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Abstract

This study interrogates structural changes in industrial clusters by applying the innovation ecosystem approach and demonstrates the evolution of industrial clusters in Hamamatsu, Japan, in terms of intra- and inter-regional networks and policy support for innovation. In Hamamatsu, the industrial cluster has transformed owing to the application of advanced technologies in the medical and optical industries, whereas transport, machinery, and musical instruments are basic industries. The study notes that the factors contributing to this transition include positioning Hamamatsu as a research and development basis for core companies, the development of new fields through spontaneous research networks among small and medium enterprises in the area, and technical support from universities and public research organizations. The study uses mixed methods with secondary data for quantitative analysis and primary data through interviews with respondents from selected companies. The findings show that dense intra-regional networks facilitate cooperation between industry and academia, whereas inter-regional networks serve as knowledge and information pipelines. Furthermore, the study concludes that political support underpins regional innovation in terms of finance and technology, augmenting the government's role in the industrial network. Thus, the innovation ecosystem notion is valid in advancing empirical research on regional innovation systems.

Keywords: innovation ecosystem, entrepreneurial ecosystem, industrial structure, industrial cluster, innovation systems, cluster evolution

1. Introduction

1.1 Ecosystem concept in innovation studies

Due to the rising geographical interest in innovation, many academic journals have published special issues featuring the keyword "ecosystems." However, the concept of ecosystems is fuzzy (Markusen, 2003). It is also no longer a buzzword as the term has been adopted in policymaking, for example, in Japan's support for the country's start-up ecosystem. Sternberg (2022) noted that entrepreneurial ecosystem are a trending research topic surrounding entrepreneurship; however, the author cautioned that policymakers and practitioners may use them as a policy concept that has not received sufficient academic scrutiny. Research on entrepreneurship ecosystems has also surged due to pioneering research findings (Stam, 2010; Spigel, 2017). Stam (2015, p.1765) defined an entrepreneurial ecosystem as “a set of interdependent actors and factors coordinated in such a way that they enable productive entrepreneurship.” Therefore, the entrepreneurial ecosystem positions high-growth startups as central actors that represent a source of innovation. By contrast, the innovation ecosystem represents the process of building an environment in which industrial innovation is continuously created and enhanced. Nauwelaers (2011, pp.468–469) defined the innovation ecosystem as “a system which all components are present in a balanced way and develop positive interactions, and in which firms in particular are engaged in networks of co-operators and competitors oriented toward innovation.” Therefore, the innovation ecosystem involves creating a conducive environment that allows for continuous industrial improvement. Success is possible when key stakeholders are engaged in technological and industrial innovation. The relationship between the nation-state and national institutions echoes the innovation system approach. The national innovation system pioneered studies on the innovation systems approach (Lundvall, 1992), noting the significance of the nation-state and national institutions in promoting innovation (Freeman, 1995). Conversely, for smaller localities within the nation-state, the regional innovation system (RIS) approach is utilized to explore the innovative practices of local networks within industrial clusters (Cooke, 1992). Isaksen et al. (2018, p.3) noted that the RIS approach was introduced in the 1990s, aiming to highlight the key strengths of innovation systems in support of industrial progress. This approach continues to shed light to date. Over the years, the regional innovation ecosystem has undergone various conceptual refinements, such as introducing the ecosystem as a concept that helps bring progress to RIS.

Owing to the continuous improvement of the regional innovation ecosystem approach, the practical approach intended to deal with regional innovation ecosystems aimed toward industrial progress has limitations. Studies on innovation ecosystems mainly focused on the national state innovation systems, with minimal studies on regional ecosystems. The present study focuses on the regional innovation ecosystem in industrial clusters in the Hamamatsu area, Shizuoka prefecture, Japan.

1.2 Introducing path dependency in RIS

Arguments based on evolutionary economic geography have been advanced for new industry creation and development in clusters. Evolutionary economic geography has shifted from discussions about equilibration to specific paths, such as lock-in, to a focus on path dependence, which argues for economic development through a nonequilibrium path based on regional trajectories of technologies, industries, and institutions (Martin and Sunley, 2006, 2010; Martin, 2010). Discussions are also underway to examine new industry creation and development in clusters based on concepts related to path dependence (e.g., path creation, path expansion, path renewal, and path diversification) (Chapman et al., 2004; Coenen et al., 2015; Chaminade et al., 2019). In addition, as a model of regional evolutional economics, Martin and Sunley (2011) have constructed a cluster life cycle model comprising phases—exploitation, conservation, release, reorganization, mutation, stabilization, reorientation, and disappearance—arguing that evolutionary processes such as stabilization, reorientation, and disappearance occur.

Evolutionary economic geography has largely focused on routines at the organization and firm levels; however, the need to align with theoretical aspects of institutional economic geography has also been identified (Boschma and Frenken, 2009; Essletzbichler, 2009; MacKinnon et al., 2009). Evolutionary and institutional economic geography reject utility maximization and equilibration, and instead consider historical and geographical contexts; however, they differ in their stance toward general modeling (Boschma and Frenken, 2006). Institutions such as markets, competitors, collaborators, and policy and regulatory regimes have been considered the external environment of the cluster (Martin and Sunley, 2011), influencing the cluster's firm behavior, and firms and organizations recursively influence and coevolve into the external environment.

There has been an increase in theoretical and empirical research on new industry creation and development in clusters, applying the concept of path dependency. Path development research, which incorporates evolutionary and institutional economic geography, attempts to capture the interrelationships between agency and institutions in regional industrial transformations (Isaksen et al., 2019; MacKinnon et al., 2019). Grillitsch and Sotarauta (2020) and Sotarauta et al. (2023) proposed a "change agency" framework consisting of innovative entrepreneurship, institutional entrepreneurship, and place leadership, and also stressed the importance of focusing on the interrelationships between agency and institutions to path development. Frangenheim et al. (2020) integrate agency, regional institutions, and policy frameworks in extending the discussion of regional interpath relationships.

Evolutionary and institutional economic geography have turned toward the innovation systems approach in the coevolution between technologies, markets, and institutions (Boschma and Frenken, 2006). RIS discussions have increasingly incorporated the notion of regional path dependence. Isaksen and Jacobsen (2017) point to the need for complementarity between actor- and system-based policies in encouraging regional new industry creation and attempt to combine RIS and system-based policies. Isaksen and Trippl (2016) discussed new path development in different types of RIS, while Isaksen et al. (2019) discussed the different roles of firm- and system-level agencies for path development in RIS. The former contributes to novel economic development for the region, such as path creation and path diversification, while the latter contributes to development based on existing pathways, such as path extension and upgrading. Notably, RIS types lead to differences in regional path development. Isaksen and Trippl (2016) and Isaksen et al. (2019) argue that in an organizationally thick and diversified RIS, endogenous and interindustry diversity-based path creation and renewal take place. While, they find that in organizationally thick and specialized RIS and organisationally thin RIS, paths are formed around path extension. It is then argued that in organizationally thick and specialized RIS and organizationally thin RIS, the importance of system-level agencies increases in the creation of new industries.

Although the discussion of path dependency–related concepts and RIS is advancing, some research challenges remain. First, as Hassink et al. (2019) pointed out, path dependency and RIS are discussed in the context of multiscale relationships. At the firm or organizational level, RIS are not limited to actors within the intra-regional network; actors located in a wide geographical area (in particular, research institutes outside the regions that serve as knowledge bases) are important as knowledge and information pipelines. In policy support encouraging continuous innovation, the multilayered relationship amongst nation state, regional governments and industry support agencies also has an impact on regional path development. A geographical political economy approach has also been attempted with regard to national and regional layering (MacKinonn et al., 2009, 2019).

Besides international comparisons of the multilayered nature of industrial policy are insufficient, partly because the evolution of RIS has been mainly discussed in Europe. It is relevant to consider these dynamics in East Asia, where, in the developmental state model, centralized industrial policy support has been a source of economic growth (Hassink, 2011). Strong state intervention in East Asia is seen in restructuring in old industrial areas, but state intervention also acts as a barrier to regional innovation (Cho and Hassink, 2009; Hassink et al., 2018). Since the 2000s, however, with the spread of the cluster concept, East Asian governments have shifted their policy regimes from state-led industrial support and deployment to spontaneous industrial policy formation by regional governments and complementary national support. The multilayered industrial policy support and its coherence in this context need to be added to the innovation ecosystem discussion.

Second, in discussions aiming to integrate existing path dependency and RIS, the typology of RIS is based on European (especially Nordic) findings. Isaksen and Trippl (2016) argued that organizationally thick and diversified RIS are metropolitan areas, organizationally thick and specialized RIS are regional areas consisting of a single or a small number of industrial districts, and the organizationally thin RIS are peripheral regions. In contrast, Chaminade et al. (2019) showed that even organizationally thick and specialized RIS industrial districts have a shared vision for new industries, reinforced by national and regional policy initiatives, showing that pathway development other than through path extension can be achieved. Thus, the relationship between path development and RIS type remains at a stage where much discussion is needed, and the RIS of local areas promoting industrial development and cluster growth must be identified on the basis of empirical research.

To overcome these existing challenges, it is worth discussing the formation of new industries through regional innovation ecosystems in a multilayered relationship with the state and its regions. In doing so, it is necessary to fully discuss the position of East Asia, where the nation-state has traditionally played a pivotal role. Nagata (2022) introduced several examples of budding innovation ecosystems in Japan. Based on case studies, he found that leaders who promote innovation-related projects with a clear objective are indispensable components of innovation ecosystems.

Using the Hamamatsu region in Japan as a case, this study examines the role of firm- (organizational) and system-level agencies and their interrelationships in generating regional innovation ecosystems. The Hamamatsu region is a cluster in a nonmetropolitan area of Japan that fosters certain institutional foundations as well as a diversity of industries, such as musical instruments, textiles, and automobiles. In addition, the Hamamatsu region is a pioneering example, having been selected several times as a target region for Japan's national cluster policy aimed at creating innovation (Yokura, 2021; Yokura et al., 2013).

2. Industrial development trajectory in Hamamatsu Cluster

2.1 Industrial evolution in Hamamatsu cluster

This study focuses on regional innovation ecosystems in industrial clusters such as the Hamamatsu area, Shizuoka prefecture, Japan (Figure 1). The Hamamatsu cluster is a multi-industry area (Otsuka, 1986a) where several industries have been created based on the technological relatedness of existing industries.

In the 19th and early 20th centuries, the Hamamatsu cluster evolved from woodworking techniques and cotton cultivation to expand into production of machinery such as looms and musical instruments. After

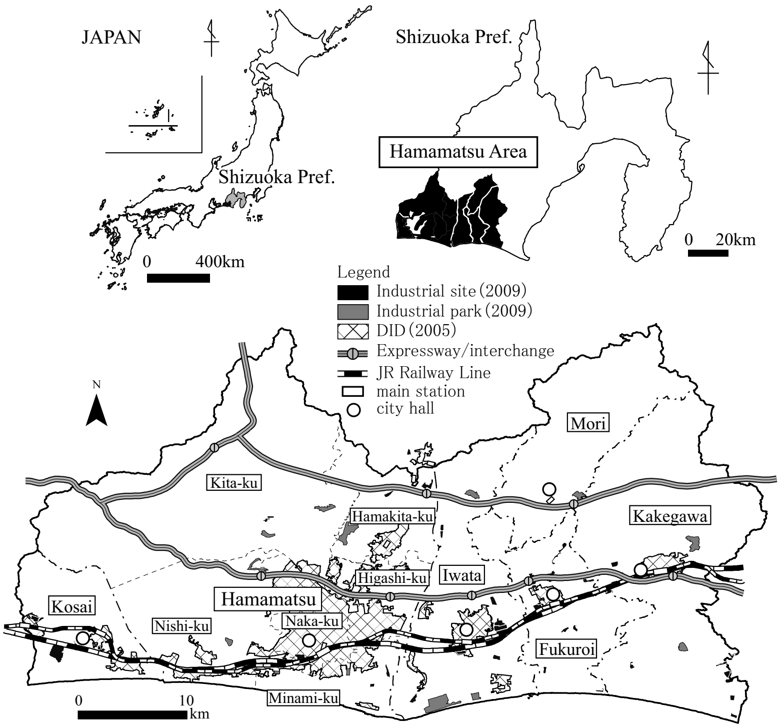

Figure 1. Overview of the Hamamatsu area

Notes: Hamamatsu city excludes Tenryu-ku.
Source: Digital national land information, Ministry of Land, Infrastructure, Transport and Tourism.

World War II, transport machinery, such as cars and motor cycles[1], and electronics and optical machine industries, such as televisions, began to develop. In particular, transport machinery, textiles, and musical instruments were regarded as the three major industries in the Hamamatsu cluster. Since the 1970s, textile and motorcycle production began to decline due to the overseas transfer of production; subsequently, industries requiring advanced technology and knowledge, such as electronics and optical machinery, emerged (Figure 2).

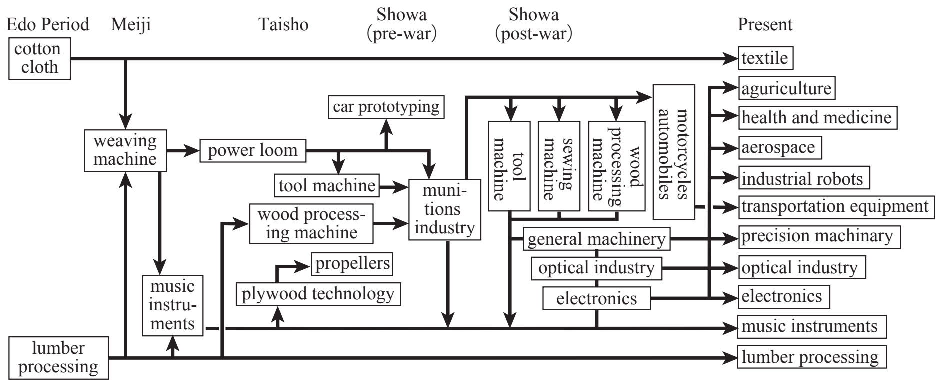

Figure 2. Industrial evolution in the Hamamatsu region

Source: Based on Otsuka (1986a, p.178) and Hamamatsu Agency for Innovation.

The evolution of the Hamamatsu cluster is attributed to four interrelated factors: the presence of entrepreneurs, research institutes as a technological base, dense interorganizational networks, and national policy.

First, entrepreneurs used existing industries to branch out into new industries. In the Hamamatsu region in particular, entrepreneurial spinoffs from companies and research institutes contributed significantly to the creation of new industries (Otsuka, 1986b; Nagayama, 2009, 2012).

Second, universities and public research institutes were established in the Hamamatsu region before World War II[2] and contributed to the technical development and commercialization of local firms. Spin-offs from research institutes, such as in the optical industry, contributed to the creation of new industries (Nagayama, 2009, 2012).

Third, in the Hamamatsu region, small and medium-sized enterprises (SMEs) in the region have formed spontaneous networks and actively hold workshops and collaborations on new industries. In addition to these firms, universities, local governments, industrial partnerships, and industrial support agencies have

1) According to Hamamatsu city (2012), the reasons the motorcycle manufacturing industry flourished in the Hamamatsu cluster were (1) the concentration of firms involved in plating, sheet metal, pressing, forging and welding, and (2) low entry barriers for small and medium-sized enterprises that do not manufacture components.

2) These research institutes include the Hamamatsu Branch of Shizuoka Prefectural Industrial Experiment Laboratory in 1906, the Shizuoka Prefectural Textile-Dyeing School in 1915 (currently Hamamatsu Technical High School), and the Hamamatsu Technical Higher School in 1922 (currently Faculty of Engineering, Shizuoka University).

supported these research activities (Hamamatsu Shinkin Bank and Shinkin Central Bank Research Institute, 2004; Tsujita, 2004; Hosoya, 2009; Kawabata, 2017).

Finally, as part of the national industrial policy, Hamamatsu became a designated technopolis site in the 1980s (Sternberg, 1995), leading to the establishment of industry–university–government collaboration hubs. Additionally, the industrial support agencies established after the national technopolis designation worked to attract new companies and provide technical, financial, and information support to firms in the region.

Prior to its designation as a technopolis, the Local Association for Technical Innovation and the Electronics Technology Research Institute were established in 1981 and 1983 (both public interest incorporated foundations)[3]. These organizations became industry support agencies for attracting new companies and providing technical, financial and information support to companies in the area.

2.2 Industrial dynamics and policy direction in Hamamatsu from the 2000s

Since the 2000s, the Hamamatsu cluster has been forced to change its industrial structure. Figure 3 shows the number of establishments, employees, and product shipment values reported in the Census of Manufacture Statistics Table in Hamamatsu City by industry sector.

The number of establishments peaked in 1980 but has declined since then despite several municipal

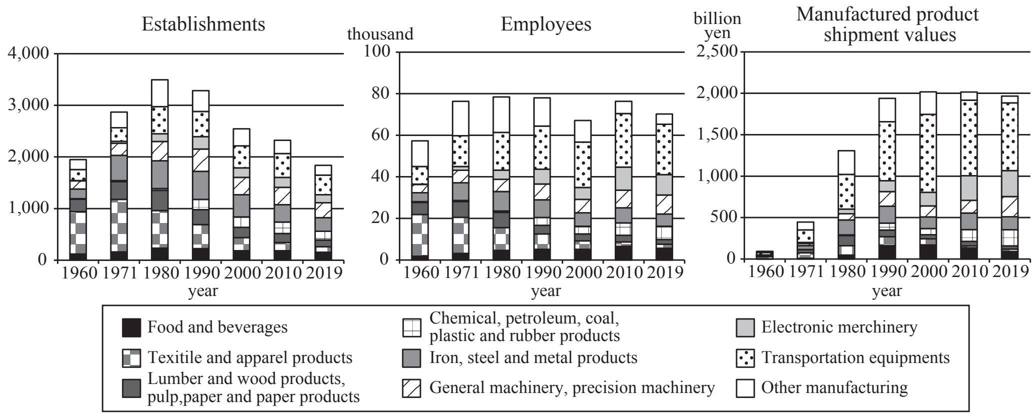

Figure 3. Trends in the numbers of establishments, employees, and manufactured product shipment values in Hamamatsu city (establishments with four or more employees)

Note: For 2010 and 2019, the numbers reflect the new city area following the municipal merger in 2005.
Source: Census of Manufacture Statistics Table.

3) The two public interest incorporated foundations were consolidated in 1991 to form the Technopolis Promotion Organization. Subsequently, the Hamamatsu Agency for Innovation was established in 2012 as a result of the consolidation of the Technopolis Promotion Organization with the Hamamatsu Industry Creation Center, which was established within the Chamber of Commerce and Industry in 2007.

mergers. The number of employees has been declining steadily over this period. Conversely, product shipment values continued to rise until 2010. Analysing by industry sector, transportation equipment, and musical instruments (categorized as "other manufacturing" in Figure 3) are the three major industries in the Hamamatsu cluster; all indices started to decline from 2010. Since then, the share of product shipment values relating to general machinery and electronics has increased. Furthermore, the number of employees in the general machinery industry has continued to grow.

Figure 4 indicates that the number of workers in manufacturing establishments has been declining since 2000. In particular, the number of production processing and labor operators has decreased. However, the number of employees in specialized and technical occupations increased, representing over 10% of the total in 2015. These statistics suggest that in the Hamamatsu cluster, the industrial structure is shifting from a labor-intensive to a high-tech industry, as well as from a production function to a research and development (R&D) function. Additionally, the number of firms and employees is shrinking.

This is largely due to changes in manufacturing's exogenous environment. Large companies (particularly those that produce transportation equipment and musical instruments) are increasingly relocating overseas. They are shifting production bases mostly to other countries in Asia to improve production efficiency and develop global markets. The withdrawal of large companies from the Hamamatsu cluster, combined with the recession caused by the Lehman Brothers collapse, has resulted in the restructuring of component manufacturing and processing companies in leading industries.

In addition to these changes in local industry, Hamamatsu has also had to make significant modifications to its industrial policy. National industrial policy has changed significantly since the 2000s, shifting toward a

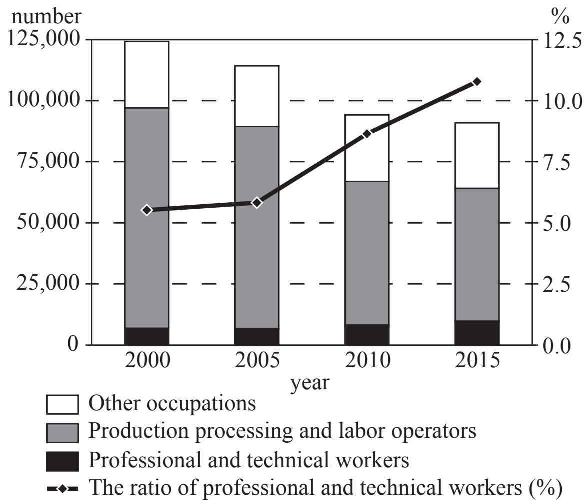

Figure 4. Trends in the number of employees by occupation in Hamamatsu

Note: Based on the location of employment. For 2000 and 2005, the numbers include the areas later incorporated through the municipal merger.
Source: National Population Census.

system of selective support for clusters that seek to endogenously develop their own industries. Local governments have had to respond to this national level development by establishing their own policies, coordinated with multiscale and nongovernment stakeholders involved. The Hamamatsu region has not received any large-scale industrial policy support from the national government since its designation as a technopolis, independently formulating its own cluster policy that defines the industries and technologies to be targeted.

3. Innovation ecosystem in Hamamatsu

3.1 Methodology

In response to the situation regarding industry and policy, this study examines how the Hamamatsu cluster is promoting the transformation and creation of new industries based on the innovation ecosystem model. In particular, this study examines the Hamamatsu cluster's innovation ecosystem through the activities of R&D networks comprising multiple stakeholders (e.g., firms and industry–academia–government collaborative arrangements) and the political and institutional foundations that facilitate interactions among them and lead to innovation and creation of new industries.

The research was conducted as follows. First, materials were obtained on the direction, achievements, and challenges of Hamamatsu's innovation policy. Additionally, data were collected through interviews with officials from industry department and industrial support agencies in Hamamatsu. We also interviewed 16 companies recommended by city officials and industrial support agencies and agreed to by the respective firms, with regard to (1) new product development in each firm, (2) participation in networks for product development, and (3) use and evaluation of policy support (Sato, 2018). The survey was conducted between August and December 2014, which corresponds to the period of recovery following the Lehman Brothers collapse (Table 1).

Respondent companies A–D are large firms that manufacture end products. Of these, A is a manufacturer of musical instruments, B and C manufacture transport machinery, and D is an imaging and optical machinery manufacturer. In contrast, companies E–P are SMEs comprising enterprises that mainly produce parts for transportation equipment (Companies E, F, G, and H), those that engage in 3D CAD and system development (Companies I, J, K, and L), and others (Companies M, N, O, and P). Companies E–H have been subcontracting the production and processing of components to companies B and C. Companies I–L were established within the Hamamatsu cluster as spin-offs from company B (Nagayama, 2009, 2012) or by founders from outside the region. Among Companies M–P, Company M develops and produces human-made polycrystalline diamond-tipped saws, Company N engages in the production and contracting of small machine tools (specialized machines) for transportation equipment, and Company O is a manufacturer of optical disk drives. Company P started as a screw trading company and subsequently moved into production and sales of screws and related products for various manufacturing companies.

Table 1. Summary of companies

Company ID	Year established	Number of employees	Products	Company's strategies for new products and R&D
A	1887	19,851	Musical instrument, electrical machinery	Moved from organ and piano to electronic instruments. Currently, the production department is further divided Establishment of global manufacturing and supply structures.
B	1955	53,382 (entire group) 10,245 (individual company)	Motorcycle, boats, automobile, amusement machinery	Development and manufacturing of various programs utilising engine technology. Transfer of production bases within the Hamamatsu area.
C	1909	14,751	Automobile, motorcycle, boats	Major domestic manufacturers of Light vehicles and motorcycles. Shift in overseas market product to local production. Domestic plants' focus on R&D and the production of domestic market products.
D	1953	3,045	Optical equipment	Optical equipment, research and development related to optical technology Improvement of R&D capabilities through intrapreneurship and establishment of a graduate university.
E	1944	300	Automobile parts, metal moulds, resin processing, LED products	Cooperative company, i.e., Company B, producing parts and metal moulds. Start of LED and food products production from participation in a research group with university faculty.
F	1970	60	Automobile parts, metal moulds	Originally, a producer of motorcycle parts that subsequently entered the production of parts for four-wheeled vehicles. Engagement in the development of lightweight and 3D shapes using pipe processing.
G	1969	72	Jig and tool, metal mould, measuring device, prototypes, medical devices	Grew from transportation equipment to magnesium processing and patient care equipment. Member of HAMING.
H	1947	171	Automobile parts	Evolved from motorcycle parts manufacturing to titanium processing, carbon fiber reinforced resin processing, and medical products development. Member of HAMING.
I	1999	73	3D data software	A spin-off company from Company B. The main business is the founder's software development.
J	1997	6	CAD/CAM software, technical consulting	A spin-off company from Company B. The main business is software development and technical consultation and support to companies in the area.
K	1990	25	Plastic injection moulding, parts processing, software	A spin-off company from Company B. Promotion of the commercialisation of injection moulding of carbon fiber reinforced resin and metal moulds. Mould development using CAD and CAM technology.
L	1985	80	System development	Founded by entrepreneur from outside the Shizuoka prefecture and engaged in system development from the beginning. Strengths in getting business from major companies inside and outside the area.
M	1956	80	Tipped saw and knives, jig moulds, aerospace parts cutting processing	Production of tipped saw and knives continues to be its main business today. Participation in SOLAE aiming to expand into the aerospace industry.
N	1948	115	Industrial machinery, machine tools, NC machine tools,	Continued production of automation equipment. Increase in the amount of orders placed by companies outside the area.
O	1969	154	Optical disk equipment, applied electronic equipment and devices	A spin-off venture from Company D. Engagement in the development of medical devices using measurement technology after a slump in sales of optical discs.
P	1955	16	Screws and medical equipment	Started as a company trading in screws and moved onto the manufacturing of screws. Entry into titanium business and medical device field. Member of HAMING.

Source: Based on the profiles and materials provided by companies and interviews.

3.2 New product development

Large companies A–C have not seen any significant changes in their products. Their production system can be characterized as follows: (1) large companies are offshoring mass-produced items to Southeast Asia and South Asia and (2) large companies positioned the Hamamatsu cluster as a base for R&D, as well as a for high value-added production. However, Company D is shifting its main products to optical components and machinery. The breakdown of Company D's sales as of 2014 was optical sensors (~40% of the sales), photomultiplier tubes (~40%) in addition to LED devices, photometric devices, and medical equipment, such as X-rays and CTs (~20%).

In contrast to large companies, SMEs tend to (1) continue to produce existing products and (2) develop new products within the Hamamatsu cluster, applying technologies relevant to their experience, knowledge, and expertise. Firms in the transport machinery industry in particular have largely continued to manufacture their existing product lines. The first reason for this is that despite an overall decrease in production volumes within the Hamamatsu cluster, cars and motorcycles (especially domestic and high-end products) continue to be produced. A second reason is the increase in business with transport machinery manufacturers outside the region, particularly in the Toyota area to the west of Hamamatsu. Companies F and N report increases in their orders from Toyota-related companies.

The latter reason has been adopted by many companies regardless of their original field. The new fields of business expansion are mainly those that require advanced technologies or science-based knowledge, such as medical and care equipment (Companies G, H, O, and P), agricultural lighting devices (Company E), optical technology (Companies E and O), and aerospace (Company M)[4]. These initiatives can be understood as an attempt to apply the technologies and products accumulated within each company in addition to their own R&D.

Companies I–L have developed ICT-based businesses either from outside the Hamamatsu cluster or through spin-offs from Company B. The founders of these enterprises have pioneered industrial fields that were technologically relevant and could utilise specialised advanced technology.

Some companies are engaged in new businesses but have a high sales share of existing products. As demonstrated among interviewees who stated that "Care equipment production began as an experimental attempt to expand business partners with different industries" (Company G); "Of the 17 employees including part-time employees, 4 employees are assigned to medical equipment manufacture, and the sales share of medical equipment is 40%" (Company P); "Aerospace-related projects receive orders from each company belonging to the cooperative association" (Company M); and "The sales share of LEDs and sensors are

4) Regarding commercialization since the 2010s, some examples of medical and care equipment manufactured are lightweight wheelchairs, surgical instruments, and X-ray diagnostic devices; an example of collaboration among agriculture, commerce, and industry is the development of agricultural lighting; an example in the optical industry is optical measuring instruments; in the aerospace field is advanced cutting and processing using blade technology.

～7%” (Company E). The SMEs in the Hamamatsu area are engaged in new product development while continuing their existing production.

3.3 Regional R&D networks for innovation

First, all large companies established a R&D base in Hamamatsu and promoted developments using their own unique major technology. However, R&D projects relating to large companies A, B, and C are increasingly being completed in-house, which has weakened their R&D relationships with other companies in the cluster[5)].

By contrast, Company D founded the graduate school to create new photonics industries in 2005 to advance joint research and establish several optical industry venture companies while maintaining existing partnerships with academic institutions, such as Shizuoka University. As of March 2015, a total of 27 venture companies offer optical technology–based systems development, measuring instruments, image processing, and agricultural production in Hamamatsu.

Compared with large companies, in the case of SMEs, the establishment of a cooperative association, participation in research groups, and promoting industry–university–government partnerships are sources of R&D. These play a complementary role to human resources, technical knowledge, and market information that are lacking within individual companies.

Cooperative associations among SMEs are formed in fields that entail high technology and in cases when a single company cannot manage R&D, advance new technology, develop markets, and place orders. Examples of cooperative associations include the Hamamatsu Medical Innovative Group (HAMING) and the Shizuoka Aerospace Industry Project Cooperative (SOLAE). Company P established the HAMING in 2012. HAMING comprises four participating companies, including Companies G, H, and two other SMEs in the Hamamatsu cluster. The creation of the Hamamatsu area’s titanium business research group’s medical project in 2010 is responsible for HAMING. Through this medical project, six companies engaged in the test production of tongue depressors, cages for animals, and other products made of titanium in June 2011. The project concluded in June 2012, but four companies continued to produce titanium medical instruments, leading to the creation of HAMING. The development and production of medical and care instruments mainly made of titanium-related materials are distributed among participating companies of the HAMING. Joining the HAMING led to technical improvement of Company G leading to the development of lightweight wheelchairs using magnesium.

SOLAE was formed by engineering and processing companies that won orders in the aerospace sector,

5) According to the Commerce and Industry Department of the City of Hamamatsu, many joint research activities between core companies and universities were conducted until the latter half of the 1990s. From another aspect, such activities were limited between SMEs. Moreover, during interviews with companies, the participation of SMEs in research groups was stagnant, except for Company D.

following the aerospace development trend in Aichi Prefecture, west of Hamamatsu. Under SOLAE, Company M brought entities together to jointly supply high-level product processing related to aerospace. SOLAE comprises companies dealing with welding, cutting, jig and tool making, laser machining, and specialized machine tool manufacturers.

For SMEs, participation in research groups has the advantage of engaging not only with academic institutions and public research centers but also with engineers and trading companies. Additionally, it provides an opportunity for information exchange and cross-industrial interaction. In 2014, the study and networking events promoted by industry support agencies played an important role in innovations for each company involving new product development and the commercialization of new materials, which has been promoted through information exchanges in new material research group meetings planned by the Hamamatsu Agency for Innovation (HAI), an industrial support organization sharing information from industrial support agencies and learning from material companies. Since March 2015, research groups within HAI dedicated to carbon fiber-reinforced plastic (CFRP), titanium, magnesium, and ultra-high-tension materials have been active. Among the companies surveyed in this study, Companies F, G, H, and P are members of the titanium group, Companies G, H, and K belong to the magnesium group, and Companies H, K, and M participate the CFRP group. Furthermore, their activities are associated with new product development. The Hamamatsu creation of new industries conference organized by the Hamamatsu Chamber of Commerce and Industry consists of four special interest groups composed of SMEs distributed throughout Hamamatsu. This creation promotes the sophistication of R&D activities in a wider area (Figure 5).

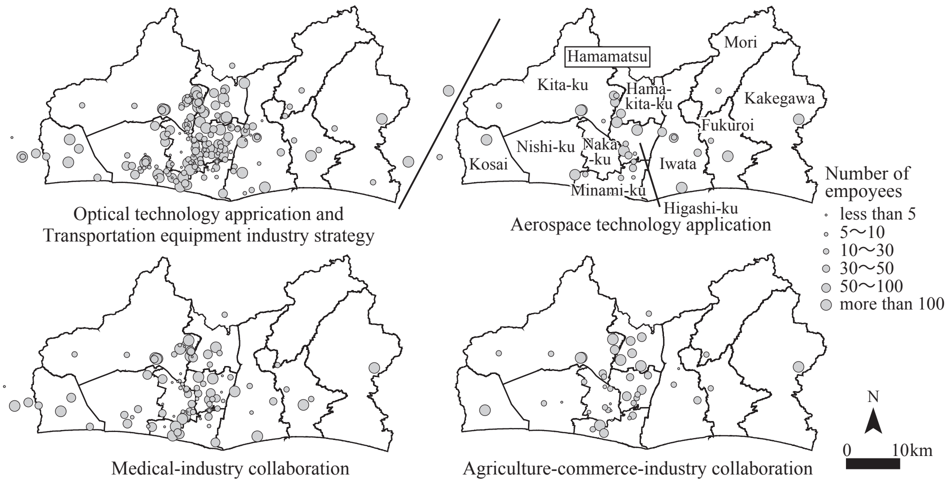

Figure 5. Distribution of companies participating in the special interest groups of the Hamamatsu creation of new industries conference

Note: Includes only companies located in the Hamamatsu area and neighboring municipalities (excludes the Tenryu district of Hamamatsu city).
Source: The Hamamatsu Industrial Force Book in 2014.

Companies that participate in multiple research groups and exchange meetings tend to be actively involved in projects organized by HAI. Such projects include promoting human resource development and providing start-up support and new business development support. In particular, Companies J and L play a central role in the study group network (Yokura, 2012)

Occasionally, research groups interact with academic institutions and practitioners in specialized fields. Technical advice from experts or scientists can be a source of inspiration for new business projects for SMEs[6]. For example, Company E (LED), Company G (piston engine cylinder development), Company K (CFRP commercialization), Company O (X-ray measurement medical device), and Company P (surgical tools) commercialized a new product, inspired by consultations with university faculty members and proposals at exhibitions.

These relationships are a source of innovation due to the dense networks within the region. However, many companies look for sources outside Hamamatsu to acquire end-user information and advanced technology. In developing medical devices, Company P pointed out the importance of relationships with medical device trading companies in the Tokyo metropolitan area in expanding trade and understanding user needs. In addition, from improving in-house technology for system development and 3D CAD companies, new technological know-how and products from relevant sources, such as researchers and trading companies outside the region, should be obtained.

3.4 Policy and institutional foundations for innovation

In the Hamamatsu cluster, industrial support organizations, which were established at the same time as the technopolis designation, provide support for business activities. In the Hamamatsu cluster, HAI, established in 2012 as the successor organization to the Technopolis Promotion Organisation, plays a nodal role for innovation. HAI has a role in attracting new companies and providing technical and financial support to companies in the region, which had been previously carried out by the Technopolis Promotion Agency. In addition, HAI provides support in four major areas: (1) cross-industry exchanges and the collection and publication of industry information and consultations; (2) succession of base technologies, development of human resources for the industrial sector, and practical application of research and technology development; (3) promotion of innovation; and (4) debt guarantees for companies (according to the HAI's 2013 business plan). To promote these programs, HAI hires former engineers and city officers who help build a system that provides information, consultation, research activities, and other forms of support. The abovementioned research group for the development of new materials is one of HAI's core activities.

6) The Faculty of Engineering, Shizuoka University plays a central role in the relationship between companies and universities in the Hamamatsu area. Based on interviews with business owners, Mizuno (2005) showed that the alum network of the Faculty of Engineering, Shizuoka University, is not only organizing research groups and engaging in the industry–university–government collaboration but also laying the foundation of business–to–business exchanges throughout the region.

Additionally, HAI provides its own subsidy grants and information on national industry support grants for firms in the cluster. The subsidies offered by HAI include support for regional industry revitalization projects centered on new product development, manufacturing, sales channel development projects for SMEs in response to market needs and market research, commercial feasibility research, and patent application support projects aimed at acquiring patents in Japan and overseas. The HAI acts as an intermediary, searching for and accumulating information on subsidies and support for industry issued by national ministries and agencies and informing companies in the cluster.

The surveyed companies evaluated the support provided by HAI and participation in the workshops very highly. In addition, government policy grants (especially for SMEs) have been acquired by companies E, F, G, K, M, N, and P, leading to new product development and capital investment for innovation.

The Hamamatsu city government also promotes innovation through industrial policy programs. First, in the shift in national industrial policy, the Hamamatsu area has been continuously designated as a fostering cluster since 2000. The innovation policy in Hamamatsu is characterized by two main orientations: (1) formulating geographically wider area innovation for the San-En Nanshin region and (2) creating and developing new industries related to medical–engineering collaboration and optical technology and creating new business markets.

The former orientation aims at creating businesses across prefectures, such as the Mikawa region of Aichi Prefecture and the Nanshin region of Nagano Prefecture. Cross-prefectural innovation policy began in 2001 in the industrial cluster plan initiated by the Ministry of Economy, Trade, and Industry. In this industrial cluster plan, the San-En Nanshin Vitalization Council, formed in August 2002, promoted businesses, namely transportation equipment, optical equipment, and industrial equipment. In 2010, the San-En Nanshin area was defined as a wider collaboration project area while obtaining consent for the plan related to the Act on the Act on Formation and Development of Regional Industrial Clusters through Promotion of Establishment of New Business Facilities, etc.

The latter orientation aims at creating new industries through collaboration between different sectors and originated in the Knowledge Cluster Initiative by the Ministry of Education, Culture, Sports, Science, and Technology (MEXT) in 2002. The Knowledge Cluster Initiative for the Hamamatsu area was set as the "Optronics Cluster" to develop optics-related industries. First period of the programs included product development using "super-visual technology" and second period involved the development of highly functional imaging devices and intellectual information processing. This initiative and its plan were designated as the "Hamamatsu–Higashi Mikawa Life Photonics Innovation" in 2014, which is a strategic support program for regional innovation. It was planned by MEXT in conjunction with other ministries and agencies.

The HAI, universities, and financial institutions are involved in the Hamamatsu–Higashi Mikawa Life Photonics Innovation program. The program's objective is to create businesses that link optical and electronic technology with medical treatment and patient care. Academic and financial institutions from Aichi

Prefecture are also deeply involved together with those in Hamamatsu. Furthermore, the program's regional strategy aims at promoting interdisciplinary integration, training young researchers and engineers, enhancing personnel coordination, and strengthening global expansion.

Hamamatsu city government also launched its own planning in 2011, the Hamamatsu Industrial Innovation program. The plan will take measures to support the following six sectors to develop into key industries: next-generation transportation equipment, health and medical industry, new agriculture, optical and electronic industry, environment and energy industry, and digital network and content industry. This program supports the development of new businesses by companies, which established the subsidy for new industry creation in Hamamatsu in 2012[7].

Furthermore, Hamamatsu city government provides its own support for the creation and capacity improvement of companies by supporting overseas expansion, human resources development, research group activities, intellectual property utilization, and assistance for funding procurement. Under these guiding policies, the city has established many loan systems and subsidies, such as compensation for temporary leave from work, new business formation, and overseas expansion.

However, these programs were not implemented by the city government alone. The Hamamatsu city government launched these programs with HAI, universities, and financial institutions, all of which are involved in the Hamamatsu–Higashi Mikawa Life Photonics Innovation program. Furthermore, the program's regional strategy aims at promoting interdisciplinary integration, training young researchers and engineers, enhancing personnel coordination, and strengthening global expansion.

4. Discussion

Regional innovation in Japan changed rapidly in the 2000s. The Hamamatsu region is an example of a nonmetropolitan cluster that has been continuously innovating and developing new industries despite global pressure. In the aftermath of the Lehman Brothers collapse, the Hamamatsu cluster has been on a way of path renewal (Chapman et al., 2004), aiming to expand its fields by applying existing technologies. In this section, the features of the Hamamatsu cluster's innovation ecosystem are discussed in the context of firm- and system-level agency initiatives and in relation to the multiscale geographical dimensions of the developmental state.

Significant differences in the activities of the Hamamatsu cluster at the firm level have evolved since the 2010s between large firms and SMEs. First, large firms positioned the Hamamatsu cluster as an R&D and production base for high value-added products and reduced mass production. In contrast, SMEs have

7) A subsidy of between 1.5 and 10 million yen (the maximum subsidy rate is 50%) is provided as an aid for new industry creation project expenses per year to companies engaging in new product or technology development in Hamamatsu city. In 2012, 20 themes were selected, and in 2013, the number was 17. For each year, the total subsidies were 110 million yen.

spontaneously promoted innovation through product transformation in individual companies and through interfirm networking. In particular, pioneering firms have responded to exogenous shocks, such as the decline in orders and recession due to the overseas transfer of manufacturing bases of large companies, by forming cooperatives, promoting interfirm learning through study groups, and developing networks and mutual learning strategies through industry–academia–government collaborations, all of which have led to the development of new products and new industries.

These were not mutant developments. In particular, the businesses that have been created during this recent period of industrial evolution within the Hamamatsu cluster since the World War II have led to a positive and continuous innovation ecosystem. Companies I–L have established networks within the cluster that encourage regional learning, and these enterprises were still hubs in the R&D network in the 2010s (Yokura, 2012).

In addition, support systems such as information and technical assistance from local industrial support agencies were important in the formation of these interfirm networks. Moreover, the Hamamatsu city government played an important role in supporting regional innovation by applying for nationally supported competitive regional industrial policy programmes and by providing support and creating subsidies for knowledge-intensive industries such as medicine and optical machinery. These organizations are positioned as system-level agencies within the innovation ecosystem. The findings in the case of the Hamamatsu cluster confirm that firm- and system-level agencies, as pointed out in the innovation ecosystem discussion (Isaksen et al., 2019; MacKinnon et al., 2019), as well as the cumulative relationships among them, are necessary.

Furthermore, industrial agency support was also vital in the development of these networks. The city's formulation of policies for national designation and support for knowledge-intensive industries such as medicine and optical machinery, based on industrial trends within the cluster, were also important. The technopolis designation led to the growth of industrial support organizations within the cluster, their positioning as networking hubs within the cluster, and improvements to the policy-making capacity of the Hamamatsu city government. Positive evaluations of these organizations' projects by firms and research institutions in the region have also been an important factor in this context.

However, the Hamamatsu cluster's innovation ecosystem did not emerge solely on the basis of intra-cluster relationships. Learning at the firm and organizational level during the creation of new industries requires introducing novel knowledge and technology from outside of the region. These are important in the path renewal of more knowledge- and technology-intensive industries, such as the Hamamatsu cluster. The discussion of innovation ecosystems suggests the significance of establishing links with extraregional knowledge bases in a process of continuous regional innovation.

At the same time, local governments, which support innovation as system-level agencies, remain heavily influenced by their vertical relationships with the state. Until the 1990s, Japan had a centralized, development-oriented economic policy system in which the state led the selection of regions and industries to promote. In the 2000s, economic policy became more decentralized, with a system of spontaneous planning at a lower level than the nation state. However, in practice, the national government has continued to take a central position in determining subsidies and aid schemes for the clusters. In this context, the technopolis designation of the Hamamatsu cluster in the 1980s, together with growth within industrial support agencies and the development of hub companies within the cluster, led to an improvement in the policy-making capacity of the Hamamatsu city government. However, in the formation of the Hamamatsu city government's innovation policy, interrelationships with the national government remained important for supporting companies and universities in the creation of new industries. In addition, industrial support organizations within the Hamamatsu cluster function as hubs for policy support and information in their relations with the national government. The cluster's industrial support organizations are system-level agencies that have made pioneering contributions in nonmetropolitan areas in Japan, yet their relationship with the state remains critical. This can be seen as a unique feature of the regional innovation ecosystem model in the developmental states of East Asia.

In response to discussions on the innovation ecosystem, this study suggests the need to examine the positioning of firms in the clusters. In the Hamamatsu cluster, there is a disconnect between the large firms that produce finished products and the SMEs that have become subcontractors to them. However, the participation of large companies in research groups and cooperatives has declined, with the exception of companies such as Company D, which seems to fit with the direction of evolution. This is primarily because large companies have internalized their R&D policies and new industries have little relevance for them, while SMEs remain open to innovation within clusters.

In addition, to elevate the discussion on innovation ecosystems, sophistication is needed in the institutions. In the Hamamatsu cluster, formal institutional foundations such as industrial support organizations and government agencies have become essential, while informal institutional foundations were not necessarily important for developing new industries in the 2010s. Within the Hamamatsu cluster, formal and informal interorganizational relations used to be important for information exchange. However, one company notes that relations between enterprises and between individuals through informal venues are rapidly disappearing in Hamamatsu (according to an interview with Company I). Formal networks have become more significant as a source of innovation ecosystems, especially in the Hamamatsu cluster.

5. Conclusions

This study examines industry clusters in non-metropolitan areas in Japan to determine the validity of geographical innovation ecosystems. Our findings indicate that an environment in which innovation is continuously generated is the foundation of innovation ecosystems. Moreover, the networking and ongoing interrelationships among governments, industry support organizations, and inter-firm networks are vital in non-metropolitan clusters in East Asia, as in the European debate. Furthermore, the geographical dimensions of regional innovation ecosystems, i.e., inter-regional networks and intra-cluster relationships, are vital. Inter-regional networks act as pipelines to attract novel knowledge and information that can evolve cluster's industries; thus, the innovation ecosystem can advance empirical research on RIS. Future elaboration of the innovation ecosystem debate requires expanding the discussion to incorporate cluster evolution attempted in this study. Furthermore, the variances between metropolitan/non-metropolitan clusters and international comparisons according to different economic systems should be discussed to generalize the debate on innovation ecosystems.

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