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A Preliminary Analysis of Patent Applications and Inter-regional Knowledge Flows by Companies Driving Regional Growth in Japan

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Abstract

In this study, based on the patent applications filed by the “companies driving regional growth” (certified by the Ministry of Economy, Trade and Industry in Japan), their IP activities and inter-regional knowledge flows are investigated. These companies are quite active in patent application activities, especially in the manufacturing industry. According to the analysis of their joint patent applications, it is found that they build inter-firm networks beyond regional boundaries to engage in knowledge creation. In addition, comparing the patents in 2000s and those in 2010s, the average distance between multiple applicants in joint patent applications increases significantly. The result suggests that "proximity of partner organizations", which has been emphasized in the context of industrial agglomeration and knowledge creation theory, is losing the importance with the development of the information technologies.

Keywords: Regional Innovation, Knowledge Flow, Patents, SMEs.

1 Introduction

In Japan, which has entered a phase of population decline, the gaps between metropolitan areas with large population concentrations and other local areas are widening. Focusing on average income by prefecture, it is pointed out that Tokyo's dominance had strengthened between 2007 and 2017 [1]. In other words, the gains from the growing Tokyo area have not spread to the rest of the country.

In order to overcome this situation, it is essential to create innovations utilizing the resources and characteristics of each region which will boost regional industries and economies. Against this background, the Ministry of Economy, Trade and Industry (METI) enacted the "Act on Promotion of Regional Investment for the Future" in 2017 [2]. METI also certified excellent local companies in high-growth fields that utilize regional resources (i.e., (1) "medical equipment, aircraft, biotechnology and new materials industries", (2) "agriculture, forestry, fisheries and regional trading", (3) "4th industrial revolution (IoT, AI, etc.) related", (4) "tourism, sports, culture and urban development", (5) "environment and energy", (6) "healthcare and education") as "Companies Driving Regional Growth”, providing intensive support.

The majority of 4,751 companies certified as "Companies Driving Regional Growth” are small and medium-sized enterprises (SMEs). All these companies are considered to be contributing to the revitalization of the regional economy by providing distinctive products and services. In

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other words, they are key players leading regional innovation. In this paper, we focus on their intellectual properties in order to investigate the innovative activities and capabilities of these firms. More specifically, we attempt to visualize R&D activities and the status of collaboration with other partner companies based on patent application data.

In general, SMEs do not have abundant management resources. Therefore, they are thought to create open innovations through the procurement of scarce resources based on collaboration with external organizations [3]. On the other hand, there are many case reports of geographically concentrated firms in given local area that actively create innovation and sustain competitive advantage [4]. However, it is also pointed out that "geographical proximity is not always a necessary condition for knowledge creation" [5]. In this paper, we examine changes in "geographical proximity" for knowledge creation, focusing on the location and distance of applicant corporations that jointly file patents.

2 Former Studies

Concerning the innovation creations in SMEs, there are a number of studies on their enablers (albeit not as active as those of large firms) ([6], [7], [8]). The results of these studies demonstrate that (i) "SMEs with active R&D and IP activities", (ii) "SMEs that export (e.g., in Europe)" and (iii) "SMEs that closely link their internal culture and formal strategies to the innovation process" are more active in innovation creation than SMEs that do not.

On the other hand, regional innovation research which considers regions as "a group of companies or organizations" and studies their innovative nature as a group, has its origins in research on industrial agglomerations. Marshall pointed out that industrial agglomeration has an "external economic effect" on firms in four aspects: (1) information acquisition and technological development, (2) raw material procurement, (3) production, and (4) securing of human resources ([9], [10]). Of these, (1) is likely to be deeply related to the gradual creation of innovation. Based on this investigation, the "Marshall Arrow Rome (MAR)-type externality" caused by the concentration of identical industries [11] and the "Jacobs-type externality" caused by the concentration of a wide variety of industries [12] have been proposed. Among these, the effectiveness of the latter externality has been shown for product innovation in high-tech industries [13].

By the way, human knowledge is broadly classified into two types: one is formal knowledge that is explicitly verbalized and expressed, and the other is tacit knowledge which is not ([14], [15]). In general, technology and know-how are strongly characterized by the latter. Since tacit knowledge is transmitted "non-verbally," face-to-face communication that does not rely on conversations or documents is considered to be important, and it is not difficult to imagine that the "geographical proximity" of companies due to their concentration would be effective in its transmission [16]. However, in today's society with well-developed information technology, it is not difficult to send images or videos to remote locations. Therefore, it is presumed that "geographical proximity is not always necessary for the exchange of tacit knowledge, even if it is difficult to express it by texts or characters".

In this study, we examine the status of patent applications, an enabler of innovation creation, by “Companies Driving Regional Growth”. In addition, we also focus on joint patent application data in order to investigate knowledge flows between different regions. It is inferred that joint patent applications with other organizations are enablers that contribute to the creation of open

innovation in SMEs. Therefore, if we focus on the locations of multiple applicants (partner organizations) in each patent, knowledge flow between the locations of each applicant can be visualized. In addition, we will conduct a simple measurement of the geographical distance between these partner organizations and test the hypothesis that "the average distance between applicants is increasing with the development of information technology".

3 Patent Applications filed by Companies Driving Regional Growth

The selection of "Companies Driving Regional Growth" was conducted three times by METI in 2017, 2018 and 2020, with a total of 4,751 companies certified.

Table 1: Patent Applications by Companies Driving Regional Growth (2000-2019)

Industry	Number of companies	Number of companies that filed patent applications	Percentage of firms that filed	Number of applications	Number of applications per company	Number of applications per company per year
A Agriculture, forestry	53	13	25%.	25	1.92	0.10
B Fishery	5	2	40%.	5	2.50	0.13
C Mining, quarrying, gravel extraction	3	2	67%.	112	56.00	2.80
D Construction	401	152	38%.	1,141	7.51	0.38
E Manufacturing	2,816	1,944	69%.	91,571	47.10	2.36
F Electricity, gas, heat supply, and water supply	9	3	33%.	19	6.33	0.32
G. Information and Communication Industry	123	79	64%	743	9.41	0.47
H Transportation, postal industry	160	23	14%.	58	2.52	0.13
I Wholesale and retail trade	745	287	39%.	7,017	24.45	1.22
J Financial and insurance industry	11	5	45%	127	25.40	1.27
K Real estate and goods rental	44	15	34%	91	6.07	0.30
L Academic research, professional and technical services	77	42	55%	825	19.64	0.98
M Accommodation and food services	73	5	7%	13	2.60	0.13
N Lifestyle-related services and entertainment	70	16	23%.	90	5.63	0.28
O Education, learning support industry	9	1	11%.	1	1.00	0.05
P Medical care, welfare	21	10	48%	151	15.10	0.76
Q Combined services business	15	2	13%.	14	7.00	0.35
R Service industry	116	40	34%	442	11.05	0.55
Total	4,751	2,641	56% of	102,445	38.79	1.94

The basic attributes of target companies for this selection are "SMEs" or "mid-sized enterprises". Among these, the latter category excludes (i) SMEs, (ii) large companies with sales of 100 billion yen or more, or capital of 1 billion yen or more, and (iii) companies listed on the First Section of the Tokyo Stock Exchange. In this program, companies are selected (1) if their profile and business performance meet the given criteria, or (2) if they are recommended by local stakeholders such as local government or local financial institutes. Concerning the condition (1), the company is evaluated on its "value added", "growth potential" and "whether it serves as a node for business transactions within and outside the region", with reference to its sales, business transactions, employment contribution and other factors. As for (2), local governments, commerce and industry organizations, financial institutions, and other interested parties nominate

companies engaged in attractive businesses that are expected to become new driving forces in the region.

In this study, we analyze the patent filed by these firms to the Japanese Patent Office (JPO) for 20 years between 2000 and 2019 (Table 1). Among the 4,751 firms, 2,641 firms have filed at least one patent application, which corresponds to 55.6% of the total firms. In general, IP activity in SMEs is not very active. In fact, only 0.33% of all SMEs file at least one patent application in a year [12]. Although this is a somewhat rough calculation, if this figure is simply multiplied by 20, it is estimated that about 6.6% of all SMEs file applications on average. Compared to this figure, the IP activities of the target companies in the present analysis are much more active than those of average SMEs.

The total number of applications filed over the 20-year period was 102,444. The most active sectors in terms of application activity are "Manufacturing" (69%, 47 applications/company on average), "Mining, quarrying, and gravel extraction" (67%, 56 applications/company), "Information and communications" (64%, 9 applications/company) and "Academic research, professional and service" (55%, 19 applications/company).

4 Visualization of Inter-regional Knowledge Flow based on Joint Patent Applications

In general, when SMEs with limited resources attempt to create innovation or conduct advanced R&D, it is reasonable to expect that they will actively collaborate with external organizations.

Table 2: Joint Patent Applications by Companies Driving Regional Growth (2010-2019)

No.	Prefecture	Num. of Patents	Partner in Identical Prefecture	Partner in Tokyo	No.	Prefecture	Num. of Patents	Partner in Identical Prefecture	Partner in Tokyo
1	Hokkaido	100	18%	19%	25	Shiga	80	6%	19%
2	Aomori	22	27% of	23%.	26	Kyoto	336	15%.	24%
3	Iwate	85	14%.	25%.	27	Osaka	981	8%	13%.
4	Miyagi	110	24%	19%	28	Hyogo	349	11%.	27% of
5	Akita	45	22%.	31%.	29	Nara	82	5%	23%.
6	Yamagata	262	3	16%	30	Wakayama	66	18%	35%.
7	Fukushima	55	7%	27% of	31	Tottori	43	40%.	7%
8	Ibaraki	143	17%.	15%.	32	Shimane	45	36%.	18%
9	Tochigi	114	4%	23%.	33	Okayama	227	6%	36%.
10	Gunma	59	31%.	24%	34	Hiroshima	216	19%	21%.
11	Saitama	164	3	34%	35	Yamaguchi	76	18%	21%.
12	Chiba	167	6%	34%	36	Tokushima	44	7%	39%.
13	Tokyo	1930	11%.	11%.	37	Kagawa	162	11%.	27% of
14	Kanagawa	294	9%.	22%.	38	Ehime	79	22%.	20%.
15	Niigata	119	2%	34%	39	Kouchi	77	19%	25%.
16	Toyama	199	13%.	30	40	Fukuoka	364	21%.	26%.
17	Ishikawa	146	13%.	27% of	41	Saga	60	3	53%.
18	Fukui	175	18%	34%	42	Nagasaki	48	10%	35%.
19	Yamanashi	36	3	42%	43	Kumamoto	89	16%	26%.
20	Nagano	280	15%.	27% of	44	Oita	38	11%.	26%.
21	Gifu	209	5%	20%.	45	Miyazaki	28	32%	18%
22	Shizuoka	228	9%.	32%	46	Kagoshima	40	38%.	10% (%)
23	Aichi	647	20%.	19%	47	Okinawa	19	21%.	26%.
24	Mie.	67	1	19%					
						Total	9,205	12%.	21%.

As a result of inter-firm collaboration, important research outcomes that are useful to business are often jointly applied for patents. Of the patent applications listed in the previous section, 18,606 were joint applications. This represents 18% of the total.

What is the regional nature of the partner firms in such joint applications? As mentioned earlier, in the traditional context of knowledge creation in the region, "proximity among partner organizations" is important, as it presupposes the sharing of tacit knowledge. However, with the penetration of information technology and changes in our business practices, the geographical proximity of partner firms may be less important than before. In this study, we attempted to visualize the recent knowledge flow in Japan by examining the locations of companies that have filed joint applications.

Table 2 shows the status of joint patent applications by region since 2010. The largest number of patent applications involving our target companies has been filed in Tokyo (1,930 applications), followed by Osaka (981 applications), Fukuoka (364 applications) and Kyoto (336 applications). These are all metropolitan cities with a high concentration of R&D-oriented companies. In addition to the above, Table 2 also shows (1) the percentage of patents jointly filed by firms located in the same prefecture and (2) the percentage of patents jointly filed with a partner firm in Tokyo. The top three prefectures in (1) are Tottori (40%), Kagoshima (38%) and Shimane (36%), while those in (2) are Saga (53%), Yamanashi (42%) and Tokushima (39%). Note that "joint applications by companies in the same prefecture" is consistent with the traditional image of regional innovation based on the inter-firm collaboration in the neighborhood, but even in Tottori, the ratio is less than half (40%), and the overall average is only 12%. In other words, these ratios suggest that in the current Japan, inter-regional knowledge flows are occurring beyond the boundaries of prefectures. In particular, it is evident that the flow of knowledge from Tokyo has a

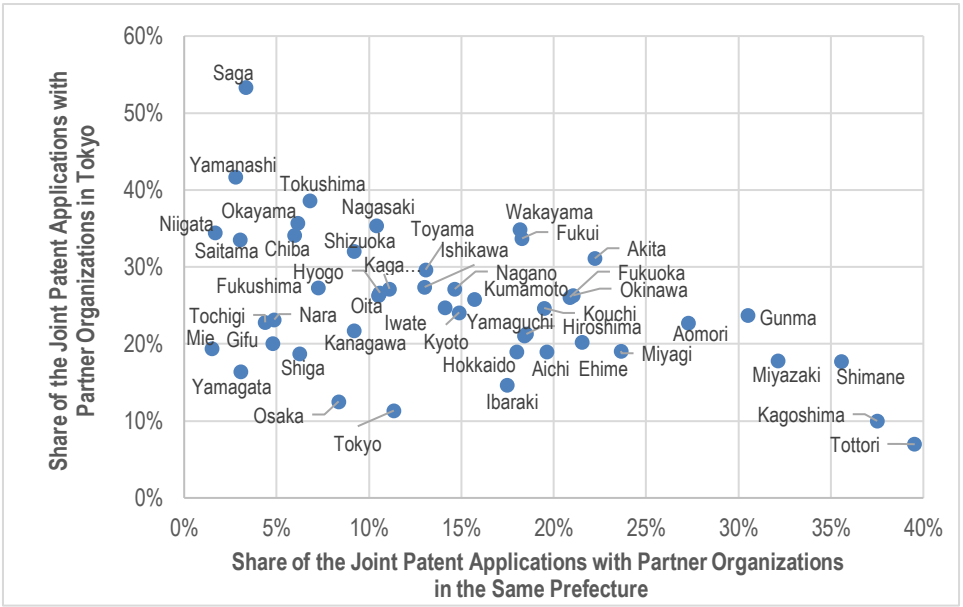

Figure 1: Share of Patents filled with Partner Organizations in the Same Prefecture versus that in Tokyo (Joint Patent Applications: 2010-2019)

significant influence.

In Figure 1, we show a scatter plot of prefectures using the data in (1) and (2). From this figure, it can be understood that companies in Tokyo and Osaka often file joint applications with companies in other prefectures, serving as the starting point for cross-regional knowledge flows. The results also suggest that the knowledge flow from Tokyo has a strong influence not only on the neighboring areas such as the Kanto region, but also on remote areas such as Saga, Tokushima, Nagasaki and Okayama.

5 Distances between Partner Organizations

The results of the previous section suggest that, at least, the simple concept of geographic proximity defined by prefecture boundaries, is losing its importance. To confirm this idea from a different perspective, this study further examines the distance between the partner firms that filed joint applications.

Table 3 shows the approximate distance between the applicants for jointly filed patents that include “Companies Driving Regional Growth” as an applicant, for two different decades.

In measuring the distances in this table, no exact GPS data or other detailed geographic data was used. Instead, we focus on the applicants’ prefectures and regarded the distance between the prefectural capitals of each as the approximate distance between the two firms. Concerning the precise distance between prefectural capitals, we referred to the "Distance between Metropolitan and Prefectural Capitals" published by the Geospatial Information Authority of Japan (GSI, 2022). Although this is only a simplified measurement, since our data includes a reasonably large number of companies, it is considered to be reasonably accurate for understanding overall trends.

Following the standard method to test the differences of two means [], it is found that the average distance of 314km between applicants in the 2010s (2010-2019) increased significantly from that of 281km in 2000s (2000-2009). Concerning the prefectural view, we find that (1) the distance between applicants significantly increased in 32 prefectures, while (2) it significantly decreased in 12 prefectures. Although there exists differences by region, the overall trend is that the distance between partner organizations in joint filings is increasing.

In other words, the results suggest that "the movement to utilize inter-organizational networks that transcend geographical restrictions" is becoming stronger.

6 Summary and Future Issues

In this study, we focused on patents applied for by "Companies Driving Reginal Growth" certified by METI, and conducted a preliminary analysis concerning knowledge flows between regions based on joint applications. The results reaffirmed the importance of Tokyo in terms of knowledge creation, but also suggested that Tokyo-based companies and regional companies are forming alliances to create innovations. In addition, the distance between partner organizations collaborating with each other is getting longer, suggesting that active open innovation beyond regional barriers is taking place.

In the near future, we intend to refine the present analysis by using more accurate GPS data, and also, conduct an additional questionnaire survey on firm-level innovations to verify the enablers of innovation for local companies, which will serve as the basis for both the efficient innovation management and the effective policy making for regional revitalization.

Table 3: Estimated Distances between Partner Organizations in Joint Patent Applications

No.	Prefecture	2000-2009 Num. of Joint Patent Applications	2000-2009 Ave. Distance between Partners (km)	2000-2009 Std. Dev.	2010-2019 Num. of Joint Patent Applications	2010-2019 Ave. Distance between Partners (km)	2010-2019 Std. Dev.	Difference in Ave. Distances (km)	Significance
1	Hokkaido	125	763.0	408.1	100	805.8	464.5	42.9	†††
2	Aomori	21	213.2	297.3	22	474.9	334.2	261.6	†††
3	Iwate	108	428.6	223.1	85	448.5	266.9	19.8	†††
4	Miyagi	133	453.4	225.3	110	346.4	267.6	-107.0	†††
5	Akita	40	199.4	198.8	45	382.2	287.9	182.7	†††
6	Yamagata	189	335.3	226.3	262	488.3	197.3	153.0	†††
7	Fukushima	56	310.2	197.6	55	353.6	238.8	43.4	†††
8	Ibaraki	125	308.6	258.7	143	297.7	304.9	-10.9	†††
9	Tochigi	75	255.2	228.1	114	210.2	175.4	-45.0	†††
10	Gunma	96	180.2	165.8	59	131.3	132.6	-48.9	†††
11	Saitama	305	224.0	246.8	164	225.1	244.9	1.2	
12	Chiba	163	264.5	265.0	167	230.4	214.4	-34.1	†††
13	Tokyo	2637	319.3	259.1	1930	340.5	270.8	21.2	†††
14	Kanagawa	378	267.9	225.4	294	281.8	272.6	13.9	†††
15	Niigata	220	262.7	135.8	119	386.9	213.2	124.1	†††
16	Toyama	287	205.5	157.9	199	208.4	139.4	2.9	†††
17	Ishikawa	169	183.8	149.9	146	210.3	129.5	26.5	†††
18	Fukui	189	181.3	152.0	175	201.7	144.3	20.3	†††
19	Yamanashi	40	133.2	93.9	36	152.3	121.9	19.1	†††
20	Nagano	355	177.0	134.3	280	205.6	168.4	28.5	†††
21	Gifu	242	210.9	174.2	209	210.7	169.0	-0.1	
22	Shizuoka	405	224.1	186.7	228	204.3	152.0	-19.8	†††
23	Aichi	1014	167.8	160.4	647	190.6	164.1	22.8	†††
24	Mie.	96	224.5	160.5	67	214.6	146.2	-9.9	†††
25	Shiga	146	174.6	171.2	80	192.7	198.9	18.1	†††
26	Kyoto	304	230.6	179.6	336	214.9	188.0	-15.6	†††
27	Osaka	1294	244.3	214.2	981	322.1	246.3	77.8	†††
28	Hyogo	482	244.6	206.3	349	250.1	205.1	5.5	†††
29	Nara	162	193.4	181.6	82	230.2	181.9	36.8	†††
30	Wakayama	115	197.4	200.2	66	274.1	229.5	76.7	†††
31	Tottori	13	201.3	203.1	43	183.8	220.5	-17.5	†††
32	Shimane	27	327.3	260.5	45	206.4	216.7	-120.9	†††
33	Okayama	338	320.8	208.5	227	367.8	210.6	47.0	†††
34	Hiroshima	328	345.5	295.2	216	397.7	285.4	52.2	†††
35	Yamaguchi	84	518.6	332.6	76	367.5	309.7	-151.1	†††
36	Tokushima	70	274.0	281.0	44	336.5	300.6	62.5	†††
37	Kagawa	155	272.5	231.9	162	312.0	207.8	39.5	†††
38	Ehime	132	426.2	281.1	79	294.9	267.4	-131.3	†††
39	Kouchi	108	284.3	236.3	77	297.4	239.0	13.1	†††
40	Fukuoka	411	465.6	372.1	364	513.6	385.1	47.9	†††
41	Saga	113	508.8	413.8	60	670.0	310.1	161.2	†††
42	Nagasaki	60	586.8	409.3	48	609.4	377.6	22.5	†††
43	Kumamoto	83	322.3	369.6	89	537.0	370.0	214.6	†††
44	Oita	45	275.1	332.1	38	367.3	318.6	92.2	†††
45	Miyazaki	17	507.9	384.3	28	391.8	367.8	-116.1	†††
46	Kagoshima	28	373.6	371.9	40	389.8	366.9	16.2	†††
47	Okinawa	18	757.0	702.2	19	1154.6	718.1	397.6	†††
	Total	12,001	281.4	256.3	9,205	313.9	273.4	32.5	†††

†††: significant at the 1% level

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