\frac{x_{ij}}{\sum_i x_{ij}} \right)^2 \quad (2)$$

where,

xij : number of employees of industry i in region j, or
number of establishments of industry i in region j.

In this paper, xij is the number of employees/establishments of maritime manufacturing industry in prefecture j (j=1, ･･･, 47).

Figure 4 shows the HHIs of the Japanese 47 prefectures based on the number of employees in 2014. The HHIs range from 0.007 (Osaka) to 0.083 (Aichi). This means there is a relatively large difference among the prefectures. The second highest is Gunma (0.035), so Aichi will be an outlying observation with a prominent agglomeration of automobile enterprises. Overall, the Japanese 47 prefectures have a low value for the HHI, so they have industrial diversity without any concentration of a specific industry.

Figure 5 shows the HHIs of the Japanese 47 prefectures based on the number of establishments in 2014. The HHIs range from 0.007 (Shiga) to 0.027 (Nagasaki). Unlike those based on the number of employees, there is no large difference among the prefectures. The Japanese 47 prefectures have industrial diversity in terms of the number of establishments, as well.

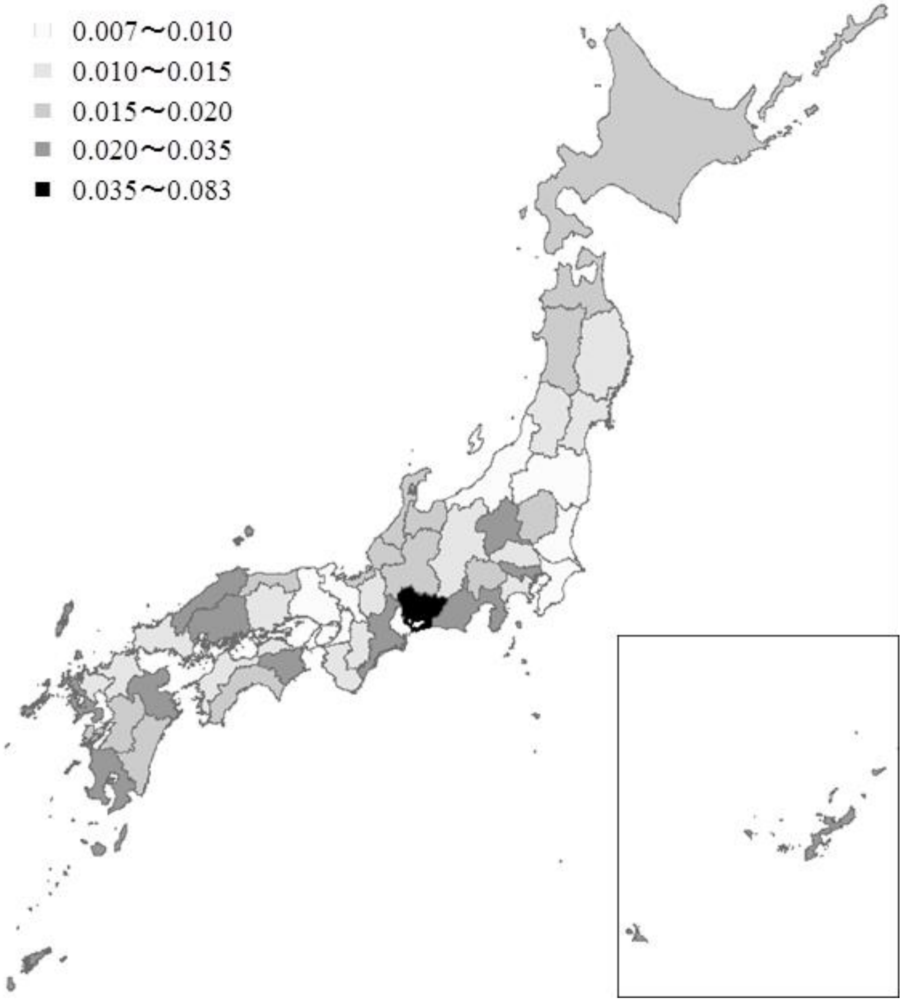

Figure 4. Herfindahl-Hirschman index of Japanese 47 prefectures, 2014 (based on the number of employees)

Source: Calculated by authors from the Census of Manufacture 2014.

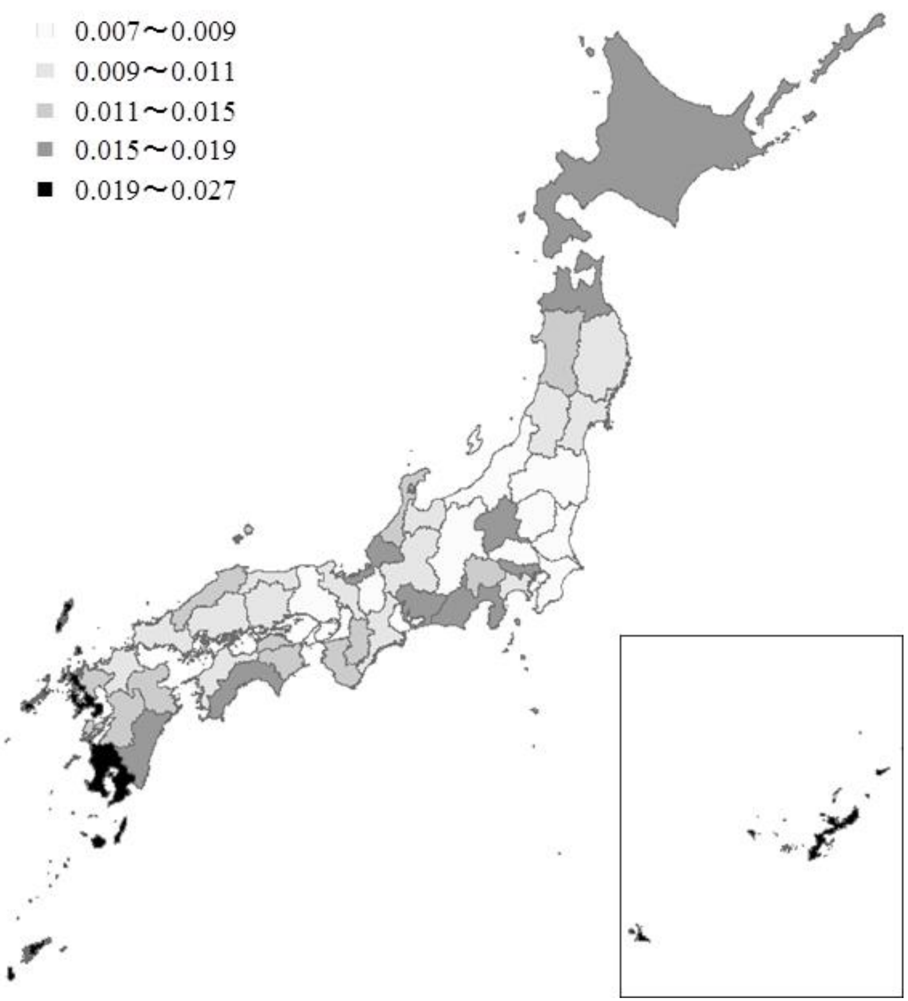

Figure 5. Herfindahl-Hirschman index of Japanese 47 prefectures, 2014 (based on the number of establishments)

Source: Calculated by authors from the Census of Manufacture 2014.

3.2.2 Location quotient: regional specialization

The most popular measure used to spatially delimit agglomerations is the location quotient (LQ). The LQ typically measures the ratio between the local and national percentage of employment, attributable to a particular industrial sector. When the percentage of people employed within a particular industry in a local area is equal to the national percentage of people employed in that industry, an LQ of one is derived. An industry is said to be over-represented within an area if it has an LQ of over one and under-represented if it has an LQ of less than one. Areas with high levels of over-represented industry are often held to constitute clusters because they have an above average concentration of employment in that industry.

Here, the LQ of industry i in region j is expressed as follows:

$$LQ_{ij} = \frac{x_{ij} / \sum_i x_{ij}}{\sum_j x_{ij} / \sum_i \sum_j x_{ij}} \tag{3}$$

where,

xij : number of employees of industry i in region j, or number of establishments of industry i in region j.

The numerator in equation (3) is the share of employees/establishments of industry i to the total employees/establishments in region j and the denominator is the share of employees/establishments of industry i to the total employees/establishments in a country. In this paper, xij is the number of employees/establishments in maritime manufacturing industry in prefecture j (j=1, ・・・, 47).

Figure 6 shows the LQs of the Japanese 47 prefectures for maritime manufacturing industry in 2014, based on the number of employees. As shown in this figure, the LQs are greater in the western part of Japan, particularly in the prefectures in Kyushu region (Nagasaki: 16.23, Saga: 3.61, Kumamoto: 3.50, Oita: 3.49) and surrounding Seto Inland Sea (Ehime: 6.02, Kagawa: 5.69, Hiroshima: 4.98, Okayama: 3.30, Kochi: 3.02).

Figure 7 shows the LQs of the Japanese 47 prefectures for maritime manufacturing industry in 2014, based on the number of establishments. Overall trend is almost same with those based on the number of employees. The LQs of the prefectures in Kyushu region (Nagasaki: 16.23, Saga: 3.61, Kumamoto: 3.50, Oita: 3.49) and surrounding Seto Inland Sea (Ehime: 6.02, Kagawa: 5.69, Hiroshima: 4.98, Okayama: 3.30, Kochi: 3.02) are much higher than those in other regions.

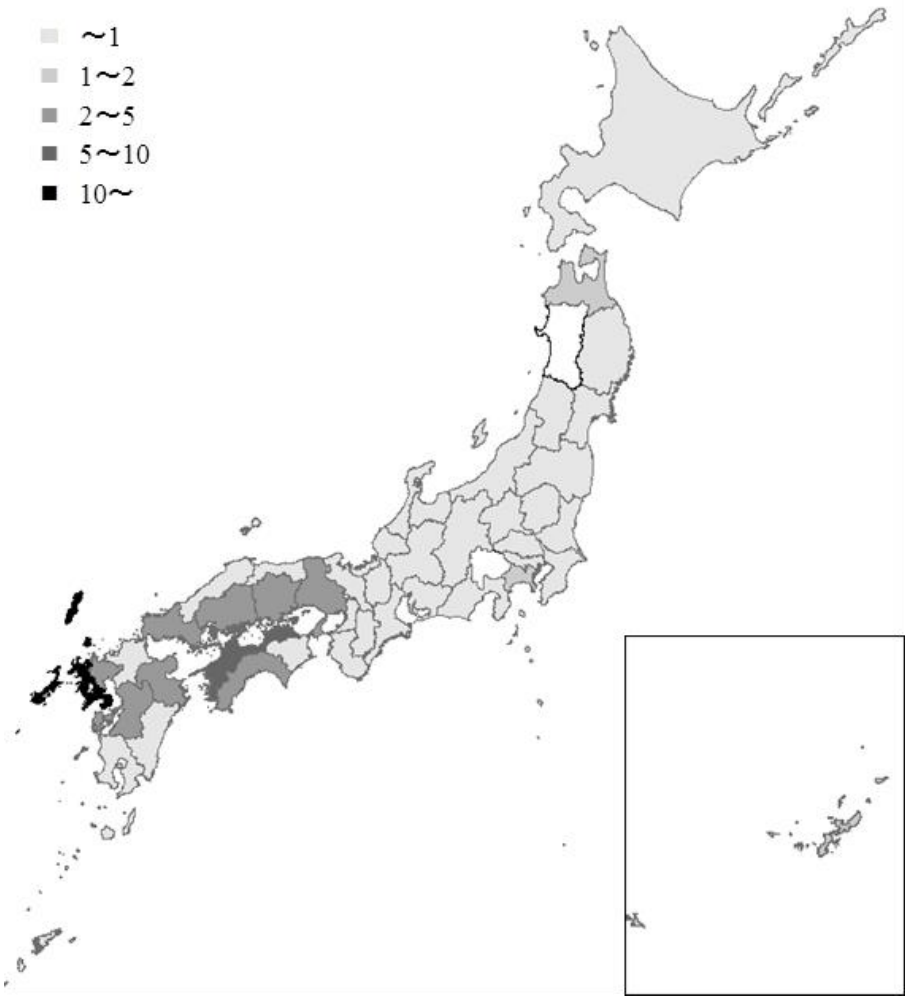

Figure 6. Location quotient for maritime manufacturing sector at the prefectural level, 2014 (based on the number of employees)
Source: Calculated by authors from the Census of Manufacture 2014.

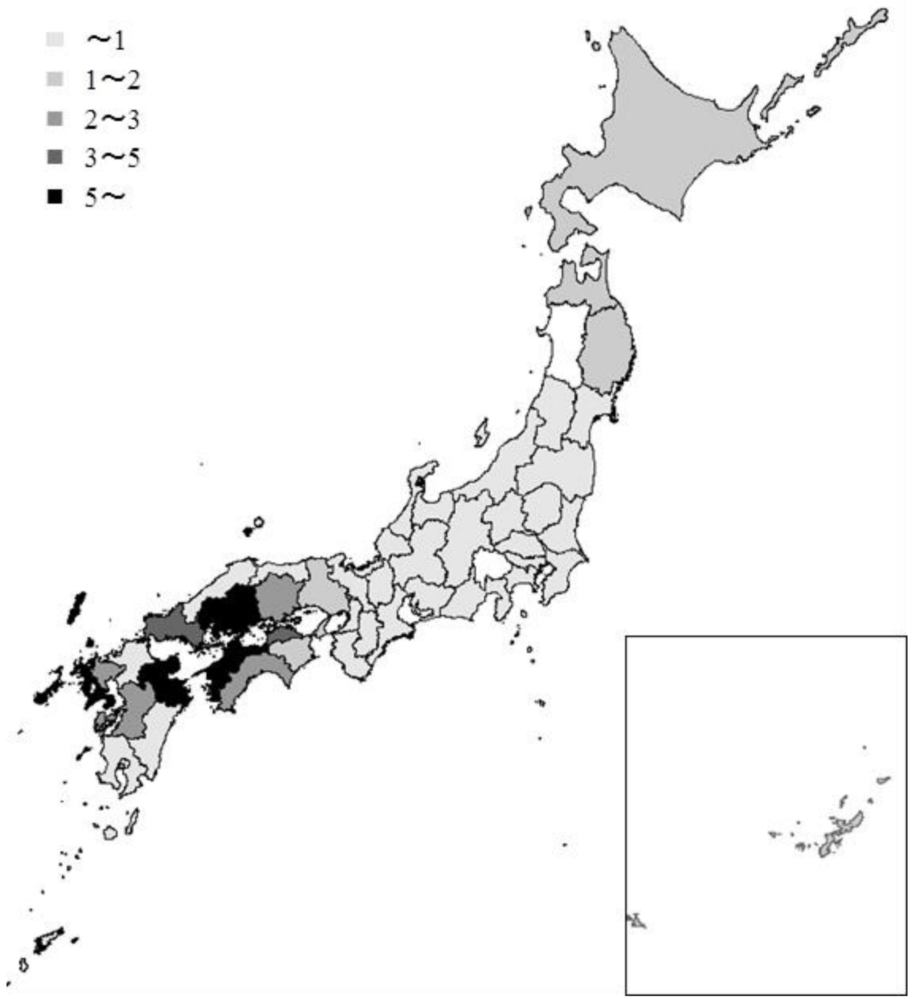

Figure 7. Location quotient for maritime manufacturing sector at the prefectural level, 2014 (based on the number of establishments)
Source: Calculated by authors from the Census of Manufacture 2014.

3.2.3 Competition index: regional competition

The concentration of large-scale establishments is different, in nature, from that of small-scale establishments. In the following, the LQ based on the number of employees is expressed as ($LQ_{ij}^{employees}$) and that based on the number of establishments as ($LQ_{ij}^{establishments}$). If $LQ_{ij}^{employees} > LQ_{ij}^{establishments} > 1$, region j is characterized as the concentration of large-scale establishments. If $LQ_{ij}^{establishments} > LQ_{ij}^{employees} > 1$, region j is characterized as the concentration of small-scale establishments.

Here, $LQ_{ij}^{employees}$ and $LQ_{ij}^{establishments}$ of industry i in region j are again expressed as follows:

$$LQ_{ij}^{employees} = \frac{x_{ij}^{employees} / \sum_i x_{ij}^{employees}}{\sum_j x_{ij}^{employees} / \sum_i \sum_j x_{ij}^{employees}} \quad (4)$$

$$LQ_{ij}^{establishments} = \frac{x_{ij}^{establishments} / \sum_i x_{ij}^{establishments}}{\sum_j x_{ij}^{establishments} / \sum_i \sum_j x_{ij}^{establishments}} \quad (5)$$

where,

$x_{ij}^{employees}$: number of employees of industry i in region j,

$x_{ij}^{establishments}$: number of establishments of industry i in region j.

Thus,

$$\begin{aligned} \frac{LQ_{ij}^{employees}}{LQ_{ij}^{establishments}} &= \frac{x_{ij}^{employees} / \sum_i x_{ij}^{employees}}{\sum_j x_{ij}^{employees} / \sum_i \sum_j x_{ij}^{employees}} \Big/ \frac{x_{ij}^{establishments} / \sum_i x_{ij}^{establishments}}{\sum_j x_{ij}^{establishments} / \sum_i \sum_j x_{ij}^{establishments}} \\ &= \frac{x_{ij}^{employees} / x_{ij}^{establishments}}{\sum_i x_{ij}^{employees} / \sum_i x_{ij}^{establishments}} \Big/ \frac{\sum_j x_{ij}^{employees} / \sum_j x_{ij}^{establishments}}{\sum_i \sum_i x_{ij}^{employees} / \sum_i \sum_j x_{ij}^{establishments}} \\ &= \frac{\text{Re}\,lative\, scale\, of\ industry\, i\, in\, region\ j}{\text{Re}\,lative\, scale\, of\ industry\, i\, in\, a\, country} \end{aligned} \quad (6)$$

Equation (6) means if $LQ_{ij}^{employees} > LQ_{ij}^{establishments}$, industry i is regionally monopolistic in region j because there is relatively a concentration of large-scale establishments of industry i in region j. Meanwhile, if $LQ_{ij}^{establishments} > LQ_{ij}^{employees}$, industry i is regionally competitive in region j because there is relatively a concentration of small-scale establishments of industry i in region j.

Figure 8 and Figure 9 show regionally monopolistic prefectures and regionally competitive prefectures, respectively. Note that $LQ_{ij}^{employees}$ and $LQ_{ij}^{establishments}$ are over one in these prefectures. As for the concentration of large-scale establishments, the ratio ($LQ_{ij}^{employees} / LQ_{ij}^{establishments}$) of Nagasaki (1.65) is the largest, followed by Kumamoto (1.49), Saga (1.37), Okayama (1.34), Hyogo (1.28), Kochi (1.23) and Kagawa (1.19). Regarding the concentration of small-scale establishments, the ratio ($LQ_{ij}^{establishments} / LQ_{ij}^{employees}$) of Oita (1.43) is the largest, followed by Hiroshima (1.30), Yamaguchi (1.16), Ehime (1.15) and Aomori (1.03).

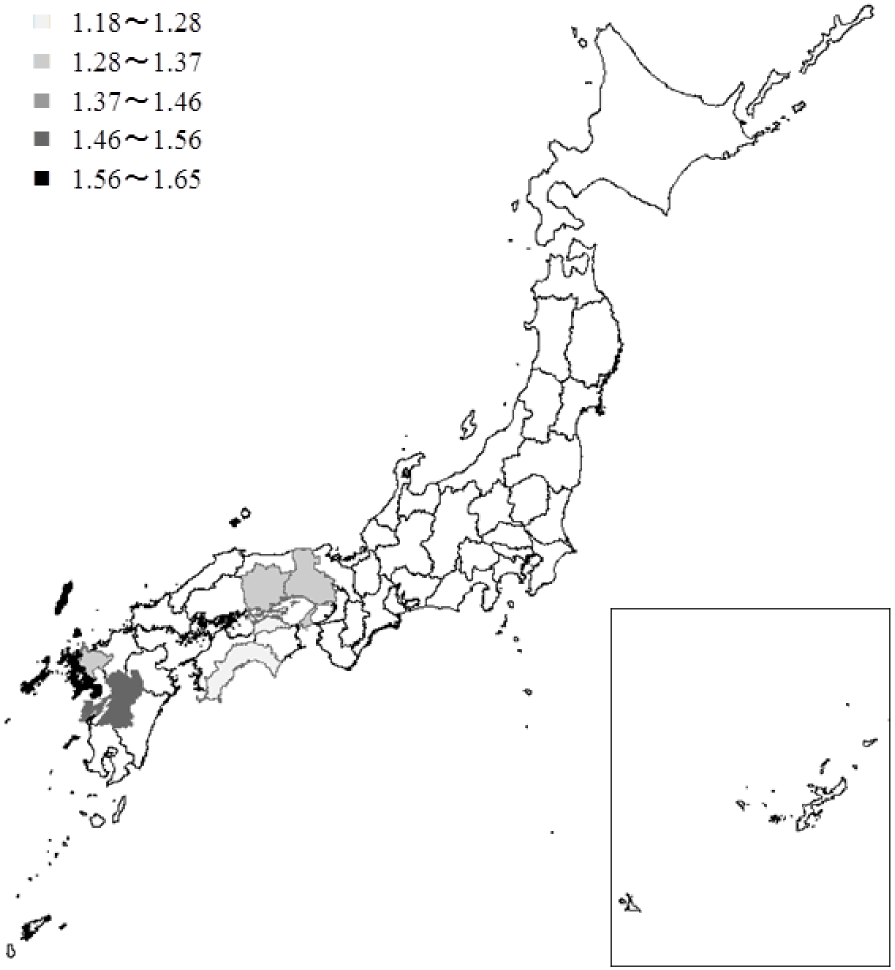

Figure 8. Level of regional monopoly in selected prefectures

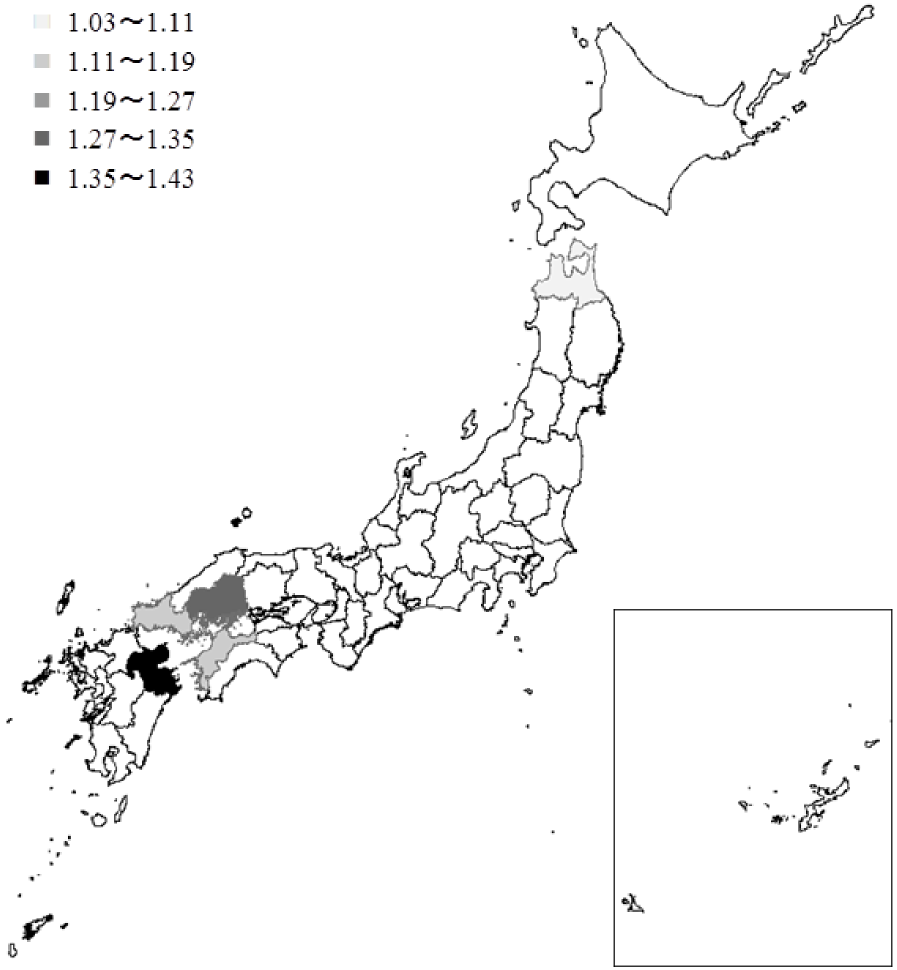

Figure 9. Level of regional competition in selected prefectures

4. ANALYSIS OF AGGLOMERATION ECONOMIES IN MARITIME MANUFACTURING SECTOR

4.1 Two Types of Agglomeration Economies

In general, firms in some industry are highly concentrated in a specific region, rather than dispersed across regions. From urban economic theory, it is called localization economies resulting from industry-specific agglomeration. In other words, localization economies arise when an increase in the size of an industry leads to an increase in the productivity of an entire industry due to factors outside of an individual firm (Figueiedo et al, 2009). Originally, this idea is based on Marshall (1920), which pointed out economic benefits external to a firm and internal to an industry in a particular region. He indicated three reasons why firms of the same industry concentrate within a particular region: labor market pooling, input sharing and knowledge spillover. The first is the pooling of specialized workers peculiar to the industry, which facilitates the matching process among workers. The second is the formation of corporate network of a wide array of various input suppliers, which provides highly specialized intermediate goods at lower prices. The third is the spillover of industry-specific knowledge, which brings about product innovation to firms. These three positive externalities lead to increased specialization and result in the improvement of productivity for firms.

Another type of agglomeration economies is urbanization economies. This results from an increase in the productivity of an entire city/region due to factors outside of an individual firm. As is the same case with localization economies, there are three sources of urbanization economies, which include input sharing, labor market pooling and knowledge spillover on a scale of entire city/region. In other words, urbanization economies arise when urban diversity and a size of a city/region lead to an increase in the productivity of several different industries.

At the firm level, both agglomeration economies of localization and urbanization are external, but localization economies are internal at the industry level. A related branch of literature argues that clustered firms enjoy not only the benefits of agglomeration economies (Feser, 2008; Ellison et al., 2010), but also higher collective learning and tacit knowledge exchange (Keeble and Wilkinson, 2000; Maskell, 2001; Cohen and Fields, 1999; Leamer and Storper, 2001). Despite the growing literature on clusters, maritime clusters have received scant attention.

Figure 10 depicts the mechanism of localization economies which is specific to the maritime manufacturing sector. This shows the formation of spatial agglomeration in intermediate goods/services suppliers and final goods producers (their consumers), based on a variety of intermediate goods/services. Supply of a more variety of intermediate goods/services in maritime manufacturing sector will lead to the increase in the productivity of final goods producers, which will result in the agglomeration of final goods producers to maritime manufacturing sector (forward linkage effect). Meanwhile, demand increase in the intermediate goods/services market will lead to the agglomeration of specialized firms to maritime manufacturing sector, which will result in the supply of a more variety of intermediate goods/services in maritime manufacturing sector (backward linkage effect). This positive feedback mechanism will form the agglomeration of intermediate goods/services suppliers and final goods producers, which facilitate maritime localization economies. Debaere et al. (2010) examined the location decision of South Korean multi-national firms across regions in China with firm-level data and confirmed the agglomeration effects at both the industry and national levels.

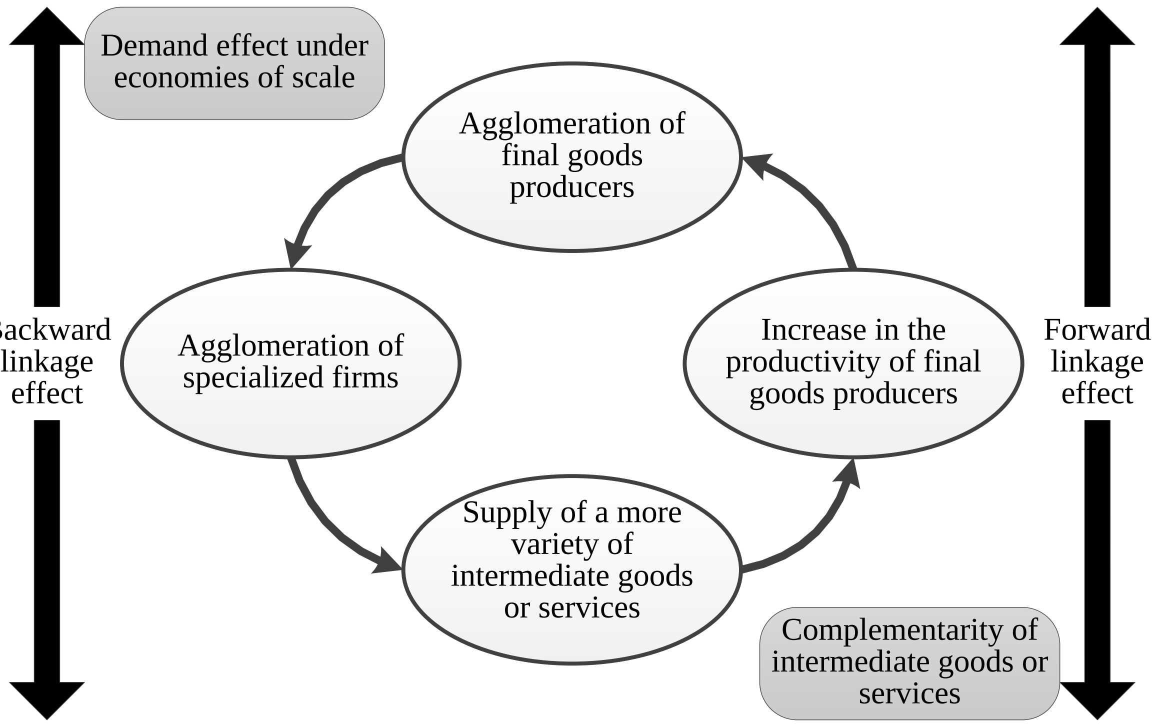

Figure 10. Mechanism of maritime localization economies

4.2 Estimation of Production Function in Maritime Manufacturing Sector

In most cases, the effect of agglomeration economies is indirectly measured by estimating production function or cost function. In this section, production function is estimated in terms of capital-labor ratio and labor productivity.

4.2.1 Model

In the following, agglomeration economies in maritime manufacturing sector are examined in the selected ten prefectures over the past twenty years from 1995 to 2014.

Here, the production function is specified as follows:

$$P_{ij,t} = Ae^{\lambda Time} K_{ij,t}^{\alpha} L_{ij,t}^{\beta} e^{\gamma Diversity_{j,t}} e^{\delta Specialization_{ij,t}} e^{\varepsilon Competition_{ij,t}}, \quad \alpha + \beta = 1 \qquad (7)$$

where,

$P_{ij,\,t}$	: production amount in industry i in region j in year t,
$K_{ij,\,t}$	: capital amount in industry i in region j in year t,
$L_{ij,\,t}$	: labor amount in industry i in region j in year t,
$Diversity_{j,\,t}$	: level of industrial diversity based on the number of employees in region j in year t,
$Specialization_{ij,\,t}$	: level of regional specialization based on the number of employees in industry i in region j in year t,
$Competition_{ij,\,t}$	: level of regional competition in industry i in region j in year t,
Time	: proxy variable for trend, and
A	: constant.

Transforming Equation (7) into log form after normalizing by L,

$$\ln\left(\frac{P_{ij,t}}{L_{ij,t}}\right) = \ln A + \lambda Time + \alpha \ln\left(\frac{K_{ij,t}}{L_{ij,t}}\right) + \gamma\, Diversity_{j,t} + \delta\, Specialization_{ij,t} + \varepsilon\, Competition_{ij,t} \tag{8}$$

We selected ten prefectures out of 47, which have the high level of concentration in the maritime manufacturing sector: Hyogo, Okayama, Hiroshima, Yamaguchi, Kagawa, Ehime, Saga, Nagasaki, Kumamoto and Oita. All of these prefectures are located in the northern part of Kyushu region or surrounding Seto Inland Sea. The analyses are conducted to the whole industry of shipbuilding and repairing, and marine engines (JSIC code: 313). Therefore, industry i is maritime manufacturing industry and region j is prefecture (j=1, ･･･, 10) in Equation (7) and (8). Note that there may be some missing four-digits industries, because the data from the Census of Manufacture on capital by four-digits industry are available only for the establishments with thirty or more employees. In addition, if there are only one or two establishments in an industry, all data, except for the number of employees and establishments, are unrevealed for confidentiality.

The analyses below are conducted separately by three models. The basic model is Model 1, where only three variables of capital, labor and time are considered. In Model 2, specialization and competition are added. Diversity is included only in Model 3.

4.2.2 Results

Table 3 shows the estimation results by ordinary least-squares (OLS) regression analysis. The overall model fits in most of these prefectures are relatively good except for Kumamoto. Meanwhile, many of the estimated values of parameters for diversity, specialization and competition variables in Model 2 and Model 3 are insignificant even at the 10 % level.

In all models, the estimated values of parameters for the capital-labor ratio variable are quite small, indicating that the labor productivity is higher in all of these ten prefectures because $\alpha + \beta = 1$. This will be an outcome possibly linked to the existence of agglomeration economies in maritime manufacturing sector.

As for the industrial diversity, Okayama, Hiroshima, Kagawa, Nagasaki and Kumamoto prefectures show positive sign. On the contrary, Hyogo, Yamaguchi, Ehime, Saga and Oita prefectures show negative sign, which might mean that there is urbanization economies in maritime manufacturing sector in these prefectures. Regarding the regional specialization, Hiroshima, Kagawa, Saga, Nagasaki and Oita prefectures show positive sign, while Okayama, Yamaguchi and Kumamoto prefectures show negative sign. Hyogo and Ehime prefectures show different signs in Model 2 and Model 3. It could be said that there will be localization economies in maritime manufacturing sector in the five prefectures with positive sign. Concerning the regional competition, Hiroshima, Nagasaki and Kumamoto prefectures have positive sign, while Hyogo, Yamaguchi, Kagawa, Saga and Oita prefectures have negative sign. Okayama and Ehime prefectures show different signs in Model 2 and Model 3. This could suggest that maritime manufacturing sector in the prefectures with positive sign benefit from regionally competitive environment, while that in the prefectures with negative sign benefit from regionally monopolistic environment. Meanwhile, the estimated values of parameters for time would partly reflect the effect of mergers and acquisitions between shipbuilding companies over the years analyzed, as mentioned earlier.

Table 3. Estimation results on production functions

		Hyogo			Okayama			Hiroshima			Yamaguchi			Kagawa		
		Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Constant	lnA	7.70	8.30	9.33	7.52	7.97	6.55	7.38	6.74	6.57	7.69	8.37	9.79	7.38	7.30	7.09
		(27.38***)	(14.20***)	(9.50***)	(30.92***)	(10.23***)	(5.98***)	(38.60***)	(11.47***)	(7.74***)	(34.51***)	(11.44***)	(10.70***)	(31.30***)	(7.52***)	(5.63***)
K/L	α	0.09	0.12	0.11	0.21	0.22	0.24	0.19	0.19	0.18	0.14	0.10	0.07	0.31	0.31	0.31
		(-1.50)	(1.89*)	(1.74)	(3.61***)	(3.48***)	(3.96***)	(4.85***)	(4.57***)	(3.81***)	(2.83**)	(1.39)	(1.15)	(6.96***)	(6.24***)	(5.96***)
Time	λ	0.01	0.01	0.00	0.01	0.00	0.02	0.00	0.01	0.02	0.01	0.01	-0.01	-0.01	-0.02	-0.02
		(1.41)	(1.07)	(0.27)	(1.51)	(0.19)	(1.36)	(0.55)	(1.24)	(1.04)	(1.80*)	(1.11)	(-0.87)	(-2.05*)	(-0.80)	(-0.76)
Diversity	γ	-	-	-97.59	-	-	58.02	-	-	12.51	-	-	-66.13	-	-	14.03
		-	-	(-1.30)	-	-	(1.74)	-	-	(0.29)	-	-	(-2.20*)	-	-	(0.27)
Specialization	δ	-	-0.05	0.06	-	-0.06	-0.03	-	0.01	0.01	-	-0.15	-0.06	-	0.03	0.05
		-	(-0.18)	(0.23)	-	(-0.39)	(-0.23)	-	(0.34)	(0.37)	-	(-1.28)	(-0.57)	-	(0.29)	(0.35)
Competition	ε	-	-0.52	-0.72	-	-0.11	0.11	-	0.50	0.49	-	-0.07	-0.62	-	-0.04	-0.08
		-	(-1.57)	(-2.00*)	-	(-0.44)	(0.43)	-	(1.05)	(1.01)	-	(-0.12)	(-1.07)	-	(-0.09)	(-0.18)
Adj.R^2		0.21	0.34	0.37	0.52	0.47	0.54	0.54	0.52	0.49	0.45	0.44	0.56	0.72	0.68	0.66
D.W.		1.14	2.00	2.09	2.42	2.39	2.18	2.38	2.59	2.60	1.21	1.10	1.23	2.54	2.53	2.51
Observations		20	20	20	20	20	20	20	20	20	19	19	19	20	20	20

		Ehime			Saga			Nagasaki			Kumamoto			Oita		
		Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Constant	lnA	7.47	7.44	9.29	6.63	6.66	7.64	7.04	5.87	4.79	8.20	8.28	8.24	7.47	7.33	7.50
		(29.90***)	(9.54***)	(4.73***)	(19.28***)	(16.27***)	(3.92***)	(16.70***)	(15.67***)	(6.29***)	(19.36***)	(11.78***)	(4.42***)	(29.92***)	(8.00***)	(5.65***)
K/L	α	0.18	0.18	0.13	0.23	0.24	0.24	0.26	0.18	0.10	0.01	-0.08	-0.08	0.15	0.11	0.11
		(4.02***)	(2.87**)	(1.79*)	(3.69***)	(2.54**)	(2.46**)	(2.65**)	(2.67**)	(1.18)	(0.06)	(-0.76)	(-0.73)	(2.72**)	(1.54)	(1.50)
Time	λ	0.05	0.05	0.02	-0.01	-0.01	-0.03	0.02	0.01	0.02	0.01	-0.02	-0.01	0.02	0.02	0.02
		(11.52***)	(4.42***)	(1.02)	(-0.63)	(-0.40)	(-0.64)	(2.18*)	(1.18)	(1.91*)	(0.90)	(-0.67)	(-0.46)	(2.19*)	(2.53**)	(0.64)
Diversity	γ	-	-	-77.20	-	-	-50.16	-	-	41.96	-	-	2.32	-	-	-11.26
		-	-	(-1.03)	-	-	(-0.52)	-	-	(1.61)	-	-	(0.02)	-	-	(-0.18)
Specialization	δ	-	0.00	-0.03	-	0.12	0.14	-	0.10	0.12	-	-0.15	-0.15	-	0.31	0.28
		-	(-0.01)	(-0.31)	-	(0.33)	(0.38)	-	(2.21*)	(2.63**)	-	(-0.66)	(-0.50)	-	(1.94*)	(1.39)
Competition	ε	-	0.04	-0.14	-	-0.30	-0.35	-	0.16	0.10	-	0.93	0.94	-	-1.30	-1.08
		-	(0.12)	(-0.34)	-	(-0.38)	(-0.44)	-	(0.45)	(0.31)	-	(1.52)	(1.19)	-	(-1.00)	(-0.60)
Adj.R^2		0.91	0.89	0.89	0.43	0.36	0.33	0.50	0.78	0.80	-0.06	-0.01	-0.08	0.42	0.48	0.45
D.W.		1.78	1.80	1.76	1.75	1.87	1.90	1.54	1.68	1.38	1.51	1.34	1.35	0.97	1.16	1.18
Observations		20	20	20	20	20	20	20	20	20	20	20	20	20	20	20

Note: Figures in (   ) are t-values; ***, ** and * indicate significance at the 1 %, the 5 % and the 10 % levels, respectively.

In summary, the empirical results revealed no strong evidence of agglomeration economies, but judging from the signs of parameters, production amount in maritime manufacturing sector might be affected by the industrial diversity, the levels of regional specialization and regional competition in maritime manufacturing industry in some prefectures.

4.3 Classification of Agglomeration

According to Glaeser et al. (1992), there are three types of agglomeration: Marshall-Arrow-Romer (MAR), Porter and Jacobs. As shown in Table 4, MAR type of agglomeration is characterized as regional specialization and monopoly, Porter type of agglomeration as regional specialization and competition and Jacobs type of agglomeration as diversity and regional competition.

Table 4. Classification of agglomeration types

	MAR	Porter	Jacobs
Diversity	−	−	+
Specialization	+	+	−
Competition	−	+	+

Table 5 classifies the prefectures analyzed by these three types of agglomeration in maritime manufacturing sector. According to the signs of parameters, maritime manufacturing sectors in Hyogo and Oita prefectures could be characterized as MAR type of agglomeration and those in Okayama, Hiroshima and Ehime prefectures as Porter type of agglomeration. Meanwhile, other prefectures, Yamaguchi, Kagawa, Saga, Nagasaki and Kumamoto, show no specific type of agglomeration. There is no Jacobs type of agglomeration in maritime manufacturing sector of any prefectures.

Table 5. Classification of maritime manufacturing sectors of prefectures by three types of agglomeration

Types of agglomeration	Prefectures
MAR	Hyogo, Oita
Porter	Okayama, Hiroshima, Ehime
Jacobs	−

5. DISCUSSION AND CONCLUSION

This paper investigated agglomeration economies in maritime manufacturing sector at the prefectural level in Japan. The empirical results revealed no strong evidence of agglomeration economies, partly because this regional division is probably rather wide to analyze agglomeration economies. This would be one of the drawbacks and limitation to this paper. Actually, almost all of the previous studies related to this issue in Japan relied on the prefectural data because of data availability. From the calibration of production function for examining the effect of agglomeration economies, however, it would be observed that production amount in maritime manufacturing sector might be affected by the industrial diversity, the levels of regional specialization and regional competition in maritime manufacturing industry. Among the prefectures analyzed, regional specialization and local monopoly could encourage the increase of production amount in maritime manufacturing sector in Hyogo and Oita prefectures. This suggests that knowledge spillovers could more easily occur in the geographically concentrated and regionally monopolistic prefectures, consistent with the theory of MAR. Meanwhile, production amount could be inspired by regional specialization and local competition in maritime manufacturing sector of Okayama, Hiroshima and Ehime prefectures, characterized by the Porter type of agglomeration.

At present, the formation of maritime industrial clusters isn't listed among the industrial cluster projects nationwide by Industrial Cluster Policy. However, it now attracts attention for vitalizing maritime sector in Japan. The shipbuilding industry has now a scale of nearly 83 thousand employees and one thousand establishments in Japan. As for the marine engines industry in Japan, it is nearly 47 thousand employees and 1.1 thousand establishments. These two core industries form maritime industrial clusters combined with other industries such as shipping industry and ship owners. The Minister of Land, Infrastructure, Transport and Tourism (MLIT) announced the basic guideline for the resurgence of Japanese shipbuilding industry in 2011 (MLIT, 2011). In this guideline, MLIT underlines the crucial importance of maintaining and strengthening the formation of maritime industrial clusters around a focal core of shipbuilders and related manufacturers. For the central and local governments, it is important to identify three types of agglomeration to take regional or industrial policies for the formation of maritime industrial clusters vitalizing a city or a region.

Because of the data availability on capital stock used to estimate production function, the analyses are made at the prefectural level, not at the municipal, throughout the paper. However, it will be better to look for other geographical scope which will be an ideal areal unit for analyzing agglomeration economies in the maritime manufacturing sector. For example, maritime manufacturing industry may agglomerate across prefectural boundaries. Also because of its ease of use, the accessibility of data and its applicability at different geographical scales, the LQ is, among a range of techniques, the most common to measure or delimit the extent of industrial agglomeration or concentration (O'Donoghue and Gleave, 2004; Guillain and Gallo, 2010; De Dominicis et al, 2013). However, there are some problems in using the LQ concerning what level of industrial concentration or regional specialization should be taken to indicate the possible existence of clusters. In other words, there are no theoretical LQ cut-off values for defining a cluster, which is the most critical limitation in using the LQ (Martin and Sunley, 2003). For example, Miller et al (2001) used a cut-off value of 1.25 to identify clusters within a range of UK industry. Malmberg and Maskell (2002) defined an industrial agglomeration with an LQ larger than 3. In this way, a cut-off point has been defined arbitrarily in the previous research, but defining such a critical level of concentration should be theoretical if clusters are to be identified in a consistent and objective way. A further drawback of using the LQ to delimit clusters is that the measure does not provide any information on the absolute size of local industry, as pointed by O'Donoghue and Gleave (2004). Therefore, it will be possible to obtain a high LQ value for an industry that has small workforce in absolute terms.

In this sense, this research will be developed further. Evaluating the spatial location patterns of maritime manufacturing industry by exploratory spatial data analysis or spatial autocorrelation analysis will be the next step of the current research to examine agglomeration economies in the Japanese maritime sector and further to facilitate the formation of maritime industrial clusters in Japan. These remain to be elaborated on in a future research of the work presented here.

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