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Research Article

Spatial Concentration of Aerospace Industry and Agglomerations Economies in Aircraft Parts Industry: A Case Study in Japan

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Abstract: The concept of industrial clusters has drawn considerable attention as a new perspective of regional and industrial policies in Japan. As for aerospace industry, Chubu region, including Aichi prefecture, was designated the International Strategic Comprehensive Special Zone in 2011. After providing an overview of the spatial concentration of aerospace industry at the municipal level in Japan, this paper aims to examine agglomeration economies with a special focus on aircraft parts industry in Aichi prefecture. The empirical results reveal strong evidence of urbanization economies or Jacobs type of externalities in contrast to maritime manufacturing sector. This suggests that knowledge spillovers and technological innovation could more easily occur in the industrially diversified environment. The paper concludes with the suggestion that agglomeration economies will play a more prominent role in the formation of aerospace industrial clusters.

Keywords: Agglomeration Economies, Aircraft Parts Industry, Aerospace Industrial Cluster, Special Zone, Chubu Centrair International Airport, Japan

1. INTRODUCTION

The concept of industrial clusters has recently drawn worldwide attention as a new perspective of regional, industrial or economic policies. A lot of research has frequently discussed agglomeration economies, which is the theoretical background of industrial clusters (Yamada and Kawakami, 2016, 2015; Basile and Ciccarelli, 2015; Lafourcade and Mion, 2007; Alecke et al, 2006; Bertinelli and Decrop, 2005; Rosenthal and Strange, 2004; Barrios et al, 2003; Fujita and Thisse, 2002; Maruel and Sédillot, 1999; Glaeser et al., 1992). 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, 1998).

From this perspective, the formation of aerospace industrial clusters attracts much more attention to vitalize the aerospace sector in Japan. The aerospace industrial cluster policy aims to enhance the global competitiveness of Japanese aerospace industry and to invigorate local economy in the country by fostering the evolution of a concentration of aerospace industry. The Japanese government intends to promote the aerospace industrial cluster policy for the growth of its aerospace industry as a key and flagship sector after automobile industry in the next coming decades.

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Reflecting these backgrounds, the main purpose of this paper is to examine agglomeration economies in aircraft parts industry with a special focus on Aichi prefecture in Japan from the perspective of urban economics. The remainder of this paper is organized as follows. The next section provides an overview of the spatial concentration of aerospace industry at the municipal level and the recent development of aerospace industrial clusters in Japan. Section 3 measures industrial diversity, regional specialization and local competition in aircraft parts industry at the prefectural level in 2014 after classifying agglomeration economies. In Section 4, a model is specified to explore the types of agglomeration economies with a special focus on aircraft parts industry in Aichi prefecture over the last 20 years from 1995 to 2014, in comparison with shipbuilding and repairing industry in Nagasaki prefecture. Discussion and conclusion with future work follow in the final section.

2. SPATIAL CONCENTRATION OF AEROSPACE INDUSTRY IN JAPAN

2.1 Study Area

Figure 1 indicates the 47 prefectures in Japan, which are the regional division mainly used in the analyses below. This figure divides Japan into eight regions: Hokkaido, Tohoku, Kanto, Chubu, Kansai, Chugoku, Shikoku and Kyushu. These have been traditional division of Japan, which is also used in this paper.

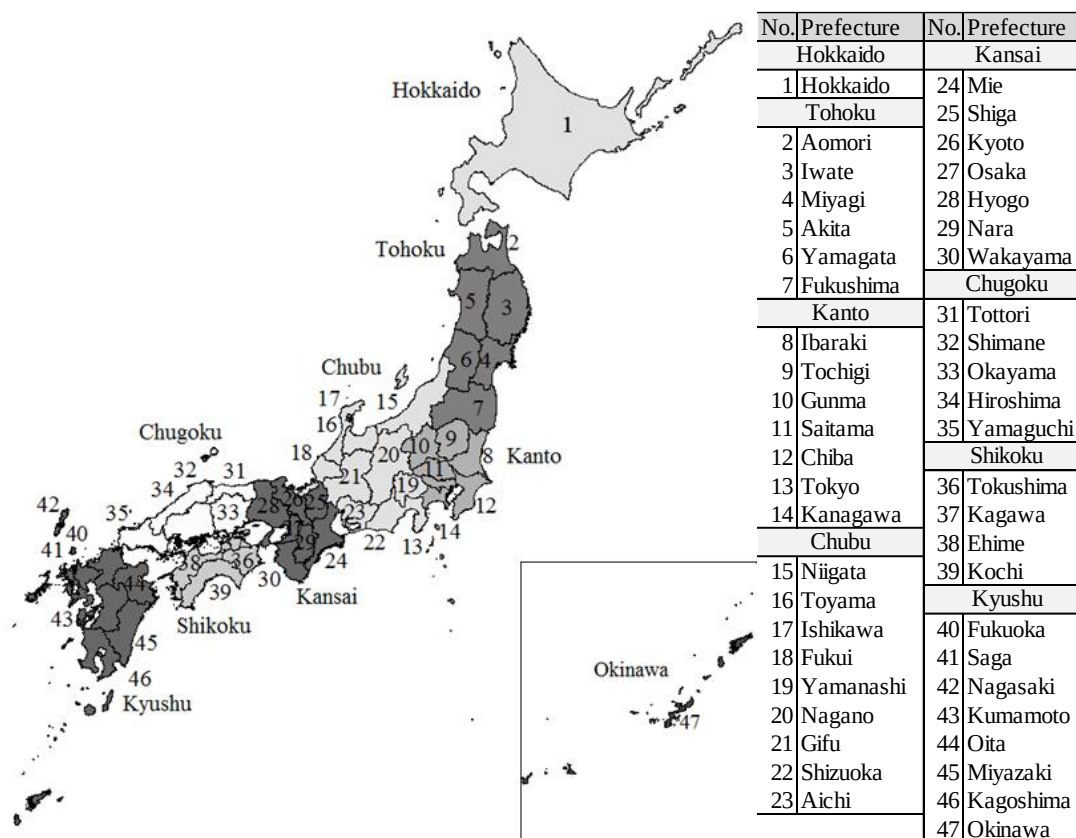


Figure 1. Forty-seven prefectures in Japan

2.2 Data

We got the data related to aerospace industry from the Economic Census in 2014 and the Census of Manufacture from 1995 to 2014, both of which are conducted by the Japanese Ministry of Economy, Trade and Industry (METI). These surveys aim to clarify the actual conditions of industries in a nation and to obtain the basic data for regional, industrial or economic policies. The reference period of each year's Census is as of December 31.

Among the statistic tables of the Census of Manufacture, the Report by Respective Industry is mainly used, which covers establishments with four or more employees at the prefectural level and provides the data on the number of establishments and employees, value of tangible fixed assets (capital stock), value added (gross value added), etc. in the industries that are classified by three-digits and four-digits of the Japan Standard Industrial Classification (JSIC). Note that the data on value of tangible fixed assets is related to the establishments with thirty or more employees. We mainly focus on the industry of aircraft and parts (JSIC code: 314), with a further breakdown to aircraft (JSIC code: 3141), aircraft engines (JSIC code: 3142) and miscellaneous aircraft parts and auxiliary equipment (JSIC code: 3149). Miscellaneous aircraft parts and auxiliary equipment include such items as crop dusting apparatus, armament racks, inflight refueling equipment and external fuel tanks.

The analyses in this paper are conducted over the Japanese 47 urban and rural prefectures, as shown in Figure 1.

2.3 Overview of Spatial Concentration of Aerospace Industry

2.3.1 Concentration of aerospace industry at municipal level

Table 1 shows the ranking in the number of employees per ten thousand population in aerospace industry at the municipal level in 2014. This table consists of two sectors. One is the manufacturing sector, aircraft and parts industry (JSIC: 314), and the other is the transportation sector, air transportation industry (JSIC: 46). Aerospace industry is composed of these two sectors in this paper.

Table 1. Ranking in the number of employees per ten thousand population in aerospace industry at the municipal level in Japan, 2014

No.	City, County	Prefecture	Aircraft and parts	No.	City, County	Prefecture	Air transportation	No.	City, County	Prefecture	Aerospace industry
1	Nishikasugai	Aichi	1,489	1	Nishikasugai	Aichi	493	1	Nishikasugai	Aichi	1,982
2	Soma	Fukushima	392	2	Narita	Chiba	325	2	Soma	Fukushima	392
3	Nishitama	Tokyo	391	3	Tokoname	Aichi	106	3	Nishitama	Tokyo	391
4	Kakamigahara	Gifu	351	4	Izumisano	Osaka	80	4	Kakamigahara	Gifu	351
5	Akishima	Tokyo	316	5	Kirishima	Kagoshima	48	5	Narita	Chiba	344
6	Musashino	Tokyo	193	6	Miyako	Okinawa	47	6	Akishima	Tokyo	316
7	Fuwa	Gifu	157	7	Sennan	Osaka	47	7	Musashino	Tokyo	193
8	Yatomi	Aichi	157	8	Ashibetsu	Hokkaido	46	8	Fuwa	Gifu	157
9	Kuwana	Mie	151	9	Ikeda	Osaka	46	9	Yatomi	Aichi	157
10	Ama	Aichi	104	10	Chitose	Hokkaido	43	10	Kuwana	Mie	151
	National average		3		National average		4		National average		8

Note: Aerospace industry is the total of aircraft and parts industry and air transportation industry.

Source: Calculated by authors from the Economic Census 2014.

Overall, aerospace industry in Japan concentrates mainly in cities or counties in Kanto and Chubu regions, particularly in Tokyo Metropolitan and Aichi prefecture at the prefectural level. As for aircraft and parts industry, Nishitama (No.3), Akishima (No.5) and Musashino (No.6) are in Kanto region and Nishikasugai (No.1), Kakamigahara (No.4), Fuwa (No.7), Yatomi (No.8), Kuwana (No.9) and Ama (No.10) are in Chubu region. Insofar as air transportation industry is concerned, airport cities, such as Narita (No.2), Tokoname (No.3), Izumisano (No.4), Sennan (No.7), Ikeda (No.9) and Chitose (No.10), occupy the top ten.

Meanwhile, Figure 2 describes the LQs in aerospace industry at the municipal level in 2014 (See Section 3.2.2 for the location quotient (LQ)). Those cities or counties which have the LQs over 20 include Nishikasugai in Aichi (138.59), Soma in Fukushima (53.69), Kakamigahara in Gifu (49.48), Akishima in Tokyo (43.91), Nishitama in Tokyo (41.33), Narita in Chiba (30.64) and Fuwa in Gifu (24.76). All of them are located in Chubu region or Tama area in the western part of Tokyo Metropolitan, except for Soma and Narita. Here again, aerospace industry in Japan can be said to agglomerate mainly in these two regions.

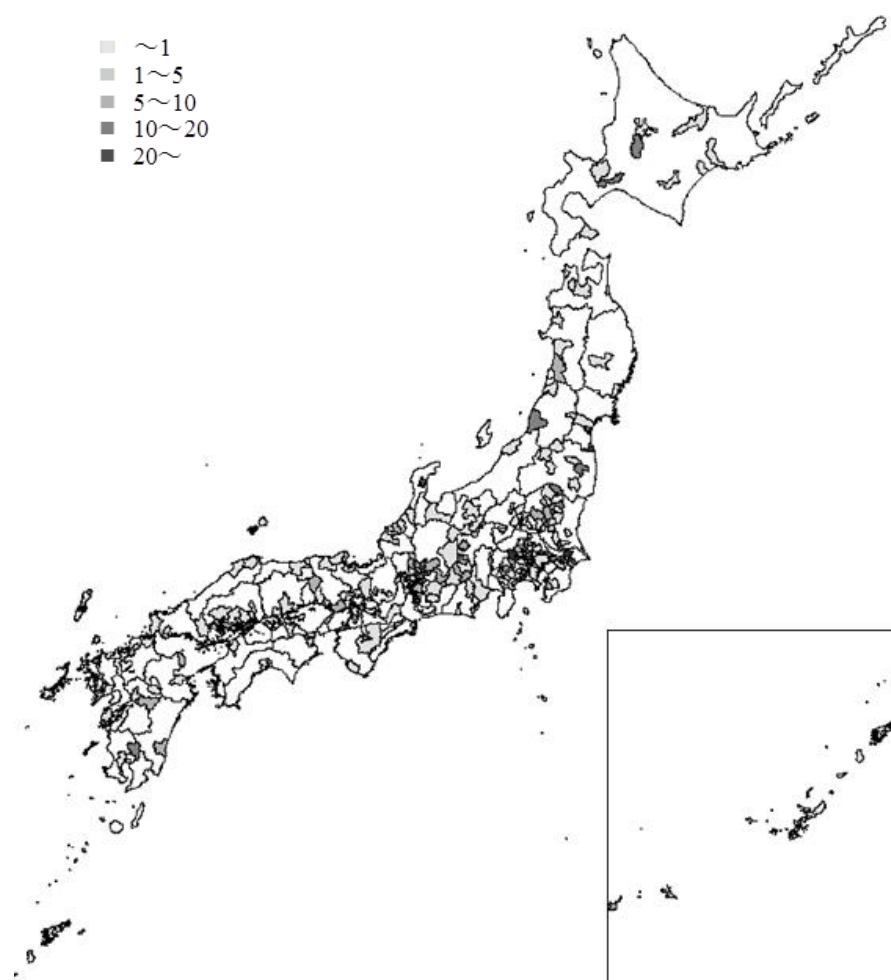


Figure 2. The LQs in aerospace industry at the municipal level, 2014
Source: Calculated by authors from the Economic Census 2014.

Chubu region, including Aichi, Gifu and Mie prefectures, was designated the International Strategic Comprehensive Special Zone (Special Zone to Create Asia No.1 Aerospace Industrial Cluster) in 2011. Moreover, Chubu Centrair International Airport opened in Aichi prefecture in 2005, which plays a more and more important role in international air

cargo movements mainly from/to Chubu region. For example, this airport serves as an airlift base of Japanese components of the Boeing 787 aircraft, which is produced at Mitsubishi Aircraft Corporation located nearby, to the assembly facility in the US. Meanwhile, there is also agglomeration of aircraft parts industry in Kanto region, particularly in Tama area (Western Tokyo), described in Table 1 and Figure 2. The number of employees or added value amount in aircraft parts industry in Tokyo Metropolitan, however, is approximately only one tenth compared with those in Aichi prefecture in 2014. Therefore, the analyses below mainly focus on the aircraft parts industry in Aichi prefecture.

2.3.2 Trends in aircraft and parts industry

Figure 3 shows the temporal changes on the number of establishments and employees in aircraft and parts industry, with a breakdown to four-digits industries, in Japan over the last 38 years from 1977 to 2014.

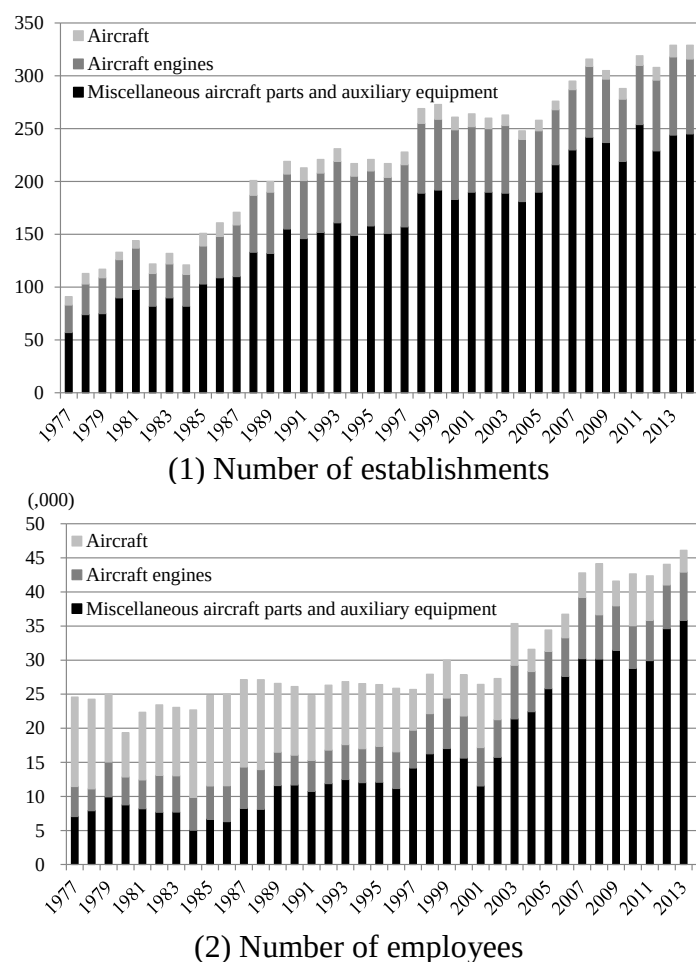


Figure 3. Temporal changes on the number of establishments and employees in aircraft and parts industry in Japan, 1977-2014

Source: Compiled by authors from the Census of Manufacture.

Overall, both of the numbers of establishments and employees have been basically increased over these years. The number of establishments has increased by 238 from 91 in 1977 to 329 in 2014, while that of employees by 20,864 from 24,588 in 1977 to 45,452 in

2014. Behind these increases is the rising demand for aircrafts in response to higher demand for air transportation especially after the worldwide liberalization of aviation in the 1990s and 2000s.

Among the four-digits industries, miscellaneous aircraft parts and auxiliary equipment (hereafter “aircraft parts industry” for short) occupies the highest shares. In 2014, the share of aircraft parts industry is 74.47 % and 74.52 % in the number of establishments and employees, respectively. For this reason, the analyses below mainly focus on aircraft parts industry.

3. AGGLOMERATION ECONOMIES IN AIRCRAFT PARTS INDUSTRY IN AICHI PREFECTURE

3.1 Agglomeration Economies

3.1.1 Static externalities

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 comes from Marshall (1920), who 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 spillovers. The first is the pooling of specialized workers peculiar to an 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 spillovers 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: labor market pooling, input sharing and knowledge spillovers on a scale of entire city/region. In other words, urbanization economies arise when industrial diversity and a size of a city/region lead to an increase in the productivity of several different industries.

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

3.1.2 Dynamic externalities

Meanwhile, Glaeser et al. (1992) classifies agglomeration economies into three types, Marshall-Arrow-Romer (MAR), Porter and Jacobs, all of which underline the role of industry-specific knowledge spillovers in encouraging growth in industries, cities or regions.

As shown in Table 2, MAR type of agglomeration is characterized as regional specialization and local monopoly, Porter type of agglomeration as regional specialization and local competition and Jacobs type of externalities as industrial diversity and local competition.

Here in this paper, economic effect of agglomeration could be linked to labor productivity, which is assumed to be enhanced by knowledge spillovers and technological innovation. Based on this idea of how to measure the economic benefit of agglomeration, we explore the production environments where knowledge spillovers and technological innovation could more easily occur: industrial diversity (HHI), regional specialization (LQ) and local competition (CI).

Table 2. Classification of agglomeration economies

Static externalities		Dynamic externalities		
		Diversity (HHI)	Specialization (LQ)	Competition (CI)
Localization economies	MAR externalities	—	○	—
	Porter externalities	—	○	○
Urbanization economies	Jacobs externalities	○	—	○

3.2 Production Environments

3.2.1 Industrial diversity

The Herfindahl-Hirschman index (HHI) is one of the measures to express the spatial concentration of industries in a region, which is relevant to industrial compositions inside a region. 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. Glaeser et al. (1992) investigated the dynamic externalities in the US industries on the city level. In their analysis, the measure of city diversity is calculated from the share of top five industries in a city to the total city employment, which is basically identical to the way we calculate the index of industrial diversity here in this paper. In the analyses below, the increase in HHI generally indicates a decrease in industrial diversity within a region.

In this paper, the HHI for a measure of industrial diversity in region j is expressed as follows.

$$HHI_j = \sum_i \left(\frac{x_{ij}}{\sum_i x_{ij}} \right)^2 \quad (1)$$

where,

x_{ij} : the number of employees of industry i based on four-digits industries in prefecture j ($j=1, \dots, 47$).

Figure 4 shows the HHIs of the Japanese 47 prefectures in 2014. The HHIs range from 0.007 (Osaka) to 0.083 (Aichi). This means that there are relatively large differences among the prefectures. The second highest is Gunma (0.035), so Aichi will be an outlying

observation with a prominent agglomeration of automobile industry. Overall, the Japanese 47 prefectures have a low value for the HHI, so they have industrial diversity without any concentration of a specific industry.

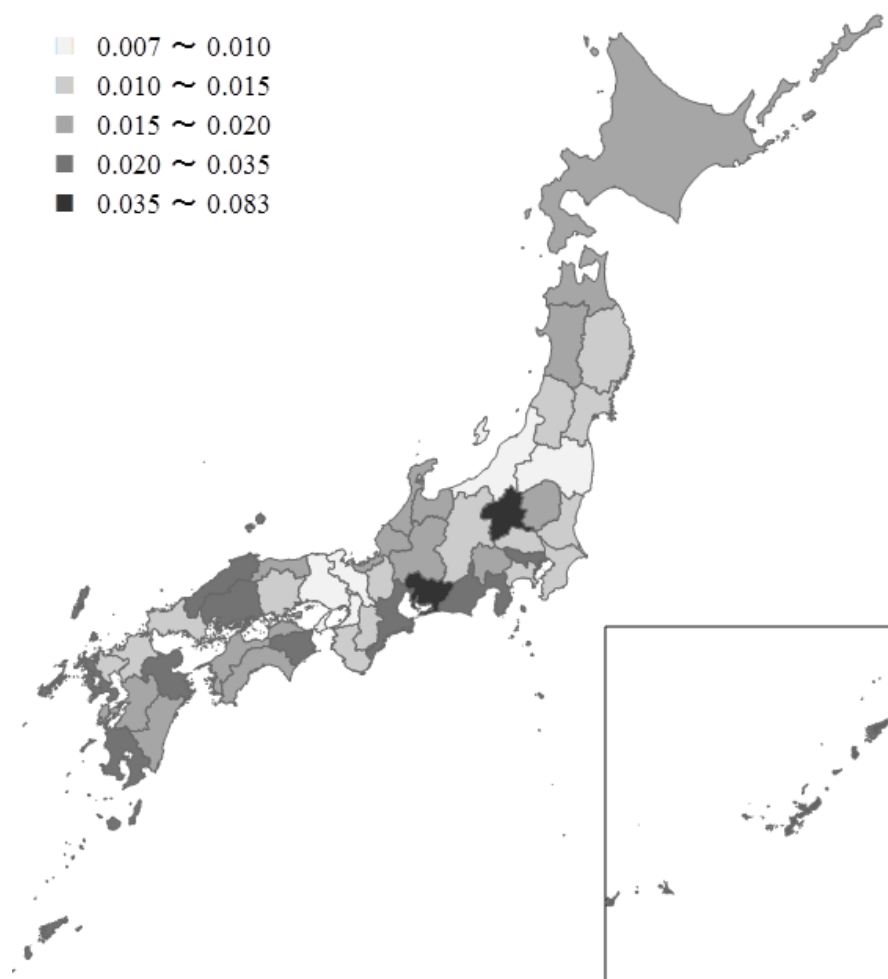


Figure 4. The HHIs of Japanese 47 prefectures, 2014
Source: Calculated by authors from the Census of Manufacture 2014.

3.2.2 Regional specialization

A range of quantitative methods have been employed to measure the spatial concentration and regional specialization of industrial activities. We focus here on the location quotient (LQ), which is the most popular and widely used measure because of its ease of calculation and its limited data requirement.

The LQ typically measures the ratio between the local and national percentage of employment, attributable to a particular industrial sector, to spatially delimit agglomerations. When the percentage of employees within a particular industry in a local region is equal to the national percentage of employees in that industry, an LQ of one is derived. An industry is said to be over-represented within a region if it has an LQ of over one and under-represented if it has an LQ of less than one. Regions with high levels of over-represented industry often 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. The numerator in equation (2) is the share of employees in industry i to the total employees in region j and the denominator is the share of employees in industry i to the total employees in a country.

$$LQ_{ij} = \frac{x_{ij} / \sum_i x_{ij}}{\sum_j x_{ij} / \sum_i \sum_j x_{ij}} \quad (2)$$

where,

x_{ij} : the number of employees in aircraft parts industry in prefecture j ($j=1, \dots, 47$).

Figure 5 shows the LQs of the Japanese 30 prefectures where aircraft parts industry exists in 2014. As shown in this figure, the LQs are greater especially in the prefectures in Chubu region (Gifu: 8.75, Aichi: 3.12, Mie: 1.40) and Kanto region (Tochigi: 4.15, Kanagawa: 2.19). Other than these prefectures, those of Hyogo (1.59) and Miyazaki (1.05) are over one.

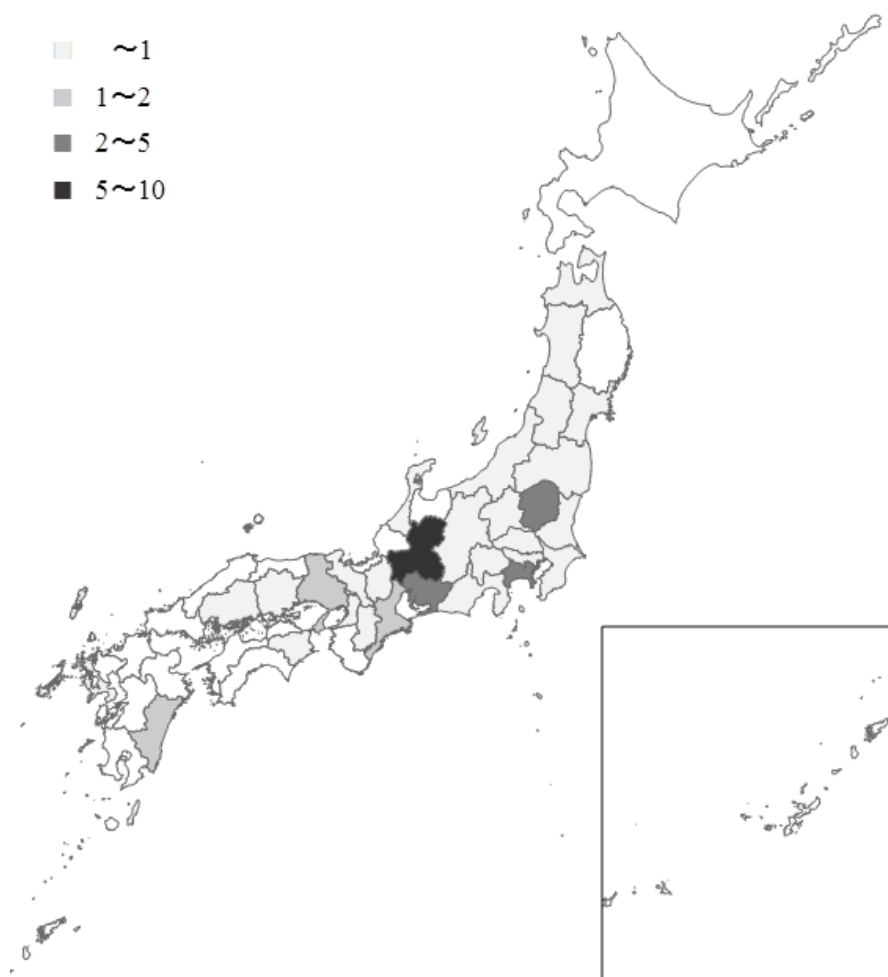


Figure 5. The LQs of Japanese 30 prefectures in aircraft parts industry, 2014
Source: Calculated by authors from the Census of Manufacture 2014.

3.2.3 Local competition

According to Glaeser et al (1992) and Nakamura (2008), 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. In other words, industry i is locally monopolistic in region j because there is relatively a concentration of large-scale establishments in industry i in region j. Meanwhile, if $LQ_{ij}^{establishments} > LQ_{ij}^{employees} > 1$, region j is characterized as the concentration of small-scale establishments. This means that industry i is locally competitive in region j because there is relatively a concentration of small-scale establishments in industry i in region j.

Here, $LQ_{ij}^{employees}$ and $LQ_{ij}^{establishments}$ of industry i in region j are again expressed as follows. In this paper, $x_{ij}^{employees}$ is the number of employees in aircraft parts industry in prefecture j ($j=1, \dots, 47$) and $x_{ij}^{establishments}$ is the number of establishments in aircraft parts industry in prefecture j ($j=1, \dots, 47$).

$$LQ_{ij}^{employees} = \frac{x_{ij}^{employees} / \sum_i x_{ij}^{employees}}{\sum_j x_{ij}^{employees} / \sum_i \sum_j x_{ij}^{employees}} \quad (3)$$

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

Thus, competition index (CI) is expressed as follows:

$$\begin{aligned} CI &= \frac{LQ_{ij}^{employees}}{LQ_{ij}^{establishments}} \\ &= \frac{x_{ij}^{employees} / \sum_i x_{ij}^{employees}}{\sum_j x_{ij}^{employees} / \sum_i \sum_j x_{ij}^{employees}} / \frac{x_{ij}^{establishments} / \sum_i x_{ij}^{establishments}}{\sum_j x_{ij}^{establishments} / \sum_i \sum_j x_{ij}^{establishments}} \\ &= \frac{x_{ij}^{employees} / x_{ij}^{establishments}}{\sum_i x_{ij}^{employees} / \sum_i x_{ij}^{establishments}} / \frac{\sum_j x_{ij}^{employees} / \sum_j x_{ij}^{establishments}}{\sum_i \sum_j x_{ij}^{employees} / \sum_i \sum_j x_{ij}^{establishments}} \\ &= \frac{\text{Relative scale of industry i in region j}}{\text{Relative scale of industry i in a country}} \end{aligned} \quad (5)$$

Equation (5) means if $LQ_{ij}^{employees} > LQ_{ij}^{establishments}$, industry i is locally monopolistic in region j because there is relatively a concentration of large-scale establishments in industry i in region j. Meanwhile, if $LQ_{ij}^{establishments} > LQ_{ij}^{employees}$, industry i is locally competitive in region j because there is relatively a concentration of small-scale establishments in industry i in region j.

Figure 6 shows the CIs of the Japanese 5 prefectures in aircraft parts industry. Note that $LQ_{ij}^{employees}$ and $LQ_{ij}^{establishments}$ are over one in these five prefectures. As for the concentration of large-scale establishments, the CI of Kanagawa (1.96) is the largest, followed by Aichi (1.35), Gifu (1.33) and Hyogo (1.20). Regarding the concentration of small-scale establishments, Tochigi is the only prefecture with the CI of 0.71, which is below one.

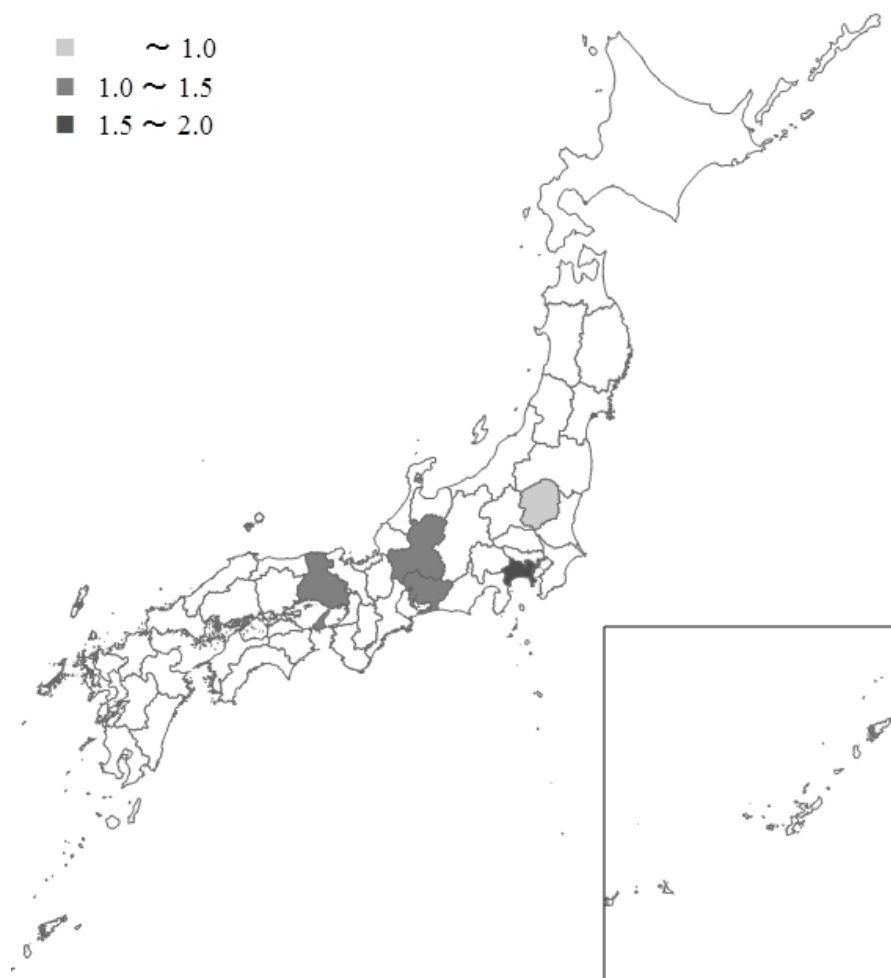


Figure 6. The CIs of Japanese 5 prefectures in aircraft parts industry, 2014
Source: Calculated by authors from the Census of Manufacture 2014.

4. ESTIMATION OF PRODUCTION FUNCTION IN AIRCRAFT PARTS INDUSTRY IN AICHI PREFECTURE

4.1 Model

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, along with industrial diversity, regional specialization and local competition discussed in Section 3.2.

In the following, agglomeration economies in aircraft parts industry are examined for Aichi prefecture over the last twenty years from 1995 to 2014, by incorporating into

production function three measures of industrial diversity, regional specialization and local competition. In addition, three dummy variables are introduced in the model; one is a new airport dummy variable after 2005, another is a special zone dummy variable after 2012 and the other is a global financial crisis (Lehman shock) dummy variable for the years from 2007 to 2009.

Here, production function is specified as follows:

$$V_t = A e^{\lambda Time} K_t^\alpha L_t^\beta e^{\gamma Diversity_t} e^{\delta Specialization_t} e^{\varepsilon Competition_t} e^{\zeta D_1} e^{\eta D_2} e^{\theta D_3} \quad (6)$$

$$\alpha + \beta = 1$$

where,

V_t	: added value amount in aircraft parts industry in Aichi prefecture in year t,
K_t	: capital amount in aircraft parts industry in Aichi prefecture in year t,
L_t	: labor amount in aircraft parts industry in Aichi prefecture in year t,
$Diversity_t$	: industrial diversity in Aichi prefecture in year t,
$Specialization_t$	: regional specialization in aircraft parts industry in Aichi prefecture in year t,
$Competition_t$	: local competition in aircraft parts industry in Aichi prefecture in year t,
D_1	: new airport dummy after 2005,
D_2	: special zone dummy after 2012,
D_3	: global financial crisis dummy for the years from 2007 to 2009,
$Time$	: proxy variable for trend, and
A	: constant.

Transforming Equation (6) into log form after normalizing by L,

$$\ln\left(\frac{V_t}{L_t}\right) = \ln A + \lambda Time + \alpha \ln\left(\frac{K_t}{L_t}\right) + \gamma Diversity_t + \delta Specialization_t + \varepsilon Competition_t + \zeta D_1 + \eta D_2 + \theta D_3 \quad (7)$$

Eberts and McMillen (1999) define production function, among others, to estimate agglomeration economies as $Y(t) = A(t) f(K(t), L(t))$. Here, $Y(t)$ is output or added value and $A(t)$ represents technological innovation over time. Our formulation on production function for the empirical analysis here in this paper depends largely on the idea from this research. One of the earlier studies with this idea is Domae and Matsumoto (2018), which examined agglomeration economies in aircraft parts industry based on the cross-sectional data across fifteen prefectures in Japan. The paper also investigated the productivity of aircraft parts industry in Aichi prefecture by statistical correlation analysis to the production environments (industrial diversity, specialization and competition). The empirical results revealed some evidence of localization economies (MAR type of agglomeration) in aircraft parts industry across these prefectures in Japan, while they also showed the possibility of urbanization economies (Jacobs type of agglomeration) in Aichi prefecture.

4.2 Results

Table 3 shows the estimation results by ordinary least-squares (OLS) regression analysis. The adjusted R^2 is 0.66 for Model 1 with all variables in Equation (7), so the overall model fit is

relatively good. Insofar as the estimated values of parameters are concerned, only industrial variety and regional specialization in aircraft parts industry are significant at the 5% level. This indicates that the more diversified industries and the less specialized aircraft parts industry, the more added value created in aircraft parts industry in Aichi prefecture. This will be an outcome undoubtedly linked to urbanization economies or Jacobs type of externalities.

Because other explanatory variables are statistically insignificant or have a counter intuitive sign, estimation is conducted again dropping some of them one by one. In Model 2, time variable is removed, supposing that production environments reflect technological innovation. In model 3, special zone and global financial crisis dummy variables are dropped, because only a few years have passed since its designation as for the former and the latter is statistically insignificant. In Model 4, local competition variable is skipped. In summary, the analysis is conducted separately by four models. The basic model is Model 1, where all variables are considered. In Model 2, time is removed. Then, time, dummy 2 and dummy 3 in Model 3, and time, local competition, dummy 2 and dummy 3 in Model 4 are dropped.

After all, the statistical significance for industrial diversity variable rose up to the 1% level and a new airport dummy variable became significant at the 10% level in Model 2. In Model 3, the statistical significance for regional specialization variable rose up to the 1% level and local competition variable became significant at the 10% level, but a new airport dummy variable became statistically insignificant. In Model 4, a new airport dummy variable became significant at the 5% level, though the statistical significance for regional specialization variable fell to the 5% level.

Throughout all models, the signs of industrial diversity and regional specialization variables are minus and statistically significant, so there is strong evidence of urbanization economies or Jacobs type of externalities, not localization economies nor MAR type of externalities, in aircraft parts industry in Aichi prefecture.

Table 3. Estimation results on production functions

		Model 1		Model 2		Model 3		Model 4	
Constant	lnA	12.53	(8.68***)	12.77	(10.76***)	12.70	(11.29***)	13.04	(10.59***)
Time	λ	-0.02	(-0.33)	—	—	—	—	—	—
K/L	α	0.00	(0.01)	0.00	(0.02)	-0.01	(-0.05)	-0.04	(-0.32)
Diversity	γ	-309.20	(-2.93**)	-328.18	(-3.86***)	-323.29	(-4.03***)	-322.25	(-3.63***)
Specialization	δ	-0.80	(-2.28**)	-0.79	(-2.35**)	-0.90	(-3.20***)	-0.41	(-2.35**)
Competition	ε	1.18	(1.16)	0.98	(1.23)	1.26	(2.09*)	—	—
D ₁	ζ	0.76	(1.74)	0.75	(1.79*)	0.64	(1.71)	0.87	(2.19**)
D ₂	η	0.08	(0.21)	0.03	(0.08)	—	—	—	—
D ₃	θ	-0.22	(-0.67)	-0.23	(-0.75)	—	—	—	—
Adj. R ²		0.66		0.69		0.72		0.66	
D.W.		2.35		2.40		2.32		2.03	
Observations		20		20		20		20	

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

4.3 Comparison with maritime sector

In this section, agglomeration economies in aircraft parts industry are compared with those in the maritime manufacturing sector. In the Census of Manufacture, it corresponds to the industry of shipbuilding and repairing, and marine engines (JSIC code: 313), which is further broken down to 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). Among them, we selected the industry of shipbuilding and repairing for comparison with aircraft parts industry.

Figure 7 shows the LQs of the Japanese 37 prefectures where shipbuilding and repairing industry exists in 2014. As shown in this figure, the LQ of Nagasaki prefecture is 20.51, which is the absolute highest in Japan. Overall, the LQs are greater in the western part of Japan, particularly in the prefectures in Kyushu region (Oita: 4.48, Saga: 3.60, Kumamoto: 2.80) and surrounding Seto Inland Sea (Ehime: 7.56, Hiroshima: 5.82, Kagawa: 5.79, Yamaguchi: 4.51, Kochi: 2.07).

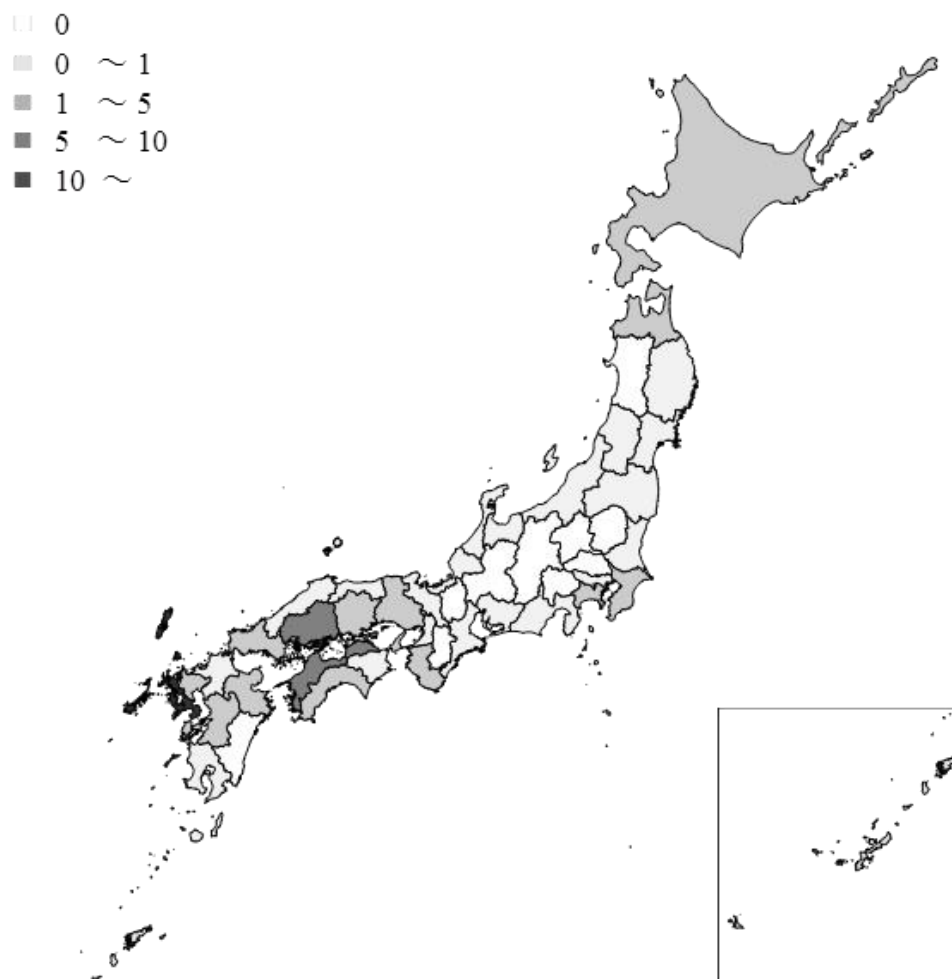


Figure 7. The LQs of Japanese 37 prefectures in shipbuilding and repairing industry, 2014
Source: Calculated by authors from the Census of Manufacture 2014.

Table 4 shows the comparison of estimation results in aircraft parts industry in Aichi prefecture and those in shipbuilding and repairing industry in Nagasaki prefecture. Note that the parameters for aircraft parts industry in Aichi prefecture have been estimated without three dummy variables. Judging from the signs of parameters, shipbuilding and repairing industry in Nagasaki prefecture could be characterized as MAR type of externalities. This would suggest that knowledge spillovers and technological innovation could more easily occur in the geographically concentrated and locally monopolistic environment. Domae and Matsumoto (2017) explored dynamic externalities in the Japanese maritime manufacturing sector from

the perspective of employment growth and found that regional specialization and local monopoly could stimulate employment growth in the Japanese maritime manufacturing sector, basically consistent with the theory of MAR.

Henderson (1995) revealed that there is evidence of MAR type of externalities for mature capital goods industries. Meanwhile, for new high-tech industries, there is evidence of Jacobs types of externalities in the US. Aircraft parts industry is relatively immature with less accumulated technology in Japan in comparison with Seattle in the US or Toulouse in France, where huge aerospace industrial clusters have been formed. In this sense, industrial diversity could stimulate labor productivity in aircraft parts industry in Aichi prefecture, suggesting that knowledge spillovers and technological innovation could more easily occur in the industrially diversified environment.

Table 4. Comparison of agglomeration economies
between aircraft parts and shipbuilding & repairing industries

		Aircraft parts industry in Aichi prefecture		Shipbuilding & repairing industry in Nagasaki prefecture	
Constant	$\ln A$	11.32	(8.16***)	2.17	(0.81)
K/L	α	-0.003	(-0.02)	0.05	(0.21)
Time	λ	-0.005	(-0.08)	0.04	(1.33)
Diversity	γ	-238.84	(-2.33**)	90.57	(0.99)
Specialization	δ	-0.83	(-2.66**)	0.03	(0.17)
Competition	ε	1.55	(1.68)	0.90	(0.78)
Adj.R ²		0.68		0.21	
D. W.		1.85		1.6	
Observations		20		20	

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

5. DISCUSSION AND CONCLUSION

This paper examines agglomeration economies with a special focus on aircraft parts industry in Aichi prefecture over the last twenty years, by incorporating into production function three measures of industrial diversity, regional specialization and local competition in aircraft parts industry. The idea behind this is that economic effect of agglomeration could be linked to labor productivity, which is assumed to be enhanced by knowledge spillovers and technological innovation. We have explored the production environments where knowledge spillovers and technological innovation could more easily occur. The empirical results reveal strong evidence of urbanization economies or Jacobs type of externalities in aircraft parts industry in Aichi prefecture, in contrast to shipbuilding and repairing industry in Nagasaki prefecture, which confirms the possibility of existence of localization economies or MAR type of externalities. This suggests that industrial diversity could encourage labor productivity in aircraft parts industry in Aichi prefecture, suggesting that knowledge spillovers and technological innovation could more easily occur in the industrially diversified environment. From this calibration of production function for examining the effect of agglomeration economies, it can be said that central and local governments should identify these types of agglomeration when they take regional or industrial policies for the formation of aerospace industrial clusters vitalizing a city or a region.

Because of the data availability on capital stock used to estimate production function,

the analysis is conducted at the prefectural level, not at the municipal level. This regional division is probably rather wide to examine agglomeration economies, which would be one of the drawbacks and limitation in this paper. For example, aircraft parts industry may agglomerate across prefectural boundaries. Actually, almost all of the previous studies related to analyses on agglomeration economies in Japan relied on the prefectural data, but it will be necessary to look for other geographical scope which will be more appropriate for analyzing agglomeration economies in aircraft parts industry.

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 concentration or regional specialization (De Dominicis et al., 2013; Guillain and Gallo, 2010; O'Donoghue and Gleave, 2004). However, there are some problems in using this measure, 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 this index (Martin and Sunley, 2003). A further drawback of using the LQ to delimit clusters is that this measure does not provide any information on the absolute size of local industry, as pointed out 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 the absolute term.

A final consideration relates to the model applied to examine agglomeration economies. In the current research, the effect of agglomeration economies is measured by estimating production function embedded with three indexes of industrial diversity (HHI), regional specialization (LQ) and local competition (CI) in a time series approach. However, the industrial diversity index (HHI) is relevant to industrial compositions inside Aichi prefecture, which is based only on the data-set in Aichi prefecture. Meanwhile, the indexes of regional specialization (LQ) and local competition (CI) are relative ones derived from nationwide data-set, including that in Aichi prefecture. This implies that the relative industrial structures in all prefectures, except Aichi prefecture, had not changed over the period of analysis, which is the strong assumption of the current approach. In this sense, the panel data analysis is appropriate in order to estimate more accurately the impact of agglomeration economies across prefectures at different times.

These considerations will provide more new insights to the efficient and effective execution of industrial cluster policy from the perspective of agglomeration economies.

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