

**Location Patterns of R&D Institutions Based on the Spatial
Relationships of Intra-firm Organizations:
Case Studies of Shanghai and Tokyo**

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ABSTRACT

Enterprise plays a critical role in research and development (R&D). Businesses, not nations, are the principal actors in competitiveness. As the main carrier of R&D activities, R&D institutions are distributed unevenly on both global and national levels, and are highly concentrated in metropolitan areas. Their locations, especially those of multinational R&D, have attracted the attention of geography scholars. However, previous studies have shown that the spillover effects of multinational R&D are very limited and that most R&D is undertaken in home countries rather than in host countries. Therefore, this paper examines domestic enterprise R&D institutions sited in metropolitan areas. Usually, R&D location is the results of the firm strategy. While a R&D location is being decided, its location relationships with other intra-firm organizations are taken into account. Previous studies focused on the commonalities among R&D location factors and ignored the diversities among enterprises, regional features, economic situations, and even historical location changes. This paper, focusing on domestic enterprises, explores the location patterns of enterprise R&D institutions in metropolitan areas in terms of their location relationships among intra-firm organizations and empirically investigates how location factors and firm behavior influence R&D location.

Taking Shanghai and Tokyo and surrounding area as its study areas, this paper analyzes the location patterns of the two areas' enterprise R&D institutions in terms of intra-firm organizational spatial relationships and attempts to explore their locational

similarities and differences. To measure the R&D location relationships with other organizations, this paper classifies R&D institutions into four location types: (i) the same location as headquarters and production plants (H+P+R type), (ii) the same location as headquarters (H+R type), (iii) the same location as production plants (P+R type), and (iv) independent R&D institutions (R type). Using this classification, the paper analyzes the R&D location patterns of each R&D institutions type and then explains the location factors in R&D location changes and relocations through case studies.

The results show that, first, R&D institutions in Shanghai are concentrated mainly in industrial parks and that those in and around Tokyo are more highly concentrated than those in Shanghai, especially so within the Ken-O expressway, about 50 kilometers from central Tokyo. Moreover, as enterprises grow, their R&D institutions tend to become separated from other organizations. Currently, the H+P+R type is the most common in Shanghai, while the R type is the most common in and around Tokyo. Although the proportions of R&D institutions by location type differ greatly in the two areas, they both show the tendency towards location separation from other organizations, the inevitable result of several factors. While R&D institutions in both areas usually pay attention to their proximity to headquarters as they carry out R&D on orders from headquarters, the separation tendency in Shanghai is not expected to be as strong as it is in and around Tokyo.

Second, despite the common location factors, R&D institutions do not necessarily show the same location patterns. For example, there are location differences between multinational and domestic enterprise R&D institutions in Shanghai, driven by China's

early policies and the firms' different developmental stages. Regional policymakers should note the fact that R&D institutions in different areas and linked to different firms may be influenced by different location factors.

Third, several specific location factors, such as regional image, educational level and R&D climate, restrict R&D concentrations to a few areas. Although R&D institutions show some spatial decentralization, metropolitan cities remain attractive for R&D despite of their high costs. Nevertheless, these factors are also likely to apply in neighboring areas. Consequently, the spatial cross-border autocorrelation is very important.

Finally, this paper also confirms that R&D institutions' locations and their relationships with other organizations depend on product cycles. The location differences between Shanghai and Tokyo seem related to the differences among the stages of development at which the firms faced similar problems. Furthermore, this paper points out that, though enterprises may not take clustering into account while deciding upon R&D locations, clustering in fact enhances competitiveness, as it stimulates an enterprise's positive engagement in R&D activities.

Keywords: enterprise R&D institutions, location patterns, location relationships,
Shanghai, Tokyo

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CHAPTER 1

Introduction

1.1 Background and Problem Statement

1.1.1 Background

The world of today is one of constant reconstruction, set within the context of globalization and internationalization. The processes of informationalization and digitalization are increasing communication between regions and countries and promoting the international flow of production factors, contributing to the acceleration of globalization and structural changes in the world economy. This means that on one hand, manufacturers face increasing challenges and competitions in both their home and foreign markets, while on the other hand, they are confronted by cost pressures caused by tightening energy supplies. For these reasons, manufactures have to engage in innovation activities to survive, ensure that product innovation is tightly connected with customer demands, and commercialize new inventions with increased speed and efficiency. Particularly for manufacturers in developed markets, continuous innovation is a primary defense against increasing competition from emerging markets in low-cost locations such as China and India (Economist Intelligence Unit 2006).

These issues raise the fundamental question of how to best engage in innovation. Enhancing research and development (R&D) activities is regarded one of the most effective measures for promoting innovation. According to the Organization for

Economic Co-operation and Development (OECD), R&D is “the creative work undertaken on a systematic basis in order to increase the stock of knowledge and the use of this stock of knowledge to devise new applications.” It is usually divided into three kinds of activities: basic research, applied research, and experimental development.

“Research” includes the activities of basic investigation, while “development” concerns the application of basic research results, the creation and refinement of new products and technology, and the improvement of existing products or procedures. As Yan et al. (2004) have pointed out, the ampersand in R&D is not a simple piece of punctuation, and has profound implications. In this context, the ampersand does not only imply a permutation of a series of similar objects, but also includes the meaning of “ $1+1>2$ ” in system theory. In other words, for industries and enterprises, the potential of R&D activities are best realized when there are strong links between research and development. Therefore, the abbreviation R&D is used instead of “research and development” in this paper.

In modern economic growth theory, R&D activities and the subsequent production of new knowledge are driving forces of long-term regional growth (Koo and Kim 2009). As the organizations that spearhead most R&D activities, R&D institutions¹ positively influence regional economic development through direct contributions to the local economy, and through their spillover effects on local industries and other companies (Osaka Prefecture Institute for Advanced Industrial Development 2007). Most importantly, enterprises play particularly decisive roles in innovation and knowledge spillover through their R&D activities. R&D activities implemented by enterprises not only promote science and technology at the national level, but increase their countries’

global economic influence. As a result, R&D institutions have grown rapidly in both developed countries such as the USA and Japan, and developing countries such as China and India.

Within this context, alongside the spatial clustering of R&D and related innovation activities (Audretsch and Feldman 1996), there has been a strong tendency toward R&D globalization (Florida 1997; Cantwell 1995). Studies on the location of R&D institutions have raised concerns in the field of economic geography, with extant studies on enterprise-level R&D concentrating mainly on multinational corporations (MNCs), which are the main contributors to long-term R&D activity. Most of previous studies have focused on two issues: (i) the organizational network characteristics of MNCs' R&D activities and the location changes of MNCs' R&D institutions (Robert 1977; Kuemmerle 1999; Sun 2003; Dunning 2000), and (ii) the location factors of MNCs' R&D institutions (Niosi 2003).

Overall, enterprise-level R&D generally remains highly geographically concentrated at the global economic core, despite the generally increased internationalization of R&D. It continues to be one of the least globalized activities of MNCs, despite the growing significance of overseas R&D, as a proportion of total enterprise R&D activity (Pavlínek 2012; UNCTAD 2005; Reger 2004; Kumar 2001). The largest R&D centers are usually located in organizations' home countries. The chances of peripheral regions attracting sizable foreign direct investment (FDI) in R&D are limited, and are most likely to take place when MNCs' needs and local/regional assets are strategically coupled (Pavlínek 2012). Researchers have argued that the knowledge spillovers of multinational R&D are very limited, and R&D performed at home is significantly more

productive than that undertaken abroad (Lychagin et al. 2010). No significant spillover effects of foreign investments in technological innovation are generally observed, and advanced technologies cannot typically be imported from foreign countries, and can only be developed internally (Sun and Du 2010). Given this context, the positions and locations of domestic enterprise R&D within countries should be a focus, rather than MNCs' R&D at the global level.

Furthermore, although R&D institutions are characterized by strong decentralization on the global scale, at the national level, they are still highly concentrated in metropolitan areas. This spatial concentration pattern is also seen at the regional level, where high-tech industries tend to be more spatially concentrated and R&D activities are mainly located in already established metropolitan areas (Kranich 2008). The place-specific experience, tacit knowledge, and competence embedded in particular regions are reasons for their importance to enterprises (Asheim 2003; Malmberg and Maskell 2003). Some empirical studies have suggested that the locations best qualified to nurture R&D labs are those that are able to accommodate those labs' dual dependence upon firm productivity and utility-bearing worker amenities, as well as those willing to offer facilitative land market environments (Sivitanidou and Sivitanides 1995). Such locations can easily be found in metropolitan areas. This makes the location of enterprises' R&D institutions in metropolitan areas particularly important.

In measuring the efficiency of regional innovation activities, many studies have taken the economic analysis perspective on R&D activities. However, firm-specific characteristics underlie R&D location choice. The spatial division of labor and external economies associated with a nation's hierarchical city system may be part of the process

of spatial filtering in industrial development, which shapes the spatial diversity of enterprises. As part of this process, the high labor costs in metropolitan areas cause less competitive industries to restructure their operations or be priced out of larger labor markets (Moriarty 1983). Such transformations cause cities to shift from sectoral to functional specialization. In addition, enterprises' R&D institutions, which are the main factors in R&D activities, are characterized by distinct geographic differences at the global, national, and regional scales.

Large companies, R&D labs, and single-plant firms are not attracted by the same local features. This is particularly important because it means that regions' attractiveness varies according to the characteristics of the firm involved (Autant-Berard 2006). Managerial allocation creates linkages of economic activity within and across firms. The locations of R&D institutions vary greatly according to industry, enterprise, geographical location and historical background. It is not necessary for an enterprise to locate its R&D divisions, management, production plants and marketing departments in the same place in order to maximize profit (Porter 1986). R&D institutions can even be attached to those of other organizations to create integrated management structures, or particular R&D divisions can be allocated to various departments to achieve specialization (Nishioka 1990). Moreover, regional differentiation in production occurs during industrial transfers to surrounding metropolitan areas and regions, and various R&D location features are shaped through this filtering process (Kimura 1990). Therefore, it is important to study enterprises' R&D institutions within the context of intra-firm organizational location relationships, and to take into account their heterogeneity. This makes it possible to better understand the mechanisms underlying the location choices of different kinds of departments and activities, as well as their

impacts on economic dynamics.

1.1.2 Problem Statement

This paper focuses on enterprises' R&D institutions and, based on the information described above, addresses the following questions:

(i) Although MNCs' R&D institutions play important roles in knowledge and technology transfer, domestic enterprises' R&D institutions actually make greater contributions to innovation. What characteristics do domestic enterprises' R&D institutions have, and what geographic characteristics do they display at the national or regional levels?

(ii) R&D institutions are highly concentrated in metropolitan areas. What are the details of geographic distribution for enterprises' R&D institutions in metropolitan areas? What distribution changes occur over different periods?

(iii) Enterprises locate their divisions in different areas, which shapes the geographic diversity of firms and intra-firm organizations. What kinds of location relationships exist between R&D and other divisions? These relationships are currently undergoing dynamic changes. What changes have occurred in these location relationships?

(iv) How do changes in R&D locations and location relationships with other organizations occur? What kinds of location factors bring about these changes?

(v) R&D locations geographically diverse, and are affected by the impacts of various location factors. Are the geographic features of enterprises' R&D divisions different or the same in different metropolitan areas? What similarities and differences can be found in different metropolises?

1.2 Research Purpose and Research Approach

1.2.1 Study Area

Previous studies on R&D institutions paid much more attention to MNCs, and many research results were from the academic circles of Europe and America. These studies also provided policy implications not only on how to organize R&D activities more efficiently for MNCs, but also on how to attract more R&D investment for host countries. In recent years, as the emerging markets, Asian countries' growth has aroused concern of the world. With the economic growth, R&D expenditure in Asian countries also is increasing rapidly. However, the study on R&D in Asia is very lacking. Consequently, this paper turns its attention to the study on R&D institutions in Asian countries, especially Eastern Asian countries with higher levels of economic development and R&D input.

This paper focuses on the R&D institutions in Japan and China. Japan is taking a leading position in the economic development of the world. Despite many existing studies on Japan's economic policies and development model, the study on R&D institutions in terms of geographic distribution did not arouse attention. In Japan, both industries and political institutes show the unipolar concentration in Tokyo, which is the political and commercial capital and management center of Japan. Meanwhile, another East Asian country - China now has been the world's fastest-growing economy, and its development has aroused much attention from economist, policy analysts, and geographers. Although Beijing is China's political center, Shanghai has the highest levels of commercial and industrial development as the economic center.

Moreover, different policies cause different innovation model and efficiency, as well as various R&D locations. In order to illuminate the similarities and differences in R&D location in metropolitan area, and explore the impacts that different policies have on R&D distribution, Shanghai and Tokyo, as the representative economic concentration areas, are regarded as the study areas of this paper.²

1.2.2 Research Purpose

Firms rather than nations, are the principal drivers of competitiveness, and the influences of nations on the international competitive performance of firms occurs through the ways are affected by how “a firm’s proximate environment shapes its competitive success over time” (Porter 1990, cited in Grant 2010). Therefore, based on the questions outlined in section 1.1.2 above, this paper aims to explore the location patterns of enterprises’ R&D institutions in metropolitan areas. It does so in terms of the location relationships among intra-firm organizations, and empirically investigates how regional advantages and firm characteristics influence the location of R&D institutions.

Location relationships between R&D institutions and other organizations are in constant flux. In order to analyze these location relationships, this paper classifies R&D institutions into four location types according to their location relationships with headquarters and production plants. These types are as follows: (i) those with the same location³ as the headquarters and production plant (H+P+R type), (ii) those with the same location as the headquarters (H+R type), (iii) those with the same location as the production plant (P+R type), and (iv) those with an independent location from other divisions (R Type)⁴. (Figure.1.1)

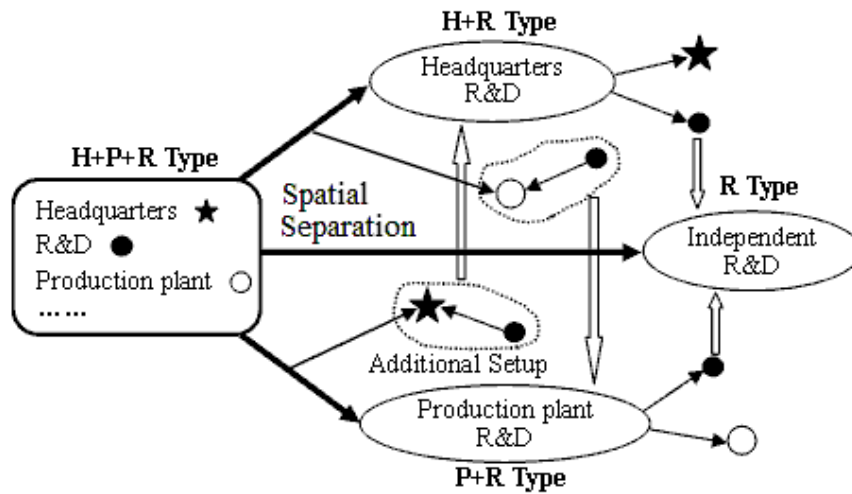


Figure.1.1. Dynamic Process of the Shape of R&D Location Types

Note: The solid arrow means spatial separation and integration of intra-firm organizations, the hollow arrow means classification of R&D's location types.

Source: compiled by author.

Using this classification system, this paper examines the location patterns of R&D institutions and their dynamic changes over different periods. Location patterns for each R&D location type are revealed, and the location features for each type are summarized. Based on an analysis of case studies, the paper provides further explanations of the details of location factors that influence location types and patterns. Furthermore, through an analysis of R&D institutions in Shanghai and Tokyo, similarities and differences in location patterns and location factors are described, ultimately leading to a description of the location determinants used to decide on the geographic distribution of R&D.

1.2.3 Research Method

In order to analyze R&D institutions' industrial features and geographic

distributions, this study began with the collection of related data and information for different periods from statistics books and research reports. As mentioned above, the intra-firm organizational location relationship is one of the main focuses of this paper. The location information for headquarters, R&D departments, and production plants was found by searching the websites of each of the enterprises included in this study, so as to verify the R&D location type.⁵

Based on the collected data mentioned above, enterprises within different industries, of varying sizes, and in diverse locations were chosen, to receive questionnaires and participate in survey interviews. The survey mainly focused on R&D strategy, location relationships between R&D departments and other organizations, and factors in R&D location tendencies. Surveys on regional governance were also administered in order to understand the role of regional governance in R&D location choice and innovation activities.

An empirical analysis of the aforementioned data and survey results was then carried out. Firstly, the overall location features and location changes of R&D institutions were examined by using the data obtained in different periods, and the dynamic processes of agglomeration were analyzed. Secondly, based on the location relationships among intra-firm organizations, the location patterns for each type of R&D institutions were then explored. Furthermore, details of location factors that influence R&D location, location changes, and location types were considered based on survey results and case studies. Finally, details on R&D location in Shanghai and Tokyo were compared to decipher similarities and differences in the location patterns and location mechanisms of R&D institutions. (Figure.1.2)

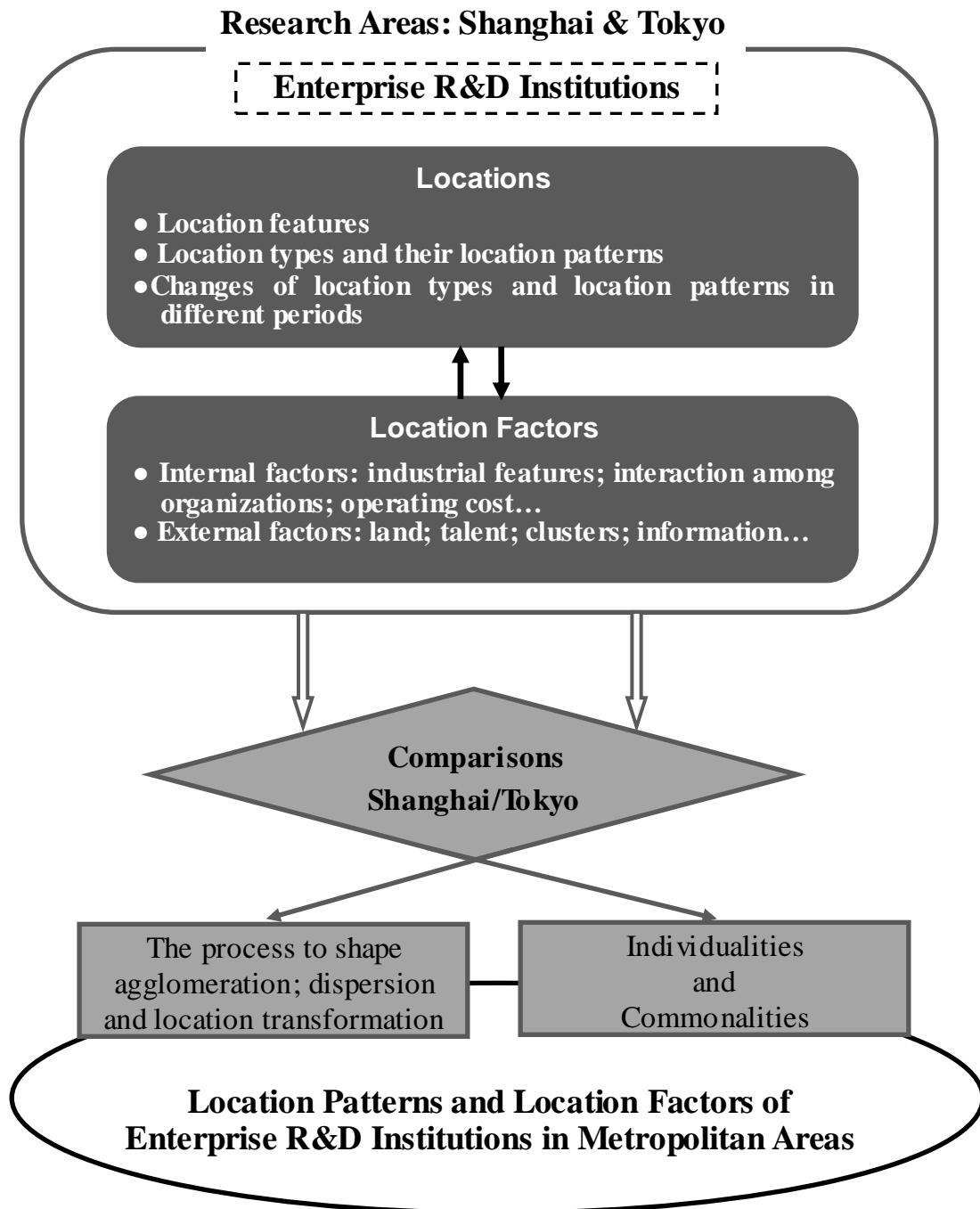


Figure.1.2. Research roadmap

Source: compiled by author.

1.3 Summary of Subsequent Chapters

In examining the crucial issues described above, this paper is structured as follows.

Chapter 2 reviews and summarizes the most important ideas and arguments related to the study's findings on R&D activities, and particularly focuses on the geography of enterprises' R&D institutions. This acts as the basis for a critical examination of R&D issues. More specifically, the chapter first introduces some viewpoints and theories related to R&D activities, and then addresses the location factors and location patterns of multinational R&D. Based on these discussions, chapter 2 further elaborates on enterprise R&D location within countries.

Chapter 3 introduces R&D activities within the context of globalization, and makes international comparisons between them. It does so to clarify the overall situation of R&D activity in the modern world. Based on this analysis, the chapter focuses on R&D activities in China and Japan, and provides more detail on R&D activities and previous studies of R&D in the two countries. This chapter also provides further explanation as to why Shanghai and Tokyo have been chosen as study areas.

Chapter 4 presents an empirical analysis of the location patterns of enterprises' R&D institutions in Shanghai. It summarizes R&D-related policies and enterprises' R&D distribution in China, in order to clarify the national background. Then, the chapter introduces enterprises' R&D institutions' features in Shanghai, and explores their location types in terms of the location relationships between R&D and other intra-firm organizations. Moreover, the chapter presents detailed analyses of the different types of R&D institutions' location features, and examines location factors through case studies.

Chapter 5 carries out a similar type of analysis to chapter 4, but concerns enterprises' R&D institutions in and around Tokyo. In considering R&D institutions within the electrical and electronics equipment manufacturing industries, this chapter first analyzes the distribution of R&D institutions in Japan, examining which location types of R&D occur regionally and analyzing dynamic location changes over different periods. Based on this analysis and case studies, and by focusing on R&D institutions located in the Kanto region that have headquarters in Tokyo, this chapter provides further explanation of how R&D location is affected by other organizations' location changes.

Based on the above analysis, chapter 6 compares location patterns and location factors of R&D institutions in Shanghai and Tokyo and surrounding area, and explains their similarities and differences. In presenting the results of the comparison, this chapter provides some policy implications.

Finally, chapter 7 returns to the research questions and offers conclusions derived from empirical analysis. It also discusses the study as a whole and suggests directions for future work.

Notes:

1. In this paper, not only the research institutes and branch corporations that specialize in R&D as independent economic entities, but also the R&D departments as a part of the enterprise are included in enterprise R&D institutions.

2. The reasons for this choice are further explained in chapter 3.
3. The term “same location” here means the same site or spot, not the same region or area.
4. In this paper, independent R&D institutions (R type) include not only independently-owned companies specializing in R&D for the purpose of providing technology and technical services to parent or other companies, but also enterprises’ R&D divisions that are located at sites that are independent of other organizations.
5. Details on the data for Shanghai and Tokyo are given in chapter 4 and chapter 5, respectively.

CHAPTER 2

Theoretical Foundation and Literature Review

Based on the widespread assertions that industrial R&D activity fosters regional growth, in recent years, regional scientists, economic geographers, and policy analysts alike have intensified their efforts to uncover the underlying determinants of industrial R&D activity's geographic distribution (Erken and Kleijn 2010; Sivitanidou and Sivitanides 1995). MNCs, in particular, play a positive role in R&D activities and international technology transfer, and their R&D strategies and distributions in home and host countries have attracted considerable attention in previous studies (Cantwell and Piscitello 2002, 2005; Niosi 2003; UNCTAD 2005).

Past attempts to explain R&D activities have resulted in a number of research findings in diverse fields, on issues such as R&D spillovers and regional innovation and production (Simonen and McCann 2010; Audretsch and Feldman 1996; Cantwell and Piscitello 2002), R&D location factors (Niosi 2003; Autant-Bernard 2006; Erken and Kleijn 2010), enterprise R&D strategy and transfer of knowledge (Yu and Tong 2003; Sivitanidou and Sivitanides 1995), and enterprise spatial organization and R&D institutions' distribution (Akimoto 1989; Du 2001; MRI 2002). This chapter focuses on these dimensions of existing literature on R&D activities.

2.1 R&D Activities and the Geography of Innovation

2.1.1 R&D Activities and Regional Growth

Many studies have also recognized the role of R&D activities in maintaining enterprise competitiveness and improving regional innovation (Asheim et al. 2003; Feldman 1994). R&D activities and their institutional set-ups (i) create economic efficiency directly by building R&D institutions, (ii) produce spillover effects on regional industries through R&D activities and economic revitalization through the commercialization of R&D results, and (iii) have beneficial effects on other firms by locating R&D institutions nearby, carrying out R&D activities, and developing business relationships among firms (Osaka Prefecture Institute for Advanced Industrial Development 2007).

Although extensive research has found that R&D activities significantly contribute to regional growth, empirical evidence does not always corroborate these findings. For example, Koo and Kim (2009) have empirically analyzed the correlations between R&D spending and the growth of gross state products (GSP), and find seemingly weak or nonexistent associations between R&D and regional growth. In their research on an agglomeration of private research institutions in Tsukuba Science City, Nakagawa et al. (1992) have found that the level of commodity interflow among these institutions is relatively low. Sternberg (1996) confirms that government policy has always favored balanced regional growth. However, he points out that the unintended spatial effects of R&D expenditures play an important role in regional growth, especially in the early stage of technology-oriented growth. In addition, in more established high-tech regions, commercial markets tend to gain importance, reducing the significance of government R&D. Moreover, for mature and very large high-tech regions, technology policies represent, at best, only weak determinant of regional growth.

The above mentioned findings show that R&D is only one of the factors in the development of a high-tech region. In the absence of other factors, R&D expenditures by the government can hardly be expected to promote industrial development (Feldman 1994). The higher the level of knowledge commercialization and retention factors, such as entrepreneurial activity, university research, human capital, and industrial diversity, the greater the importance that industrial R&D has for regional growth. This implies that newly created knowledge can contribute to a regional economy only when various other factors are also present in the region (Koo and Kim 2009).

2.1.2 R&D-Related Theories

(i) Competitive advantage theory

Porter (1990) promotes the theory of “competitive advantage” as a means of explaining the differences in prosperity and growth among regions and nations, and proposes a development process involving four-stages: factor conditions, investment, innovation, and wealth. According to Porter’s analysis, national prosperity is closely linked to the “upgrading” of competitive advantage. Maintaining a sustained advantage depends on firms upgrading their competitive advantages through innovation and investing in “advanced” factors of production (such as communications infrastructure, sophisticated skills, and research facilities). Firms lose their competitive positions in the most price-sensitive industries as they develop into more capital- and technology-intensive industries. Within specific industries, as firms move toward more differentiated segments, they shift many of their lower-technology activities overseas, and within their home bases, concentrate on activities that require the highest levels of skill and expertise.

At the same time, Porter also emphasizes the importance of firm strategy, structure, and rivalry, which are important determinants of the industry pattern of competitive advantage within each country. In particular, he stresses the critical importance of domestic rivalry in the creation and maintenance of competitive advantages, and in pressuring firms to cut costs, improve quality, and innovate. He especially points out that it is the intense domestic rivalry present in the Japanese automobile, camera, audio equipment, and facsimile industries that have helped these industries succeed in overseas and domestic markets (Grant 2011).

(ii) Product life circle theory

The product life circle theory is an economic theory that was developed by Vernon in the 1960s. It is very much worth considering as an explanation of who produces what and why. It is simple and persuasive, and seems to be consistent with the real-world situations of at least some industries, such as pocket calculators and televisions. In Vernon's theory, products go through three phases: the new product stage, the maturity stage and the standardized product stage (Vernon 1966).

In the initial stage of new product, R&D leads to the new products, which is mainly occurred in advanced countries. Most sales are domestic and exports are limited. In the maturity stage, the new technology is more developed, and so the price elasticity of demand increases. Manufacturers begin investing in foreign countries that have relatively high levels of technology, skilled labor, and similar types of demand to the home countries. They build branch plants in host countries, in order to produce and sell products locally and export them to other countries. In the standardized product stage, the design of the product is well understood and the product starts to resemble a

commodity. Mass production through low-cost labor is emphasized and the monopoly of technology vanishes. Production is then transferred toward areas where labor-intensive industries can be carried out.

Based on product life circle theory, Nishioka (1990) analyzes the correlation between R&D activity and regional growth. According to his analysis, in the initial stage of the product life cycle, nations or regions with innovation elements such as high technology, abundant talent, and entrepreneurship easily benefit from R&D activity. In the next stage, because of reduced technological dependence, production is decentralized from regions or nations with core technology, which in turn causes the diffusion of R&D. In the standard product stage, more technological input is unnecessary, and production is transferred to low-cost countries or regions. Mairesse and Mohnen (2004) also regard innovation as more sensitive to R&D in the low-tech sectors than in the high-tech sectors.

2.1.3 R&D Spillovers and Geography of Innovation

Technology and R&D spillovers are characterized by significant externality. The knowledge acquired through R&D activities typically ends up becoming public property. This causes R&D entities or centers to miss out on potential benefits. Knowledge can be diffused to rival firms or related entities, and can produce externality even without entering the market (Shinbo et al. 2005). In this way, (i) firms can acquire information created by others without paying for it in a market transaction, and (ii) the creators (or current owners) of information have no effective recourse, under prevailing laws, if other firms utilize that information (Grossman and Helpman 1992).

Location and geographic space are key factors explaining the determinants of innovation and technological change (Audretsch and Feldman 2003). Intellectual breakthroughs cross hallways and streets more easily than oceans and continents (Glaeser et al. 1992). The proximity of breakthroughs accelerates the diffusion of innovation, increases investment in facilities and skills, and promotes the development of supporting industries. Moreover, according to Jaffe (1986), firms whose neighbors engage in more R&D produce more patents. While the net effect is positive for high R&D firms, firms engaging in R&D activity that is below the mean are made worse off overall by the increased R&D of others.

Social interaction also plays an important role in knowledge spillovers. As Doloreux and Parto (2004) have explained, innovation can be thought of as embedded in social relationships. This kind of face-to-face, frequent, and repeated communication is the best way to transfer knowledge. When social interaction, observation, and communication are frequent, the cost is the lowest for the transmission of knowledge, and in particular, for tacit knowledge.

With regard to the significance of clusters in innovation, Porter (1998) provides the following explanation:

- Clusters play a vital role in a company's ongoing ability to innovate. The ongoing relationships with other entities within a cluster also help companies to learn early about evolving technology, component and machinery availability, service and marketing concepts, and so on. Such learning is facilitated by the ease of making site visits and frequent face-to-face contact.

- Clusters do more than make opportunities for innovation more visible. A company within a cluster often can source what it needs to implement innovations more quickly. Local suppliers and partners can and do get closely involved in the innovation process, thus ensuring a better match with customers' requirements.
- Companies within a cluster can experiment at lower cost and can delay large commitments until they are more assured that a given innovation will pan out. In contrast, a company relying on distant suppliers faces greater challenges in every activity it coordinates with other organizations.

Jacobs (1969, cited in Glaeser et al. 1992) also finds that local competition speeds up the adoption of technology. However, unlike Porter, she believes that the most important knowledge transfers come from outside the core industry. The variety and diversity of geographically proximate industries promote innovation and growth, rather than geographical specialization. Meanwhile, Glaeser et al. (1992) argue that spillovers may be of great importance when a new industry is born and goes through the process of organizing itself in a location, but may become unimportant as the industry matures and geographical proximity becomes less crucial to the transmission of knowledge.

2.2 Multinational R&D Location

The location of R&D institutions is determined by a comprehensive set of factors, including reasonable distance from headquarters and other entities. Many studies have shown that R&D is concentrated in a few regions in either developed or developing countries. Moreover, as mentioned in previous studies, MNCs are the main contributors

to long-term R&D activities, and their R&D locations have also attracted considerable attention. With this in mind, this section discusses the R&D location decisions of MNCs.

2.2.1 Location Determinants of MNCs' R&D Institutions

Important factors in attracting MNCs' R&D investment are generally considered to include the existence of large local markets, fully-developed infrastructures, policy environments that are favorable for investment, relatively high levels of technology, and substantial R&D resources in the host country (Kumar 2001). Zheng (2000) concludes that MNCs are attracted to R&D investment in host countries by (i) the direct application of R&D results in the branch plants of a host country and (ii) cultural variety, openness, and a vibrant industrial climate. Geographical and cultural proximity also play major roles in the location patterns of multinational R&D (Niosi 2003).

Human capital and level of intellectual property protection are regarded as decisive factors in overseas R&D investment (He and Wang 2006). However, with regard to patent protection variables, Kumar (2001) has demonstrated that restrictive trade regimes and a lack of adequate patent protection do not affect the attractiveness of a country that is otherwise well-suited to R&D activity. This is because MNCs are able to obviate the constraints of the host country's patent regime by registering patents in their home countries.

2.2.2 Multinational R&D Location Models

The quality and extent of externalities that accrue from MNCs' R&D activities are associated with their investment motivation, which needs to be spatially linked to the

location advantages available to MNCs (Narula and Dunning 2000; Cantwell and Narula 2001). Some researchers classify R&D organizations into different model types, according to their investment motivation and function, as shown in Table.2.1. These models represent international R&D function at different stages.

Table.2.1. Models of International R&D Organization

Authors	Models
Ronstadt (1984)	Technology transfer unit; Indigenous technology unit; Global technology unit; Corporate technology unit.
Bartlett & Ghoshal (1989)	Central-for-global R&D; Local-for-local R&D; Locally-linked R&D; Globally-linked R&D.
Kuemmerle (1999)	Home-base-exploiting R&D; Home-base-augmenting R&D.
Pearce and Papanastassiou (1999)	Support laboratories; Locally-integrated laboratories; Internationally-integrated laboratories.
Niosi and Godin (1999)	Vertical integration; Related diversification; Global units.
Du (2001)	Production-supporting R&D; Technology-tracking R&D; Resource-seeking R&D.
Archibugi and Lammarino (2002)	International exploration; Global generation, Global technological collaborations.

Source: Saur-Amaral and Borges Gouveia 2008 and author's collection.

For example, Ronstadt (1984, cited in Odell 2006) classifies multinational R&D models into four types: transfer technology units (established to help certain foreign subsidiaries transfer manufacturing technology from the parent while also providing related technical services for foreign customers), indigenous technology units (established to develop new and improved products expressly for the foreign market), global technology units (established to develop new products and processes for simultaneous application in major world markets of the company), and corporate

technology units (established to generate new technology of a long-term or exploratory nature expressly for the parent).

Saur-Amaral and Borges Gouveia (2008) have summarized the historical evolution of multinational R&D organizations in their work (Figure.2.1). At the beginning of the 1980s, centralized structures were the most commonly used among multinational R&D organizations. At that stage, technology was developed in home countries, and specific R&D units were set up abroad to support technology transfers and adaptation to local market demands. Between the mid-1980s and the beginning of the 1990s, the most frequent structures were polycentric. R&D units were decentralized, and had distinct goals, resources and coordination patterns. In the second half of the 1990s, international R&D structures transformed into globally integrated networks, as strategic technological alliances started to involve external partners and focus on international learning. In the 2000s, firms started to source technology for exploring asset-augmentation, and developed coherent integration strategies and multiple learning centers for this purpose. The cooperative arrangements and networks used in this stage help improve absorptive capacity, accelerate flexible and fast connections between distributed competency centers.

Moreover, different models of multinational R&D involve diverse location preferences. Du (2001) points out that production-supporting R&D institutions, which are usually located close to existing factory sites, are generally found in countries with huge markets. In contrast, technology-tracking R&D institutions are most strongly influenced by the competitiveness and science and technology levels of their host countries, and thus favor nations or regions with high levels of technology. Resource-

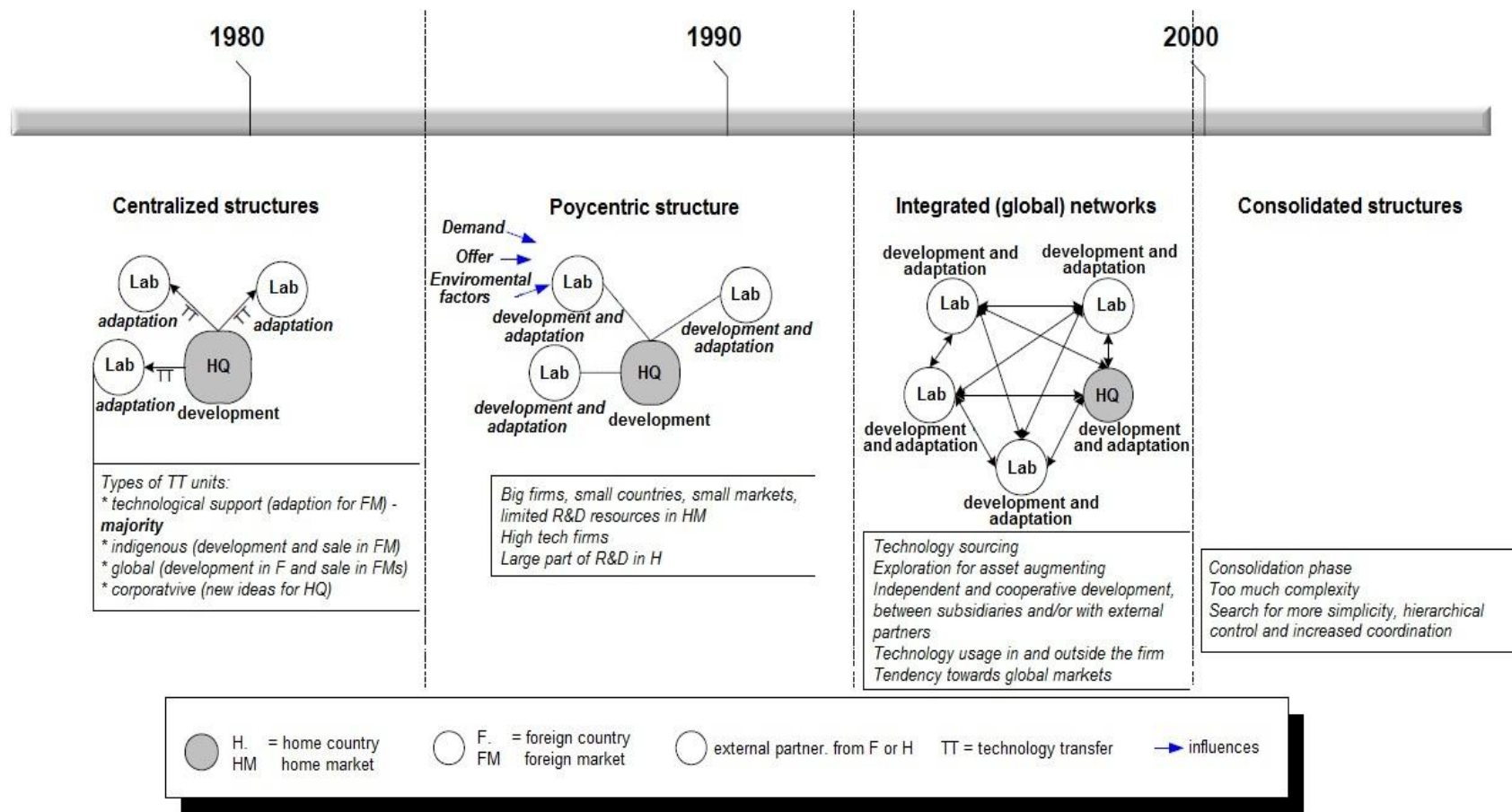


Figure.2.1. Historical Evolution of the Structures of International R&D Organization

Source: based on Saur-Amaral and Borges Gouveia 2008, pp: 6.

seeking R&D institutions prefer to be located in regions with an abundance of talent.

The studies described above show that multinational R&D has thus far focused on common location factors at the global scale, as well as the function of R&D organizations regarding trade and investment in different stages and regions. In reality, however, MNCs usually work with their wholly-owned affiliates to spread innovation while keeping things in-house (Hirshfeld 2005). As one part of MNCs, R&D institutions must also consider easy connections with headquarters and other divisions in deciding their location sites. Despite being able to determine common location factors, previous studies have severely neglected national and regional differences and diversity in enterprises. Moreover, detailed studies on the spatial relationships between R&D institutions and other organizations and agencies have been extremely limited.

2.3 Location of Enterprise R&D within Countries

The previous section discussed location determinants and the spatial evolution of MNCs' R&D institutions, and explained how host countries can attract MNCs' R&D activities. However, as mentioned in chapter 1, knowledge spillovers in multinational R&D has been found to be very limited, and such spillover more easily occurs within regions and nations. Therefore, research on domestic enterprise R&D at the national and regional levels is of great significance. Issues involved in R&D institutions' location factors and location patterns are discussed in this section.

2.3.1 R&D Location at the National Scale

R&D institutions show high levels of geographic concentration within countries,

and tend to be located in metropolitan areas. Malecki (1979) points out that large firms' location choices and changing roles in technology have had a major impact on regional economic development. His study on the location of 330 large firms in the U.S. demonstrates that most R&D institutions are located together with headquarters, but that their geographic concentration is not as high as for headquarters. Although R&D institutions were mainly distributed in the New York and New Jersey areas, they were also found to have diffused to other areas, and especially the Los Angeles metropolitan area.

A study of delocation and European integration (Midelfart-Knarvik and Overman 2002) has shown that the manufacturing concentration across European countries has not greatly changed as a result of their integration, but manufacturing activities at the regional level have become more concentrated in the recent two decades. Combined with the higher regional labor mobility, this has led to the weakening of dispersive forces and the enhancement of forces of agglomeration between regions. As a result, growing high-tech clusters have tended to be located in already established metropolitan areas, such as London, Munich, and Paris (Kranich 2008).

The location factors of regional or local R&D institutions have also been discussed in existing research. In general, their location preferences are similar to those of multinational R&D institutions, including access to abundant research personnel, preferential policies, and proximity to other firm organizations. Based on surveys on R&D location in the U.S., Lund (1986) has concluded that proximity to headquarters, abundance of research personnel, high quality of life and complete community facilities, proximity to production plants, and proximity to universities and research institutes are

the five leading factors in R&D location. In fact, these factors are interrelated and thus interact with each other. For instance, university or national R&D centers are generally located in regions with a concentration of high-tech talent, where many high-tech companies and R&D institutions are distributed. Moreover, these regions have beautiful surroundings and complete infrastructure facilities, and their residents enjoy high-quality community life.

Table.2.2. Location Theories on Enterprise R&D

Location Force	Examples of Location Factors	
Agglomeration force	External factors	Information source (university, government, market, partners and competitors); Pool of research personnel; Industrial agglomeration; Face-to-face interaction; Cooperative research; Easy transportation system; Supporting policies and preferential tax; etc.
	Intra-firm factors	Cost saving; Management efficiency; Exchange of information; Equipment sharing; etc.
Dispersion force	External factors	Information leakage; Land scale and land cost; Quality of life environment; etc.
	Intra-firm factors	Enlargement of firms; Internal divisions of labor; Commercialization of research result; etc.

Source: compiled by author according to Nakajima (1989).

Using industrial and behavioral location theories, Nakajima (1989) has systemized R&D location theories, in terms of both agglomeration and dispersion forces (Table.2.2). The core idea of Nakajima's (1989) theories concerns locating R&D sites for the purposes of profit maximization and the fast commercialization of research results. He concludes that several location factors have led to the concentration of R&D in a few metropolitan regions, such as access to information sources and highly-qualified talent, ease of transport and face-to-face communications between researchers and partners,

and preferential policies. In terms of saving costs and fully utilizing equipment and buildings, proximity to headquarters and other intra-firm organizations is extremely important. In particular, many R&D institutions tend to be located close to their headquarters, although those developing short-term products or exploiting production technology are usually located near or within production plants.

As land costs increase in high-concentration regions, the decentralization of R&D to suburbs can be observed. However, enterprises' R&D institutions are not as sensitive to land costs as production plants are (Mano 1987). In regions with a large amount of information, firms have difficulty learning from their partners (Sampson 2007), which is another factor leading to R&D diffusion. In addition, as firms grow, internal divisions of labor and hierarchical reorganizations take place, leading to the spatial separation of R&D and affecting R&D location relationships with other departments.

R&D location can also be explained by the theory of social capital. As noted in section 2.1, knowledge spillovers are involved in social relationships. Therefore, R&D location decisions are, to some extent, also social capital choices. Maskell (2000, cited in Westlund 2006) describes the social capital implications by stating that:

- In a knowledge-based economy the perhaps most significant rent originates from the way in which the easy exchange of knowledge enhances enterprises' innovative capabilities. Reducing your development to commercialization time is often worth virtually whatever you have to pay and social capital contributes by cutting the expenses and reducing the time needed to benefit from knowledge residing elsewhere.

Maskell (2000) links social capital not only to an enterprise's internal knowledge production but also to knowledge exchange between enterprises that have production-related links. These links, which are obviously important in R&D projects, are summarized in Figure.2.2 (Westlund 2006). Social and non-formalized links between enterprises that have production relationships with each other increase the flows of knowledge and information. Moreover, feedback from an enterprise to its suppliers, and to the enterprise from its customers, is increased and sped up by these links. Maskell's views on valuing easy change and reducing time are clearly consistent with Nakajima's (1989) ideas on cost saving and profit maximization.

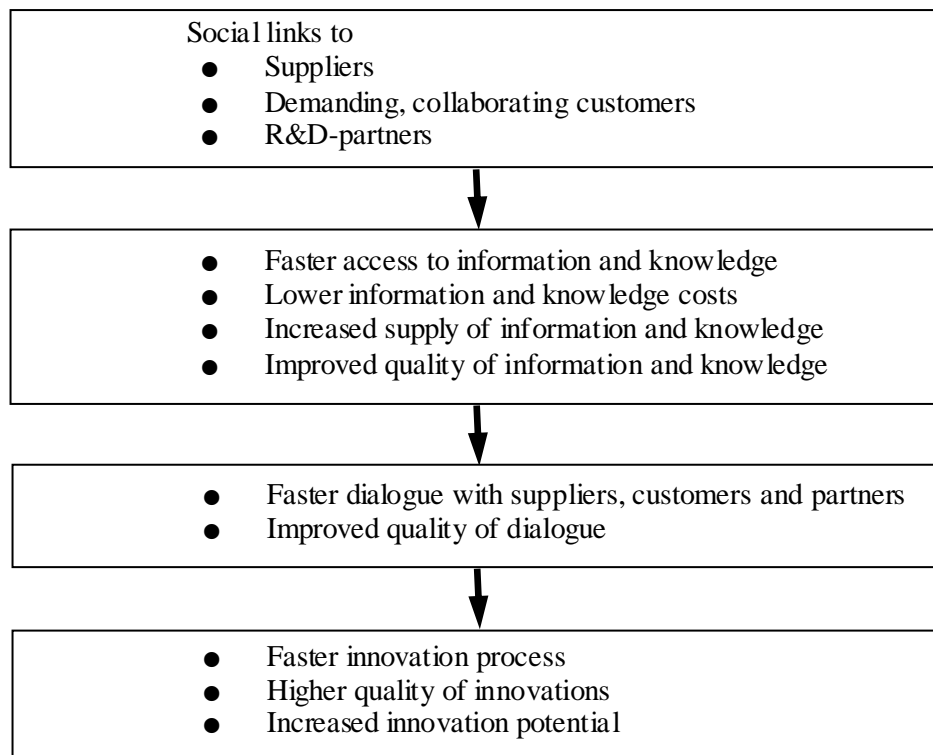


Figure.2.2. Summary of Production-related Social Links and Their Effects

Source: adapted from Westlund 2006, pp: 56.

Furthermore, residential attractiveness considerations are among the top factors in

firm's R&D location selection (Howells 1984; Lund 1986). R&D requires clusters of highly-educated workers, and so lifestyle amenities are needed that are attractive to a pool of talent, which plays a critical role in shaping the interurban geography of R&D labs (Kilvits 2012; Sivitanidou and Sivitanides 1995). If the living environment is satisfactory only in some regions, investment-intensive new high-technology and high-value-added jobs will only be created in those regions. Only top specialists and skilled workers in the regions will benefit from these jobs, and not the "ordinary people" in other regions. Such structural changes may even increase economic, social, and regional stratification (Kilvits 2012).

2.3.2 R&D Location Patterns

The functional and locational diversity of R&D institutions is the result of various factors. R&D functions, location factors, and R&D locations all affect each other. As stated above, previous studies have focused on MNCs' R&D location models from the viewpoint of R&D functions in different countries and stages. Similarly, Mitsubishi Research Institute (MRI) (2002) analyzes the functions of R&D institutions within a country and divides them into three groups:

(i) Technology-solution R&D: These R&D institutions aim to address technology solutions. They include central labs, specialized labs for different departments, and other organizations developing new products. Many enterprises launch R&D activities and locate R&D institutions through such entities.

(ii) Regional R&D: As R&D-supporting organizations, these kinds of R&D institutions are primarily established to support production. However, it is extremely difficult for technology to cross regional barriers in such organizations, and thus strengthening market orientation is also an important issue.

(iii) Hybrid R&D: These R&D institutions evolve as an enterprise grows in size and spreads across regions. Hybrid R&D institutions are the most commonly employed, because an entire R&D institution cannot typically be put together as a one-time project, and is instead usually established gradually. However, repeated establishment of R&D institutions with the same functions can easily lead to low efficiency.

R&D location diversity does not only occur with regard to spatial differences, but also location relationships with other organizations (Figure.2.3). Although R&D institutions' proximity to headquarters is widely regarded as an important consideration, their location relationships with production plants should not be ignored. Akimoto (1989) believes that R&D location patterns are closely related to production models, and many R&D institutions were once parts of production plants. When an enterprise has only one R&D division, R&D is mainly focused on developing short-term technology and products. When a company has more than one plant, R&D divisions are likely to split from production plants and launch cooperative research on middle-term products. Large-scale enterprises with more than one R&D division tend to launch R&D activities in different departments, and their R&D divisions can easily break away from other departments, become independent institutes or companies, and develop new products and technology over time.

R&D activity involves organized research, and is carried out in purpose-built labs that are often separate from the central decision-making, sales/marketing, and production divisions of industrial enterprises (Sivitanidou and Sivitanides 1995). Like multinational R&D organizations whose structures evolve from centralized to consolidated, enterprise R&D institutions within countries also undergo organizational

change through the impacts of external and internal factors. Therefore, location relationships between R&D institutions and other organizations are typically in a state of flux. Moreover, they are marked by geographic differences, at both the national and regional levels.

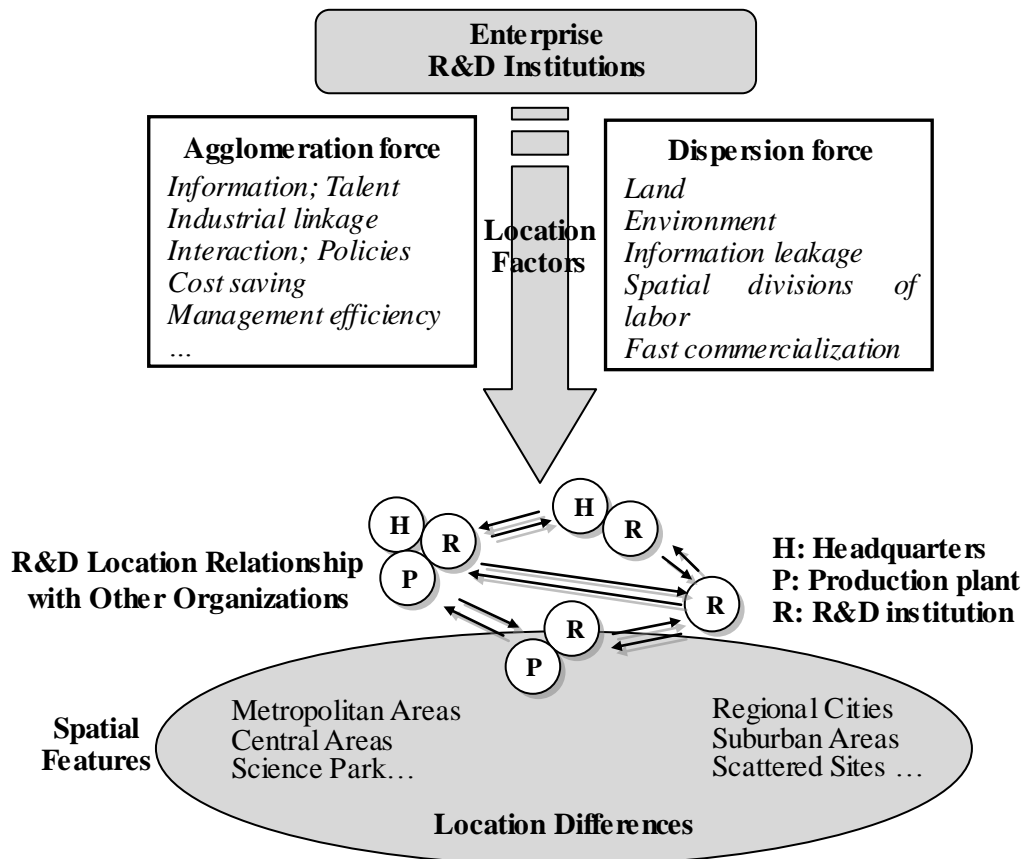


Figure.2.3. Location Factors and Differences of Enterprise R&D institutions

Source: compiled by author.

However, despite the numerous studies that have been conducted on R&D location factors within countries, descriptions of the dynamics of R&D institutions of domestic enterprises are lacking. Although R&D location relationships with headquarters and production plants are involved, it would be biased to justify R&D location or relocation based on these alone. Furthermore, the existing literature usually ignores the insights of

enterprise decisions into the selection of R&D location. The development and change of R&D location and location relationship with other organizations should be the subject of further academic attention.

2.4 Summary

Extant literature on R&D activities confirms that R&D institutions play important roles in the regional growth and innovation capacity of enterprises. Although R&D activities can improve productivity, location still matters for R&D. The location of R&D institutions is majorly influenced by product cycles, geographic proximity, clustering (including rivalry), diversity of proximate industries, and social interactions. The positive externalities of R&D activities are realized only when knowledge commercialization and retention factors are also present in a region. This means that locations that combine all of the above factors will attract more R&D activity.

Large local markets, fully developed infrastructures, favorable policies, high levels of technology, and R&D talent are generally considered important to multinational R&D institutions in choosing a host country. Moreover, MNCs' R&D institutions evolve from centralized to consolidated structures under the influence of firm strategies, R&D functions, product cycle stages, and the environment. Despite this, previous studies have emphasized on the generalities of MNCs' R&D location models, while largely neglecting the diversities of regions and enterprises.

Meanwhile, R&D conducted in a home country tends to be significantly more productive than that undertaken abroad. Therefore, location factors for national or local R&D should be the subject of greater concentration. Domestic enterprises and MNCs

take different approaches to deciding on R&D locations. The location of domestic enterprises' R&D institutions is based on intra-firm and inter-firm linkages, social connections, the images of places, and other factors, which are all elements of social capital.

This chapter has also addressed the location patterns of R&D institutions within a country. R&D location and relocation are determined by enterprises' strategies, their R&D functions, and their production models. With the growth and transformation of an enterprise, R&D location relationships with other organizations also change in a manner that is impacted by internal and external location factors, shaping their location diversity.

Although previous studies have discussed the determinants of R&D institution location on both the global and regional scales, many issues remain unresolved and necessitate further research. Such research should shed more light on issues such as R&D location relationships with other organizations and R&D location factors at the intra-urban level, as well as the spatial features of these different location relationships. This paper aims to address these issues through further research. It does so by systematically examining the location patterns and location characteristics of enterprise R&D institutions in metropolitan areas, from the perspective of location relationships among intra-firm organizations. Moreover, it explains location factors that influence diversity in location relationships and location patterns.

CHAPTER 3

R&D Activities: An International Comparison

3.1 International R&D Activities

3.1.1 International Comparisons of R&D Performance

Expenditure on R&D is one of the most widely used measures of innovation inputs, and is a key indicator of governments' and private sectors' efforts to obtain competitive advantages in science and technology. Many countries attempt to strengthen their innovation capacity by increasing expenditure on R&D. In 2011, the total global expenditure on R&D reached \$1,435 billion. The U.S., China, Japan, and Germany are the top countries in terms of R&D spending, as shown in Figure.3.1.

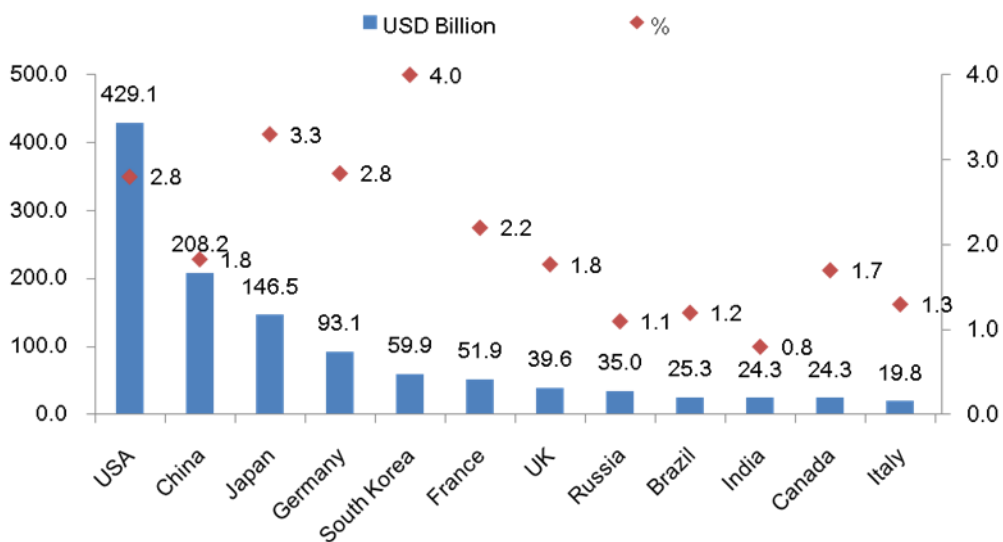


Figure.3.1. R&D Expenditure and R&D Intensity in Selected Countries (2011)

Source: National Science Board 2014.

Roughly three-quarters of worldwide R&D expenditure are spent in six leading countries: the U.S., China, Japan, Germany, South Korea, and France. Notably, R&D in the U.S. alone accounts for nearly a third of global R&D. With the constant increase of R&D spending in Asian countries such as China and India, the geographic pattern of R&D has begun to shift. With its \$208 billion of R&D expenditures in 2011, China became the world's second-largest spender on R&D. The U.S., however, still remains the world's largest R&D spender by far.

In addition to expenditure on R&D, one of the main indicators used for international comparison is the ratio of gross domestic R&D expenditure to GDP, which is also called R&D intensity.¹ In terms of this measure, Japan and South Korea are both above 3%, while the U.S. and Germany, both at 2.8%, are slightly ahead of France (Figure.3.1). Among the top R&D-performing countries, R&D intensity results in different performance outcomes. Most of the R&D intensity growth in the U.S. can be attributed to increases in nonfederal R&D spending, and primarily that financed by business. In Germany, the R&D intensity increased modestly from 2.5% in 2001 to 2.9% in 2011. Japan's ratio also increased at a modest pace, from 3.1% in 2001 to 3.4% in 2011, which can be attributed to its declining GDP and stable R&D inputs. At the same time, significant increases in R&D intensity occurred in China and South Korea. R&D intensity in China doubled over the period from 2001 to 2011, from less than 1.0% in 2001 to somewhat above 1.8% in 2011, while South Korea's R&D intensity increased from 2.5% in 2001 to 4.0% in 2011 (National Science Board 2014).

Although R&D activities are highly concentrated in the larger economic powerhouses, some smaller economies also play important roles. Israel, Finland,

Sweden, Denmark, and Taiwan have relatively high levels of R&D intensity (Table.3.1), indicating that they carry out R&D activities positively. These smaller countries do very well by participating in cross-border R&D (Hirshfeld 2005).

Table.3.1. R&D Expenditure and R&D Intensity in Selected Smaller Countries
(in descending order of R&D intensity)

	R&D Expenditure (Billion)	R&D Intensity (%)
Israel	9.8	4.38
Finland	7.6	3.78
Sweden	13.2	3.37
Denmark	7.1	3.09
Taiwan	26.5	3.02
Switzerland	10.5	2.87
Austria	9.8	2.75
Singapore	7.1	2.23
Belgium	8.7	2.04

Source: National Science Board 2014.

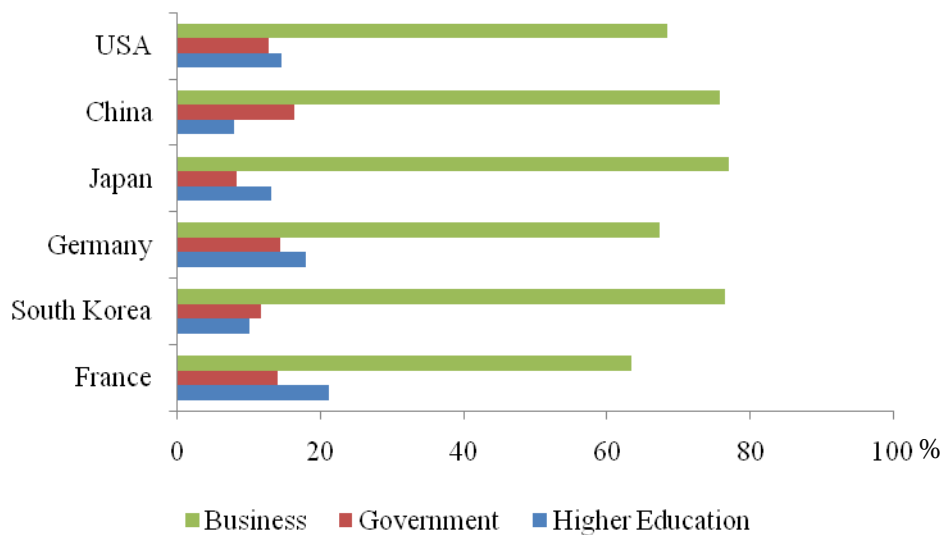


Figure.3.2. R&D Expenditure by Sectors in Selected Countries (2011)

Source: OECD (2011) *Main Science and Technology Indicators*.

Furthermore, enterprises play particularly decisive roles in innovation and knowledge spillovers through their R&D activities. They are the main organization

responsible for R&D expenditure in most countries (Figure.3.2). Among the leading countries in R&D expenditure, Japan's business sector is the biggest spender, followed by academic R&D institutions. Proportion of R&D expenditures by the business sectors in China and South Korea is also well above the U.S. level, although academic R&D institutions in China hold a lower share of expenditure.

In addition, MNCs are critical players in R&D spending. Business spending on R&D is mainly carried out by large MNCs. In the U.S., the 15 largest R&D-intensive companies are responsible for roughly about 32% of all of the U.S. business spending on R&D. In Europe, the largest 15 companies spend about 44% of the total, while the figure for Asia is roughly 14% (Hirshfeld 2005). Meanwhile, MNCs also play active roles in R&D globalization, bringing more financial inputs and R&D activities into other countries or regions. However, as mentioned above, R&D centers are very rarely diffused, because they are closer to primary markets and have access to specialized technical resources. Moreover, most of their R&D activities are undertaken in their home countries.

Figure.3.3 presents the R&D spending by U.S. MNCs, both at home and abroad, from 1997 to 2010. The amount of R&D spending by foreign affiliates of U.S. firms increased by \$25 billion over this period, while R&D spending by the same firms inside the U.S. increased by \$106 billion. This suggests that while R&D spending has increased among foreign affiliates, MNCs still carry out the vast majority of highly-skilled activities in the United States. Branstetter and Foley (2010) have studied the FDI conducted by U.S. firms in China, and discovered that relatively few R&D activities in China are conducted by U.S. affiliates, despite widespread interest in the

possible emergence of China as a center of technological innovation.

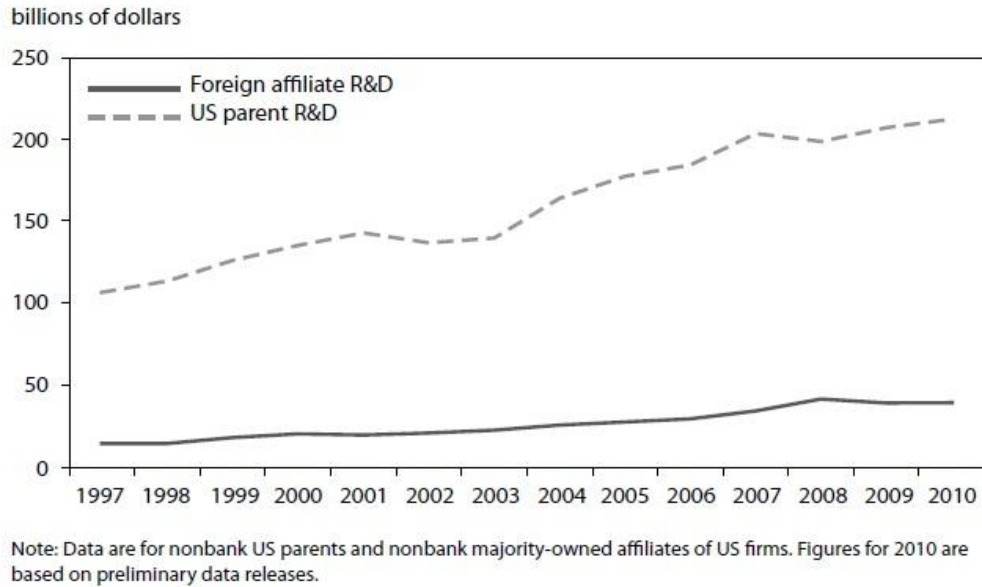


Figure.3.3. R&D by US MNCs at Home and Abroad (1997-2010)

Source: adapted from Hufbauer, G. et al. 2013, pp: 31.

3.1.2 Geographic Distribution of R&D Performance

The global distribution of R&D activities is uneven. As shown in Figure.3.4, global R&D is mainly concentrated in North America, Asia, and Europe. North America (the United States, Canada, and Mexico) accounted for 32% of worldwide R&D in 2011; while East/Southeast and South Asia combined accounted for 34%, and European countries accounted for 24%. The remainder of countries, in the regions of Central and South America, Central Asia, the Middle East, Australia/Oceania, and Africa, comprised around 10% of total R&D (National Science Board 2014).



Figure.3.4. Global R&D Expenditure by Regions (2011)
(Billions of U.S. PPP dollars)

PPP=purchasing power parity.

Notes: Foreign currencies are converted to U.S. dollars through PPPs. Some country figures are estimated. Countries are grouped according to the regions described by *The World Factbook*, available at www.cia.gov/library/publications/the-world-factbook/index.html.

Source: adapted from National Science Board 2014, pp: 6.

After the financial crisis of 2008, the Asian R&D communities, and China in particular, increased their R&D investment and stature (Table.3.2). Although China entered the subsequent recession with a decade of strong economic growth, it also increased R&D spending by roughly 10% each year. In Japan, R&D spending has kept increasing steadily, despite the recession in the world economy. In the U.S., a recession-related drop in industrial R&D spending in 2009 was counteracted by predicted increases in 2010 and 2011 (Battelle 2010).

Table.3.2. Global R&D Spending

	2009 GERD PPP Billions, \$	2009 R&D Intensity %	2010 GERD PPP Billions, \$	2010 R&D Intensity %	2011 GERD PPP Billions, \$	2011 R&D Intensity %
Americas	433.2	2.2%	446.7	2.2%	458.0	2.2%
U.S.	383.6	2.7%	395.8	2.7%	405.3	2.7%
Asia	372.5	1.9%	400.4	1.9%	421.1	1.8%
Japan	139.6	3.4%	142.0	3.3%	144.1	3.3%
China	123.7	1.4%	141.4	1.4%	153.7	1.4%
India	28.1	0.8%	33.3	0.9%	36.1	0.9%
Europe	267.0	1.7%	268.6	1.6%	276.6	1.7%
Rest of World	34.2	1.2%	34.8	1.2%	36.3	1.2%
Total	1,107.0	1.9%	1,150.6	1.9%	1,192.0	1.9%

PPP: Purchasing Power Parity

Source: adapted from Battelle 2010, pp: 3.

In contrast, R&D activity in Europe has been far less rosy, and has faced the challenges of the weak economies of Greece, Spain, and Ireland. With the exception of Sweden, Denmark, and Germany, the members of EU-15 invest far too little on R&D, which threatens to leave their industries vulnerable to commoditization and competition from low-cost regions (Battelle 2010; Economist Intelligence Unit 2006).

The distribution of R&D activities is not only uneven at the global level, but at the national level. R&D in the U.S., for example, is geographically concentrated (Table.3.3). In 2007, the 10 states with the greatest R&D expenditure levels accounted for 64% of all U.S. R&D expenditure. California's R&D spending alone represented 22% of U.S. R&D, and was triple that of Massachusetts, which was the next highest-contributing state (National Science Board 2010). In 2007, R&D spending from both academic and business sectors in California ranked first in the nation (Table.3.3).

Table.3.3. Top 10 States in R&D Performance, by Sector and Intensity (2007)

All R&D			Sector ranking			R&D intensity	
Rank	State	Amount (current \$millions)	Business	Higher education	Government	State	R&D /GDP (%)
1	California	77,608	California	California	Maryland	New Mexico	7.53
2	Massachusetts	24,557	Massachusetts	New York	California	Massachusetts	6.97
3	New Jersey	19,552	New Jersey	Texas	New Mexico	Maryland	5.34
4	Texas	17,853	Michigan	Maryland	Virginia	Washington	4.85
5	Michigan	17,402	Texas	Pennsylvania	District of Columbia	Connecticut	4.82
6	New York	15,939	Washington	Massachusetts	Massachusetts	Michigan	4.58
7	Washington	15,061	Illinois	North Carolina	Tennessee	California	4.31
8	Illinois	14,287	New York	Illinois	Washington	New Jersey	4.24
9	Maryland	14,130	Pennsylvania	Ohio	Illinois	District of Columbia	4.17
10	Pennsylvania	13,510	Connecticut	Florida	Florida	New Hampshire	3.71

Source: National Science Board 2010.

3.2 R&D Activities in China

China is the fastest-growing economy in Asia, and remains the top-ranked destination for foreign investors, which is a status that it has held since 2002 (A.T. Kearney Global Business Policy Council 2010). Since the beginning of the 1990s, many advanced countries have invested in China, and the Chinese government has also established a variety of policies to attract overseas investment. Along with its economic growth, China is attractive as the most populous consumer market, which has continuously created increased opportunities for MNCs in many fields.

Accompanying the increasing overseas investment in China, more and more MNCs are establishing R&D centers in China, where a high-quality talent pool exists, as well as easy access to skilled labor. By applying the financial investment technology of FDI, China's economy has progressed significantly. Meanwhile, the Chinese government has

realized the significance of self-innovation activities in promoting the country's competitiveness, and has started increasing R&D input at home. As mentioned above, in 2011, China became the second-largest country with regard to R&D expenditure, following the USA.

3.2.1 R&D Performance in China

R&D expenditure in China is increasing (Figure.3.5). As mentioned, by 2011, it had reached \$208.2 billion, ranking second in the world. However, despite the fact that the R&D intensity ratio in China is also constantly increasing (Figure.3.5), it is still behind those of more advanced countries (Figure.3.1). By 2011, the R&D intensity in China was 1.8%, which was far less than the levels of its neighboring countries, such as Japan (3.3%) and South Korea (4%) (Figure.3.1). Moreover, expenditure on basic research is very low in China. The country's preference for experimental development has left its basic research ability weak (Figure.3.6).

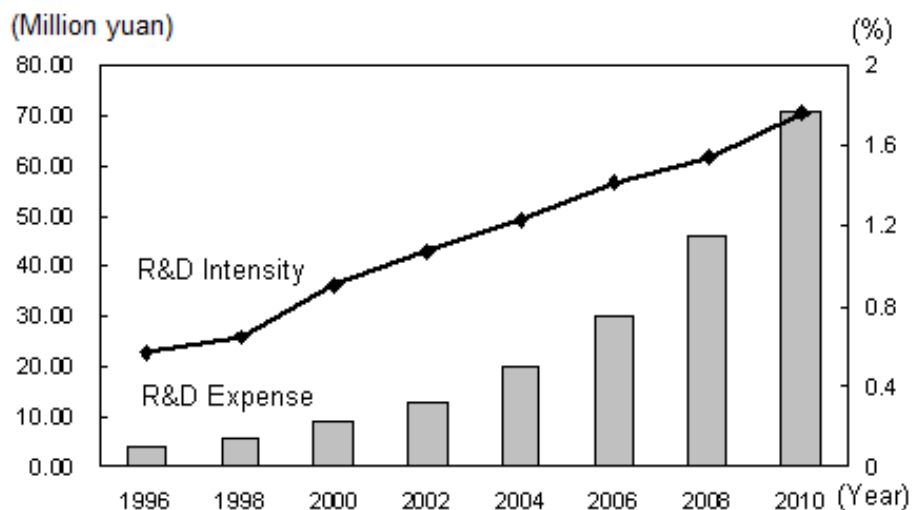


Figure.3.5. R&D Expenditure and R&D Intensity in China

Source: China Statistical Yearbook on Science and Technology.

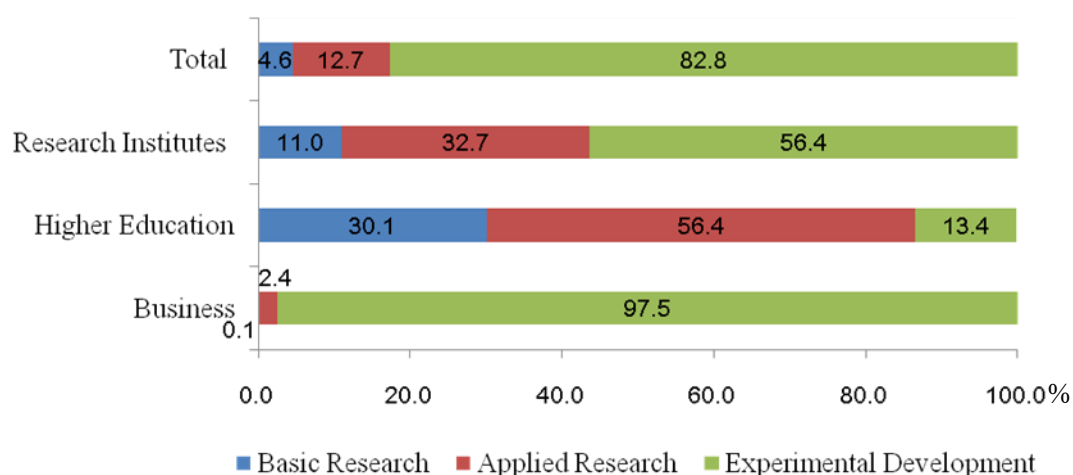


Figure.3.6. GERD by Type of Activity in China (2010)

Source: China Science and Technology Statistics Data Book 2011.

Enterprises are currently the main parties involved in R&D activities in China (Figure.3.2). In promoting R&D activities, large- and medium-sized industrial enterprises have played especially critical roles. As shown in Figure.3.7, not only is intramural expenditure on R&D activities substantially increasing, but so is the proportion of R&D expenditure to sales revenue among enterprises. This proves that enterprises are placing more emphasis on the positive effects of R&D activities, in order to improve productivity and exploit the markets.

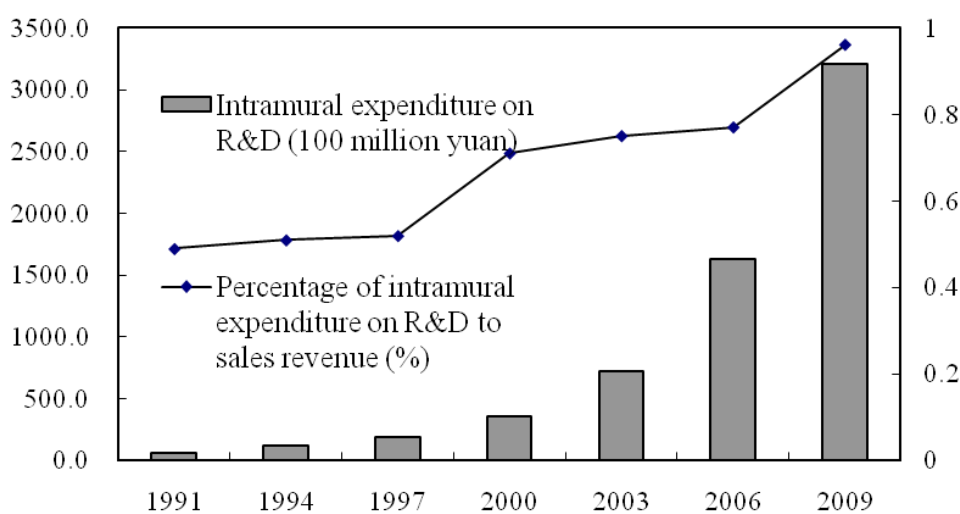


Figure.3.7. Expenditure on R&D in Large- and medium-sized Industrial Enterprises

Source: China Statistical Yearbook on Science and Technology.

In addition, as can be seen from Table.3.4, R&D activities in China are mainly concentrated in the manufacturing of electronic equipment, medicine, measurement instruments, office machinery, and other equipment. Enterprises from these industries carry out R&D activities much more frequently, and this is particularly true of medicine manufacturing enterprises of which approximately 62.5% have R&D institutions.

Table.3.4. R&D Institutions in Large- and medium-sized Industrial Enterprises by Industry (2009)

(Top 10 Industries by Proportion of Numbers of Enterprises having R&D Institutions)

	Number A	Number of Enterprises Having R&D Institutions	
		B	B/A
Total	40792	11741	28.8%
Medicine	1011	632	62.5%
Measurement Instrument, Machinery for Cultural and Office Work	612	302	49.3%
Special Equipment	1480	711	48.0%
Extract of Petroleum and Natural Gas	81	38	47.0%
General Purpose Machinery	2416	1090	45.1%
Electrical Machinery and Equipment	2929	1269	43.3%
Transport Equipment	2620	1065	40.6%
Chemical Fiber	238	96	40.3%
Tobacco	97	35	36.1%
Communication Computer, Other Electronic Equipment	3203	1077	33.6%

Source: China Statistical Yearbook on Science and Technology 2010.

3.2.2 Spatial Distribution of Enterprise R&D Institutions in China

In 1990, the total number of R&D institutions of large- and medium-sized industrial enterprises in China was 8,116, while by 1995, the number reached 13,106 (Figure.3.8). However, it is noteworthy that R&D institutions decreased in number during the late 1990s, and fell to 7,601 by 2000. This decrease was largely due to reforms made to

state-owned enterprises during 1993-2003, which mainly included enterprise restructuring and merging. In 1999, the Technological Innovation Conference was held in China, at which a plan *to strengthen technical innovation, develop high technology, and realize industrialization* was proposed. The number of R&D institutions then began increasing again at the beginning of the 21st century. There have also been clear regional differences in the spatial distribution of enterprise R&D institutions (Figure.3.8), which are evident from distribution trends.

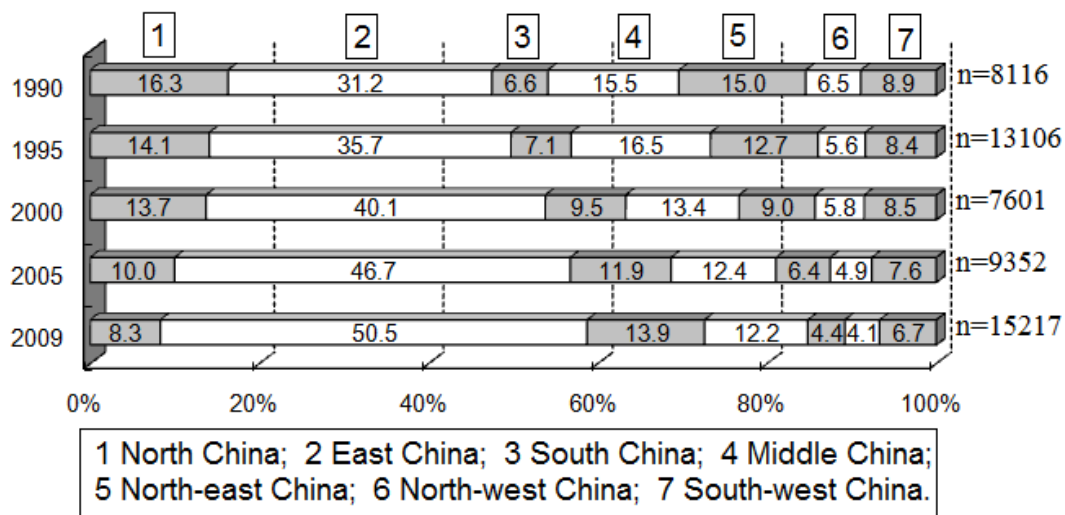


Figure.3.8. Large- and medium-sized Industrial Enterprise R&D Institutions by Region over Periods

Source: China Statistical Yearbook on Science and Technology.

East China, with centers like Shanghai, Zhejiang Province, and Shandong Province, has become the country's most attractive region for enterprise R&D activities. The proportion of R&D institutions in East China and South China (with Guangdong Province as its center) continues to increase, while other regions have suffered varying degrees of decline. The economic levels in China's old northeastern industrial zone have particularly fallen in recent years, and the number of R&D institutions in the region has decreased sharply. Moreover, North China, with Beijing as its center, does not have the

same level of advantage in attracting enterprise R&D institutions as East and South China do. East China, with Shanghai as its center, is the most successful region in terms of enterprise R&D activities.

3.2.3 Comparison of Regional Innovation Capability in China

In recent years, different regions of China have placed increased importance on R&D input. In 2012, Jiangsu, Guangdong, Shandong, Beijing, and Zhejiang were the top five regions of the country in terms of R&D expenditure. However, in terms of R&D intensity, Beijing ranked first, followed by Shanghai and it has been maintained this status to date (Table.3.5).

Table.3.5. R&D Expenditure and R&D Intensity by Region in China (2012)

(Top 10 Regions by R&D Intensity)

Regions	R&D expenditure (100 million yuan)	R&D intensity (%)
Average	10298.4	1.98
Beijing	1063.4	5.95
Shanghai	679.5	3.37
Tianjin	360.5	2.80
Guangdong	1236.2	2.17
Jiangsu	1287.9	2.38
Zhejiang	722.6	2.08
Shandong	1020.3	2.04
Shanxi	287.2	1.99
Hubei	384.5	1.73
Anhui	281.8	1.64

Source: Bulletin on China's S&T Budget 2012.

As the capital of China, Beijing is home to a large number of national research institutes and universities, on which nearly 60% of total R&D expenditure is spent,

while only 30% is spent on business sectors. This special R&D input pattern, which is related to Beijing's capital function, is losing its relevance. Instead, in Shanghai, the main performer of R&D activities is enterprise. Shanghai ranks first among Chinese provincial regions in terms of per-capita GDP, and the GDP of its service industries has exceeded 50% of its total GDP since 2000. Its economy and R&D intensity levels have reached those of a post-industrial society, and its R&D input is in accordance with its economic level (Zhou 2006).

Since 1999, the Science and Technology Group of China has carried out a comprehensive annual evaluation of regional innovation capability annually. Regional innovation capability refers to a region's capability to transfer knowledge to new products, new techniques, and new services. The comprehensive evaluation of regional innovation capability is based on knowledge creation, knowledge acquisition, enterprise innovation, innovation efficiency, and innovation environment. According to the *Report on Regional Innovation Capability in China 2006-2007*, Shanghai was ranked first in innovation capability for the three years in row after (Table.3.6).

In addition, according to the *Special Investigations of Enterprise Innovation 2006* (National Bureau of Statistics of China 2006), more than half of surveyed enterprises take innovation seriously and regard Shanghai as the most favorable city in China for R&D institutions, followed by Beijing, Hangzhou², Qingdao³, Shenzhen⁴, and Suzhou⁵. Furthermore, the *Report on Regional Innovation Capability 2005-2006* shows that although Beijing has the most scientific and technological resources, Shanghai has become the most innovative region of China, because of its favorable commercial climate, strong industrial foundation, and close economic links through the Yangtze

River Delta. In addition, Shanghai and Beijing can be distinguished by one another by their levels of enterprise innovation capability. Shanghai has been the representative area for enterprises' R&D activities, and it is for this reason that it has been selected as one of the focus in this paper.

Table.3.6. Ranking and Categories of Regional Innovation Capability in China

Region	R	C	Region	R	C	Region	R	C	Region	R	C
Shanghai	1	1	Fujian	9	4	Hebei	17	4	Xinjiang	25	4
Beijing	2	1	Chongqing	10	4	Sichuan	18	4	Guizhou	26	5
Guangdong	3	2	Shanxi	11	4	Henan	19	4	Gansu	27	5
Jiangsu	4	2	Anhui	12	4	Inner Mongolia	20	4	Ningxia	28	5
Zhejiang	5	2	Hubei	13	4	Jilin	21	4	Yunnan	29	5
Shandong	6	3	Heilongjiang	14	4	Jiangxi	22	4	Qinghai	30	5
Tianjin	7	3	Hunan	15	4	Guangxi	23	4	Tibet	31	5
Liaoning	8	4	Shanxi	16	4	Hainan	24	4			

Note: R means "Rank"; C means "Categories of innovation."

Among categories of innovation, '1' represents the region with *super strong* innovation capability; '2' represents *much stronger*; '3' represents *strong*; '4' represents *average*; '5' represents *weak*.

Source: Report on Regional Innovation Capability 2005-2006.

3.2.4 Previous Studies on Geography of Enterprises' R&D Institutions in China

In China, geographic studies of enterprise R&D institutions began being carried out during the 1990s, with the majority concentrating on R&D locations and location factors of MNCs and FDI (Xue et al. 2002; Zhang and Du 2006; Wang and Du 2007). These studies point out that R&D institutions in China are concentrated in East China, with most located in industrial parks. Although R&D institutions have also recently increased in number in Western China, eastern coastal cities, and especially Shanghai, followed by Beijing and Shenzhen, remain the preferred destinations for MNCs to

establish R&D facilities (Liu and Liu 2007; Du et al. 2010).

Moreover, there is a distinct spatial differentiation among MNCs' R&D institutions in China, according to their industry and home country. R&D investment by MNCs in Beijing is largely by companies within the electronic communications industry, whereas that in Shanghai is mainly by companies from the chemical biology industry. American-origin R&D in China is mainly within the electronics and communication industry, and most R&D institutions are located in the Yangtze River Delta region (centered in Shanghai) or in Bohai Rim (centered in Beijing). In contrast, almost all European R&D institutions are concentrated in the Yangtze River Delta region, as is R&D investment by Japanese companies (Du et al. 2010).

Du (2001) points out that the most important factors attracting MNC R&D investment in China are the huge market potential and the abundant and cheap R&D talent. The complete infrastructure and active economy also have positive effects on R&D activities. While absorptive capacity for FDI is important, market potential and human capital are also regarded as key factors in the regional differentiation among MNCs' R&D activities in China (He and Wang 2006).

Previous studies on R&D in China and on the international level have something in common: both focus on the locations of R&D institutions. However, previous China-focused studies have concentrated on the distribution of R&D institutions and location factors at the national level, but have failed to provide detailed local-level analyses of regions, cities or firms' heterogeneity. In addition, despite the abundance of literature on R&D in China, most concerns MNCs, while literature discussing

enterprises' R&D institutions from the perspective of domestic capital, is lacking.

In recent years, there has been increasing academic interest in the location of enterprise R&D institutions in Shanghai (Xu and Du 2004; Dong 2007; Wang 2007). Findings from previous studies show that despite the decentralization of R&D institutions from the central city to the suburbs, most are still concentrated in a few industrial zones and high-tech parks. Due to their favorable locations, high-tech parks attract R&D investment, while rising land costs in central city areas accelerate the decentralization of R&D institutions to the suburbs (Dong 2007). In analyzing the location types of enterprises' R&D institutions in Shanghai, Wang (2007) has classified R&D institutions engaged in FDI in terms of three different characteristics: (i) R&D function, (ii) location relationships between R&D institutions and other organizations, and (iii) location characteristics of R&D institutions' sites.

However, past studies pay much more attention to MNCs and FDI-founded R&D institutions than to those founded by domestic enterprises. Furthermore, these studies have, for the most part, only been descriptive, lacking any detailed or deep analyses of the location features of different types of R&D institutions. Therefore, this paper aims to explore the location types of enterprise R&D institutions in Shanghai in terms of the location relationships between R&D institutions and other organizations. It also includes detailed analyses of the location patterns of R&D institutions according to their different types, with domestic enterprises as its main study target.

3.3 R&D Activities in Japan

Japan has long been one of the world's most innovative countries, and its innovation system has been enthusiastically studied. In particular, Japanese firms' steady increase in R&D input and output and their strong research linkages with academic facilities have aroused much interest. In fact, as can be seen from Figure.3.2, the government's role in R&D expenditure is very limited in Japan, when compared to other leading nations. The ability of Japanese firms to develop new technology is regarded as the key factor in the recovery of sustained economic growth in Japan (Branstetter and Kwon 2004).

Japanese enterprise R&D activities are implemented domestically. As mentioned above, most R&D activities for the core technologies of enterprises are still performed in their home countries. Despite the rising trend in international R&D among Japanese MNCs, the internationalization of Japanese MNC's R&D is an even more recent phenomenon, and is still occurring only at very low levels (Kumar 2001). Given the above information, enterprises' R&D activities in Japan should be paid much more attention, particularly from the perspective of geography.

3.3.1 R&D Performance in Japan

Japan is one of the leading countries in the world in R&D expenditure. By 2008, R&D expenditure in Japan was in a constant state of increase (Figure.3.9). Although R&D expenditure declined in 2010, R&D expenditure in the country has remained at a stable level overall. In 2010, R&D expenditure in Japan reached 17,110 billion yen, among which the proportions made up by basic research, applied research, and

experimental research were 14.7%, 23.1%, and 62.2% respectively (Figure.3.10). Evidently, the proportion of R&D expenditure on basic research in Japan is far higher than that in China, where basic research accounts for only 4.7%.

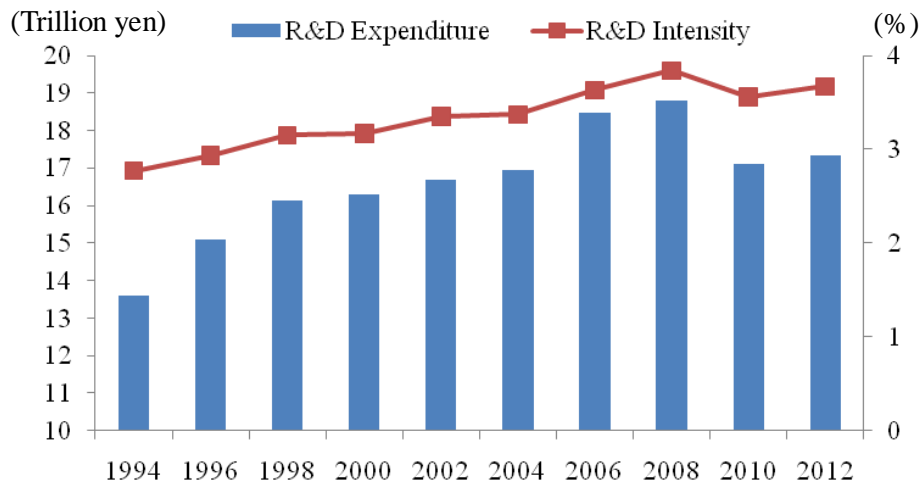


Figure.3.9. R&D Expenditure and R&D Intensity in Japan

Source: Ministry of Internal Affairs and Communications of Japan. *Survey on Science and Technology Research*.

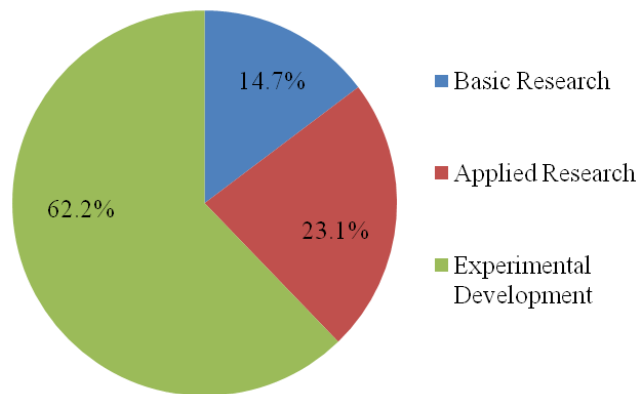


Figure.3.10. GERD by Type of Activity in Japan (2010)

Source: Ministry of Internal Affairs and Communications. *Survey on Science and Technology Research (2011)*.

In Japan, large-scale enterprises are the main players in R&D activities, and their

R&D expenditure makes up 74% of total enterprises' expenditure (Figure.3.11). This means that enterprises carry out R&D activities more actively, with higher fund scales.

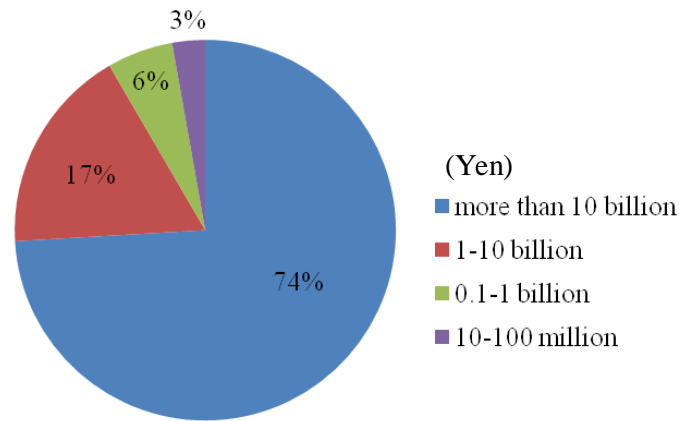
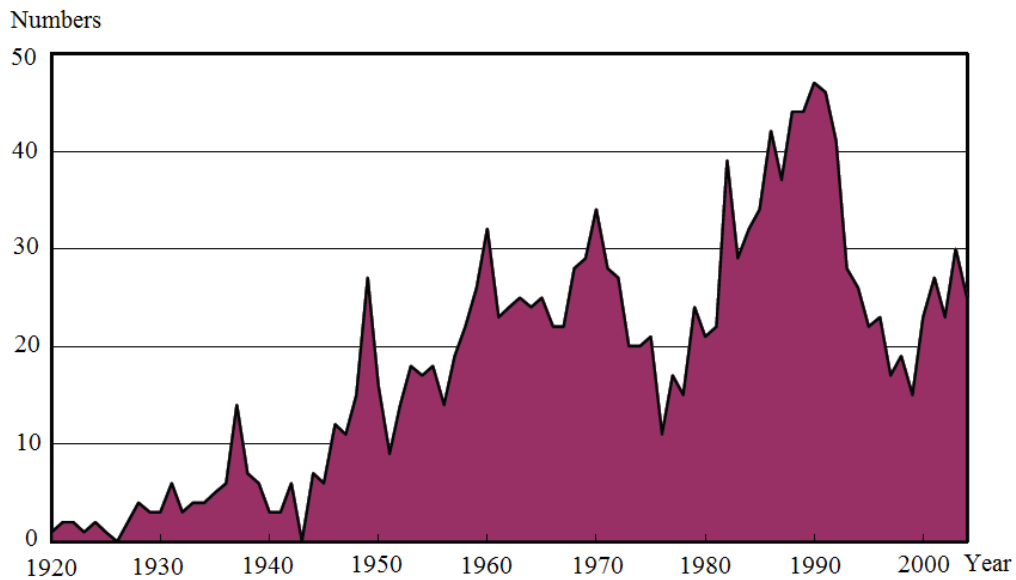


Figure.3.11. Enterprise R&D Expenditure by Fund Scale (2012)

Source: Ministry of Internal Affairs and Communications. Survey on Science and Technology Research (2013).

3.2.2 The Establishment of Enterprise R&D Institutions in Japan

Figure.3.12 shows the numbers of enterprises' R&D institutions that are established annually in Japan. It shows that there have been two establishment booms since World War II. The first boom occurred from the 1950s to the mid-1970s. During this time, both the Japanese government and industries prioritized the independent development of science and technology, and many research institutions were established as economic growth progressed. During the next decade, the Japanese economy took a beating as a result of the First Oil Crisis, and the numbers of newly-established R&D institutions subsequently decreased.



**Figure.3.12. Numbers of Enterprise R&D Institutions
Established Annually in Japan**

Source: Osaka Prefecture Institute for Advanced Industrial Development 2007, pp: 36.

The second boom occurred in the period from the 1980s to the 1990s. According to Ishigami (1986) and Akimoto (1989), during this time, with the onset of microelectronics technology innovation, global competition increased, and it became difficult for enterprises to introduce new outside technologies. Thus, enterprises had to more actively engage in R&D, which brought about an increase in the numbers of R&D institutions.

The Japanese economy then shifted from the “Bubble Boom” into the “Heisei Depression” in 1991. The numbers of newly-established R&D institutions were again reduced during this time. They began to increase at the beginning of the 21st century. In order to avoid ongoing economic depression in the 21st century, restore the viability of enterprises, and maintain competitiveness under pressure from other emerging countries experiencing rapid growth, Japanese enterprises had to allot more importance to R&D

activities at the time (Osaka Prefecture Institute for Advanced Industrial Development 2007)

**Table.3.7. Distribution of Enterprise R&D Institutions in Japan
by Regions (2006-2007)**

Regions	Number of R&D Institutions	Proportion (%)	
Hokkaido	24	0.7	
Touhoku	88	2.7	
Kanto	Ibaraki	165	5.0
	Tochigi	93	2.8
	Gunma	57	1.7
	Saitama	208	6.3
	Chiba	167	5.1
	Tokyo	499	15.1
	Kanagawa	382	11.6
	Sub-total	1,831	55.6
Chubu	Shizuoka	134	4.1
	Aichi	176	5.3
	Others	22	0.7
	Subtotal	332	10.1
Kansai	Kyoto	89	2.7
	Osaka	300	9.1
	Hyogo	173	5.2
	Others	136	4.1
	Sub-total	698	21.2
Chugoku	143	4.3	
Shikoku	68	2.1	
Kyushu Okinawa	112	3.4	
Total	3,296	100.0	

Source: based on Osaka Prefecture Institute for Advanced Industrial Development 2007, pp: 32.

Enterprises' R&D institutions in Japan are mainly concentrated in the Kanto region, of which Tokyo is the center. According to the *Research Report on the Establishment of Enterprises' Institutions* (Osaka Prefecture Institute for Advanced Industrial

Development 2007), 1,831 enterprises' R&D institutions were distributed in the Kanto region in 2005, accounting for more than half of the total (Table.3.7). In particular, Tokyo is the most concentrated area, and is home to 499 R&D institutions. It is followed by Kanagawa prefecture and then Osaka. Nearly one quarter of enterprises' R&D institutions are concentrated in the two areas of Tokyo and Kanagawa.

With respect to industrial distribution, the largest percentage of R&D institutions is within the electricity and electronic manufacturing industry (11.5%). This is followed by the general machinery manufacturing industry (10.3%) and the plastic product manufacturing industry (9.2%) (Table.3.8). R&D institutions within almost all industries are concentrated in Tokyo, while metal product manufacturing and chemical industries make up a high percentage of the R&D institutions in Osaka.

Table.3.8. List of Numbers of R&D Institutions by Industry (2006-2007)

Industries	Numbers of R&D Institutions	Proportion (%)
Electricity and electronic manufacturing	378	11.5
General machinery manufacturing	341	10.3
Plastic products manufacturing	302	9.2
Construction	273	8.3
Food Manufacturing	236	7.2
Other chemical manufacturing	204	6.2
Transportation equipment manufacturing	166	5.0
Pharmaceutical manufacturing	164	5.0
Metal products manufacturing	142	4.3
Others	1,090	33.1
Total	3,296	100.0

Source: based on Osaka Prefecture Institute for Advanced Industrial Development 2007, pp: 41.

It is clear from the above findings that enterprises' R&D institutions in Japan are highly concentrated in the Kanto region, with Tokyo as its center, and it is for this reason that Tokyo has been chosen as the second area of focus for this paper. However, a large number of R&D institutions are also located in the Kanagawa and Saitama prefectures. Therefore, in exploring the location of R&D institutions in Tokyo, it is also necessary to consider the larger area of Tokyo and its surroundings.

3.2.3 Previous Studies on the Geography of Enterprises' R&D institutions in Japan

In Japan, previous geographical studies of R&D institutions have mainly focused on the locations and location factors of R&D institutions. Previous studies have found that most R&D remains extremely highly concentrated in and around Tokyo, despite the fact that assembly and integrated manufacturing systems in Japan are spread across the country (Mano 1987; Kimura 1990; Takeuchi 1996; Nakagawa 1996). Although R&D institutions in Japan were once decentralized away from metropolitan area towards peripheral regions because of promotion policies and acts such as the *Industrial Relocation Promotion Law (1973)* and the *High-tech Industrial Zone Promotion Act (1983-1998)*, they have now returned to metropolitan regions (Ishigami 1986; MLIT 2006).

It is notable that most of the enterprises' R&D departments within electronic industry in Japan have not shown any strong tendency to move away from the Keihin region⁶. This kind of "unipolar concentration" is largely due to the existence of powerful complex, including related industries, research and development, production technology, and mass production of devices and components, which makes the region particularly attractive (Takeuchi 1996).

Nakagawa (1996) has classified R&D institutions into different types according to their industrial sectors, and has analyzed the distributions of different types of R&D. According to his findings, R&D institutions of the basic material type are mainly distributed in Osaka, Ibaraki, Chiba, Toyama, Hiroshima, and Yamaguchi, and most of them are located close to seaside production plants. Assembly and processing R&D institutions are mainly concentrated in Tokyo and Kanagawa, where many of their corresponding plants are distributed. In contrast, most life-related R&D institutions are distributed in regions along the Pacific Belt that are outside the Tokyo metropolitan area. In addition, information service R&D institutions are mainly concentrated in Tokyo and Kanagawa.

With regards to the location factors of R&D, Ishigami (1986) has found that R&D activities tend to be concentrated in big cities, where the important R&D factors of information exchanges and face-to-face communications are much easier to finish. Nakajima (1989) has concluded that there are five location factors of R&D institutions: (i) benefits resulting from access to information sources, (ii) labor costs, (iii) regulations and preferential government policies, (iv) agglomeration forces, and (v) dispersion forces. He points out that R&D location theory, unlike industrial location theory, not only focuses on labor costs but on access to information sources. Furthermore, land factors (e.g., land scale), organization of enterprises (e.g., proximity to headquarters and other departments), and surroundings (e.g., proximity to human resource and information sources) also have a great impact on the location and relocation of R&D institutions (Oda and Saso 1987; Kato et al. 1996; Sato 2004; Nakagawa et al. 1992).

Within countries, control functions are for the most part geographically concentrated

in metropolitan cities (Roger 1997). Extensive research into head-offices and R&D activities has been conducted. In Japan, some studies also have touched on the location relationships between R&D and headquarters. These studies indicate that enterprises attach great importance to proximity to headquarters when deciding on R&D locations, and that this tendency increases in strength for larger enterprises (Nakajima 1989). Moreover, enterprises with single R&D institutions generally locate them together with headquarters, while those with multiple R&D institutions are more inclined to locate them far away from headquarters (Nakagawa 1996). Although many R&D institutions are separate from their headquarters, most tend to be distributed in the region or area close to their headquarters (Mano 1987).

As mentioned in Chapter 2, Akimoto (1989) believes that R&D patterns are closely related to production models, and many R&D institutions have separated from plants to which they formerly belonged. Nevertheless, according to Mano (1987), the distribution of R&D does not follow the decentralization of production plants.

Although many previous studies on R&D location in Japan have been conducted, most of have concerned location analysis on the national scale, while ignoring analysis at the regional or local scale. In addition, despite R&D's proximity to headquarters, previous studies have hardly touched on the location relationships between R&D and both headquarters and plants. More importantly, no research has addressed the dynamic changes in R&D location and location relationships with other organizations over different periods.

Based on this context, taking Tokyo and its surroundings as the study area, and

concerning the location relationships between R&D and other organizations, this paper aims to examine R&D location patterns and their dynamic changes over different periods. In particular, by drawing on the electricity and electronics manufacturing industry, which has the largest proportion of R&D institutions of all industries, this paper employs case studies to further explain how R&D location is affected by the location changes of other organizations and the diffusion of production.

3.4 Summary

This chapter firstly explored the international performance of R&D activities. It found that the U.S. is still the largest country in terms of R&D spending. In recent years, R&D spending in developing countries has grown significantly. In particular, in 2011, China became the second largest country in the world in terms of R&D expenditure, followed by Japan and Germany. It is for this reason that this paper includes China as one of the study countries. Despite the fact that China invests much into R&D input, its level of R&D intensity is still lower than those of other developed countries. Moreover, this chapter shows that enterprises are the main players involved in R&D activities in most countries, and that Japanese enterprises are particularly involved in R&D activities. In contrast to other advanced countries, Japan's government plays a very limited role in R&D activities. This is why this paper includes Japan as the other study country.

This chapter also determined that MNCs are critical players in national R&D activities, and that most enterprise spending is carried out by large MNCs. However, it is notable that although MNCs play an important role in the internationalization of R&D, most R&D activities are undertaken in the MNCs' home countries. Furthermore, R&D

activities are unevenly geographically distributed at both global and national levels, and are highly concentrated in metropolitan areas. Therefore, this paper specifically addresses the necessity to study domestic R&D institutions in metropolitan areas.

Based on an international comparison of R&D activities, this chapter has analyzed R&D performance in China. It shows that large- and medium-sized industrial enterprises have become the main parties involved in R&D activities. Moreover, the industrial concentration of R&D institutions in China is very distinct, with a particular focus on medicine, extraction of petroleum and natural gas, special purpose machinery, and other high-tech manufacturing. There is also a large distribution imbalance in R&D in China. The majority of enterprises' R&D institutions are highly concentrated in East China, and especially in the Yangtze River Delta with Shanghai as its center.

In addition, through a comparison of regional innovation capability, this chapter has found that although Beijing and Shanghai are the two most attractive cities for R&D activity in China, the high R&D intensity in Beijing can be mainly attributed to its abundance of national research institutes, universities, and colleges, while in Shanghai, enterprises are the main performers of R&D. Shanghai is thus regarded as the most innovative city, which is why this paper focuses on the geographic features of enterprises' R&D institutions in Shanghai.

Previous China-focused studies have concentrated on the distribution and location factors of R&D institutions at the national level, but have neglected to engage in detailed analysis at the local scale. Moreover, most previous studies have paid much attention to multinational R&D institutions, but have not involved studies of domestic

enterprises from the perspective of location relationships among intra-firm organizations. This matter will be taken into account in this paper.

After describing R&D activities and related studies in China, this chapter performed a similar analysis of its other region of focus, Japan. As a globally leading country in R&D expenditure, Japan has maintained R&D at a stable level. Although there has been no marked increase in R&D expenditure in Japan over recent years, R&D intensity continues to be at a high level. Japan also invests more into basic research activities than China, and large-scale enterprises play more critical roles in R&D activities in general.

Large numbers of enterprise R&D institutions in Japan were created in both the periods of the 1960s-1970s and the 1980s-1990s, during which the Japanese economy experienced rapid growth. Since the 1990s, newly-built R&D institutions have decreased in number due to the economic depression. In terms of geographic distribution in Japan, most R&D institutions are highly concentrated in the Kanto region, which has Tokyo as its center. In particular, Tokyo and Kanagawa are areas with the highest concentrations of R&D institutions, which is why Tokyo and its surrounding areas are the other study focus of this paper. In addition, the largest numbers of enterprise R&D institutions are within the electricity and electronics manufacturing industry. Therefore, this paper engages in detailed analysis of enterprises' R&D institutions within this industry.

Like previous studies in China, existing studies of R&D institutions in Japan from a geographic perspective also mainly focused on the national scale, and have neglected

the local scale. Furthermore, studies on the R&D institutions' dynamic location changes and their location relationships with other organizations are lacking. The following chapter examines these topics that have previously failed to be uncovered.

Notes:

1. R&D intensity for a country is defined as the R&D expenditure as a percentage of gross domestic product (GDP). The gross domestic expenditure on R&D (GERD) is mainly used for international comparisons of R&D expenditures. As the National Science Foundation explains, "R&D intensity is the most frequently used measure to gauge the relative importance of R&D across industries and among firms in the same industry". In order to explain the relative level of R&D across countries, R&D intensity is used here to make comparison.
2. Hangzhou is the capital and largest city of Zhejiang province in eastern China. A core city of the Yangtze River Delta, its position on the Hangzhou Bay, 180 kilometers southwest of Shanghai, gives it economic power. It is an industrial city with many diverse sectors (such as in light industry, agriculture and textiles), and is considered an important manufacturing base and logistics hub for coastal China.
3. Qingdao is a major city in eastern Shandong Province, Eastern China. Lying across the Shandong Peninsula while looking out to the Yellow Sea, Qingdao is a major seaport and industrial center, and is perhaps best known for its Tsingtao Brewery. It is also home to Haier, a large household appliances manufacturer, and Hisense, a major electronics company.
4. Shenzhen is a major city in Southern China, situated immediately north of Hong Kong. The

area became China's first Special Economic Zone. Being southern mainland China's major financial center, Shenzhen is home to the Shenzhen Stock Exchange as well as the headquarters of numerous high-tech companies.

5. Suzhou is a major city located in the southeast of Jiangsu Province, in Eastern China, adjacent to Shanghai. It is situated on the lower reaches of the Yangtze River and is a part of the Yangtze River Delta region. Suzhou is one of the most prosperous cities in China and is home to many high-tech enterprises.
6. As a large industrial belt along the northwestern shore of Tokyo Bay, the Keihin region is one of the important industrial districts in Japan, and encompasses Tokyo, Yokohama, and Kawasaki cities. The heart of the region is the south of Tokyo (particularly the Shinagawa and Ota wards), as well as the harbor areas of Kawasaki and Yokohama cities.

CHAPTER 4

Location Patterns of Enterprise R&D Institutions in Shanghai

4.1 Science and Technology Policies in China

4.1.1 Transformation of Science and Technology Policies in China

China's science and technology policies can be traced back to the 1950s. In 1956, a draft of a 12-year plan for scientific development was completed and referred to the Soviet Academy of Science for review. However, the Cultural Revolution (1966--1976) brought the development of science and technology in China to standstill. Later, in 1985, a theory of positing that "science and technology are primary productive forces" was put forward by Deng Xiaoping. In 1995, the Chinese government announced the "Decision to Accelerate Scientific and Technological Progress," through which the "strategy of invigorating the country through science and education" was formally proposed. In 2006, realizing the importance of self-innovation, the Chinese government formulated *The National Medium- and Long-Term Program for Science and Technology Development (2006--2020)*, the first formal plan for self-innovation in China.

Before 1992, China's R&D system largely imitated that of the former Soviet Union. In that planned economy, industrial and university R&D activities were managed separately by the central government according to its own plans, while state-owned enterprises undertook production and commercialization. The government was in charge of coordinating R&D and production among the two sectors and providing R&D funds.

However, neither the government nor the R&D institutes could meet market demands effectively under this system, and research results were often different from what enterprises wanted and difficult to apply in industry. Moreover, enterprises had to wait a long time to get feedback from government after submitting an R&D plan, delaying the transfer and commercialization of R&D results. Thus, as the nation transitioned from a planned to a market economy, this kind of China's R&D system could not meet the market demand.

Between 1992 and 1998, the Chinese government called for the "industry-university cooperation" in order to promote the development of industry, science, and technology. In 1992, the "industry-university cooperative project" was launched, making the real beginning of industry-university cooperation in China. Realizing the importance of industry-university cooperation for the commercialization of R&D results and economic development, the government attempted to change its planned R&D system into one fueled by enterprises and research institutes.

While implementing the industry-university cooperative project, the Chinese government also issued support regulations reflecting the requirements expressed by industry and universities, and asked enterprises and R&D institutes to join the project. Foreign R&D activities were also strongly encouraged. The government issued policies for promoting industry-university cooperation, such as (i) promoting the corporatization of research institutes, (ii) encouraging universities and research institutes to nurture business incubators, (iii) enhancing cooperation among research institutes, enterprises, and universities through national science and research projects, and (iv) providing support and preferential policies for enterprise R&D activities. (JETRO 2007)

4.1.2 China's Policies on Enterprise Innovation

China firms benefit from various preferential R&D policies. For example, general industrial enterprises specializing in self-innovation or internal R&D can enjoy preferential policies if their R&D centers are certificated by the government. However, some companies establish R&D centers merely to obtain funding or to enjoy the preferential policies without actually pursuing R&D.

Moreover, the Chinese government has focused on developing high-tech parks as a major way of promoting national innovation, issuing a series of policies designed to encourage enterprises to move to and pursue innovation in them. These high-tech parks generally have their leading industries, and with the support of government, nurture many private science and technology enterprises. A segment of China's R&D institutions are ranked as national-, regional- or city-level technology centers according to their innovation ability, R&D contribution, and scale. These enterprises also enjoy different preferential policies. Though this rating system can motivate enterprises to launch R&D activities, it also causes them to make short-sighted decisions designed to reap the policies' benefits and obtain government support; it also inhibits innovation competition (Figure.4.1).

In the initial stages of reform and opening up, the Chinese government issued a series of policies to attract foreign investment. For example, foreign-funded enterprises enjoyed lower income tax rates, which triggered rapid economic growth. However, these policies also placed domestic enterprises in an unfair competitive environment, which strongly affected their innovation enthusiasm (Li 2008).

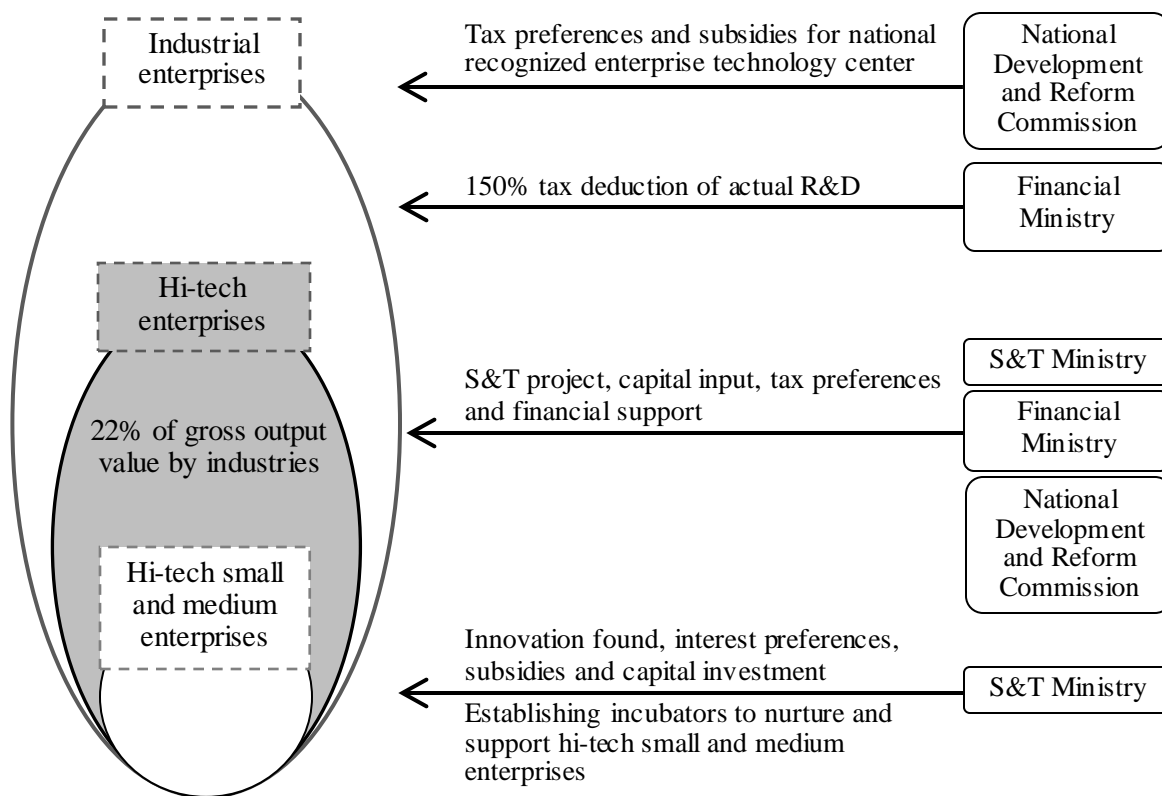


Figure.4.1. Favorable Policies on Self-innovation of Different Enterprises

Source: based on JETRO 2007, pp: 27.

4.2 Overview of Shanghai

Shanghai sits at the mouth of the Yangtze River on China's eastern coast. It is bordered on the north and west by Jiangsu Province, on the south by Zhejiang Province, and on the east by the East China Sea. The city proper is bisected by the Huangpu River, a tributary of Yangtze River. Shanghai is administratively equal to a province and is divided into 19 county-level districts¹ that collectively cover 6340.5 km². 18 districts and one county (Figure.4.2). These divisions are further divided into three subdivisions, according to the distance from the center: the central city inside the outer ring road, the

suburban areas, and the outer suburbs outside the outer ring road. The 2010 census revealed that the population of Shanghai has reached 23.02 million. Due to this rapid growth in the last two decades, Shanghai has again become one of the world's leading cities, exerting influence over finance, commerce, fashion, and culture. Shanghai has also become the most innovative region because of its favorable commercial climate, strong industrial foundation, and close economic links with Yangtze River Delta.

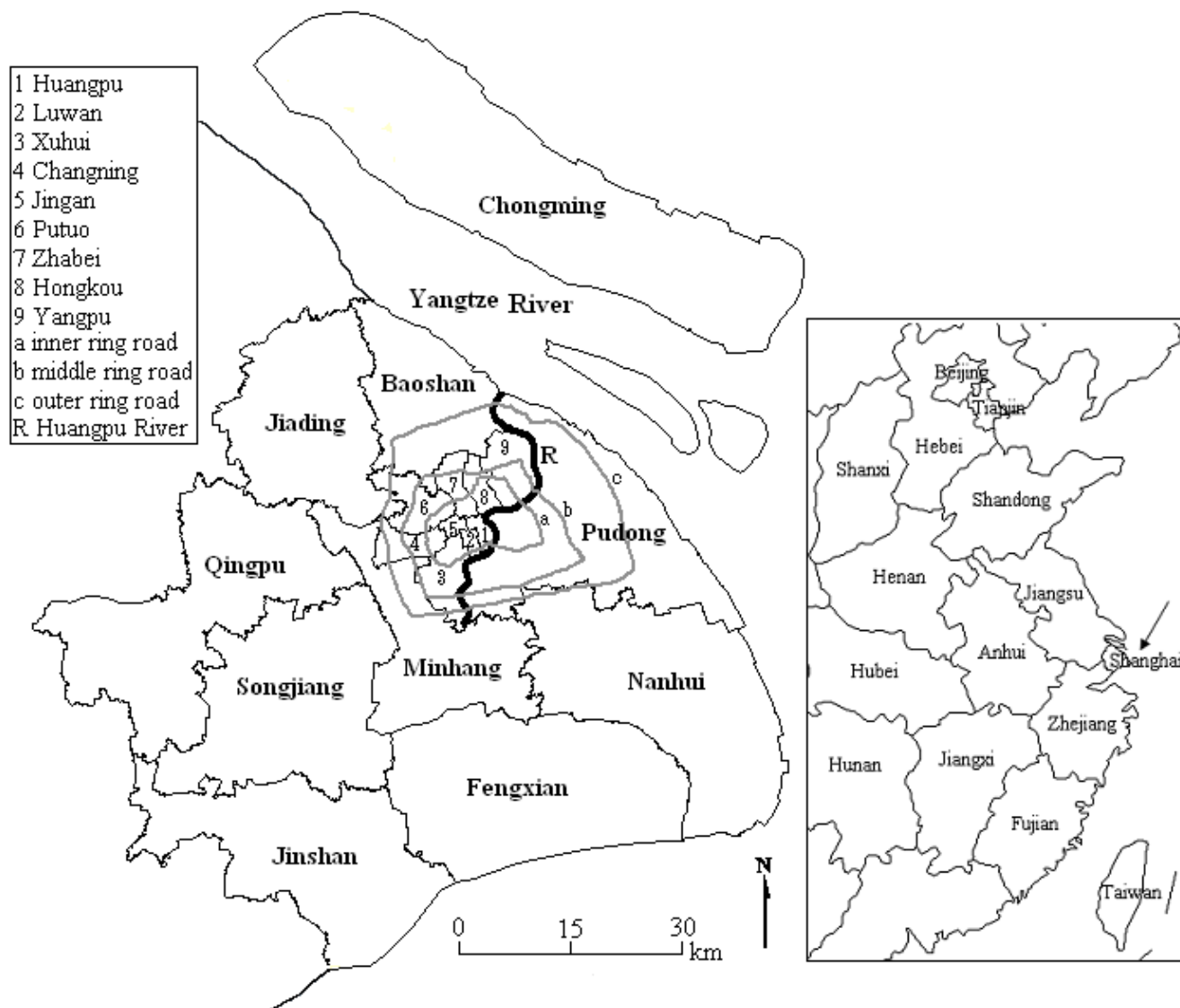


Figure.4.2. Administrative Map of Shanghai

4.3 Data and Method

This chapter explores the location patterns of enterprise R&D institutions through empirical analysis. Firstly we use statistical data to introduce the characteristics of enterprise R&D activities in Shanghai, such as their industrial features, enterprise scales, in order to grasp enterprises' overall R&D performance. Using the statistical data, the overall distribution of enterprise R&D institutions is also described.

This chapter also provides a detailed description of the firms' location patterns by analyzing a sample of enterprises, part of which comes from *Entrepreneurship, Innovation and Creation: Report on Shanghai's Private Enterprises' Innovation* (Shanghai Private Economy Development and Promotion Center 2006). Profiles on innovation achieved by private enterprises in the equipment, information, chemical and pharmaceutical, and other emerging industries are included in that report, as are some of the samples used in this paper.

However, these profiles, which include only private enterprises, cannot provide all the necessary data on R&D. Therefore, additional samples were collected from websites on Shanghai enterprise R&D institutions. Moreover, because most previous studies have focused on MNCs, we take domestic enterprises as our main study samples in this paper. By collecting the samples, we obtained a preliminary data set of 191 enterprise R&D institutions. Then, we verified the collected data by targeting the 191 enterprises via phone and email, in order to increase the data's reliability. This process produced 92 valid data, comprising 91 enterprises (one enterprise with two R&D institutions is included). Among these, 81 are in manufacturing, seven in software, three in finance,

and one in environmental management.

Based on the surveys, this chapter presents the spatial distribution characteristics and industrial features of the 92 sample R&D institutions, and then analyzes their location types by evaluating the location relationships between them and other organizations. As most of the sample enterprise R&D institutions are in manufacturing (88.8%), the samples used for analysis of location types are restricted to the 81 R&D institutions from manufacturing, including 65 enterprises founded with Chinese capital, 15 enterprises founded with foreign capital, and one Sino-foreign joint venture. Based on the analysis of location types, this chapter also examines the location patterns and industrial features of the institutions according to their location types. Furthermore, through case studies involving different location types and industries, this chapter explores the factors influencing the location of manufacturing enterprise R&D institutions at the local level.

4.4 Enterprise R&D Institutions in Shanghai

4.4.1 R&D Institutions of Large- and Medium-Sized Enterprises

Large- and medium-sized enterprises² play an important role in R&D activities of Shanghai. As Figure.4.3 indicates, science and technology personnel have a much stronger presence in larger and medium industrial enterprises than they do in universities and research institutes. In 2010, enterprise R&D expense in Shanghai reached 32.1 billion yuan, with a proportion of 66.7% of the total in Shanghai, among which 23.8 billion yuan (about 74.0% of the total enterprise R&D expenses) was implemented by large- and medium-sized industrial enterprises. By the end of 2010, the

number of large- and medium-sized enterprise R&D institutions had reached 638, most of which (55.5% of the total) was from foreign-funded enterprises³, followed by limited liability and share-holding corporations, and private-funded enterprises (Table.4.1). These statistics indicate that foreign-funded enterprises in Shanghai play an active role in R&D. We also found that industry concentration is extremely distinct (Table.4.1): more than one half of R&D institutions are concentrated in the manufacturing of communication, computer, electrical and, transport equipment, as well as specialized equipment.

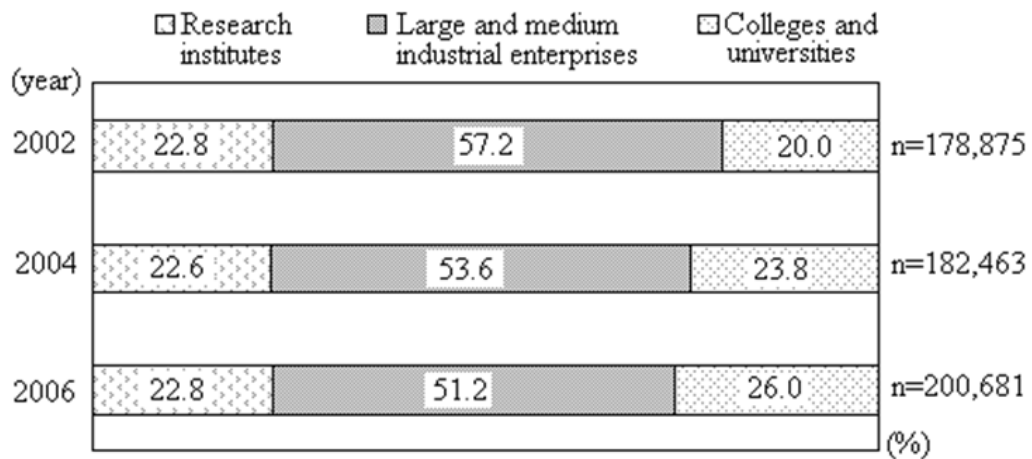


Figure.4.3. Science and Technology Personnel in Shanghai by Institution

Source: Lin et al. 2007.

Table.4.1. R&D Institutions in Large- and Medium-sized Industrial Enterprises in Shanghai (2010)

	R&D Institutions (Unit)	R&D Personnel (Person)	R&D Expenditure (Million)
Total	638(100%)	68273	22068.7
Type of Registration			
State-owned Enterprises	24 (3.8%)	2037	684.3
Collective-owned Enterprises	2 (0.3%)	92	1.4
Limited liability & Share-holding Enterprises	148(23.2%)	17515	5554.3
Private funded Enterprises	106(16.6%)	6369	999.1
Foreign-funded Enterprises	354(55.5%)	42152	14793.9
Others	4 (0.6%)	108	35.613
Industry	Number of R&D Institutions		R&D Personnel
Communication Computer, Other Electronic Equipment	104 (16.3%)	19182 (28.1%)	
Electrical Machinery and Equipment	104 (16.3%)	6999 (10.3%)	
Transport Equipment	80 (12.5%)	15748 (23.1%)	
Specialized Equipment	69 (10.8%)	4950 (7.3%)	
General Purpose Machinery	61 (9.6%)	6347 (9.3%)	
Chemical Raw Material and Chemical products	42 (6.6%)	2495 (3.7%)	
Medicine	30 (4.7%)	2674 (3.9%)	
Others	148 (23.2%)	9878 (14.5%)	

Source: Shanghai Statistical Yearbook on Science and Technology 2011.

As mentioned, foreign-funded enterprises in Shanghai play an active role in R&D activities. Shanghai has become one of the main destinations for MNCs' R&D institutions. On national-level, they are mainly located in Shanghai, Beijing and Guangdong province, and they also exhibit industrial differences according to regions (Du et al. 2010). In Beijing, most of MNCs' R&D institutions are from the electronic communication industry, whereas Shanghai attracts R&D institutions mainly from the electronic communication, chemical manufacturing, transportation equipment, and medicine manufacturing industries.

Furthermore, R&D institutions from different host countries also exhibit distinct destination preferences. For example, Japanese companies are much more inclined to invest in R&D in the Yangtze River Delta with Shanghai as its center (Figure.4.4), whereas R&D institutions by Korean companies prefer the Bohai coastal region (Du et al. 2010).

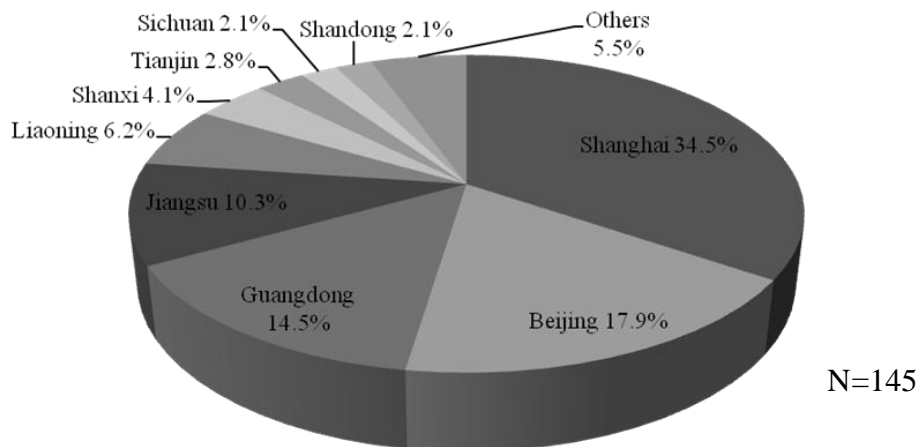


Figure.4.4. Distribution of Japanese Enterprise R&D Institutions in China

Source: based on Intellectual Property Rights Department, JETRO Beijing 2007, pp: 36.

During the 1990s, almost all large- and medium-sized enterprise R&D institutions were distributed in the center of the city (Figure.4.5). In 1992, the number of R&D institutions in Yangpu district was the largest. In 1996, along with the development and opening up of Shanghai Pudong, Pudong replaced the Yangpu district as the most attractive area for R&D institutions.

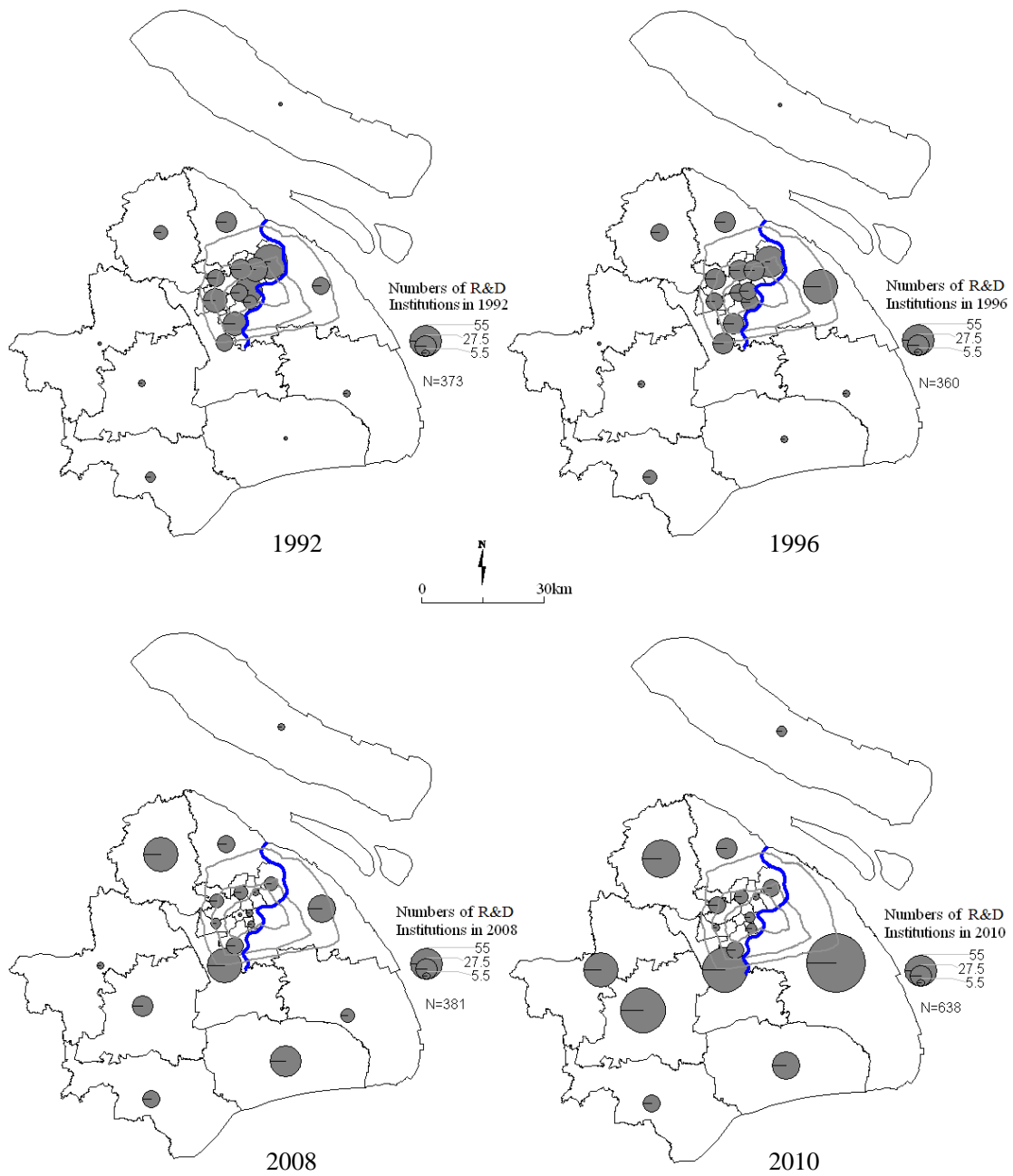


Figure.4.5. Spatial Distribution of Large- and Medium-sized Industrial Enterprise R&D Institutions in Shanghai

Note: i. In August 2009, Nanhui District merged into Pudong New area. Therefore, the boundary between Nanhui District and Pudong New area is not seen in the fourth picture.

ii. The statistics on the numbers of large- and medium-sized enterprise R&D institutions by district are discontinuous and they cannot be found in the yearbook for some years. We therefore chose data for 1992, 1996, 2008, and 2010 to describe the distribution changes.

Source: compiled by author according to the data of *Shanghai Statistical Yearbook on Science and Technology*.

Since 2000, a tendency toward decentralization has become increasingly distinct. Many R&D institutions have been decentralized to suburban districts, while fewer are operating in the central areas. As is well known, most large- and medium-sized industrial enterprises are engaged in manufacturing and thus need wide land areas. Therefore, while expanding, they are also inclined to transfer to places where they can obtain large areas of land at low costs. Meanwhile, the establishment of industrial parks in suburban areas that offer preferential policies has accelerated suburbanization.

4.4.2 R&D Institutions of PSTEs

Another R&D institutions type operating in Shanghai, private science and technology enterprises (PSTEs), is also vital to economic development and innovation. These PSTEs are knowledge and technology-intensive economic entities established by science and technology personnel and engaged mainly in R&D, technology transfer, consultation and services, and the commercialization of research results. At first, many PSTEs were founded by Chinese scholars who had returned from overseas.

The first PSTE was founded in Shanghai in 1983. By 1985, there were only 120 PSTEs in Shanghai, but they have continually increased ever since. By 2006, their number had reached 15,134. The R&D intensity of Shanghai's PSTEs has reached 5%, exceeding 10% for some enterprises, higher than the average of all enterprises in Shanghai. Many excellent PSTEs are blooming, such as Shanghai Jiaoda Only, Fudan Microelectronics Group Company, and Forward. Currently, PSTEs have been extremely active in creating employment opportunities for science and technology personnel, employing nearly 78.5% of all R&D personnel in Shanghai (Table.4.2).

Table.4.2. R&D Personnel of PSTEs in Shanghai (2006)

	PSTEs (unit)	A R&D Personnel in PSTEs (person)	B Total R&D Personnel in Shanghai (person)	A/B (%)
Number	15,134	62,870	80,140	78.5

Source: Shanghai Statistical Yearbook on Science and Technology 2007.

The distribution features of PSTEs differ from those of large- and medium-sized enterprise R&D institutions. Despite the large growth in PSTEs, most are still concentrated in the center of the city (Figure.4.6). The suburbanization of PSTEs was obvious from 1992 to 2000. By 2006, however, their presence in the central areas had greatly increased. Moreover, along with the transfer of university campuses to suburban areas and the establishment of industrial parks, the number of PSTEs in the suburban areas increased, particularly in Minhang, Songjiang, and Jinshan districts.

Many factors influence the spatial variation of PSTEs. The most important is regional science and technology policies. As early as 1998, a working group for joint service on science and technology, composed of government organizations, such as the departments of S&T, industry and commerce, finance and taxation, and personnel, was founded in Putuo district. These departments helped PSTEs solve problems efficiently. Meanwhile, cooperation between the S&T and finance departments was promoted in order to resolve the issue of PSTEs funding. The government helped some small PSTEs with pressing demand for capital but no ability to create mortgages, to cooperate with enterprises that are financially strong. Many PSTEs were attracted to Putuo district, which in 2000 had the largest number of PSTEs, because of such policies.

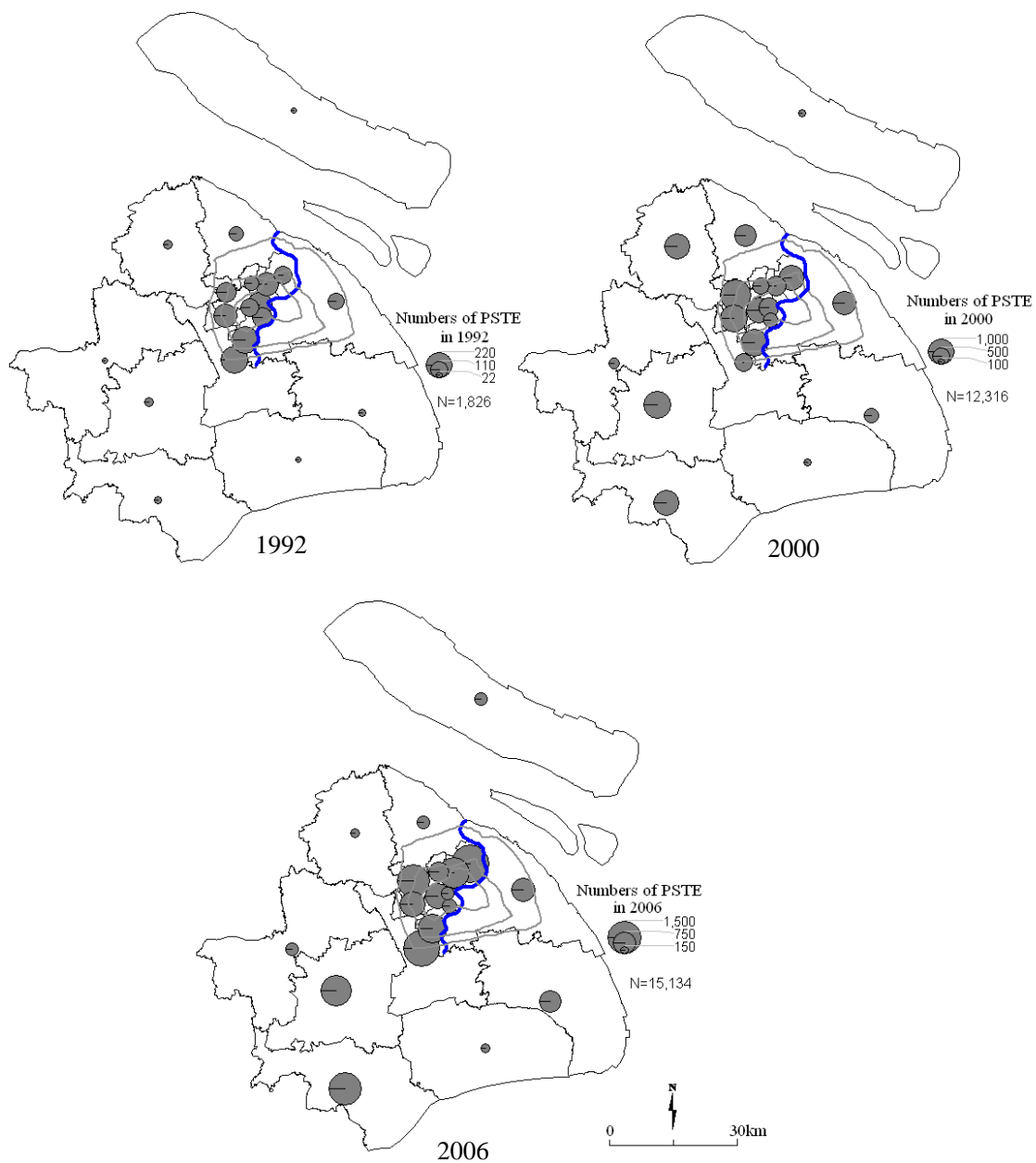


Figure.4.6. Spatial Distribution of PSTEs in Shanghai

Source: compiled by author according to the data of Shanghai Statistical Yearbook on Science and Technology.

The other key point is the cooperation between colleges and enterprises. For example, Yangpu district⁴ promotes the “Knowledge of Yangpu” concept, and has helped create science parks for Fudan University, Tongji University, and the Fisheries University as well as the Yangpu incubator center, designed for use by PSTEs.

Moreover, “three-zone linkages”--links among the university campuses, the S&T parks, and the community-- have also been built in Yangpu district. The university produces talent; the S&T parks promote R&D and realize commercialization; and the community creates a favorable environment for sustainable development. This linkages system is one of the most important reasons why PSTEs are concentrated in the Yangpu district. Meanwhile, the number of PSTEs in Minhang and Songjiang districts had greatly increased by 2006, ever since the Zizhu science park and the university campuses of Shanghai Jiaotong University and East China Normal University were established there. The establishment of the university town and the industrial park in Songjiang district also attracted a number of PSTEs.

4.5 Location Patterns of Enterprise R&D Institutions in Shanghai

Based on the systematical introduction on the characteristics of R&D activities in Shanghai, this part explores the location types and location patterns of enterprise R&D institutions.

4.5.1 Spatial Distribution of Sample Enterprise R&D Institutions

Of the 92 sample R&D institutions, the largest number are in the chemical and chemical products industries (18, 19.6%), followed by chemical products machinery and equipment (14, 15.2%), communications equipment, computer and other electronic equipment (12, 13%), and pharmaceutical and medical (8, 8.7%) industries. Figure.4.7 shows the distribution of the 92 enterprise R&D institutions. It shows that the non-manufacturing R&D institutions are all located in the core areas of the central city. In contrast, the R&D institutions of the manufacturing enterprises are distributed among

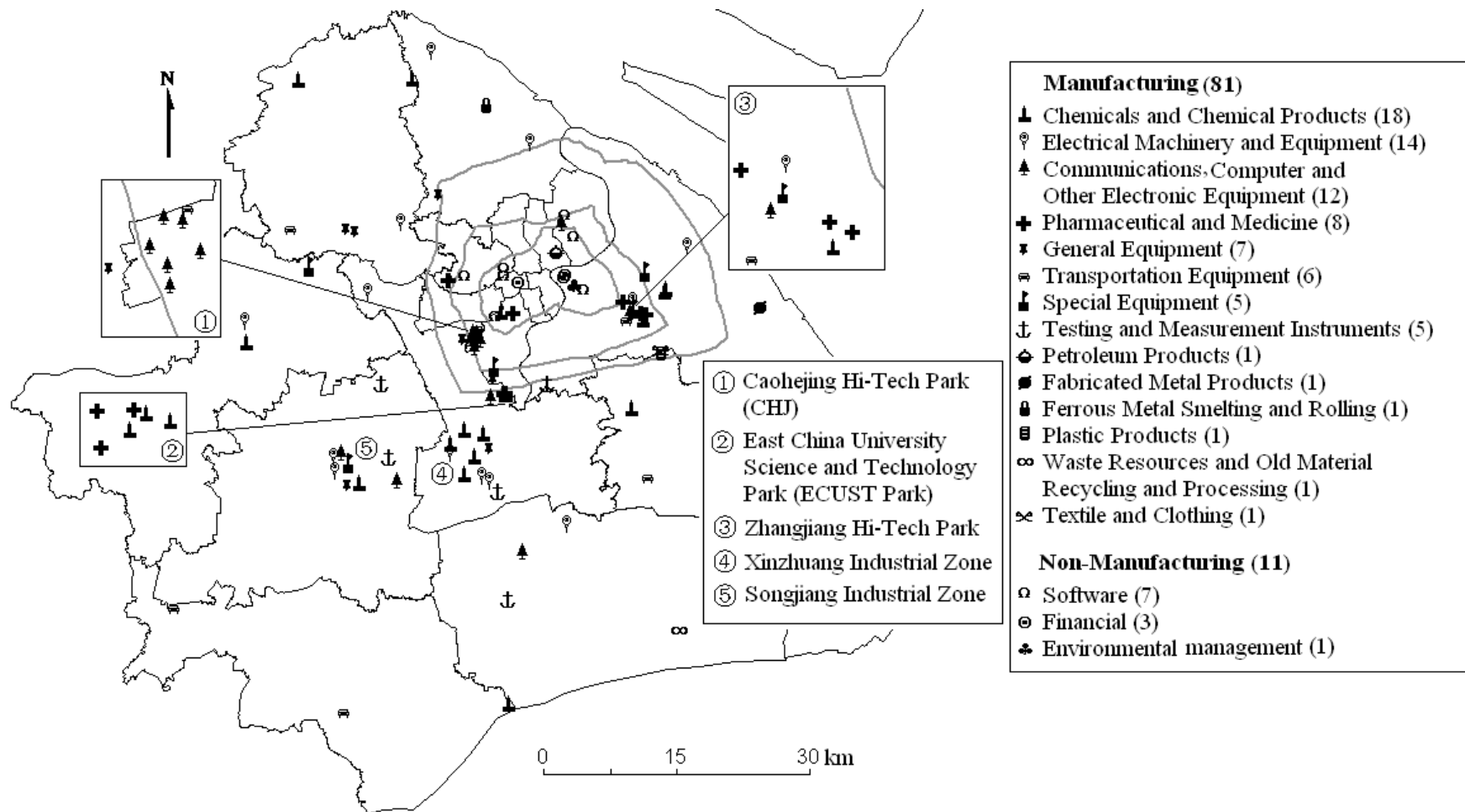


Figure.4.7. Spatial Distribution of Sample Enterprise R&D Institutions

Note: The sample enterprise R&D institutions in this figure include 65 of domestic enterprises, 15 governed by foreign capital and one founded by sino-joint ventures.

Source: author's survey.

various districts from the central city to the suburbs.

Meanwhile, although the decentralization of the R&D institutions of manufacturing enterprises is obvious, industrial zones and high-tech parks have become popular areas for enterprise R&D institutions, accounting for 52 of them, representing 64.2% of the total for manufacturing, particularly being concentrated in Caohejing High-tech Park (CHJ)⁵, East China University Science and Technology Park (ECUST Park)⁶, Zhangjiang High-tech Park⁷, Xinzhuang Industrial Zone⁸ and Songjiang Industrial Zone⁹. It can also be seen from Figure.4.7 that the R&D institutions in different industries show distribution differences. R&D institutions in the chemicals and chemical products industry are mainly located in ECUST Park and the Xinzhuang Industrial Zone in the middle and south of Shanghai; the R&D institutions in the communications and computer and other electronic equipment industries are concentrated in CHJ; most of the R&D institutions in the pharmaceutical and medicine industries are in ECUST Park and Zhangjiang High-tech Park, whereas the R&D institutions in other industries are scattered throughout the suburban areas.

This spatial pattern is conditioned by the development process and strategy of each industrial zone and high-tech park. For example, the earliest embryonic form of CHJ is “Caohejing Microelectronic Industrial Park”, which was established in 1984 for the purpose of attracting foreign investment and advanced high technology. Then the upstream and downstream industries also followed on and thus companies from the industries of microelectronics, computer, communications, biomedicine and automobile are concentrated in CHJ. Regarding Zhangjiang High-tech Park, at the first stage of its establishment, the government issued a clear-cut instruction that biomedicine would be

one of the leading industries in Zhangjiang High-tech Park. In the following period, one part of Zhangjiang High-tech Park, Zhangjiang biotech and pharmaceutical base known as “Zhangjiang Pharmaceutical Valley” was founded and has become one of the largest concentrations of pharmaceutical R&D institutions in China.

As mentioned above, foreign-funded enterprises play a positive role in promoting R&D activities. A previous study (Xu and Du 2004) contains an analysis of the distribution of R&D institutions governed by foreign capital in Shanghai, allowing us to see the spatial similarities and differences between R&D institutions governed by domestic and foreign capital enterprises.

Figure.4.8 shows that R&D institutions managed by foreign capital show a much higher concentration than those managed by domestic enterprises, especially high concentrations in CHJ and the Zhangjiang High-tech Park inside the outer ring road. Ever since the industrial zones and high-tech parks were established, the government has built much infrastructure and has implemented a series of preferential policies to attract foreign investment and high-tech enterprises, making industrial zones and high-tech parks the preferred locations for foreign investors. Moreover, as the two most developed business parks, CHJ and Zhangjiang High-tech Park are now amongst China’s most high-profile business parks, and have become hot spots for foreign R&D in Shanghai (Jones Lang LaSalle 2008).

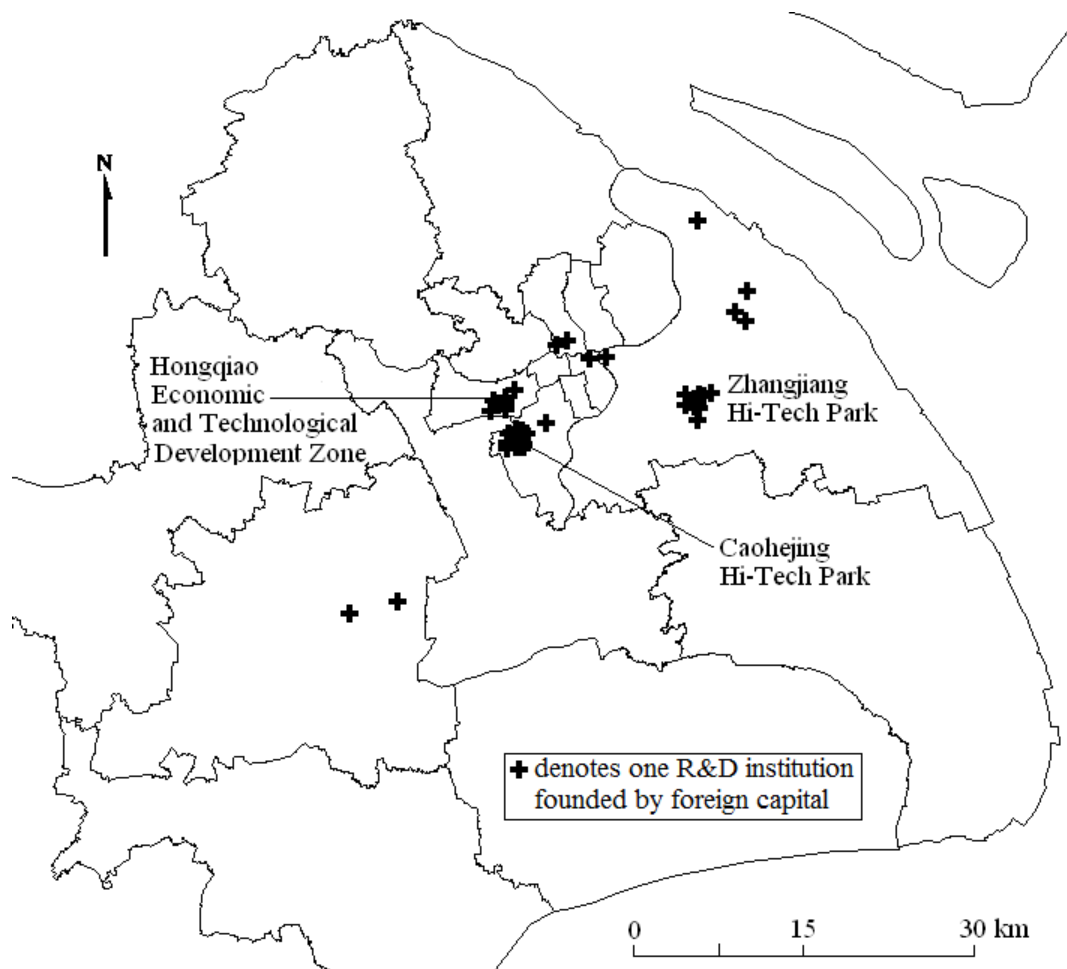


Figure.4.8. Spatial Distribution of Enterprise R&D Institutions Founded by Foreign Capital

Source: based on Xu and Du 2004, pp: 626.

4.5.2 Location Types of Enterprise R&D Institutions in Terms of Location Relationships among Intra-firm Organizations

To be profitable, business firms and forms of organizations are allocated territorially or regionally (Walker 1988). Companies organize the activities required for creating and selling products territorially or regionally and thus allocate these activities within their own enterprises and among the other firms with which they interact. Such managerial allocation of the steps involved in the production and sale of goods creates linkages of

economic activity within and across firms (Fields 2006). R&D institutions' locations and their location relationships with other intra-firm organizations can reflect an organizational distribution of economic activity. The location features that the enterprise R&D institutions form spatially and the relationship between these R&D institutions and other intra-firm organizations comprise the focus of this section.

According to the location relationships between R&D institutions and other departments, the surveyed enterprise R&D institutions are classified into four location types which have been mentioned in chapter 1: (1) the same location as headquarters and production plant (H+P+R type), (2) the same location as headquarters (H+R type), (3) the same location as production plant (P+R type), and (4) Independent R&D institutions: independent location from other organizations (R type). There are 42 R&D institutions of H+P+R type in the survey, accounting for the largest proportion (51.9%); followed by the R&D institutions of H+R type (16, 19.8%), R type (16, 19.8%), and P+R type (7, 8.6%), as summarized in Table.4.3.

Apparently, most enterprises allocate R&D institutions together with headquarters and productions. However, although production links are essential for enterprises in the manufacturing industry, more R&D institutions are allocated with headquarters than those with the production plant. Moreover, some enterprises of H+R type choose commission production in order to realize commercialization, despite the fact that related production activities are generally launched in their own production plants. There are 3 enterprises of the H+P+R type with parent companies from domestic cities other than Shanghai, 8 enterprises of the R type run by foreign entities, and 7 run by domestic enterprises with headquarters in other cities. It is notable that among

Table.4.3. Industrial Distribution of Enterprise R&D Institutions by Location Type

Location Types	Industry	Remarks
H+P+R Type (42)	Electronic Machinery and Equipment (9) Chemicals and Chemical Products (8) Special Equipment (5) Communication Equipment, Computer and Other Electronic Equipment (4) General Equipment (4) Testing and Measurement Instruments (4) Transportation Equipment (3) Others (5)	Foreign-funded Enterprises (3) Sino-foreign joint ventures (1) Parent companies in cities other than Shanghai : Zhejiang Province (3)
H+R Type (16)	Chemicals and Chemical Products (5) Pharmaceutical and Medicine (4) Communication Equipment, Computer and Other Electronic Equipment (2) Electronic Machinery and Equipment (2) Others (3)	Foreign-funded Enterprises (3) Enterprises with their own production sector (14) Enterprises commissioning production in other companies (2)
P+R Type (7)	Chemicals and Chemical Products (2) Electronic Machinery and Equipment (2) General Equipment (2) Transportation Equipment (1)	
R Type (16)	Communication Equipment, Computer and Other Electronic Equipment (6) Chemicals and Chemical Products (3) Pharmaceutical and Medicine (3) Others (4)	Foreign-funded Enterprises (8) Domestic Enterprise with headquarters in Shanghai (1) Domestic Enterprises with headquarters in cities other than Shanghai (7): Beijing (2), Jiangsu Province (2), Zhejiang Province (1), Shandong Province (1), Guangdong Province (1)

Note: Numbers in brackets indicate the numbers of R&D institutions.

Source: author's survey.

enterprises from domestic cities other than Shanghai, the enterprises from Zhejiang Province (which borders Shanghai) are most numerous, and next is Jiangsu Province near Shanghai, indicating that geographical proximity is significant in the regional allocation of economic activities.

4.5.3 Location Patterns of Enterprise R&D Institutions by Location Type

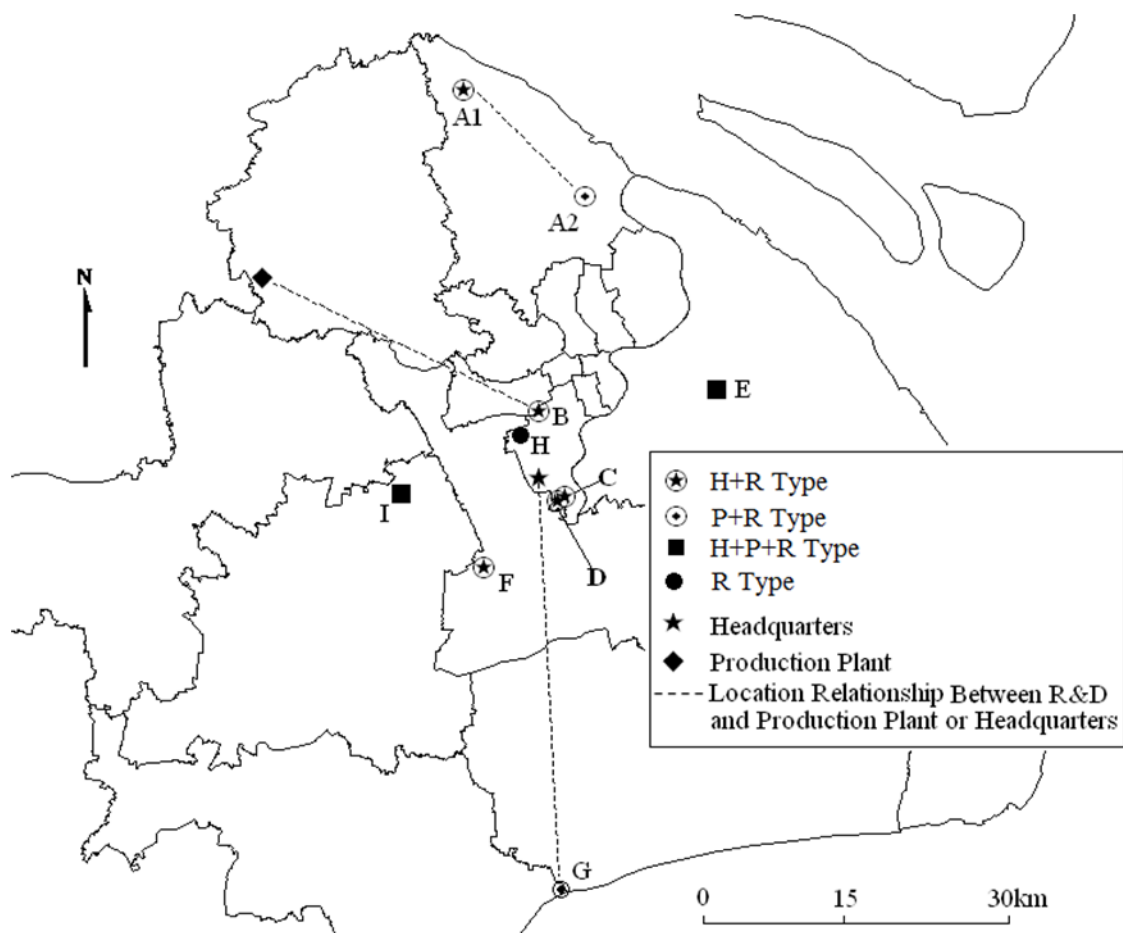


Figure.4.9. Location of Case Enterprise R&D Institutions

Source: author's survey.

The location patterns of R&D institutions vary according to the content of the R&D and their location types differ according to the product and industrial features

(Nakagawa 1996). For example, company A (Figure.4.9)¹⁰, founded on a firm of actual electrical equipment manufacturing, produces high-voltage electrical equipment and related components. Two R&D institutions are set up in company A at different sites. One R&D institution (A1), handling electronic components, is located at the same place as the headquarters, and the other one (A2), handling high-voltage electrical equipment, is established in a newly funded production base. Consequently, industrial differences across firms and product divisions within a single firm can result in a diversity of R&D location types and patterns.

H+P+R type R&D institutions are concentrated in the chemicals and chemical products and equipment manufacturing industries (Table.4.3). These enterprises include many related upstream and downstream industries and are very sensitive to land cost; they are therefore inclined to be located in suburban areas (Figure.4.10-a). In addition to equipment manufacturing, a minority of R&D institutions in other industries (such as pharmaceutical and medicine and waste resources and old material recycling and processing) are concentrated in ECUST Park. The products for those enterprises are more sensitive to market needs, and their land use scales are relatively smaller; they therefore prefer to be close to central areas with large markets.

Secondly, more than half of the H+R type R&D institutions are in the chemicals and chemical products and pharmaceutical and medicine industries, followed by equipment manufacturing. As shown in Figure.4.10-b, these R&D institutions are primarily located in CHJ and ECUST Park in Xuhui District and Zhangjiang High-tech Park in Pudong New Area. Moreover, among the 16 H+R type R&D institutions, only 5 enterprises have established production plants in Shanghai, all being located in suburban areas outside

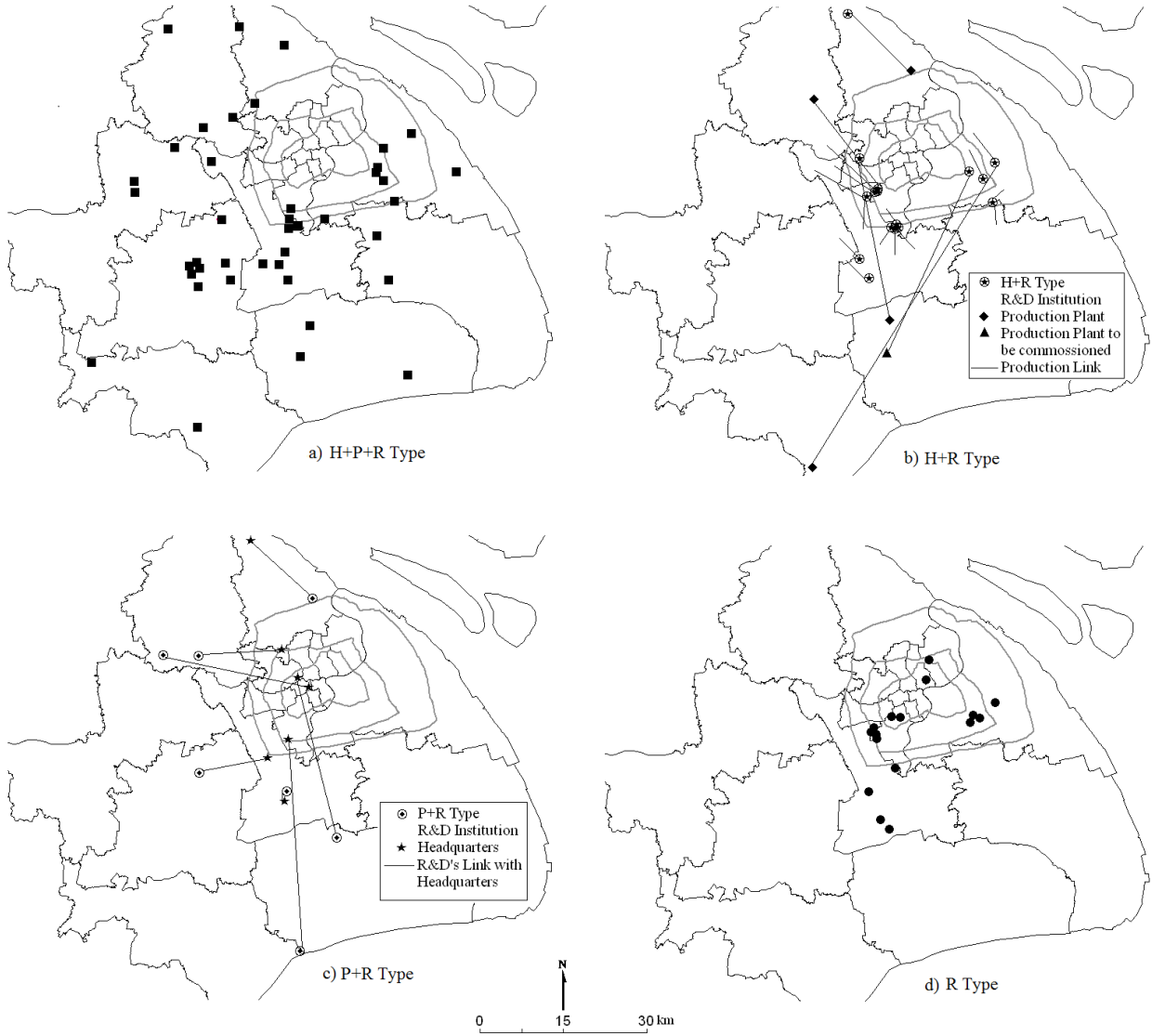


Figure.4.10. Location Patterns of Enterprise R&D Institutions by Location Type

Note: The line without end point in figure b) denotes that the production plant is located in a city other than Shanghai.

Source: author's survey.

the inner ring road, while all of the other production plants are in cities other than Shanghai.

Location allocation is a combinatorial optimization problem, which involves industrial features and product characteristics. Consequently, enterprises running H+R type R&D will have production models adapted in different ways. According to the surveys, enterprises with H+R type R&D institutions are divided into two subtypes according to their production way. The first type is an enterprise with a fixed production site. In the case of company B (Figure.4.9), the R&D institution and production plants were initially located in CHJ together with its headquarters. As the enterprise grew, company B began to seek cheaper and larger land for its production site because the land available could not meet the needs of production expansion. Then, the production plant was transferred to its present site, Anting town in Jiading district (in the outer suburbs), while the R&D institution remained at the original site, together with the headquarters. Another example is company C being engaged in pharmaceutical production. Its headquarters and R&D institution are located in ECUST Park, whereas its production plant is set up in Hangzhou, near Shanghai.

The second type is an enterprise with a non-fixed production site. An example of this type is company D. Its headquarters and R&D institution are located in ECUST Park (in Xuhui district), but the production plant is located in another city of Changzhou¹¹, near Shanghai. Company D has established partner relationships with clients in Changzhou. It is not only easier and cheaper to lease production sites and equipment in Changzhou (thus generating cost savings), but also very helpful in strengthening communication with customers so that the products can reach them

quickly. Usually, this type of enterprise begins with developing new products, and then seeks the proper production plant and performs secondary development once market feedback is received. Influenced by the rising land costs in urban areas, more enterprises are using this way to undertake R&D activities and complete the commercialization of R&D results.

P+R type R&D institutions are the least common. Of the 7 P+R type R&D institutions, 5 are in equipment manufacturing (Table.4.3). For these industries, there are close links between production and R&D activity and high demand for trial-production and production. In order to speed up the process from research and development to commercialization, the R&D institutions tend to be close to the production plant. The decentralization of the P+R type R&D institutions into the outer suburbs is very obvious in Shanghai due to the need for large scale areas of land, whereas the headquarters are almost allocated in the central city (Figure.4.10-c).

Lastly, attention is turned to the independent institutions (R type). They are separate from the headquarters and plants and generally engaged in R&D activities aiming at providing R&D services to headquarters, plants, or other enterprises. Independent R&D institutions mainly occur in high-tech industries of communication equipment, computer and other electronic equipment, chemicals and chemical products, and pharmaceuticals and medicine (Table.4.3). Enterprises from these industries, for which product update speed is the key to competitiveness, put emphasis on the role of R&D. They are extremely sensitive to market and technological changes and prefer areas with an active innovation atmosphere and advantageous locations. As shown in Figure.4.10-d, the majority of the independent R&D institutions are located in areas inside the outer

ring road, mostly concentrated in CHJ, Xuhui district and Zhangjiang High-tech Park, Pudong New Area.

As shown above, most domestic enterprises in Shanghai currently allocate headquarters, production sectors, and R&D institutions at the same location. Meanwhile, different location types and patterns occur as R&D institutions separate from other organizations. In the process of reallocating inter-firm departments territorially and regionally, R&D institutions usually become attached to headquarters, whereas a minority of the R&D institutions are located together with production plants, and many production sectors are transferred from Shanghai to other cities. Of course, this division of labor is not absolutely organizational and geographical, but rather industrial and social. In spatial terms, there are location similarities among the different types of R&D institutions. H+R type and R type R&D institutions have similar location patterns, and most of them are located in areas near the central city, particularly in industrial zones and high-tech parks (Figure.4.10-b and d). In addition, the decentralization of manufacturing enterprise R&D institutions to the suburbs is obvious, which is particularly evident for the H+P+R and P+R types of R&D institutions. These indicate that it is only the transfer of manufacturing production away from the central city that leads to the geographical decentralization of R&D activities, which can also bring about transformations in urban function and spatial structure.

4.6 Location Factors of Enterprise R&D Institutions in Shanghai

This section focuses on the local-scale factors that condition the distribution of enterprise R&D institutions in Shanghai using the interview surveys towards sample

enterprises. Shanghai's rich talent resources and relatively complete infrastructure are primary elements in the development of its R&D activities. More and more enterprises realize that choosing Shanghai is helpful to seize the huge market of Yangtze River Delta. However, each enterprise has its own concerns, and many lay emphasis on different factors at different stages. In order to explain enterprises' heterogeneity, we chose one enterprise from each type of R&D institution, all of which are from different industries, and explore the location factors through case studies of each of them.

4.6.1 Case study Analysis of Location Factors

■ Case of H+P+R type: company E

Company E (Figure.4.9), established in 1998, is located in Zhangjiang High-tech Park. It is an enterprise specializing in the development, production, and sale of electric double layer capacitors and ultra-capacitors. Its ratio of R&D personnel reaches 20%, and its R&D expenditure has reached 10% of total product sales. In addition to undertaking R&D activities in the R&D base, company E also carries out theoretical and basic research in cooperation with universities. It has a production center, a test center, a standardization center, an intellectual property department, and a project department in the R&D base, and each task must be performed by professionals in all departments of the R&D base. Consequently, proximity to an area with rich human resources becomes a key location factor for ensuring the efficiency of R&D activities.

Meanwhile, as a new energy storage device, the ultra-capacitor plays an important role in saving energy, and its development and popularization have enjoyed strong support from the government. Moreover, with the recent transfer of traditional manufacturing to middle and western China, Shanghai has issued a series of preferential

policies to encourage enterprise to enter these new industries. Therefore, company E also focuses strongly on preferential policies, thus getting technological and financial support for the improvement of its innovation capability.

For company E, it does not only help to ensure demand for talent to be located in Zhangjiang High-tech Park with rich human resources but also contributes to adopting an integrated management way to realize its commercialization. However, although company E regards rich human resources as a favorable factor, it does not think more about the importance of an R&D institution's proximity to universities or public research institutes due to well-developed transportation system and communication network in Shanghai.

Moreover, the number of enterprises engaged in the production of ultra-capacitors is still relatively small in Shanghai; thus, company E pays more attention to its interaction with upstream and downstream enterprises than to industrial agglomeration. Furthermore, given the enterprise's growth and the rise in land costs in Zhangjiang High-tech Park, company E will look for a new site with lower land costs nearby for its production base. When the R&D institution becomes able to take on more R&D programs, it will be considered to be separated from intra-firm organizations. This shows clearly the strong possibility that a separate organizational structure will be formed in company E because of the increasing R&D strength and investment inhibitions caused by rising land costs.

■ Case of H+R type: company F

Company F, founded in 1992, develops and produces high polymer materials and

has become a leading enterprise in the Chinese plastic engineering industry (Figure.4.9). At first, its organizations were located in Shanghai. As the enterprise expanded, company F transferred its production plants outside of Shanghai, establishing new production bases in Hefei (Anhui Province) in 2006, Panjin (Liaoning Province) in 2008, and Chuzhou (Anhui Province) in 2009, while its R&D institution and headquarters are still located in Shanghai. It has one central R&D institute in Shanghai, close to the Minhang campus of Shanghai Jiaotong University, and more than 85% of the R&D personnel hold Masters degrees, or higher or a senior professional title.

Company F attaches great importance to cooperation and joint research with universities. The universities near company F provide rich talents for its R&D activities. Meanwhile, as a leading enterprise in the same industry, company F also offers employment opportunities for graduate students. Although some changes have occurred in the location relationship of enterprise's organizations in company F, the R&D institution and headquarters are still located in Shanghai in order to track market trends and learn about new technologies and products from competitors. Besides, there are many enterprises within the industry which are located in Minhang District, which is favorable for the cooperation and competition between enterprises. Company F's R&D institutions is also close to Shanghai Zizhu Science-based Industrial Park¹², where there are many famous MNCs offering company F access to new technology. Another key point is that it has established customer network relationships with famous domestic enterprises and MNCs in Shanghai. This helps it keep in touch with customers in order to seize markets and adjust R&D activities to meet market demands, while carrying out R&D at the present site.

■ Case of P+R type: company G

Company G, set up in 1958, provides advanced high polymers for the production of fiberglass reinforced plastic and new materials. Its headquarters is situated in the Xuhui campus of the East China University of Science and Technology (ECUST)¹³ in Xuhui District, and its R&D institution and production plant are located in Shanghai Chemical Industry Park¹⁴ in Jinshan District, in south west Shanghai (Figure.4.9). It grew out of a school-run ECUST enterprise and has achieved innovation and recognition for its products through university-industry cooperation. When company G was founded, all of its organizations were located in the Xuhui campus of ECUST. With the expansion of its production scale, the production plant was transferred to Shanghai Chemical Industrial Park. However, the long distance between R&D and production seriously restricted the commercialization of the research results. In order to overcome the remaining barriers between R&D and production, the R&D institution was also transferred to its present site where the production plant is, while the headquarters and sales department remain at the original site for reasons of developing market and the inertial force of location.

■ Case of R type: company H

Company H, founded in 2004, is an IC design company specializing in R&D in analog and mixed signal IC with primary focus on power management and LED driving products (Figure.4.9). It is situated in CHJ, where there is a high concentration of electronics industry, including many upstream and downstream companies of IC production. Its parent company is located in Wuxi¹⁵, near Shanghai. The decisive factor for company H to be located in CHJ is the advantage of industrial agglomeration. Many related companies from within the industry as well as upstream and downstream industries are concentrated in CHJ, making it easier to get information about new

products and learn market trends in time. Consequently, company H can undertake targeted R&D activities and feed the R&D results back to the parent company. We can see that the high possibility of learning market trends and carrying out R&D activities according to market needs is an essential factor attracting company H to the location. However, although CHJ's advantageous location is acknowledged, life infrastructures (such as the public transport systems) need to be improved, in order to make work and life much easier and more efficient.

■ Case of location change for R&D institution: company I

Company I, founded in 2000, is engaged in the R&D and production of power automation devices and systems. Its departments are all located in Songjiang Industrial Zone. When company I was first established, its R&D institution was located in CHJ, while the headquarters and production plant were located in Songjiang District. However, because of the pressure of rising rent in CHJ, the R&D institution was forced to transfer to Songjiang District, where the headquarters and production plant were located, thus forming the present H+P+R organizational allocation type.

Sufficient land and R&D-related human resources are regarded as the decisive location factors in R&D investment. It is easy for company I to ensure growing land demand in Songjiang District, given the lower land costs. In addition, being in close proximity to production plant helps facilitate the R&D's commercialization. Nevertheless, though the company has more space for expansion in the suburbs than in the central city, the suburbs have some disadvantages, such as incomplete infrastructure, inconvenient transportation, and an unclean environment, that have negative effects on the development of the company. Especially serious are the occasional power outages

caused by high power demands, which affect normal operations. Considering the talent factor, company I expects to move its R&D institution back to CHJ, where there are more human resources than in Songjiang District, but the possibility of rising costs is a major concern.

4.6.2 Location Factors for Enterprise R&D Institutions on a Local Scale

The main location factors affecting R&D institutions' location patterns at local level include intra-firm, land, environmental, policy and intuitional factors. Almost all enterprises attach great importance to close cooperation among inter-firm organizations. Most of the sample's manufacturing enterprises have established R&D institutions with other organizations in order to realize functional integration and the intensive use of land, factory building, and equipment; this is why the H+P+R type of R&D institutions is the most common. Of course, this allocation method is not the most efficient for all enterprises. As an enterprise grows and transforms within a changing environment, a reallocation of location and an organizational separation is certain to occur (as with companies F, G and I).

According to our survey, in the process of organizational separation, close proximity to headquarters and the production plant is much more valued than proximity to other organizations for manufacturing R&D institutions. The reason why more R&D institutions are attached to headquarters is that much R&D activities are undertaken according to information or orders from headquarters. In order to shorten the time spent commercializing the R&D results, an interaction between R&D and production (as with company G) is emphasized. Nevertheless, along with the expansion of R&D activities and the strengthening of the R&D function, the original R&D institution will be

separated from other intra-firm units, forming an independent R&D institution, as was noted in the cases of companies E and H.

Meanwhile, land cost and land scale have become important factors in the apparent suburbanization of R&D institutions in manufacturing. Some surveyed enterprises were forced to relocate their R&D institutions due to the rising land costs or rents. For example, company I moved its R&D institution from CHJ in the central city to Songjiang District in the outer suburbs for rising land costs. Meanwhile, pressured by land costs and the land scale in urban cities, some enterprises, especially in the non-equipment manufacturing industries, choose to rent their production plants (as with company D) and even their R&D sites.

Environmental factors are those elements in the cultural, economic, regulatory, and technological environments that affect economic development and regional image. Access to a wealth of high-tech talent has become an important factor in the location choices of R&D institutions. For example, it is precisely the rich human resources in Zhangjiang High-tech Park that attracted company E. In terms of human talents, company I also hopes to move its R&D institution back to CHJ. However, it is notable that proximity to universities or research institutes is no longer regarded as the decisive factor because of Shanghai's complete transport system and well-developed communication network. Moreover, industrial agglomeration and close links with upstream and downstream industries are also important location factors for R&D institutions in the manufacturing sector (as for companies E and H). In addition, regional image, including government efficiency, power supply, public health and the environment, have also become important to an R&D institution's location decision (as

with company I).

Furthermore, with the gradual transfer of the manufacturing industry to beyond the central city or to other cities along the Yangtze River Delta, the preferential policy seems not to favor general manufacturing R&D. Nevertheless, China has recently issued a series of preferential policies in support of R&D in rising industries, such as new energies and new materials, in order to improve resource efficiency. Meanwhile, the administrative division should take on much more responsibility for the location choices of R&D institutions. For example, enterprises think it necessary for government to provide detailed information about land use in potential R&D locations. As the market grows, real estate developers and business owners will become suppliers or agents of R&D sites. Consequently, the platform between the R&D carrier and the supplier of R&D sites will help facilitate R&D efficiency.

4.7 Summary

This chapter began by introducing China's science and technology policies. The R&D system in China has shifted from a government-led to industry-university cooperation model. To stimulate firm innovation, the government has focused on establishing industrial and high-tech parks and formulating preferential policies in support of enterprise R&D activities. Despite the growth in China's enterprises and national economy, the government-led model still dominates, which stymies fair competition. Under this system, many enterprises establish their R&D institutions for utilitarian purpose.

This chapter also analyzes the characteristics and spatial distribution of enterprise R&D institutions in Shanghai. As with national-level enterprises, Shanghai's large- and medium-sized enterprises comprise the main body of R&D activities. Foreign-funded enterprises and PSTEs also play important roles in innovation. Moreover, R&D institutions exhibit obvious spatial differences depending on the forms of their host enterprises. Large- and medium-sized industrial enterprises have a strong tendency to decentralize their R&D institutions to suburban areas in order to procure land at low costs. By contrast, PSTEs are still distributed in the center of the city, likely due to their links with universities and research institutions.

Based on the above analysis, this chapter further examines the location patterns of R&D institutions through sample surveys, focusing on domestic enterprise R&D institutions in Shanghai. The sample's non-manufacturing R&D institutions are all located in the city center, but Shanghai's manufacturing R&D institutions have been suburbanized, indicating that the functional division of the urban city is correlated with the industrial division. Moreover, the high concentration of enterprise R&D institutions in industrial zones and high-tech parks reveals an increasing decentralization, presenting industrial differences among the concentration districts.

In addition, most MNCs R&D institutions are concentrated in industrial parks because of the preferential policies and development strategies of industrial parks. The concentration of R&D institutions created by foreign capital is much stronger than that of institutions created by domestic capital, and the foreign R&D institutions are more inclined to locate in industrial zones and high-tech parks with complete infrastructures and stronger competitiveness, especially in CHJ and Zhangjiang High-tech Park. This

concentration occurred because there were investment-related preferential policies for foreign enterprises in industrial zones in early stage, and because many MNCs R&D institutions can pay the high price of obtaining an advantageous location.

In a further analysis, the sample enterprise R&D institutions in the manufacturing sector are classified into four types according to the location relationships between R&D institutions and other organizations: the R&D institutions of H+P+R type, H+R type, P+R type, and R type. Of these, the H+P+R type is the most common, followed by (in descending order) the H+R type, R type, and P+R type. These four types exhibit distinct industrial differences, which not only lead to different location relationships between R&D institutions and other organizations but also produce the diversity in the R&D institutions' location patterns. Most of the H+P+R and P+R type R&D institutions are located in suburban areas, while the location pattern of H+R type R&D institutions is similar to that of independent R&D institutions, with a distribution across industrial zones and high-tech parks inside the outer ring road. As for H+R type R&D institutions, most of their production plants are located in cities other than Shanghai, meaning that their production functions will be transferred to cities other than Shanghai as their enterprises grow.

Finally, this chapter explores the location factors affecting R&D institutions' location types and patterns through case studies. It finds that most enterprises attach importance to the cooperation among all intra-firm organizations. Currently, H+P+R type R&D institutions are the main allocation vehicles for domestic enterprises in Shanghai. However, this allocation method is not the most efficient option for all enterprises. Land costs and land scales in urban cities have become important factors in

the reallocation and suburbanization of R&D institutions. From the surveys, we can predict that the tendency towards the separation of headquarters, production sectors, and R&D institutions will become more evident for limited land use scales. Concerning the land factor, R&D institutions' location choices will not be confined to the enterprises' own estates (e.g., factory buildings, workshops); new R&D location choices, such as the rental of laboratories, instruments, or equipment, will become more common. Therefore, government must build a platform between suppliers of R&D sites and R&D carriers to enable the provision of detailed information on proposed R&D sites and buildings.

Moreover, though talent plays an important role in R&D location, local R&D institutions need not be close to a university or R&D institute given Shanghai's highly developed transport and communication systems (in contrast to the national situation). As a result, enterprises generally opt for a region with rich human resources at the national level when establishing their R&D institutions. Enterprises in metropolitan areas rich in talent such as Shanghai, however, must improve themselves, strive to excel, and thus attract excellent talent at the local level. Furthermore, R&D institutions represent advanced technology and knowledge, and appeals for suitable R&D environments can be heard, turning regional image into another important factor.

Notes:

1. In August 2009, Nanhui District merged into Pudong New area, and Shanghai was divided into 18 county-level divisions. However, the distribution of R&D institutions is analyzed according to the former administrative divisions, still in effect when the survey data was

collected.

2. Large and medium-sized industrial enterprises must meet the following conditions: they must have more than 300 employees, sales of more than 30 million yuan, and total assets of more than 40 million yuan. Large-scale enterprises must have more than 2000 employees, sales amounts of more than 300 million yuan, and total assets of more than 400 million yuan.
3. Foreign-funded enterprises here include Joint-venture enterprises, Cooperation-venture enterprises, and Enterprises with sole foreign funds.
4. In Yangpu district, there are about 14 colleges and universities, such as Fudan University, Tongji University, and the Secind Military Medical University, and more than 100 scientific research institutions.
5. Caohejing High-tech Park (CHJ), emerged from the early industrial park of Shanghai Caohejing Microelectronics established in 1984, is situated to the southwest of downtown Shanghai. It is one of the first state-level economic and technological development areas and high-tech industrial zones in China to be engaged mainly in attracting foreign capital, introducing advanced technology from abroad, and developing high and new technology. More than 20 universities and colleges and over 120 R&D institutions are located nearby. Now it specializes in the development of computer hardware and software, integrated circuits, microelectronics, communications and bioengineering technology.
6. As a national university science park, the East China University Science and Technology Park (ECUST Park) was founded in 2003. Its core competencies are in the fields of fine chemical, biopharmaceutical, and new materials industries. It includes an R&D center in the south of Xuhui District, a universal incubator at the East China University of Science and Technology in Xuhui District, and an industrial base in Shanghai Chemical Industry Park, located at the boundary of Jinshan District and Fengxian District.
7. Zhangjiang High-tech Park, founded in 1992 as China's state-level high-tech industrial

development zone, is located in the middle of Pudong New Area, comprising the Technical Innovation Zone, the Biomedicine Industry Zone, the IC Industry Zone, the Scientific Research and Education Zone, and the Residential Zone. In 1999, Shanghai's Municipal Committee and Municipal Government issued the "Focus on Zhangjiang" strategy and identified the IC industry, the software industry, and biomedicine as the leading industries on behalf of which the park could play a leading innovative role. Zhangjiang has been developing rapidly ever since.

8. Shanghai Xinzhuang Industrial Zone, established in 1995, is situated in Minhang District, with an area of 13.65km². It is adjacent to the central city of Shanghai, enjoying an advantageous location and convenient transportation. There are about 26 universities, colleges, and research institutes near the industrial zone, which provide high quality talent and technology for enterprises.
9. Songjiang Industrial Zone is the first municipality-level industrial zone in Shanghai's suburbs. It is situated in Shanghai's southwest, 25 kilometers away from Hongqiao International Airport and 68 kilometers away from Pudong International Airport. The Shanghai-Hangzhou expressway also runs across Songjiang Industrial Zone.
10. The locations of all the case companies are shown in Figure.4.9.
11. Changzhou is a prefecture-level city in the southern Jiangsu province of China. It is located on the southern bank of the Yangtze River and lies 160 kilometers west of Shanghai and 110 kilometers southeast of Nanjing.
12. Shanghai Zizhu Science-Based Industrial Park, founded in 2001, is situated in the southeast of Minhang District. It consists of University Park, an R&D base and the Zizhu Peninsula. The University Park consists mainly of Shanghai Jiao Tong University and East China Normal University. The leading industries of the R&D base are micro-electronics, software engineering, digital media technology, and aerospace technology.

13. East China University of Science and Technology (ECUST), originally named East China Institute of Chemical Technology, was founded in 1952. The university has accomplished much in technical transfers and cooperation among industry, university, and research. ECUST Park relies on the rich academic resources of this university.
14. Shanghai Chemical Industrial Park lies on the north coast of Hangzhou Bay with a total planning area of 29.4 km². It is located south of Shanghai, on the boundary between Jinshan District and Fengxian District. As a top chemical base in Asia, it has attracted many enterprises in the fine chemical, biomedical, and new materials industries.
15. Wuxi is a city in Jiangsu province. It borders Changzhou to the west and Suzhou to the east. Wuxi is also dubbed “little Shanghai” because of its close proximity to the city, rapid urbanization, and booming economy.

CHAPTER 5

Location Patterns of Enterprise R&D Institutions in and around Tokyo

5.1 Formation and Evolution of Science and Technology Policies in Japan

5.1.1 Science and Technology Policies from the Late 1940s to the Early 1990s

After World War II, during the nation's economic regeneration, the Japanese government realized the necessity of developing science and technology for the sake of industrial recovery. In 1953, the *Memorandum on Economic Independence* was drafted by the Economic Planning Agency, which stressed the importance of science and technology in economic growth. The *Five-Year Plan of Economic Independence* legislated in 1955 pointed out the necessity of developing science and technology in order to achieve economic goals.

Japan's economy improved markedly in the 1960s. As the economy grew, the Japanese government issued the "income-doubling plan" under Prime Minister Ikeda, former Premier of MITI. Through this policy, the government rapidly expanded investment in infrastructure including highways, high-speed railways, subways, airports, and port facilities, which in turn stimulated the investment of private capital in industrial development and promoted strong economic growth. Japan's household electrical appliance industries experienced an astonishing development in this period.

However, this rapid economic growth increased the concentration of people and industries in metropolitan areas as well as the depopulation of rural areas. Strong economic growth coexisted with wide regional imbalances. To solve this problem, the *First Comprehensive National Development Plan*, aimed at narrowing the regional gap, was issued in 1962.

As with economic development, science and technology attracted much more attention than it had before, especially the need to increase the close linkages between knowledge and industry. As its economy and national influence grew rapidly from 1955 to 1965, Japan won many achievements in science and technology. Many research facilities and institutes were established, while old, ramshackle facilities were scrapped or rebuilt. Most national research institutes were concentrated in and around Tokyo during this period. To alleviate the urban over-concentration of people and industries, national research institutes were appealed transferred to areas other than Tokyo to promote research cooperation and the sharing of research facilities. Thus, Tsukuba Science City in Ibaraki prefecture was designated for development in 1963. The first research institute in Tsukuba Science City was completed in 1968, and the University of Tsukuba was established in 1973.

From the 1970s, the domestic policies and the international climate caused Japan to experience its first negative economic growth since World War II. After the First Oil Crisis, Japan introduced factory automation (FA) and office automation (OA), which helped enhance production value and improve business systems. During this transition, Japan shifted from a structure which emphasizing sheer scale to one emphasizing compactness and flexibility. This transition also allowed Japan to sustain its economic

growth, even during the Second Oil Crisis.

The *Industrial Relocation Promotion Act* was enacted in 1972 to promote regional economic and population balances. A national plan to promote science and technology by decentralizing industries activities nationally was also proposed. Then, in 1983, the Japanese cabinet approved a bill dubbed the *Law for Accelerating Regional Development Based upon High-Tech Industrial Complexes (Technopolis Regulation)*, which aimed to promote regional development by establishing high technology centers for semiconductors, computers, biotechnology, and other industries.

However, a key factor in science and technology is the concentration of research institutes, and most regions outside of the Tokyo metropolitan area were suffering from institutional shortages. Though local governments implemented regional policies to develop local industries and establish research institutes, only a few regions (such as Tsukuba Science City) developed high science and technology concentrations. The distribution of industries, especially high-tech industries, remained unbalanced.¹

5.1.2 Science and Technology Policies during the Early 1990s and Beyond

Beginning in the 1990s, the Japanese economy struggled with the aftermath of the burst “bubble.” Science and technology were expected to play a large role in the solution to this dilemma. The reality was, however, that science and technology in Japan had fallen into severe situations in the early 1990s: R&D investment decreased in fiscal 1993 and 1994 and had been declining in the private sector for three years in a row since fiscal 1992. Understanding the reality of the situation and the importance of science and technology, the government and private sectors realized that fostering R&D

activities was urgently necessary.

During this time, many S&T policies were designed not only to promote basic research in universities and public research institutes but also to strengthen R&D in the private sectors. In 1995, the *Private Sector Resources Utilization Law* was enacted to promote private sector resource utilization and thus improve infrastructures. Industrial concentration was promoted by the 1997 *Law on Temporary Measures for Activation of Specific Regional Industrial Agglomerations (Regional Industrial Concentrations Reinvigoration Law)*. Special emphasis was placed on the concentration of small and medium-scale enterprises, the nation's main engines of production and contributors to regional growth. Policies during this time focused more on clusters than on decentralization and also acknowledged the valuable roles played by private firms.

In the 21st century, S&T policies aimed to build a recycling-based society, focusing on new knowledge innovation, new industrial creation, property rights, and new development strategies for strengthening Japan's economic viability. To improve the productivity and technical innovation of small and medium-sized enterprises, the main engines of production, the 2006 *Act on Enhancement of Small and Medium-Sized Enterprises' Core Manufacturing Technology (SME Manufacturing Enhancement Act)* was enacted to strengthen the competitiveness of Japan's manufacturing industry and create new business opportunities. Under this act, the SME Agency assists SMEs in upgrading their core production technology in the areas of casting, forging, cutting, processing, plating, and other kinds of metal work. ²

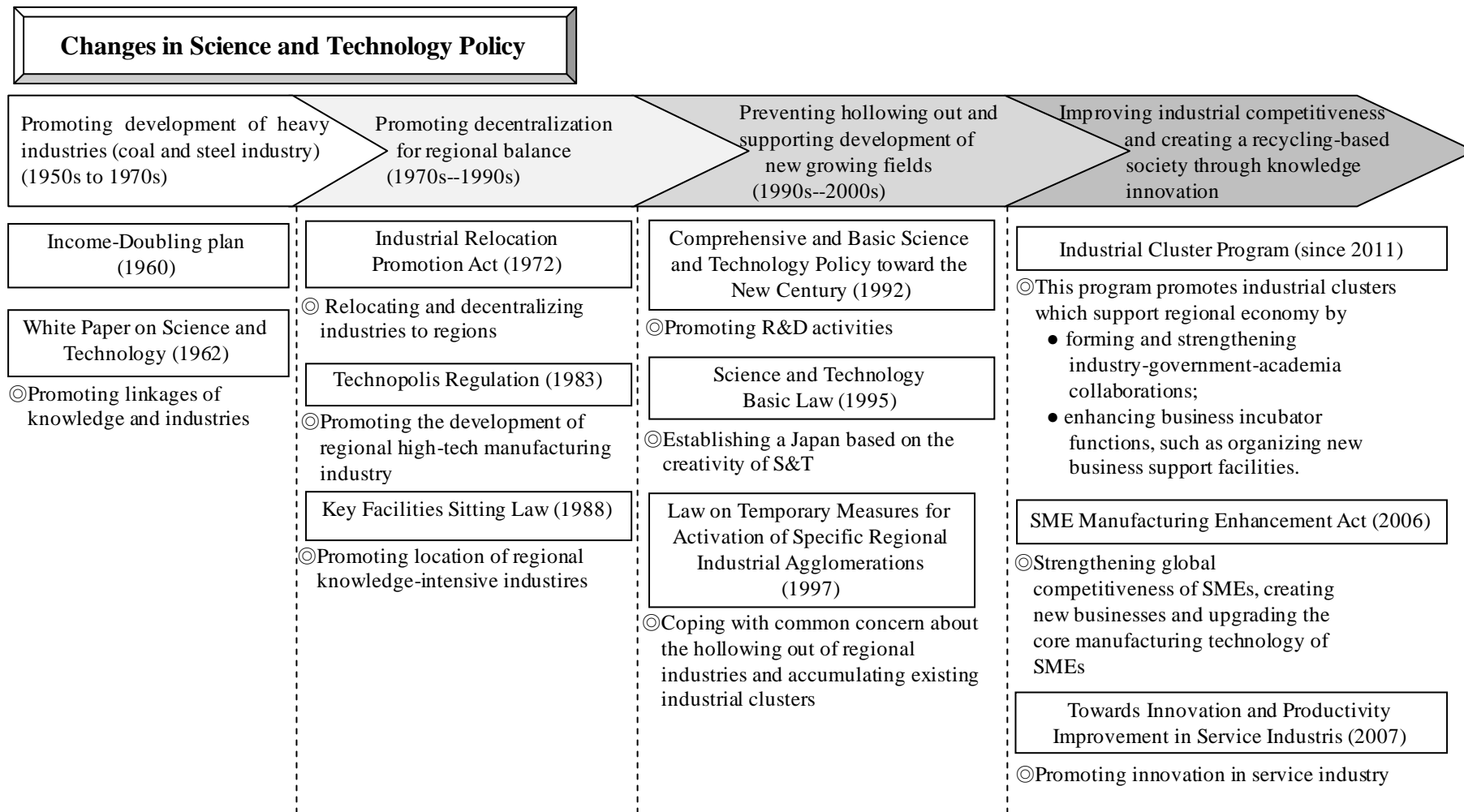


Figure.5.1. Changes in Science and Technology Policies in Japan

Source: based on Kose, T. 2006, pp: 2, and the author's collection.

5.2 Data and Method

Location relationships among enterprise organizations are fluid. As in the analysis of R&D institutions' locations in Shanghai, this chapter explores R&D location patterns in and around Tokyo. To verify the locations of R&D, this analysis relies on the database in the *Yearbook on R&D Institutes in Japan (1989-1990; 2000-2001; 2008-2009)*, which provides information on R&D institutes, including their industry, products, capital scale, addresses of R&D institutes and headquarters. Addresses are used to determine the locations of the R&D institutions and their headquarters. Those R&D institutions occupying the same location are counted as a single entity. However, the location relationships between R&D institutions and other organizations cannot be mapped by this database alone, since the addresses of departments other than the headquarters are not provided. Therefore, the location relationships among R&D institutions, headquarters, and production plants are determined through website information or the references on each enterprise included in the database.

As noted in chapter 3, most enterprise R&D institutions in Japan operate in the electric and electronic equipment industry. Since many data on enterprise R&D institutions in Japan are available, this chapter first introduces the overall distribution of R&D institutions across industries and describes their location similarities and differences. Then, this chapter provides a detailed analysis of the location patterns of the R&D institutions in the electric and electronic equipment industry. As mentioned, R&D institutions in Japan are highly concentrated in Tokyo and surrounding area. Therefore, this paper also examined Tokyo and surrounding area (i.e., the Kanto region) to gather more detail on R&D locations and explore how R&D relocation occurs.

The discussion below is organized into four sections. The first introduces the spatial distribution of enterprise R&D institutions across industries. The second section describes the concentration and decentralization of Japan's electric and electronic equipment industry, and analyzes its R&D distribution by location type at a national level. The third section describes the R&D locations' features according to their types in the Kanto region and their location changes over time. The fourth section examines the variances in R&D locations and the changes in their location relationships with other organizations through case studies. The final section summarizes the analysis.

5.3 Spatial Distribution of R&D Institutions in Japan

The spatial distributions of enterprise R&D institutions show no evident differences across industries (Figure.5.2). The R&D institutions of all industries have similar distributions and are concentrated in the Kanto region (centered on Tokyo), followed by the Kansai region (centered on Osaka). Furthermore, although the distribution of R&D institutions in the general machinery and equipment manufacturing, electric and electronic equipment, and food industries show an evident belt distribution from the Kanto region to southern Japan, the R&D institution in the pharmaceutical industry are concentrated mainly in Tokyo and Osaka. These distribution differences are related to the relevant industrial characteristics. Most electric and general equipment manufacturers have close linkages with their up- and down-stream industries, and their R&D institutions show a spatial distribution similar to their industrial distribution. However, the pharmaceutical industry has an organizational model different from that of other industries (Ohara 1996; Nanbu 2002), since its R&D activities, manufacturing processes, and sales are strictly regulated by the *Pharmaceutical Affairs Law* due to

safety concerns. Therefore, their R&D institutions are tent to be close to their headquarters and located in metropolitan cities.

The Kanto region's R&D institutions all have similar spatial distributions and most are located within the Ken-O Expressway³ (Figure.5.3). However, their locations exhibit some differences. Most of the R&D institutions of the electric and general machinery manufacturing industry are concentrated in the Keihin industrial zone and are decentralized within the northern Kanto region, along the Kan-Etsu Expressway,⁴ Tohoku Expressway,⁵ and Joban Expressway.⁶ The R&D institutions of the food, beverage, and feed manufacturing show no obvious concentration and are scattered along the expressway, though located mainly along the inner Ken-O Expressway. The R&D institutions of the pharmaceutical industry, however, are highly concentrated within Tokyo's outer ring road.

The above analysis shows that Japan's R&D institutions do not show any evident spatial differences across industries on a national scale and that most are concentrated in a few areas. However, they do show obvious distribution differences in the Kanto region.

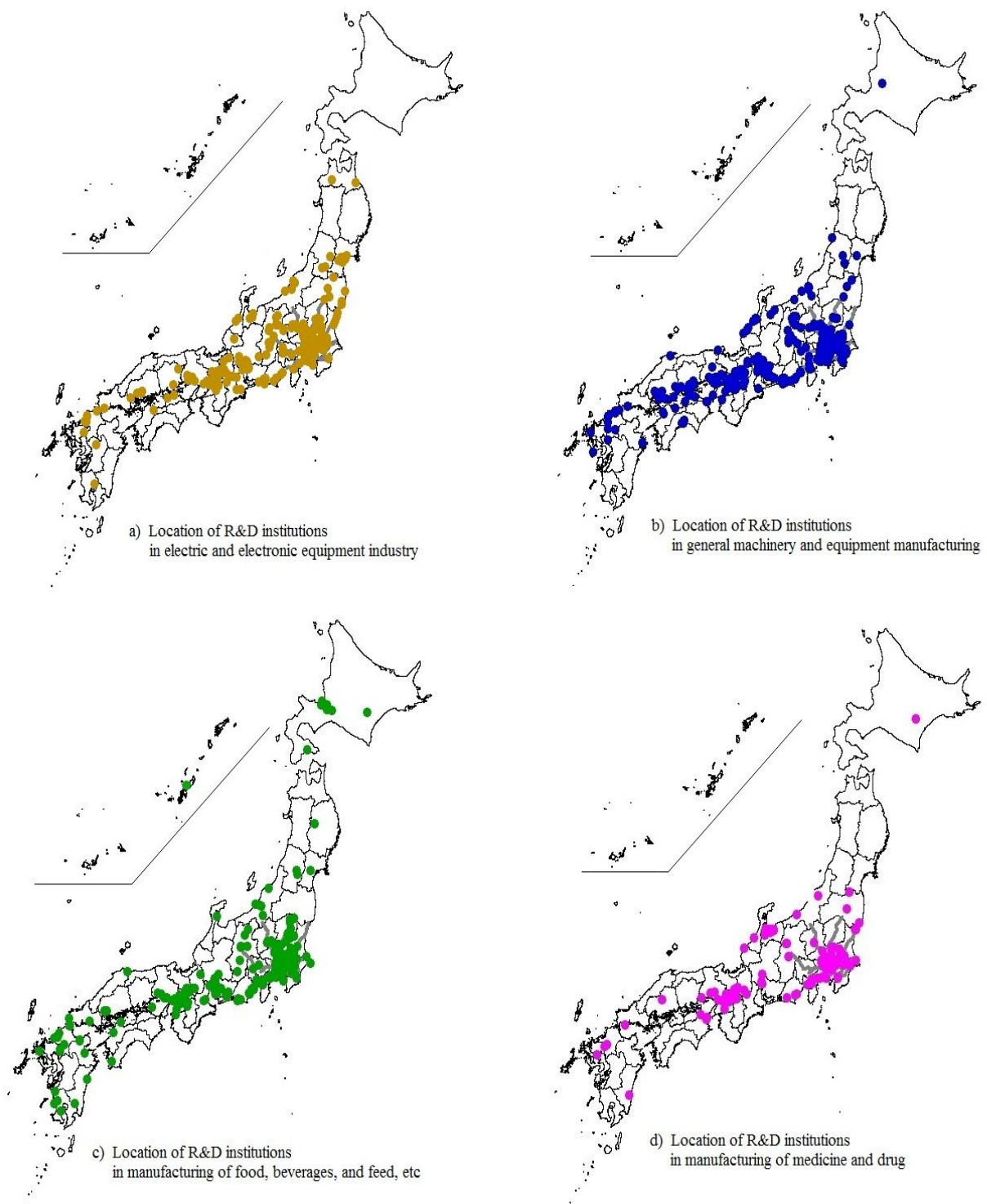
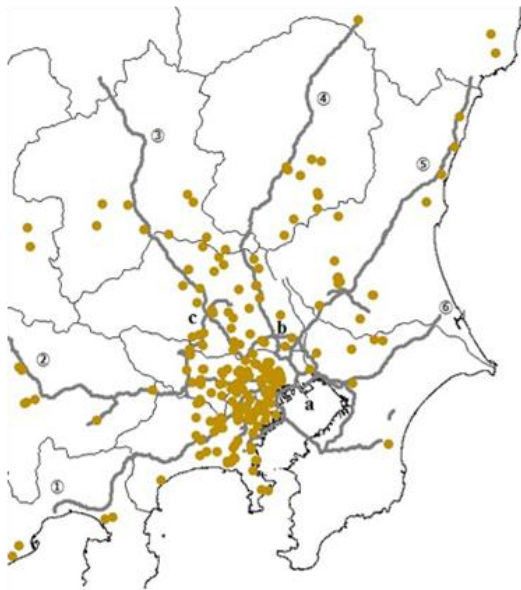
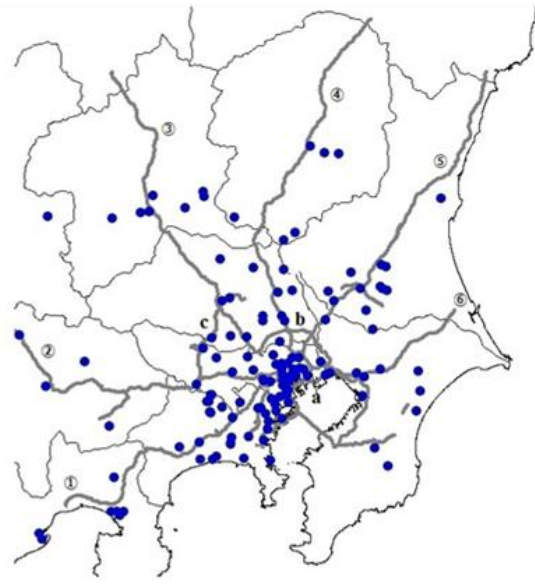


Figure.5.2. Spatial Distribution of Enterprise R&D Institutions by Industry in Japan

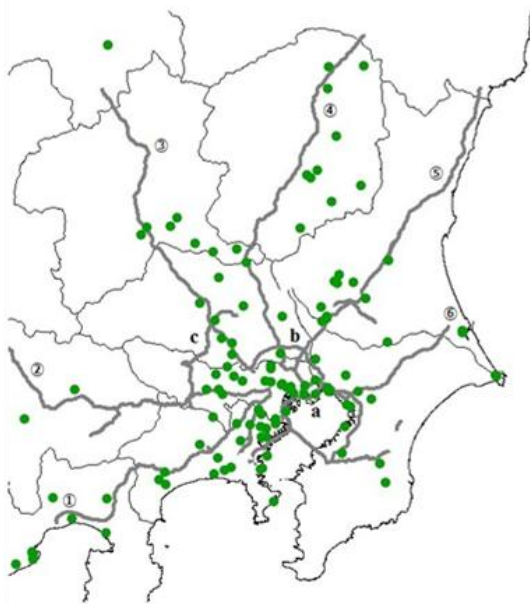
Source: compiled by author according to data in *Yearbook on R&D institutes in Japan (2008-2009)*.



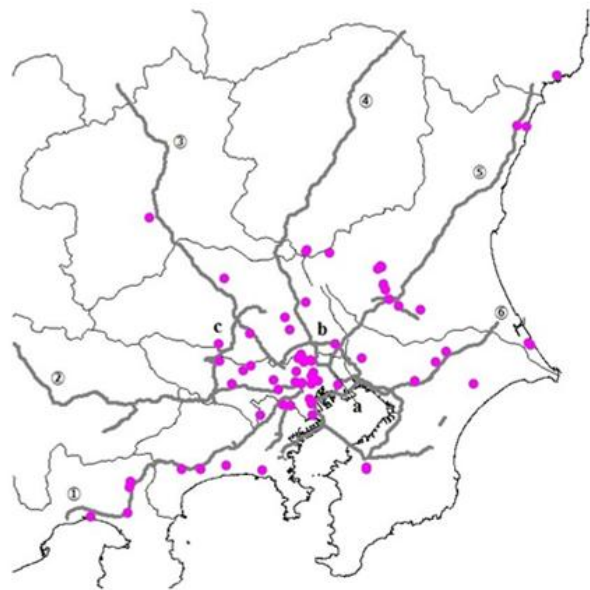
a) Location of R&D institutions in electric and electronic equipment industry



b) Location of R&D institutions in general machinery and equipment manufacturing industry



c) Location of R&D institutions in manufacturing of food, beverages, and feed, etc.



d) Location of R&D institutions in manufacturing of medicine and drug

①Tomei Expressway; ②Chuo Expressway; ③Kan-Etsu Expressway;
 ④Tohoku Expressway; ⑤Joban Expressway; ⑥Higashi-Kanto Expressway;
 a Central Circular Route; b Tokyo Outer Ring Road; c Ken-O Expressway.

Figure.5.3. Spatial Distribution of Enterprise R&D Institutions by Industry in the Kanto Region

Source: compiled by author according to data in *Yearbook on R&D institutes in Japan (2008-2009)*.

5.4 Location Patterns of Electric and Electronic Equipment Industrial Enterprise R&D Institutions in Japan

5.4.1 Concentration and Decentralization of Electric and Electronic Equipment Industry

The Japanese economy entered a period of rapid growth during the 1960s, when the electric and electronic equipment industry (particularly household electrical appliances sector) enjoyed the fastest growth and became the leading industry through expanded production and diversification. The electric and electronic equipment industry comprises three kinds of companies: comprehensive manufacturers (e.g., Hitachi, Toshiba, Mitsubishi, Fuji Electric), special manufacturers, and component and part suppliers (Kitamura and Yada 1983). The industry produces a wide range of products for both industrial use (e.g., heavy electric equipment, telecommunication equipment, semiconductors, electronic components) and civil use (e.g., refrigerators, televisions, lighting fixtures). As the industry features technology- and labor-intensive production processes, its firms' locations vary according not only to products but also to processes, even those designed for the same product. Thus, division of labor is shaped according to the regions and production network (Kondo 2007).

At the early stage of Japan's high-growth period, the electric and electronic equipment industry was highly concentrated in the Keihin region, centered on Tokyo, and the Hanshin region, centered on Osaka. With the rising land costs and labor shortages in the metropolis, firms had to change their location strategy in order to expand their production. At the same time, the *Industrial Decentralization Policy* came into force in 1960 to narrow economic gap and address environmental deterioration

(Takeuchi 1996). As a result, industrial decentralization to provincial regions was accelerated to ensure the availability of cheap and plentiful land, electricity, water, and labor to meet the demands of a rotating schedule (Matsubishi 1990). In this process, many labor-oriented factories (e.g., component factories) were decentralized along the highways from Tokyo to other areas of the Kanto region, while technology-oriented departments (e.g., electronic equipment manufacturing) were still concentrated in Tokyo and the Keihin region (Kitamura and Yada 1983; Takeuchi 1996). Meanwhile, firms' division of labor also occurred along with their restructure.

When the fast growth ended, many enterprises had to take steps to survive amid the new socio-economic changes. They began to pursue the "streamlining management" strategy in order to make business simpler and more efficient. As a consequence, production and management system changed. For example, high value added departments and growing sectors were given over to core companies' control, while low additional value departments and mature sectors were managed by branch plants; some branch factories were turned into subsidiaries, producing tremendous cost saving (Matsubishi 1990).

The "high-technologization" strategy begun in the late 1970s, promoted R&D investment, fostering not only the development of new technology and markets but also cost savings. It was this strategy that motivated core companies to launch R&D activities, trial productions, and advanced processes (Matsubishi 1990). Thus, the firms' functional differentiation is regionally shaped. As shown in Figure.5.4, most technical experts engaging in R&D activities are clustered in Kanagawa, Tokyo, Osaka, Kyoto, Chiba, and Saitama, mostly in Tokyo's surrounding area. This shows that R&D in these

areas is more prominent than is production. Adjacent areas such as Aichi, Shiga, Nagano, Shizuoka, Yamanashi, and Ibaragi feature R&D activities and trial-production; in other areas, such as Akita, production is more prominent.

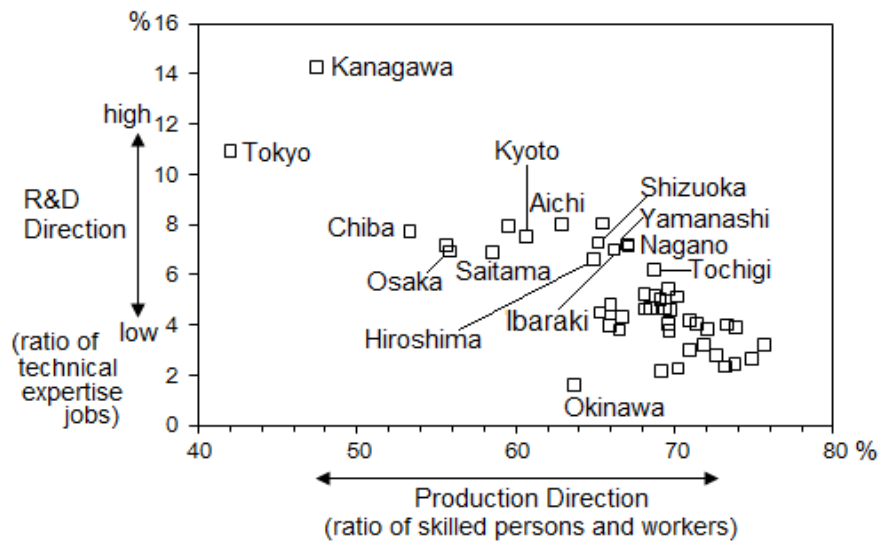


Figure.5.4. Employment-population Ratios in Manufacturing Industry (2010)

Source: compiled by author from data in *Population census of Japan 2010*.

5.4.2 Location Patterns of R&D Institutions

Within this dynamic process of industrial concentration and decentralization, R&D institutions' location relationships with other departments also change. Figure.5.5 shows that the larger the enterprise, the higher the probability that its R&D will be separated from other departments. The R&D institutions of small- and medium-sized enterprises are generally located together with both headquarters and production plants. As firms expand, more production plants are established and start to be separated from their headquarters. As enterprises grow, R&D activities are launched in branch plants to promote rapid commercialization and flexible production. Further growth also causes enterprise R&D institutions to direct their attention to new technology, products, and

processes. As a result, their R&D becomes much stronger, and these institutions start to be separated from other firm organizations.

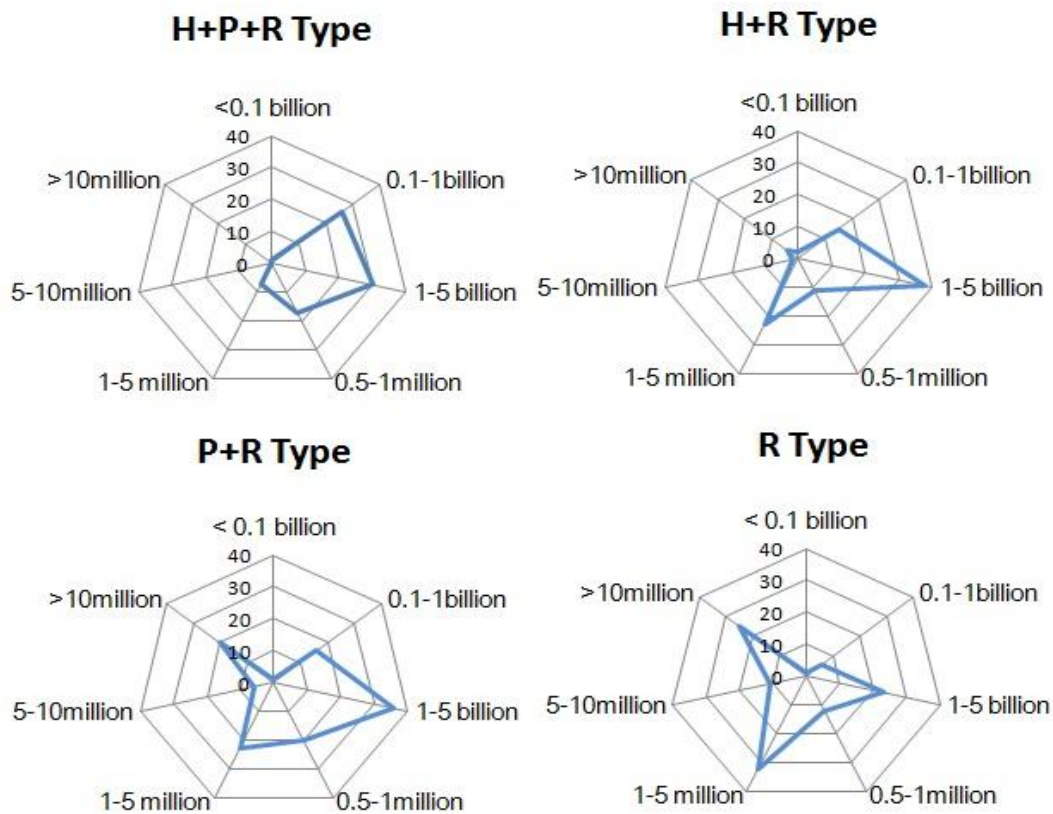


Figure.5.5. Correlations between R&D Location Types and Scales of Enterprise Capital

Source: compiled by author from data in *Yearbook on R&D institutes in Japan (2008-2009)* and author's data collection.

Table.5.1 shows the spatial distribution of R&D institutions and headquarters in Japan for various periods. Most of the R&D institutions are concentrated in the Kanto region, followed by the Kansai region, and the Chubu region (centered on Aichi prefecture). However, the R&D distribution in each region is uneven, characterized by concentration in a few areas. Tokyo and Kanagawa prefecture are the two leading areas, possessing nearly half of total R&D in the Kanto region; R&D in the Chubu region is

distributed mainly in Nagano, Aichi, and Shizuoka prefectures, while Osaka and Kyoto are the major concentration areas in the Kansai region.

**Table.5.1. Numbers of Headquarters and R&D Institutions
by Regions over Period in Japan**

Regions	1989-1990		2000-2001		2008-2009		
	H	R&D	H	R&D	H	R&D	
Hokkaido	0	0	0	0	0	0	
Touhoku	4	9	4	15	4	21	
Kanto	Ibaraki	2	10	2	11	1	14
	Tochigi	1	5	0	10	0	10
	Gunma	1	6	1	8	3	9
	Saitama	7	31	6	35	7	33
	Chiba	2	5	2	9	3	7
	Tokyo	147	89	141	86	131	71
	Kanagawa	33	71	40	82	39	71
	Sub-total	193	217	192	241	184	215
Chubu	Yamanashi	1	3	2	4	4	9
	Nagano	4	6	7	13	10	17
	Shizuoka	5	8	3	7	7	10
	Aichi	9	9	10	12	13	15
	Others	4	7	7	13	8	13
	Subtotal	23	33	29	49	42	64
Kansai	Kyoto	14	18	15	16	18	21
	Osaka	23	25	26	35	27	33
	Hyogo	6	11	9	15	11	12
	Others	2	8	3	14	3	22
	Sub-total	45	62	53	80	59	88
Chugoku	5	6	4	6	3	8	
Shikoku	2	2	2	2	4	3	
Kyushu Okinawa	4	6	4	9	5	10	
Total	276	335	288	402	301	409	

Note: 'H' in this table means headquarters.

Source: compiled by author from data in *Yearbook on R&D institutes*.

Although a slight increase in the number of R&D institutions in the Kanto region occurred from the end of the 1990s to 2000, a decline occurred from 2000 to 2009. In other regions, by contrast, particularly in the Chubu and Kansai regions, their numbers continued to increase, though only in a few areas. It is also worth noting that headquarters, unlike the R&D concentration in some areas, exhibits a unipolar concentration in Tokyo, showing that enterprises attach great importance to the city's management function.

In terms of location types, most R&D institutions occupy the same location as production plants (126, P+R type), followed by those located independently (107, R type) and those located with headquarters (95, H+R type). The fewest number of R&D institutions are those located with both headquarters and plants (81, H+P+R type). The R&D location types also show significant regional differences, though most are located in the Kanto region regardless of type (Figure.5.6). In the Kanto region, independent R&D institutions are the most common type, while R&D institutions in the Chubu region are more inclined to be located with both headquarters and production plants; most of the R&D institutions in the Kansai and Tohoku regions are located with production plants. These data demonstrate that functional and hierarchical differences among regions, at least to some extent.

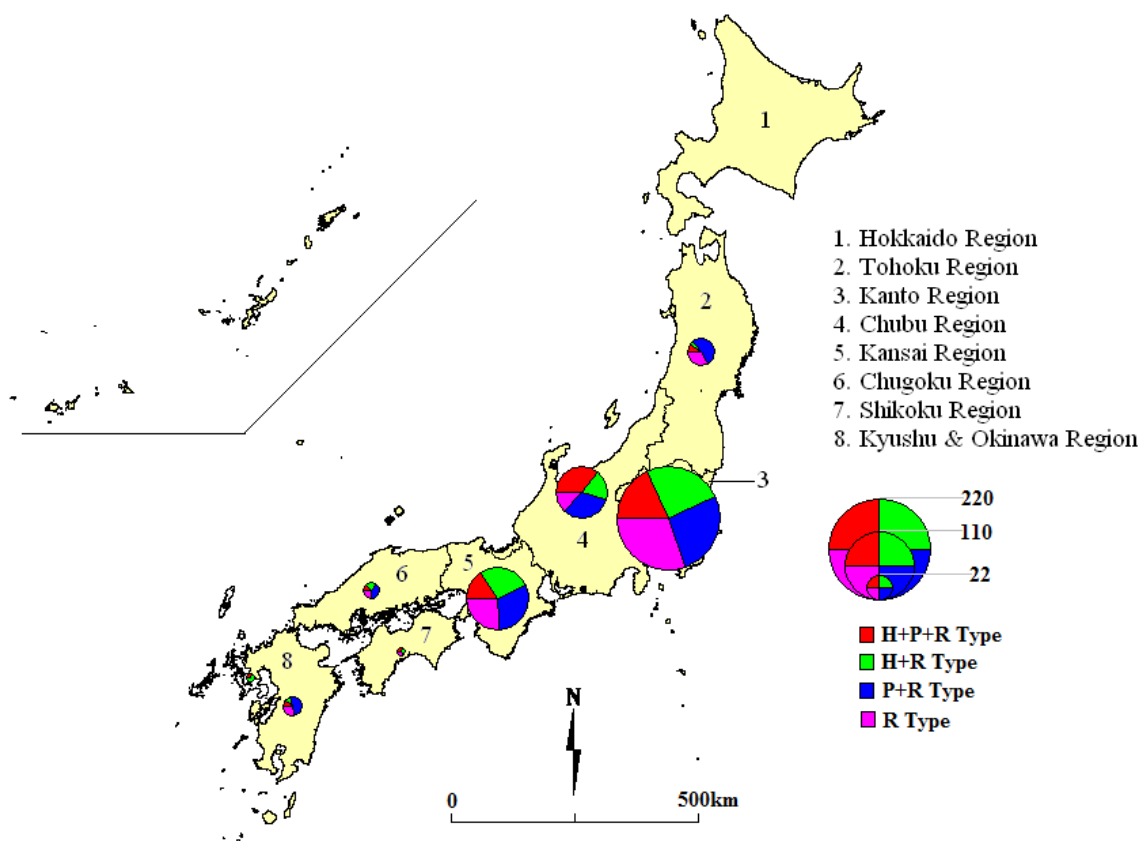


Figure.5.6. Spatial Distribution of Enterprise R&D Institutions by Location Type in Japan (2008-2009)

Source: compiled by author from data in *Yearbook on R&D institutes in Japan (2008-2009)* and author's data collection.

5.5 Location Patterns of Enterprise R&D Institutions in the Kanto Region

5.5.1 Spatial Distribution of R&D Institutions

As shown in Figure.5.7, there were 217 R&D institutions in the Kanto region from 1989 to 1990, increasing to 241 from 2000 to 2001, and then decreasing to 215 from 2008 to 2009. However, accompanying the slight changes in their numbers are the great

alternations in the location relationships between the R&D institutions and other departments. The H+R and R type R&D institutions claim a rising share, while the proportion of H+P+R and P+R type R&D institutions shrink drastically. From 2008 to 2009, the proportion of H+P+R type is the smallest of the four.

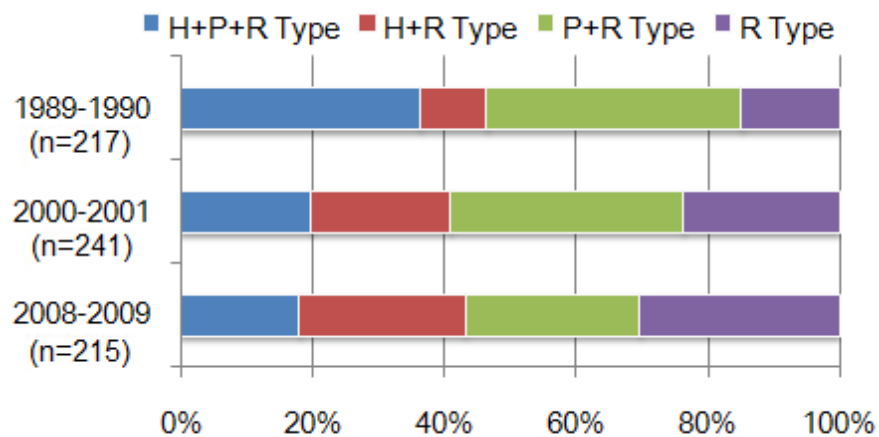


Figure.5.7. Proportion of R&D Institutions by Location Types over Period in the Kanto Region

Source: compiled by author from data in *Yearbook on R&D institutes in Japan* and author's data collection.

There are also significant regional differences among location types, even within the inner-Kanto region (Figure.5.8). While H+P type R&D institutions continues to proliferate in Tokyo, east of the city (in Kanagawa, Chiba and Ibaraki prefectures), independent R&D institutions are taking an increasingly large share. Moreover, although an increase can be seen in the proportion of independent R&D institutions in Saitama, Gunma, and Tochigi prefectures (which are adjacent to north Tokyo), most of the R&D institutions in these areas are located with production plants.

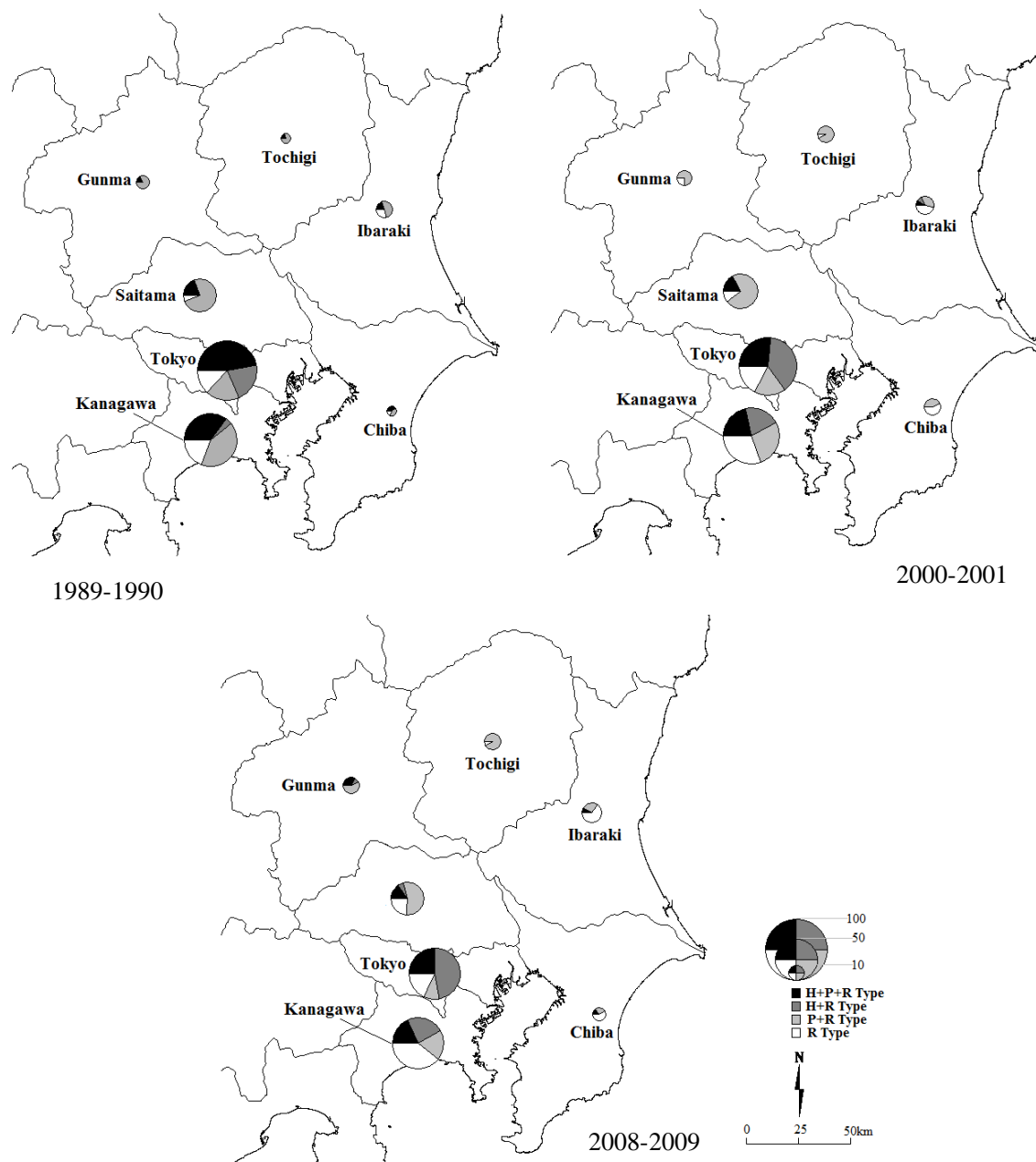


Figure.5.8. Spatial Distribution of R&D institutions by Location Type in the Kanto Region

Source: compiled by author from data in *Yearbook on R&D institutes in Japan* and author's data collection.

5.5.2 Location Changes of R&D Institutions by Location Type

Concerning R&D locations in the Kanto region (Figure.5.9), there is a high concentration within the Ken-O Expressway, especially in the areas within 50 kilometers of central Tokyo, covering central and southern Tokyo, the northern Kanagawa prefecture, and the southern and northern Tama areas of Tokyo. The R&D institutions' location changes show a remarkable tendency towards decentralization around north of Tokyo, along the highways.

In 1989 and 1990, most R&D institutions were located in the area covering southern Tokyo to northern Kanagawa, commonly known as the Keihin region. During this period, most R&D institutions were H+P+R type, and only a few H+R type was located in central and southern Tokyo. Ten years later (2000 and 2001), P+R type R&D institutions had greatly increased along the highways (i.e., the Kanetsu, Tohoku, and Joban expressways) up north of Tokyo. Meanwhile, many H+R type and R type R&D institutions appeared in the original R&D concentration, especially in the area encompassing central and southern Tokyo and northern Kanagawa prefecture. This was mostly due to the remarkable reduction in large-scale factories in these areas, especially in the Shinagawa and Ota wards (Matsubara 2009). In the Tama area of Tokyo, where many mother plants and SMEs (small and medium-sized enterprises) with advanced processing technology are concentrated, many R&D institutions are still located together with both headquarters and production plants. As Seki (1993) observes, many enterprises in the Keihin region established branch plants in the Tama area during the high-growth period; those plants then launched R&D activities and trial production as mother factories during the 1980s. These transformations helped form the industrial prototype of today's Tama area.

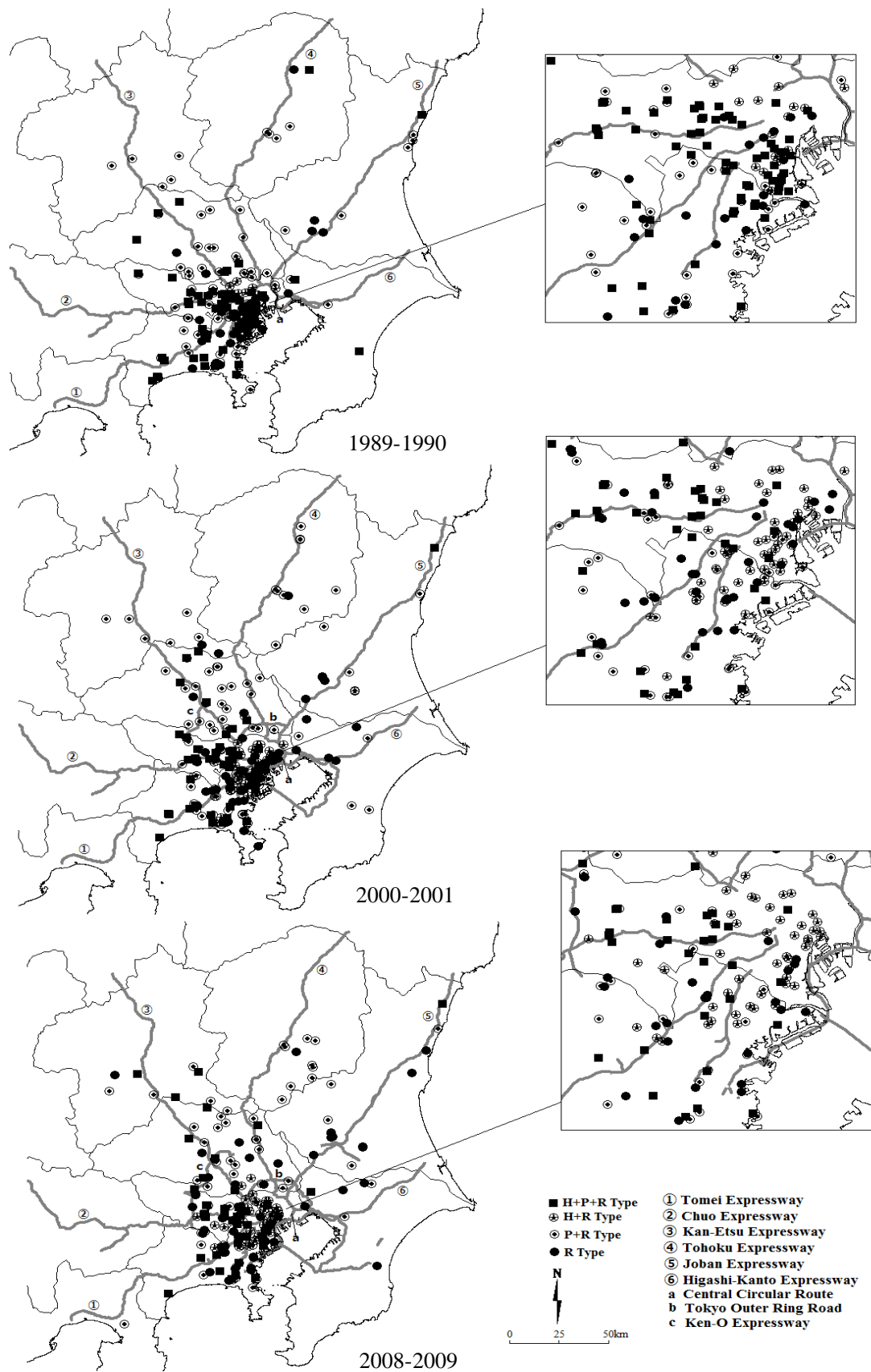


Figure.5.9. Location of R&D Institutions in the Kanto Region over Period
 Source: compiled by author from data in *Yearbook on R&D institutes in Japan* and author's data collection.

In 2008 and 2009, R&D institutions underwent no location changes as significant as those in the previous period. There was a decrease in the Keihin region and the Tama area of Tokyo however, where most R&D institutions were originally concentrated. Moreover, R&D institutions of the H+P+R and P+R types are rarely seen in this region. With the closure of many factories in the Tokyo metropolitan area along the Tokaido line⁷, many office buildings, apartments, and commercial facilities were built to replace the closed factories (Kamakura 2012). At the same time, to maintain the mother plants' production and strengthen R&D functions, some plants were maintained. In addition, some mass production factories were turned into mother plants to implement R&D (Ikura 1996). Thus, R&D institutions are diffused from the Keihin region and the Tama area of Tokyo to north of Tokyo along the highways. The western Saitama prefecture between the Kan-Etsu and Tohoku expressways attract many R&D institutions, mainly located with production plants. In an east-west direction, R&D institutions are still concentrated within the Ken-O expressway.

In fact, current R&D concentration areas include the Keihin region and the Technology Advanced Metropolitan Area⁸ (TAMA). The TAMA has become a model industrial cluster program. It covers the southwestern part of Saitama prefecture, the Tama district of Tokyo, and the central part of Kanagawa prefecture (Figure.5.10), where many science and technology colleges, large R&D institutions, mother plants, and product-developing and technology-supporting SMEs are distributed.

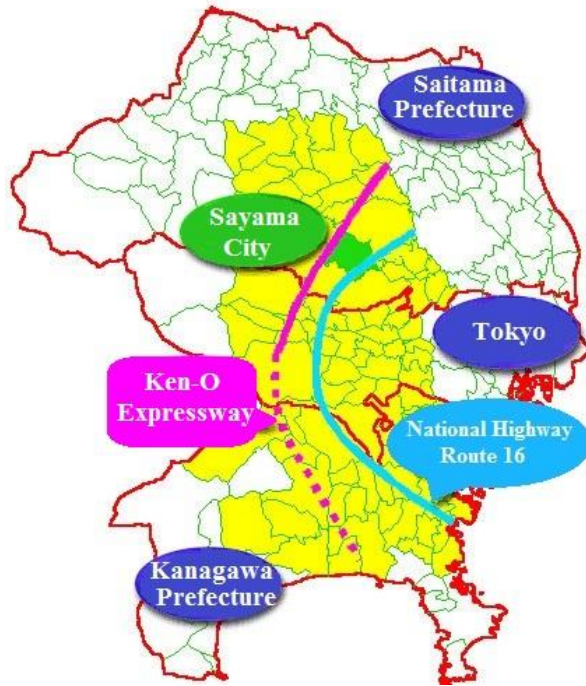


Figure.5.10. Detailed Location of TAMA

Source: based on <https://www.city.sayama.saitama.jp/jigyo/kigyo/miryoku4.html>

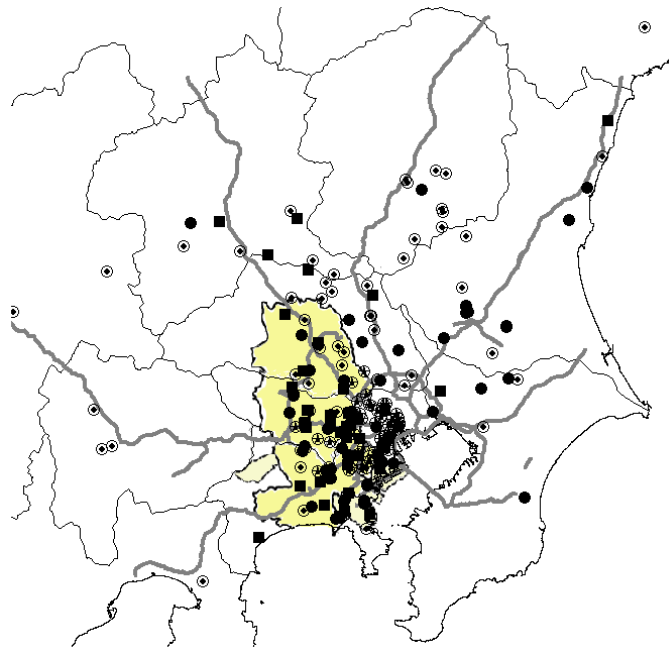


Figure.5.11. Location of Enterprise R&D Institutions in TAMA

Source: compiled by author according to data in *Yearbook on R&D institutes in Japan* (2008-2009) and author's data collection.

In April 1998, the TAMA Industrial Vitalization Council (or TAMA Association) was established as part of an industrial policy by private firms particularly SMEs, universities, municipal authorities, local chambers of commerce, industry, and individuals to strengthen industry academic cooperation and thereby promote the creation of new industries and the revitalization of local industries.

The TAMA Association is responsible for promoting information networking (e.g., web services, data bases, the TAMA virtual laboratory system), solutions to problems faced by member firms, industry-university collaboration, and business fairs. The TAMA fund is used to support new businesses established by regional financial institutions in cooperation with the TAMA association. The TAMA association also helps firms deal with human resources, start-up businesses, sales promotion, and the development of foreign business. The TAMA is composed of growing number of firms, all seeking to build R&D linkages, promote technology transfer, and realize commercialization with the support of the association (Kodama 2007). The TAMA association strives to support and promote the development of product-developing SMEs in order to strengthen their ability to design original products.

The foregoing analysis has shown regional differences among R&D location types have formed from the central Tokyo to its surroundings. In central and southern Tokyo, most R&D institutions are the H+R type, while the H+R and R types are decentralizing southward. In the Tama area of western Tokyo, many R&D institutions are still located with both headquarters and production plants, while, in north of Tokyo, they tend to be located with production plants. Examining the area with high R&D concentrations reveals the shape of the hierarchy of functions from central Tokyo to the surrounding

areas. Central Tokyo is the control and management center, while independent R&D activities and trial productions are launched in the surrounding area according to orders and decisions coming from headquarters. Additionally, the expressways accelerate the growth of new industrial districts, which in turn promotes not only the concentration of plants along the expressways but also the formation of a vertical division of labor within an industry (Yanai 1993).

5.6 Relocation of R&D Institutions with Headquarters in Tokyo

Table.5.2. Numbers of Headquarters and R&D Institutions in Tokyo

	1989-1990		2000-2001		2008-2009	
	H	R&D	H	R&D	H	R&D
Central wards	45	7	41	8	42	11
Sub-central wards	25	4	20	5	17	5
Eastern wards	7	4	9	5	6	0
Southern wards	33	29	33	23	31	13
Western wards	13	10	10	4	8	7
Northern wards	2	2	4	2	4	3
Northern Tama	16	19	17	24	13	19
Tama Area Southern Tama	4	11	5	10	8	9
Western Tama	2	3	2	5	2	4
Total	147	89	141	86	131	71

Note: 'H' in the table means headquarters.

Among R&D institutions above, four ones whose headquarters are located in areas other than Tokyo (Kyoto 2; Osaka 1; Kanagawa 1), and they are established independently in Tokyo (Minato ward 2; Shinagawa ward 1; Ota ward 1).

Source: compiled by author from data in *Yearbook on R&D institutes in Japan* and author's data collection.

As mentioned, most headquarters in Japan are concentrated in Tokyo. As Table.5.2 shows, although the numbers of headquarters in Tokyo decreased from 147 in 1989 and

1990 to 131 in 2008 and 2009, they are still highly concentrated in the central and southern wards, where nearly half of them are distributed. Most of the R&D institutions in Tokyo are distributed in the southern wards and the northern Tama area.

Moreover, the location relationships between R&D institutions and other departments in Tokyo have changed greatly (Figure.5.12). From the end of the 1980s to 2009, the percentage of the H+P+R and P+R types decreased sharply, while the proportion of the H+R and R types (particularly the former) continues to grow.

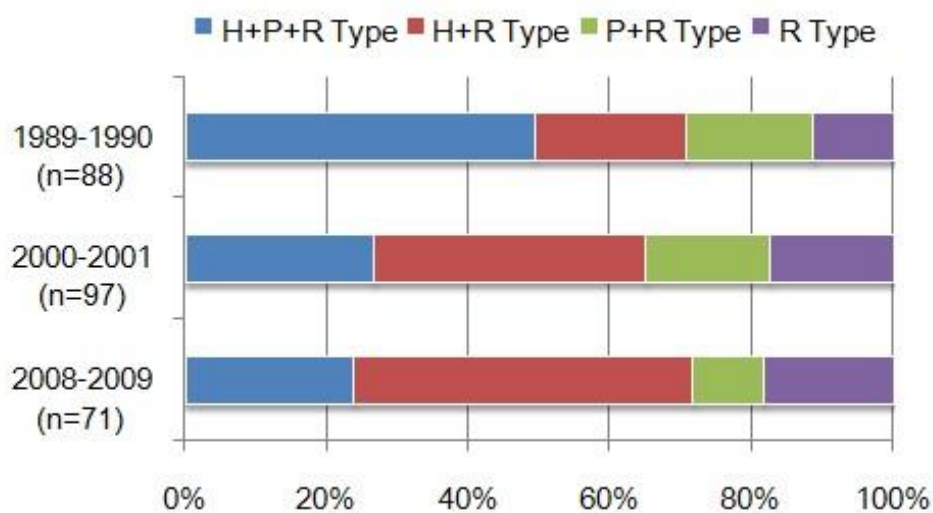


Figure.5.12. Changes in Location Types of R&D institutions in Tokyo

Source: compiled by author from data in *Yearbook on R&D institutes in Japan* and author's data collection.

In the 1980s, sales of expensive factory sites became frequent, not only in Tokyo but also in Yokohama and Kawasaki city, while urban renewal projects were initiated (Ogawa 1989). Changes in factories' division of labor also led to functional R&D specialization. Panasonic's production line for cathode ray tube televisions, for instance, was transferred in 2001 to the Utsunomiya plant in Tochigi prefecture from the Ibaraki

plant in Osaka. As a result, the Ibaraki plant started specializing in R&D related to the new technology and the production of plasma display panel televisions, while the Utsunomiya plant, Panasonic's last domestic TV factory attempted to survive and develop by producing flat screen, high-definition CRT televisions. Thus, the Ibaraki plant specializes in design and development, while the Utsunomiya plant focuses on mass production (Kondo 2004). It is this kind of functional transformation among factories that reconstructs departments' division of labor.

Taking Tokyo enterprises pursuing H+P+R type R&D in 1989 and 1990 as examples, we can analyze how R&D institutions' relocation and the variations in their location relationships with other departments occurred. Figure.5.13 shows the location changes of the R&D, headquarters, and production plants of the case companies. Along with the transfer of production towards Ibaraki, Tochigi, and Nagano prefectures, production plants generally started to separate from headquarters, while R&D institutions were still located with headquarters, thus forming H+R type R&D institutions in 2000 and 2001. As production plants were transferred and enterprises expanded, some companies allocated additional R&D institutions, placed together with production plants (A11: 2000-2001), while some (A16: 2008-2009) started to transfer R&D institutions into plants.

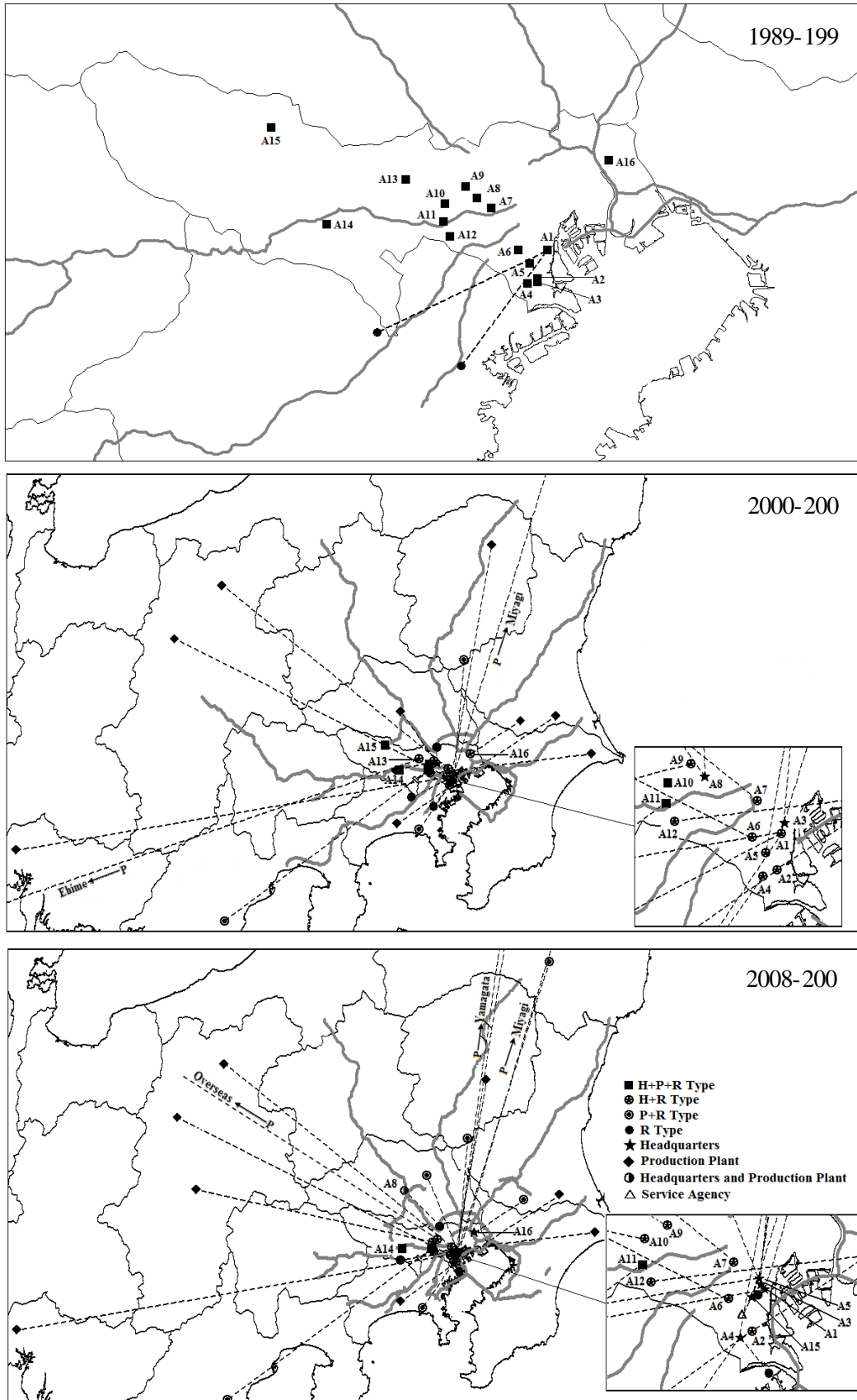


Figure.5.13. Relocation of Case Companies' R&D Institutions

Source: compiled by author from data in *Yearbook on R&D institutes in Japan* and author's data collection.

Even so, this kind of general change is not absolute. For example, A8 Company's R&D institution and production plant were transferred to different sites in Saitama prefecture in 2000 and 2001. Its headquarters was then transferred to the site of the production plant, forming an independent R&D location in 2008 and 2009. A3 Company, originally located in Ota ward, transferred its headquarters to Minato ward and allocated its plant and R&D institution to the same site in Tochigi prefecture (A3:2000-2001). A9 Company's production plant was transferred to Hachioji city in Tokyo and its R&D institution was retained at the original site during 2000 and 2001. Production was commissioned to its branch company in Malaysia; as a result, an H+R type of R&D location was formed in 2008 and 2009.

In addition to the transfer of production plants, the restructuring of enterprises also impacts R&D relocation. An example is seen in A5 Company. Located in Shinagawa ward in 1989 and 1990, it moved its production plant to Tochigi prefecture in 2000 and 2001. In 2004, A5 Company merged with another company with headquarters in Meguro ward and production plants in Yamagata and Kanagawa prefectures. After the merger, the new company allocated its headquarters to Minato ward. The original headquarters of A5 Company is now mainly engaged in sales and service provision (e.g., installation, maintenance, repair). The plant of the other company located in Kanagawa prefecture became a branch company focusing on R&D and services, while the plants in Yamagata prefecture still specialize in production. The new company also set up an R&D institution in the production plant located in Saitama prefecture.

Though many R&D institutions are located in production plants, they do not show a strong tendency to decentralize towards areas where many plants are distributed. Most

P+R type R&D institutions are located within 50 kilometers of headquarters. Those institutions that are combined with their headquarters are usually connected to their production plants by highways. Therefore, R&D institutions attach great importance to their proximity to headquarters and to their linkage and communication efficiency with the main production facilities.

Matsubara (2009) claims that, although some large-scale plants in the Keihin industrial district are vacant, many enterprises still hope to begin mass production there to maintain their domestic and overseas markets, as long as there remain areas that can be reused, such as Kawasaki Eco-Town⁹ and Minato Mirai 21,¹⁰ where many recycling facilities, R&D institutions, and incubation facilities are concentrated. Moreover, though many factories are still located in the middle of Kawasaki city and the Tama area of Tokyo, most are engaged in R&D and trial production; in fact, most have transferred much of their production to other domestic plants or overseas.

5.7 Summary

This chapter first introduced the history of S&T policies in Japan. It was found that adjustments in S&T policies were regularly made to foster economic recovery. Many R&D institutions were built in Japan during the time of rapid economic growth. The economic depression then led Japan to focus on R&D activities. The concentration of research institutes in and around Tokyo promoted the development of science and technology in Japan. Although the Japanese government implemented many policies and laws designed to decentralize the over-concentration of high-technology industries in

the Kanto region and promote regional balance, it was unsuccessful.

Almost all of Japan's R&D institutions have a similar distribution pattern: most are highly concentrated in the Kanto region, followed by the Kansai region. However, R&D institutions of pharmaceutical industries are more inclined to be located in Tokyo and Osaka because of the applicable industrial laws and regulations. In the most concentrated area of Kanto region, where R&D institutions show similar distributions and most are located within the Ken-O Expressway, their locations show some differences according to industry.

After describing the overall distribution, this chapter used the electric and electronic equipment industry as an example and analyzed the R&D institutions' location patterns from the perspective of location relationships among intra-firm organizations. The analysis revealed that the R&D location types are highly correlated with the scale of the enterprise: SMEs prefer to locate R&D institutions together with both headquarters and production plants. The larger the enterprise scale, the stronger the inclination for R&D to be allocated separately from other organizations.

Although R&D institutions in Japan are still highly concentrated in the Kanto region, their location types exhibit visible spatial differences nationally and locally. In the Kanto region, R&D institutions are more prone to be separated from other organizations, with independent R&D being the most common type, followed by the H+R type. In the Chubu region, most R&D institutions are either located with headquarters and production plants or located within production plants. Although R&D institutions in the Kansai region have a strong tendency to be separated from other organizations (as do

those in the Kanto region), P+R type R&D institutions are the most common, followed by the H+R and R types. In the other regions, the proportion of P+R type is the highest. Thus, management and R&D functions are much stronger in the Kanto region than in other regions.

In the Kanto region, R&D institutions show a decentralization towards north of Tokyo from the original concentration area of the Keihin region. Many P+R type R&D institutions appear in north of Tokyo, including Saitama, Gunma, and Tochigi prefectures, along highways. However, most R&D institutions in the Kanto region are located within the Ken-O expressway, about 50 kilometers from central Tokyo where the headquarters are highly concentrated, even though highways play an important role in both R&D location and relocation. The Keihin region and TAMA area have become the main R&D concentration areas because of their strong industrial complexes, easy connections, and convenient hubs.

A series of factors, such as the expansion of production, rising land prices, factory closures, the reuse of plants and other buildings, production offshoring, and firm restructuring, led to changes in companies' spatial division of labor. Production plants were transferred away from Tokyo, while headquarters and R&D institutions retained in Tokyo and surrounding areas. Thus, remarkable changes occurred in the location relationships among R&D, headquarters, and plants. The H+P+R and P+R type R&D institutions in the Kanto region decreased sharply, while the H+R and R types increased. This transformation indicates that an obvious spatial division of labor formed from central Tokyo to its surrounding areas. In the areas covering central Tokyo, southern Tokyo and eastern Kanagawa prefecture, management and R&D functions are

prominent, while trial production is prominent in the middle Kanagawa prefecture, the Tama area of Tokyo, and north of Tokyo. Furthermore, no matter how R&D relocation happens, most of R&D institutions value their proximity to headquarters and to the nearest plants.

This chapter's analysis also indicates that, despite the significant decentralization of production, regions other than the Kanto region have little chance of attracting R&D, as management functions are still highly concentrated in Tokyo. The focus of industrial agglomeration and clustering has recently transferred from transportation and transaction costs to possibilities for innovation implementation. Though greater access to knowledge and other assets is regarded as an important factor in realizing innovation, the reality that various factors are concentrating and even agglomerating geographically is even more important; it signifies that the connection between internal and external factors, in addition to geographic proximity, is vital to innovation (Kondo 2012). The costs of social connectivity factors such as industrial linkages and connections among intra- and inter-firm organizations will significantly impact the distribution of enterprise R&D activities.

Notes

1. This section was written with reference to the Metropolitan Areas Development Bureau of MLIT 1993.
2. This section was written with reference to the website at <https://staff.aist.go.jp/t.kotoku/policy>

/history_j.html.

3. The Ken-O Expressway or Metropolitan Inter-City Expressway, is a partially completed ticket-system toll expressway. Once completed, it will have a total length of about 300 km along a route with a radius of about 40 to 60 km from central Tokyo. It will link core cities such as Yokohama, Atsugi, Hachioji, Kawagoe, Tsukuba, Narita, and Kisarazu, forming a cluster of cities serving as regional cores in the Tokyo metropolitan area. It will also ease traffic congestion and enhance regional development while offering a wider selection of routes.
4. The Kanetsu expressway begins in Nerima Ward in the north of Tokyo and ends in Niigata prefecture.
5. The Tohoku expressway starts in the city of Kawaguchi in Saitama and passes through Gunma, Tochigi, Fukushima, Miyagi, Iwate and Akita prefectures before entering Aomori prefecture. The Tohoku highway was so named because it serves the Tohoku region as a transport and commercial artery, which connects it to the Kanto region. Numerous factories are located along this route.
6. The Joban expressway is an important route connecting the greater Tokyo area with Mito, the capital of Ibaraki prefecture. Beyond Mito, the expressway follows a northerly route along the coast of the Pacific Ocean to the city of Iwaki in Fukushima prefecture. Most of the route beyond Iwaki is incomplete; when completed, the expressway will reach the greater Sendai area. The expressway will also supplement the Tohoku Expressway as an access route between Tokyo and the Tohoku region.
7. The Tokaido line is the busiest trunk line of the Japan Railways Group (JR Group), with departures every few minutes connecting the stations of Tokyo and Kobe. It connects Japan's three largest metropolitan areas (Tokyo/Yokohama, Nagoya and Osaka/Kyoto). The study areas in Kamakura's article include the areas from Kawasaki city to Hiratsuka city in

Kanagawa prefecture along the Tokaido line.

8. The Technology Advanced Metropolitan Area (TAMA) is an inland industrial area covering an area of 3000 km², 74 municipalities, and homes for over 10 million people, of whom 4 million work for TAMA Network firms. Its entire length is connected by the Ken-O Expressway. In 1998, goods shipped from TAMA had twice the shipment value of those sent from Silicon Valley.
9. The Kawasaki Eco-Town plan was approved by the MITI (Ministry of International Trade and Industry) in 1997, with the purpose of promoting the creation of a recycle-based society based on industrial activities. The basic policies of Kawasaki Eco-Town are (i) promoting industrial firms' efforts to make their operations and systems environmental friendly and ecologically sound; (ii) promoting a program for creating a zero-emission, environmentally friendly, and ecologically sound community; (iii) implementing R&D programs to facilitate sustainable development; and (iv) establishing an information-sharing system.
10. Minato Mirai 21, often shortened to "Minato Mirai" or "MM", is a large urban development and the central business district of Yokohama. The area was once occupied by the Mitsubishi Heavy Industries Yokohama shipyard, the Japanese National Railways classification yard, the Takashima wharf, and the Shinko wharf of the port of Yokohama. The name "Minato Mirai 21" means "Port of the Future." The area is now flourishing as one of the newest urban business districts in the Greater Tokyo Metropolitan Area. It is an important business center with major corporations locating their headquarters and branches here.

CHAPTER 6

Comparing Enterprise R&D Location in Shanghai and Tokyo and Surrounding Area

6.1 Similarities and Differences

This chapter compares between R&D locations in Shanghai and Tokyo and surrounding area. As mentioned, the decentralization and relocation of domestic Chinese enterprise R&D institutions sited in Shanghai occur mainly within Shanghai itself, while Japanese firms, most of which are headquartered in Tokyo, distribute most of their R&D institutions to the Kanto region (centered on Tokyo), especially to Tokyo proper and surrounding area. This chapter outlines the similarities and differences between the two areas' R&D locations.

First, foreign enterprises play a leading role in Chinese R&D, while Japanese R&D is driven mainly by domestic enterprises, for reasons related to the two nation's economic stages growth models. Meaningful Chinese economic development only began with the "reform and open door" policies of the 1980s, 30 years after Japan's economy began to recover in the 1950s. China's economic growth was accomplished through foreign investment, and its technological development was led by foreign enterprises. China's first national innovation plan was not formally issued until 2006. In Japan, however, the importance of developing science and technology in pursuit of economic independence was strongly stressed as early as 1953. Influenced by the chan-

Table.6.1. Similarities and Differences of Enterprise R&D Locations between Shanghai and Tokyo and Surrounding Area

	Shanghai	Tokyo and Its Surroundings
Stage of Economic Development and Self-innovation Policies	<ul style="list-style-type: none"> ●Economic development started from the 1980s; ●The first plan on self-innovation was issued in 2006; ●R&D activities were led by foreign enterprises. 	<ul style="list-style-type: none"> ●Economic recovery started since the 1950s; ●Importance of self-developing technology was highly stressed in 1953; ●R&D activities are mainly taken by domestic enterprises.
Distribution	<ul style="list-style-type: none"> ●R&D institutions are mainly located in industrial parks of suburban areas; ●Single regional distribution; ●Location differences by industry is distinct. 	<ul style="list-style-type: none"> ●R&D institutions are highly concentrated within the Ken-O Expressway (within 50 kilometers of central Tokyo); ●Cross-border distribution; ●Location differences by industry is obvious.
Location Types	H+P+R Type > H+R Type > R Type > P+R Type	R Type > H+R Type > P+R Type > H+P+R Type
Location Factors	Connections with other intra-firm organizations; Land scale and land cost	
	<ul style="list-style-type: none"> ●Preferential policies; ●Completed infrastructures; ●Talent flow is restricted by household registration system; ●Heterogeneous culture; ●Regional image. 	<ul style="list-style-type: none"> ●Access to research service facilities; ●Transportation convenience to reach other regions. ●Talent flow is without restriction; ●Homogeneous culture.
Location Tendency	<ul style="list-style-type: none"> ●Along with the production transfer of traditional industry to other regions, R&D institutions and headquarters will be still located in Shanghai; but the tendency of spatial separation will not be so strong as it in and around Tokyo; ●R&D and production of the emerging industry in Shanghai are encouraged greatly. 	<ul style="list-style-type: none"> ●Restricted by land scale, R&D institutions show some inclination to be located in other regions than Tokyo and surrounding areas, but it is estimated to be difficult to decentralize because of the strong industrial complex in and around Tokyo.

ging external environment, Japanese enterprises made great efforts to automate their management systems and develop their technologies, which allowed them to remain competitive in the global marketplace.

Second, Shanghai and Tokyo and surrounding area differ in their R&D institution distributions. Enterprise R&D institutions in Shanghai are highly concentrated in industrial parks, with foreign enterprise R&D institutions showing a higher concentration than domestic ones. Meanwhile, R&D institutions in and around Tokyo are mainly concentrated in the Keihin region; show a much higher concentration than in Shanghai, with a high concentration within Ken-O Expressway, about 50 kilometers from central Tokyo. Their distributions also show a distinct industrial differentiation.

China's industrial parks are established by the government to promote industrial and economic development. Divided into state-, provincial-, city-, and county-level parks, they enjoy various preferential policies determined according to their levels. Generally, every industrial park is given a leading industry in order to promote industrial clusters. Only companies operating within a park's leading industry are allowed to move there. Most industrial parks in China are equipped with healthy civil and transportation infrastructures and thus attract many MNCs. China's mode of industrial park management causes the industrial differences in R&D institutions' distributions.

China and Japan both use industrial parks to balance regional development. However, unlike industrial parks in Europe or the U.S., most industrial parks in Japan are established as "exclusive industrial zones," in which the government plays no management role (Ji 2007); the location patterns of Japanese enterprise R&D

institutions are formed more spontaneously than are those in China. Moreover, in the R&D concentration area of the Keihin region, there are close linkages and connections among industries and enterprises, forming a strong complex. In Shanghai, by contrast, industrial parks are built to balance regional development, but they are not interconnected; Shanghai's enterprise R&D institutions are both concentrated in industrial parks and distributed towards suburban areas. Thus, R&D institutions are not as highly concentrated in Shanghai as they are in and around Tokyo.

Third, as enterprise scale grows, R&D institutions in both Shanghai and Tokyo tend to be located separately from other organizations. Japanese enterprises are reducing their domestic newly built R&D institutions due to the transfer of production overseas and the reduction in domestic production. As mentioned earlier, R type R&D institutions are the most numerous kind in and around Tokyo, followed by the H+R type, the P+R type, and the H+P+R type. In Shanghai, the H+P+R type is the most numerous, followed by the H+R, R and P+R types.

The spatial separation of organizations for Chinese enterprises headquartered in Shanghai becomes wider as enterprises expand and as production sectors are transferred to other regions. However, many enterprises still have headquarters and R&D functions in Shanghai despite the production function's transfer. Moreover, industrial parks in China are established as part of an urban development strategy, rather than as mere industrial production areas, and thus include residential, commercial, education, and recreational infrastructures in addition to production and R&D facilities (Ji 2007): cities and urban sub-centers are therefore planned with industrial parks at their centers. Furthermore, lightly polluting emerging industries are supported in Shanghai. Though

some traditional production sectors have been transferred from Shanghai to other regions, the tendency towards spatial separation among headquarters, production plants, and R&D institutions will likely not be as strong there as in Tokyo.

Fourth, although R&D institutions in Shanghai and Tokyo and surrounding area show some decentralization to some extent, Shanghai's R&D institutions are decentralized mostly towards suburban areas, while Tokyo's are decentralized towards surrounding areas. Tokyo R&D institutions exhibit "cross-border" location and relocation. China's household registration system restricts the flow of people across regions, which has been a major obstacle to intra-immigration. People registered in Shanghai have priority and thus enjoy high-quality education, and healthcare as well as preferential policies of Shanghai. Many skilled workers and technicians seek the city's household registration, and most residents have no desire to move despite the high living costs. Therefore, though Shanghai faces reductions in production and increasing labor costs, it remains attractive to skilled labor. However, amid these administrative regulations, the government pays little attention to cross-region innovation, making R&D information exchanges, technological communication, and knowledge spillovers among regions and enterprises difficult and possibly hindering innovation.

Finally, in terms of location factors, R&D institutions consider proximity to other intra-firm organizations very important, especially their connection with headquarters. In Tokyo and surrounding areas, most R&D institutions are located within 50 kilometers of central Tokyo, where headquarters are highly concentrated. Moreover, land scale and cost are the typical factors in the spatial separation between R&D institutions and other intra-firm organizations in both Shanghai and Tokyo.

However, enterprises still hope to establish R&D institutions at good locations, such as those with convenient access to the central city and transportation, completed infrastructure, and a high quality of life. Despite the high rents and land costs, these places are regarded as suitable for R&D activities, since R&D personnel are generally well-educated and require cultural, art, and recreational spaces. The industrial parks in Shanghai seem more active in satisfying their R&D personnel's living requirements. The industrial parks' management authority is exercised by commissions (which have no authority to interrupt enterprise activities, however). To enrich R&D personnel's lives, they often organize events such as seminars on enterprise development, sports events and concerts.¹

In addition, although R&D institutions exhibit geographical concentrations, enterprises are not concerned about their proximity to clusters of the same industrial R&D while choosing locations, but focus instead on connections with other intra-firm organizations. Furthermore, though many MNC R&D centers in Shanghai are concentrated in industrial parks, some domestic enterprise R&D institutions do not deem it necessary to be close to them, further supporting the view expressed in previous studies that knowledge spillovers from MNCs to domestic enterprises are limited.

6.2 Implications

These results have important implications for technological and regional policies. The locations of enterprise R&D institutions in and around Tokyo indicate that Japanese R&D activities have entered a mature stage. Moreover, the high degree of R&D institution concentration in and around Tokyo intensifies domestic firm competition,

which has led to the refinement of techniques and higher-quality goods. However, the high cost of talent, production reductions, a shrinking market and low foreign investment have become obstacles to R&D. Japan is a relatively homogenous culture, and its innovation system is characterized by diffusion and dissemination along vertical co-operation. In Japan, even inter-firm cooperation is not real co-operation since suppliers are often part of an enterprise group (Storz 2008). This kind of vertical path-dependent innovation system may close the door on medium- and small-sized enterprises with innovative potential. My interview survey² included technical personnel who left their jobs in big companies, dissatisfied with the trivial tasks and routine chores that lagged in R&D, and started their own R&D companies. The Japanese innovation system that lies in vertical division of labor should be changed in order to stimulate personal and firms' creativity and provide opportunities for new entrants. Moreover, global awareness should be heightened through international cooperation in order to increase R&D personnel's sensitivity to international markets.

As labor costs rise in eastern China, many cost-conscious sectors of domestic and foreign companies have moved to middle and western China, where the wages and cost of living are lower. Some MNCs have started moving their labor-intensive, low-margin sectors to southeastern countries, such as Vietnam, Bangladesh, and Cambodia. However, their advantages, such as frequent connection with foreign enterprises, highly educated workforces and language proficiency, ensure that China's coastal cities remain attractive for R&D activities. Many MNCs still prefer to set up regional and global R&D centers in China (Du 2014).

In response to the rising costs in China, innovation should be given more attention

than ever before. Chinese enterprises must change from their traditional production mode to an energy-saving one and provide high-quality products in order to survive. These economic pressures also offer a significant opportunity for economic and social restructuring. However, China lacks an efficient and competitive mechanism like Japan's with which to inspire enterprises to develop new, high-quality products. In this situation, the government should aim to refrain from interfering in the economy and provide an equitable and congenial environment for enterprises, especially private enterprises. Only competition can promote innovation and improve enterprises' competitiveness. The government should also strive to improve the environment, both the natural environment and civic infrastructure, since the highly educated require very high standard of living.

Notes

1. On April 27, 2013, the author visited CHJ and interviewed the staff on the CHJ management committee.
2. On October 3 and 4, 2013, the author took part in the Third Ota Research and Development Fair in Tokyo held by the Ota Industrial Promotion Organization and interviewed some of the exhibitors.

CHAPTER 7

Conclusions and Discussion

7.1 Conclusions

The preceding remarks have shown that the spillover effects multinational R&D brings to local firms are very limited. The example of US MNCs' R&D at home and abroad indicates that, although MNCs develops their businesses around the world, most of their R&D is undertaken at home. In terms of geographical distribution, R&D activities are concentrated in a few areas both globally and nationally, with especially high concentrations in metropolitan areas. As most studies on R&D locations focus on the multinational R&D's organization model and location factors, this paper turns attention to the locations of domestic enterprise R&D institutions in metropolitan area.

Regional functional hierarchies are shaped accompanying with the spatial division of labor. In this process, R&D institutions' location relationships with other intra-firm organizations are diverse, and exhibit distinct geographical differences. However, the existing studies on MNCs' R&D organization gave more concern on the R&D function in host countries, but neglected the organizational spatial relationships. In addition to external factors (e.g., economic level, talent, transport, land, cluster), this paper focus on the importance of spatial relationships of enterprise organizations in R&D location and relocation. To analyze R&D institutions' location relationships with other organizations and explore their changes, this paper proposed a classification of location types,

dividing R&D institutions into four location types: (i) the same location as headquarters and production plants (H+P+R type), (ii) the same location as headquarters (H+R type), (iii) the same location as production plant (P+R type), and (iv) independent R&D institutions (R type). Using this classification, this paper explored the location patterns of enterprise R&D institutions in Shanghai and Tokyo and surrounding area, and draws some major conclusions.

While previous studies tended to analyze R&D location through external factors such as access to universities and research institutes, the regional investment environment, and clusters, this paper's analysis of R&D location relationships with other intra-firm organizations confirms that, R&D institutions' location is determined more strongly by the firm's internal factors (e.g., firm strategy, mergers and acquisitions, organizational spatial relationships, organizational relocation) than by external factors. More importance is placed on proximity to headquarters than to other organizations because they carry out R&D activities on headquarters' orders. Though an increasing number of R&D institutions tend to separate from other organizations and become independent while their firms grow, they are still distributed around areas near headquarters. This supports the view in Castells (1992) that the connection between headquarters' location and R&D centers accounts for the formation of innovative industrial milieu in metropolitan areas. However, R&D distribution does not exhibit a concentration as high as that of headquarters, which are more inclined to be located in central areas.

Similar to the historical evolution of structure of international R&D organization in different stages mentioned in Saur-Amaral and Borges Gouveia (2008), the

differentiation of R&D institutions' location types in space and time is formed in metropolitan area. As firm grows and R&D function becomes stronger, R&D institutions are inclined to separate from other organizations and tend to be located in places near headquarters. The R&D institutions established in production plants are usually located in periphery of R&D and headquarters' concentration area. In most situations, MNCs establish R&D centers to support their productions in host countries. In our empirical analysis, it is the production transfer that causes the diversity of R&D location types and location patterns. Although proximity to headquarters is highly stressed in R&D location, the easy connections with production or trial-production should not be ignored. Our case study of Tokyo indicates that those R&D institutions that established together with headquarters are usually connected to their production plants by highways.

Many studies have attributed R&D diffusion and relocation to rising land costs, convenient transportation systems, and the development of information technology. This paper confirms, however, that R&D institutions' locations and their location relationships with other organizations are closely related to the product life cycle. When products mature, reaching an advanced technological status and expanding production volume, their production plants are usually transferred or re-founded in other regions or countries. Thus, R&D institutions become spatially separated from production plants, and some are even separated from headquarters as independent organizations. For example, our analysis revealed that the spatial separation tendency of R&D institutions and other organizations in Tokyo is much stronger than in Shanghai, where most domestic enterprise R&D institutions are located together with headquarters and production plants. Here, it is the spatial division of labor, caused by product cycles and

technology development, rather than the rising costs that changed the locations and location relationships. Despite the obvious differences in location types between Shanghai and Tokyo and surrounding areas, both location patterns appear related to the economic development stage at which the firms' strategies address similar problems.

Meanwhile, while the literature has focused on the common location model and location factors of MNCs' R&D institutions, the results in this paper offer new perspectives on the differences. The fact that several common positive location factors attract R&D institutions and personnel, including good access to information, transportation, high-tech labor, and completed infrastructures, does not necessarily mean that R&D institutions will show similar location patterns. Comparing R&D location patterns between MNCs and domestic enterprises in Shanghai shows that multinational and domestic R&D institutions are not attracted by the same local features. Multinational R&D institutions show higher concentrations in industrial parks than do domestic enterprises, especially in CHJ and Zhangjiang High-tech Park, which have many good locations. One reason for this is China's industrial parks were initially established to attract foreign enterprises through preferential policies. Another important reason is that multinational enterprises can afford the high rents of good locations.

The analysis of R&D location patterns in Shanghai and Tokyo and surrounding areas also confirms these differences. The results indicate that although R&D institutions in both Shanghai and Tokyo and surrounding areas show geographic concentrations in a few areas, they show distinct differences in location patterns. Shanghai's R&D institutions are concentrated mainly in industrial parks, which are designed to be part of urban development, and their diffusions occur mainly in Shanghai.

However, R&D institutions in and around Tokyo show a higher concentration than those in Shanghai and are highly concentrated within the Ken-O expressway, about 50 kilometers from central Tokyo. Moreover, most of their headquarters are located in Tokyo, while the R&D institutions are decentralized in Tokyo and surrounding areas, in a cross-border distribution.

Through these comparisons, this paper shows that the areas' two different location patterns are the results of different economic stages, industrial bases, regional policies, and management models, while also representing two different R&D location models in developing and advanced countries. Though perhaps biased, our observations indicate that enterprise R&D institutions' location patterns in developed countries are formed on the basis of industrial complex, while those in developing countries are formed by multinational R&D and strongly influenced by regional policies. Japanese R&D institutions' location patterns are based on the Keihin industrial complex: R&D activities are dependent on Tokyo-based, high-level management efficiency, fast information exchanges, good access to other regions, and industrial clustering, which causes R&D concentration in and around Tokyo and lowers the likelihood of R&D activities occurring in other areas. By contrast, the location patterns of China's R&D institutions have a certain administrative nature: the industrial park plan has become an important way for regional government to introduce hi-tech talent and balance regional economies. However, it also restricts fair competition and hinders innovation. Moreover, R&D institutions in Shanghai seem more sensitive to preferential policies than those in Tokyo. This indicates that regional policy plays an important role in R&D distribution; in more high-tech regions, industrial and social linkages and connections tend to gain importance, reducing the significance of policy.

Furthermore, different from the previous studies on the common factors of MNCs' R&D location, this paper's case studies indicate that regional attractiveness differs according to individual firm characteristics, a fact that should be of concern to regional policy-makers. Multinational R&D centers pay more attention to the economic level, high-tech talent, and market potential of the host countries, while local enterprise R&D institutions are more concerned about their connections with intra-firm organizations. Furthermore, although the importance of proximity to universities and other research institutes in national-level R&D locations was strongly stressed in previous studies, enterprises do not, in fact, stress this factor when deciding upon R&D locations in metropolitan areas with efficient transportation systems.

In addition, despite the arguments about clusters' important role in innovation, the results of this paper indicate that enterprises do not consider clusters important when deciding on R&D locations, but instead pay much more attention to connections with intra-firm organizations. However, this does not negate the positive role of clusters in R&D activities. Industrial parks are industrial complexes that in fact carry the functions of clusters. For example, although previous studies claim that spillover effects from multinational R&D cannot be expected, the case study on Shanghai revealed that domestic enterprises seek to be located near MNCs, from which they expect to acquire new information rapidly. The TAMA in Japan was also established to promote industrial clusters. It is worth noting that the mere industrial cluster cannot be expected to promote R&D activities. One region can attract more R&D institutions only when various other factors, including commercial, educational and cultural facilities, are also well equipped there. Moreover, our results show that, as an unobservable factor, competition plays an important role in the concentration of R&D institutions, which should be taken notice of

policy-maker.

Nevertheless, several unobservable and specific location factors give R&D concentration areas some common local features, which is why R&D is highly concentrated in a few areas. As shown in the literature, residential attractiveness (e.g., regional image, educational level, recreational facilities) and R&D climate, play critical roles in a firm's R&D location. Higher-wage, capital-intensive departments employing a significant number of managers, technicians and skilled craftsmen tend to choose locations in the larger, more accessible centers in order to take advantage of specialized labor as well as business, financial, legal, repair, transportation, communication, public services, and other external benefits more easily (Moriarty 1983). Therefore, although R&D institutions show some spatial decentralization, metropolitan areas such as Shanghai and Tokyo and surrounding areas remain attractive for R&D despite their high costs. These factors are also likely to be well equipped in neighboring areas, however. Consequently, the cross-border spatial autocorrelation is very important. The strict administrative boundaries and regulations will limit the flow of knowledge and talent, thus inhibiting innovation. However, it cannot be asserted that cross-border innovation regions are more efficient.

7.2 Future Works

Finally, the limitations of this study should be discussed.

The analysis on the location patterns in Shanghai and Tokyo and surrounding areas revealed that enterprise R&D institutions exhibit location differences by industry. As

only a small amount of data on enterprise R&D institutions was collected, this paper took manufacturing R&D institutions as its study object and explored their location types and location differences by industry, while discussing the location patterns of R&D institutions in Shanghai. However, while analyzing the location patterns of R&D institutions in and around Tokyo, the paper focused on R&D institutions in the electric and electronic equipment manufacturing industry, since much detailed data could be collected on. Using different kinds of industrial data to compare the two areas is an obvious shortcoming of this study. Different results might be obtained if the same industrial data are used. Therefore, more details on the locations of R&D institutions in one industry in Shanghai and those in another industry in Tokyo should be explored in order to explain the location patterns and location factors by industry. Furthermore, in order to examine the changes of location types in Shanghai is in accordance with Tokyo or not, further study is also needed on the locations of R&D institutions over period.

Additionally, this study discusses the location patterns of R&D institutions from the perspective of organizational location relationships. In fact, R&D location is the result of many integrated factors, including firm strategy, economic development, regional policies, knowledge transfer, and talent. How these roles influence R&D locations collectively and what linkages exist among them must be examined through further empirical analysis.

While previous studies affirm the positive role of R&D institutions in spillover effects, the situation in different areas and among different enterprises should also be considered. Although enterprises focus on connections among the intra-firm organizations while deciding on R&D locations, R&D efficiency depends on not only

internal factors but also external factors. The transfer path of R&D information and the results among different R&D institutions directly impact the spatial spillovers of knowledge. To determine how to make innovation more efficient, future studies should examine how the R&D process and results transfer between multinational and local R&D institutions, and between enterprise and academic R&D institutions. Besides, the roles of geographic specialization of cluster proposed by Porter (1998) and geographic diversity recognized by Jacobs (1969) in R&D spillovers are another issue to be concerned.

Finally, R&D talent plays a critical role in R&D. Though proximity to universities seems to be not as important in metropolitan areas (because of their efficient transportation systems), talent mobility promotes knowledge flow invisibly, through which regional image also improves. Nevertheless, whether talent mobility has significant effects on R&D activities is not examined here and needs to be tested through further empirical analysis. More detailed empirical work on the mechanisms of talent mobility and knowledge flow remains an important avenue of further research.

References

- Akimoto, K. 1989. Kenkyusho ricchi: So no chiho tenkai no kanosei (Location of research institutes: Possibilities of developing R&D in provincial regions). *Industrial Location* 2: 26-38. (J)
- Archibugi, D. and Lammarino, S. 2002. The globalization of technological innovation: Definition and evidence. *Review of International Political Economy* 9: 98-122.
- Asheim, B. 2003. On the new economic geography of post-fordist learning Economies. In Öhman, J. and Simonsen, K. eds: *Voices from the North: New trends in Nordic human geography*, Aldershot: Ashgate: 29-48.
- Asheim, B., Isaksen, A., Nauwelaers, C. and F. Tödtling. 2003. Regional innovation policy for small-medium enterprises, Cheltenham, UK and Lyme, US: Edward Elgar.
- A.T. Kearney Global Business Policy Council (GBPC). 2010. Investing in a rebound: The 2010 A.T. Kearney FDI confidence index. Vienna, U.S.A: A.T. Kearney, Inc.
- Audretsch, D. B. and Feldman, M. P. 1996. R&D spillovers and the geography of innovation and production. *The American Economic Review* 86: 630-640.
- Audretsch, D. B. and Feldman, M. P. 2003. Knowledge spillovers and the geography of innovation. *Prepared for the Handbook of Urban and Regional Economics* 4: 1-39.
- Autant-Bernard, C. 2006. Where do firms choose to locate their R&D? A spatial conditional logit analysis on French data. *European Planning Studies* 14 (9): 1187-1208.
- Battelle. 2010. 2011 global R&D funding forecast. *R&D Magazine*: December 2010.
- Bartlett, C.A. and Ghoshal, S. 1989. *Managing across borders: The transnational solution*. Boston: Harvard University Press.

- Branstetter, L. and Foley, C. F. 2010. Facts and fallacies about US FDI in China. In *China's growing role in world trade*, ed. Robert, C. Feenstra and Shang-jin Wei, 513-539. Chicago: University of Chicago Press.
- Branstetter, L. and Kwon, H. U. 2004. The restructuring of Japanese research and development: The increasing impact of science on Japanese R&D. RIETI Discussion Paper Series 04-E-021.
- Bulletin on China's S&T Budget 2012. <http://www.sts.org.cn/tjbg/tjgb/document/2013/20130927.htm> (March 25th, 2014.).
- Cantwell, J. 1995. The globalization of technology: What remains of the product cycle model? *Cambridge Journal of Economics* 19: 155-174.
- Cantwell, J. A. and Narula, R. 2001. The eclectic paradigm in the global economy. *International Journal of the Economics of Business* 8(2): 155-172.
- Cantwell, J. A. and Piscitello, L. 2002. The location of technological activities of MNCs in European regions: The role of spillovers and local competencies. *Journal of International Management* 8 (1): 69-96.
- Cantwell, J. A. and Piscitello, L. 2005. The recent location of foreign R&D activities by large MNCs in the European regions: The role of spillovers and externalities. *Regional Studies* 39 (1): 1-16.
- Castells, M. 1992. *The informational city: Information technology, economic restructuring, and the urban-regional process*. Oxford: Blackwell Publishers.
- Doloreux, D. and Parto, S. 2004. Regional innovation systems: A critical synthesis. UNU-INTECH Discussion Papers.
- Dong, L. 2007. *The agglomeration characteristics of corporation's R&D facilities in Shanghai*. Shanghai: Master's thesis, Department of Urban and Regional Economy, East China Normal University. (C)

- Du, D. 2001. *Location models of MNCs' R&D globalization by MNCs*. Shanghai: Fudan University Press. (C)
- Du, D. 2014. Five tendencies of R&D globalization. Shanghai: Wenhui Daily, April 14th, 2014. (CE)
- Du, D., Sun, Y. and Sheng, L. 2010. The spatial distribution and location trends of the R&D labs by multinational corporations in China. *World Regional Studies* 19: 1-13. (CE)
- Dunning, J. H. 2000. *Regions, globalization, and the knowledge-based economy*. Oxford: Oxford University Press.
- Economist Intelligence Unit. 2006. Globalization and manufacturing. The Economist Intelligence Unit Ltd.
- Erken, H. and Kleijn, M. 2010. Location factors of international R&D activities: an econometric approach. *Economics of Innovation and New Technology* 19 (3): 203-232.
- Feldman, M. P. 1994. *The geography of innovation*. Boston: Kluwer Academic Publishers.
- Fields, G. 2006. Innovation, time, and territory: Space and the business organization of dell computer. *Economic Geography* 82: 119-146.
- Florida, R. 1997. The globalization of R&D: Results from a survey of foreign-affiliated R&D laboratories in the USA. *Research Policy* 23: 85-103.
- Glaeser, E. L., Kallal, H. D., Scheinkman, J. A. and Shleifer, A. 1992. Growth in cities. *Journal of Political Economy* 100: 1126-1152.
- Grant, R. M. 2010. Working paper on national economic development and the competitive advantage of nations. Milan: Center for Research in Organization and Management.

- Grant, R. M. 2011. National economic development and the competitive advantage of nations. Milan: Center for Research in Organization and Management.
- Grossman, G. M. and Helpman, E. 1992. *Innovation and growth in the global economy*. London: MIT Press, Cambridge.
- He, Q. and Wang, Z. 2006. Study on the location factors of overseas R&D investment in China. *China Soft Science Magazine* 7: 113-120. (CE)
- Hirshfeld, S. 2005. Globalisation of R&D. *Technology Review*: 184.
- Howells, J. R. L. 1984. The location of research and development: Some observations and evidence from Britain. *Regional Studies* 18: 13-29.
- Hufbauer, G. C., Moran, T. H. and Oldenski, L. 2013. Globalization of R&D by US MNCs: Implications for US prosperity. In *Outward foreign direct investment and US exports, jobs, and R&D: Implications for US policy*. Washington, DC: Peterson Institute for International Economics.
- Ikura, T. 1996. *Shin Kanagawaken no chiri (New geography of Kanagawa prefecture)*. Senior High School Subjects Research Meeting of Kanagawa Prefecture for Geography Sectional Meeting. (J)
- Intellectual Property Rights Department JETRO Beijing. 2007. Chugoku ni okeru R&D to chizai hogo no genjo (Report of R&D and intellectual property rights in China). (J)
- Ishigami, T. 1986. Kigyō kenkyūsho no ritti doukō (Location trends of enterprises research institutions). *JDB Research Report* 90: 2-43. (JE)
- Jacobs, J. 1969. *The economy of cities*. New York: Vintage.
- Jaffe, A. B. 1986. Technology opportunity and spillovers of R&D: Evidence from firms' patents, profits and market value. *American Economic Review* 76: 984-1001.
- JETRO. 2007. Chugoku ni okeru R&D to chizai hogo no genjō (R&D and intellectual

- property protection in China). Beijing: IPG of JETRO's Beijing Office. (J)
- JETRO. 2007. Jishu soushin seisaku to chugoku kigyo (Self-innovation policies and Chinese enterprises). Beijing: IPG of JETRO's Beijing Office. (J)
- Ji, Z. 2007. *A geographical study on development of industrial parks and changes in rural areas: A comparison of the Tokyo and Shanghai metropolitan areas*. Tokyo: Kokon Shoin Publishers.
- Jones Lang LaSalle. 2008. China business parks: The next real estate opportunity. In *World Winning Cities: Global Foresight Series 2008*. Chicago: Jones Lang LaSalle, Inc.
- Kamakura, N. 2012. Functional changes within large factories in the Tokyo metropolitan area: Case study along the Tokaido line. *Geographical Review of Japan* 85(2): 138-156. (JE)
- Kato, K., Iwasaki, Y. and Aichia, M. eds. 1996. A study on location factors of the private research institute location: Based on logit model of disaggregate behavioral analyses. *Journal of Infrastructure Planning and Management (JSCE)* 13: 241-246. (JE)
- Kilvits, K. 2012. Living environment as location decision factor for manufacturing enterprises. *China-USA Business Review* 11(2): 217-224.
- Kimura, T. 1990. Wagakuni no kogyo ni okeru seisan kino no chiiki bunka: R&D kino no ritchi ni chumoku shite (Regional differentiation of industrial production function in Japan: from the location of R&D function). In *Sangyo kukan no dainamizumu: Kozo saihenki no sangyo ritchi · chiiki shisutemu (Dynamism in industrial space: Industrial location and regional system during reorganization)*, ed. H. Nishioka and K. Matsushashi, 72-84. Tokyo: Taimeido. (J)
- Kitamura, Y. and Yada, T. 1983. *Nihon kogyo no chiiki kozo (Regional structure of industry in Japan)*. Yokyo: Taimeido. (J)

- Kodama, T. 2007. Industrial cluster policy in Japan: Its concept, origins, development and implications. Workshop on Japanese Approaches to Local Development, Clusters, Industry-University Linkages and Implications for British Columbia, UBC, Vancouver, March 8-9, 2007.
- Kondo, A. 2004. Restructuring interplant divisions of labor and local subcontracting linkages: a case study of a Japanese TV manufacturer. *Geographical Review of Japan* 77: 649-674. (JE)
- Kondo, A. 2007. *Location strategy and spatial divisions of labor: A corporate geography in Japanese electronics firms*. Tokyo: Kokon-shoin. (J)
- Kondo, A. 2012. Ritchi to shuseki kara mita kenkyu kayihatu to innovation (R&D and innovation: Perspective of location and concentration) In *Sangyo shuseki no henbo to chiiki seisaku (Transformation of industrial concentration and regional policy)*, ed. T. Ito and M. Yanai, 61-93. Kyoto: Minervashobo. (J)
- Koo, J. and Kim, T. E. 2009. When R&D matters for regional growth: A tripod approach. *Papers in Regional Science* 88 (4): 825-840.
- Kose, T. 2006. Second term medium-range industrial cluster program. Presentation material for the 23rd Regional Cluster Seminar on September 21, 2006, Tokyo.
- Kranich, J. 2008. R&D and the agglomeration of industries. University of Lüneburg: Working Paper Series in Economics, April 2008.
- Kuemmerle, W. 1999. Foreign direct investment in industrial research in the pharmaceutical and electronics industries--results from a survey of multinational firms. *Research Policy* 28(2-3): 179-193.
- Kumar, N. 2001. Determinants of location of overseas R&D activity of multinational enterprise: The case of US and Japanese corporations. *Research policy* 30: 159-174.

- Li, S. 2008. A study on the reform of tax system that drives enterprises' self-innovation. *Asian Social Science* 4: 33-37.
- Lin, J., Science and Technology Commission of Shanghai and Shanghai Municipal Statistics Bureau. 2007. *Shanghai Statistical Yearbook on Science and Technology 2007*. Shanghai: Shanghai Popular Press. (C)
- Liu, Y. and Liu, W. 2007. Study on regional differentiation of R&D localization of TNCs in China. *Economic Geography* 27: 231-225. (CE)
- Lund, L. 1986. *Locating corporate R&D facilities*, Report No.892. New York: The Conference Board, Inc.
- Lychagin, S.; Reenen, J.V., Slade, M.E., and Pinkse, J. 2010. You can raise productivity through R&D, but geography matters a lot. London: Columns Paper of VoxEU.org.
- Mairesse, J. and Mohnen, P. 2004. The importance of R&D for innovation: A reassessment using French survey data. Cambridge: Working Paper on National Bureau of Economic Research, November, 2004.
- Malecki, E. J. 1979. Agglomeration and intrafirm linkage in R&D locations in the United States. *Tijdschrift voor Economische en Sociale Geografie* 70: 322-332.
- Malmberg, A. and Maskell, P. 2003. Localised capabilities and industrial competitiveness. In *Voices from the North: New Trends in Nordic Human Geography*, ed. Öhman, J. and Simonsen, K., 11-28. Aldershot: Ashgate.
- Mano, H. 1987. Kenkyusyo no ritti doukou no genjo to shorai (Current condition and future of research institute's location trend. *Sangyo Ritti* 12 (*Industrial location*): 43-52. (J)
- Maskell, P. 2000. Social capital, innovation and competitiveness. In *Social capital: critical perspectives*, ed. Barson, S., Field, J. and Schuller, T. Oxford: Oxford University Press.

- Matsubara, H. 2009. Tamagawa chiiki ni okeru kogyoteki totchi riyo no henka ·kino tenkan to ryuiki kankyo seibi no kadai (Report on industrial land-use changes, functional transformation and Environmental Improvement along Tamagawa River). Tokyo: The Tokyo Foundation for Better Environment. (J)
- Matsuhashi, K. 1990. Denki ·denshi kogyo no chiho bunsan to kigyonai chiikikan bungyo no tenkai (Decentralization of electric and electronic industry and spatial division of labor within firm). In *Sangyo kukan no dainamizumu: Kozo saihenki no sangyo ritchi ·chiiki shisutemu (Dynamism in industrial space: Industrial location and regional system during reorganization)*, ed. H. Nishioka and K. Matsuhashi, 97-114. Tokyo: Taimeido. (J)
- Metropolitan Areas Development Bureau of MLIT. 1993. *Kenkyu kikan no ritchi senryaku (Location strategy of research institutes)*. Tokyo: National Printing Bureau.
- Midelfart-Knarvik, K. H. and Overman, H. G. 2002. Delocation and European integration: Is structural spending justified? *Economic Policy* 17 (35): 321-359.
- Ministry of Internal Affairs and Communications of Japan. *Survey on Science and Technology Research*.
- Ministry of Science and Technology of the People's Republic of China. 2011. *China Science and Technology Statistics Data Book*.
- MLIT. 2006. *White paper on national capital region development (2006)*. Tokyo: Ministry of Land, Infrastructure and Transport.
- Moriarty, B. M. 1983. Hierarchies of cities and the spatial filtering of industrial development. *Papers in Regional Science* 53: 59-82.
- MRI (Mitsubishi Research Institute). 2002. Kenkyu kaihatsu taisei nadono hyoka shisutemu ni kansuru chyouka hokokusyo (Report on evaluation of R&D system).

- Tokyo: Ministry of Economy, Trade and Industry. (J)
- Nakagawa, T., Ji, Z., and Suyama, S. eds. 1992. Agglomeration of private research institutions in Tsukuba science city. *Japanese Journal of Human Geography* 44: 643-662. (JE)
- Nakagawa, T. 1996. Location patterns of private research institutions in Japan. *Studies in Human Geography* XX: 145-159. (JE)
- Nakajima, K. 1989. On the systematization of laboratory location theories: Principally through the survey of literatures. *Association of Economic Geographers* 35 (3): 1-20.
- Nanbu, T. 2002. Study on the organization of the pharmaceutical industry. Tokyo: Tokyo University Press.
- Narula, R. and Dunning, J.H. 2000. Industrial development, globalization and multinational enterprises: New realities for developing countries. *Oxford Development Studies* 28(2): 141-167.
- National Bureau of Statistics of China. *China statistical yearbook on science and technology*. Beijing: China Statistics Press.
- National Bureau of Statistics of China. 2006. Special investigations report on enterprise innovation. <http://finance.sina.com.cn/roll/20061023/0000991021.shtml> (2nd December 2011)
- National Science Board. 2010. *Science and Engineering Indicators 2010*. Arlington, VA (NSB 10-01).
- National Science Board. 2014. *Science and Engineering Indicators 2014*. Arlington, VA (NSB 14-01).
- Niosi, J. 2003. The location choices of R&D activities in Canadian multinationals. *International Business* 8:141-157.

- Niosi, J. and Godin, B. 1999. Canadian R&D abroad management practices. *Research Policy* 28(2-3): 215-230.
- Nishioka, H. 1990. Sentan gijutsu, chiiki kaihatsu, oyobi sangyo ritchi (Advanced technology, regional development and industrial location). In *Sangyo kukan no daidainamizumu: Kozo saihenki no sangyo ritchi · chiiki shisutemu (Dynamism in industrial space: Industrial location and regional system during reorganization)*, ed. H. Nishioka and K. Matsushashi, 1-16. Tokyo: Taimeido. (J)
- Oda, K. and Saso, J. 1987. Kenkyuusyo no ritti youin to tihou ritti ni tuite: Minkan kenkyuusyo no ritti ni kansuru kenkyuu (Study on location factors of research institutions: Case on the location study of private research institutions). *Papers on City Planning* 22: 187-192. (JE)
- Odell, K. 2006. The Perlmutter/Ronstadt matrix. Kelly's Think Tank (August 26, 2006): <http://kellyodell.blogspot.jp/>
- OECD. 2011. *Main Science and Technology Indicators*. OECD Publishing.
- OECD. 2012. *Main Science and Technology Indicators*. OECD Publishing.
- Ogawa, I. 1989. *Tokyo daitoshiken no chiiki henyo (Regional transformation in Tokyo metropolitan area)*, Tokyo: Taimeido. (J)
- Ohara, H. 1996. *Modern pharmaceutical industry in Japan (Gendai Nihon no iyakuhin sangyo)*. Tokyo: Kobundo Publisher.
- Osaka Prefecture Institute for Advanced Industrial Development. 2007. Kigyuu ni okeru kenkyuu kikan no setti jyoukyuu (kenkyuu houkokusyo) (Research report on the establishment of enterprises' institutions). Osaka: Osaka Research Center for Industry and Economy. (J)
- Pavlínek, P. 2012. The internationalization of corporate R&D and the automotive industry R&D of East-Central Europe. *Economic Geography* 88: 279-310.

- Pearce, R. and Papanastassiou, M. 1999. Overseas R&D and the strategic evolution of MNEs: Evidence from laboratories in the UK. *Research Policy* 28:23-41.
- Porter, M. E. 1986. *Competition in global industries*. Boston: Harvard Business Press.
- Porter, M. E. 1990. *The competitive advantage of nations*. New York, NY, Free Press.
- Porter, M. E. 1998. Clusters and the new economics of competition. *Harvard Business Review*: 77-90.
- Reger, G. 2004. Coordinating globally dispersed research centers of excellence: the case of Philips electronics. *Journal of International Management* 10: 51-76.
- Robert, R. 1977. *Research and development abroad by U.S. multinationals*. New York: Praeger.
- Roger, H. 1997. *The dynamics of industrial location: The factory, the firm and the production system*. Chichester: John Wiley and Sons.
- Ronstadt, R. 1984. R&D abroad by U.S. multinationals. In *Technology crossing borders: The choice, transfer and management of international technology flows*, ed. R. Stobaugh and L. Wells. Boston: Harvard Business School Press.
- Sampson, R.C. 2007. R&D alliances and firm performance: the impact of technological diversity and alliance organization on innovation. *Academy of Management Journal* 50 (2): 364-386.
- Sato, Y. 2004. Migration processes of R&D workers in Tsukuba science city: A case study of the pharmaceutical industry. *Annals of the Japan Association of Economic Geographers* 50: 205-226. (JE)
- Saur-Amaral, I. and Borges Gouveia, J.J. 2008. International R&D models applied to pharmaceutical industry: A preliminary outline of results. DRUID-DIME Academy Winter 2008 PhD Conference.
- Seki, M. 1993. *Gendai hiteku chiiki sangyoron (High technology industries)*. Tokyo:

Shinhyoron. (J)

Science and Technology Strategy Group of China. 2006. *Report on Regional Innovation Capability (2005-2006)*. Beijing: Science Press.

Science and Technology Strategy Group of China. 2007. *Report on Regional Innovation Capability (2006-2007)*. Beijing: Intellectual Property Publishing House.

Shanghai Private Economy Development and Promotion Center. 2006. *Entrepreneurship, innovation, creation: Report of Shanghai private enterprises' innovation*. Shanghai: Shanghai Scientific and Technological Publishing House.

(C)

Shinbo, T., Onishi, K. and Nishimura, Y. 2005. R&D productivity and agglomeration economy of R&D institutes. The 21st Century Center of Excellence Program of Hitotsubashi University Working Paper.

Simonen, J. and McCann, P. 2010. Knowledge transfers and innovation: The role of labor markets and R&D co-operation between agents and institutions. *Papers in Regional Science* 89 (2): 295-309.

Sivitanidou, R. and Sivitanides, P. 1995. The intrametropolitan distribution of R&D activities: Theory and empirical evidence. *Journal of Regional Science* 35 (3): 391-415.

Sternberg, R. 1996. Technology policies and the growth of regions: Evidence from four countries. *Small Business Economic* 8: 75-86.

Storz, C. 2008. Innovation, institutions and entrepreneurs: The case of "cool Japan". *Asia Pacific Business Review* 14 (3): 401-424.

Sun, Y. 2003. Strategic or tactical? Foreign research and development in developing countries: A case study of China. *Asian Geographer* 22: 143-167.

Sun, Y. and Du, D. 2010. Determinants of industrial innovation in China: evidence from

- its recent economic census. *Technovation* 30: 540-550.
- Takeuchi, A. 1996. *Kogyo chiiki no hendo (Reorganization of industrial region)*. Tokyo: Taimeido. (J)
- UNCTAD. 2005. World investment report 2005: Transnational Corporations and the Internationalization of R&D. United Nations Conference on Trade and Development. New York and Geneva, 2005.
- Vernon, R. 1966. International investment and international trade in the product cycle. *The Quarterly Journal of Economics* 80 (2): 190-207.
- Walker, R. 1988. The geographical organization of production-systems. *Environment and Planning D: Society and Space* 6: 377-408.
- Wang, C. and Du, D. 2007. R&D investment motives and location selection by Japan in China. *Economic Tribune* 17: 65-67. (CE)
- Wang, P. 2007. *The types of location of foreign R&D in Shanghai*. Shanghai: Master's thesis, Department of Urban and Regional Economy, East China Normal University. (C)
- Westlund, H. 2006. *Social capital in the knowledge economy: Theory and empirics*. New York: Springer Berlin Heidelberg.
- Xu, R. and Du, D. 2004. Study on the location of foreign capital R&D in Shanghai. *Economic Geography of China* 24: 625-628. (CE)
- Xue, L., Shen, Q. and Wang, S. 2002. Multinational R&D in China under the background of globalization: An analysis based on the industrial differences of multinational independent R&D institutions in China. *Management World* 3:33-42. (CE)
- Yan, K., Wu, L. and Ma, C. 2004. *R&D and driving force of enterprise: Cases of R&D of enterprises at home and abroad*. Beijing: China Economic Publishing House.

- Yanai, M. 1993. Kosoku kotsu taikei to kigyo senryaku (High-speed transportation system and corporate strategy). In *Kigyo Kukan to Network (Corporate Space and Network)*, ed. M. Yamakawa and M. Yanai, 76-86. Tokyo: Taimeido. (J)
- Yu, Z. and Tong, X. 2003. An innovative region in China: Interaction between multinational corporations and local firms in a high-tech cluster in Beijing. *Economic Geography* 79 (2): 129-152.
- Zhang, R. and Du, D. 2006. On the spatial difference and the regional classification of R&D industry in China. *Areal Research and Development* 25: 20-24. (CE)
- Zheng, J. 2000. Location of multinational corporation's overseas R&D facilities. *World Regional Studies* 1:1-16. (CE)
- Zhou, C. 2006. Differences in R&D intensity: An analysis based on the effect on industrial structure. *Journal of Nanjing University (Philosophy, Humanities and Social Sciences)* 3: 26-34. (CE)
- https://staff.aist.go.jp/t.kotoku/policy/history_j.html (1st, May, 2014)
- <https://www.city.sayama.saitama.jp/jigyo/kigyo/miryoku4.html> (8th, August, 2014)

Published Papers

Li Nana. Literature Review on the Geography of R&D Activities. *Annual Reports of Graduate School of Humanities and Sciences (Nara Women's University)* (29): 45-60. 2014. (Chapter 2)

Li Nana. Geographic Characteristics of Enterprise R&D Activities in Shanghai. *Annual Reports of Graduate School of Humanities and Sciences (Nara Women's University)* (28): 157-170. 2013. (Chapter 3 and Chapter 4)

Li Nana. Location Types of Enterprise R&D Institutions in Shanghai. *Geographical Review of Japan Series B* 84(2): 44-59. 2012. (Chapter 4)