THE ROLE OF INFRASTRUCTURE SUPPORT AND REGIONAL SPECIALIZATION IN THE JAPANESE MANUFACTURING SECTOR

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ABSTRACT

This study explores the results of a survey regarding new plant locations for Japanese manufacturing firms with the goal of understanding the impact of infrastructure support on the formation of new manufacturing plants and identifying industrial variety in that impact. This research finds an infrastructure advantage factor consisting of various infrastructure supports and demonstrates that the role of location varies across industries. The results indicate that the regional specialization of industries is the result of unique regional advantages that are sought out by individual industries.

Key words: manufacturing, infrastructure, Japan

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Introduction

This study uses exploratory factor analysis to examine the results of a business location survey and discusses the role of investment in infrastructure, particularly highway infrastructure, in the context of the Japanese manufacturing sector. Almost all of the empirical studies of the relationship between infrastructure and regional growth have been econometric studies; few survey-based studies investigating the role of infrastructure support have been conducted. In contrast, this study utilizes the results of a location survey of manufacturing plants, with particular emphasis on the regional impact of infrastructure support.

Haughwout (1998) noted that the role of transport infrastructure varies across industries and suggested that this may affect transport infrastructure preferences. This idea is reasonable because individual industries vary in their location requirements, products, and market conditions, and each of these factors can influence the role and benefits of transportation infrastructure on the industry. Holl (2004a) confirmed this hypothesis with an econometric study in the Spanish manufacturing sector. The impact of industrial variety on transport infrastructure can be easily extended to explain more general variation in the influence of infrastructure support. Therefore, this study investigates the regional impact of general infrastructure by evaluating the results of a location survey.

To organize the discussion, this study raises the following questions: does infrastructure arrangement actually attract new plants? How important is infrastructure compared to the other advantages of a particular location? Is the positive impact of infrastructure support equivalent across industries? Finally, is industrial specialization the result of variation in the spatial distribution of infrastructure? The first question is the focus of this study; the other questions investigate whether the influence of infrastructure might be diluted by other negative geographical conditions and/or industrial property.

The structure of this paper is as follows. The next section reviews relevant literature, the third section describes the data of the questionnaire survey, and the fourth section briefly describes the method used for exploratory factor analysis and its advantages and disadvantages. The empirical section presents the results of the exploratory factor analysis by industry and describes how location factors are diversified across industries. Exploratory factor analysis is performed for 22 SIC industries and a factor score is computed for individual industries. The factor score, which is a composite measure of industry-specific location preferences abstracted in the form of a latent location factor, is quite helpful for characterizing the location factors emphasized by individual industries. The results section concludes with an analysis of the regional share of industries grouped based on latent location factors. Finally, the last section characterizes location factors by individual industry and region to determine if the significance of location varies across industries and regions.

Literature Review

Since the work of von Thünen (1966), transportation costs have been central to the development of modern location theories. The classical Weberian location model defined the optimum location of a plant as the point that minimizes the distances to both the market and raw materials (Weber, 1929); Weber also showed that this optimum point can vary according to spatial differences in land costs and production input costs such as labor. His idea was further refined (Christaller, 1966; Losch, 1944, 1954; Isard, 1956), and the tradition of his research has been adopted by the new economic geographers. Transport costs still play a vital role in the recent literature (Krugman, 1991a; 1991b; Fujita et al., 1999; Fujita and Thisse, 2002), with such costs linked to spatial differences in the price indices of goods, which represent the positive impact of agglomeration economies[1].

Many important studies have explored the role of transport infrastructures on the location decisions made by firms. For example, based on a survey conducted from 1980 to 1990 of manufacturing plants in Georgia and South Carolina, Barkley and McNamara (1994) concluded that access to interstate highway was the most important factor in location decisions. To the best of our knowledge, this study is the only survey-based empirical research focusing on the role of infrastructure support; other empirical studies have relied upon econometric models. For instance, Coughlin et al. (1991), Friedman et al. (1992), and Smith and Florida (1994) found a positive correlation between the local development of transport infrastructure and the location choices of manufacturing plants in the U.S. In addition, a negative correlation between manufacturing activity and the distance to the highway was found by Guimarães et al. (1998) for Puerto Rico and by Luker (1998) and, in counties in the U.S., by Gabe and Bell (2004). In addition, Coughlin and Segev (2000), Holl (2004a, 2004b, 2004c), and Cieślik (2005) demonstrated that road infrastructure is crucial for attracting local manufacturing plants. All of those empirical findings support the positive role of infrastructure in the construction of new plants[2].

Among the many potential issues regarding local infrastructure, differences in the impact of infrastructure support across industries and regions are particularly important for policy planners. According to Devereux et al.

[1] See Dembour (2008) for a review of recent studies exploring the relationship between infrastructure support and location choice from the perspective of the new economic geography.

[2] In addition, Bougheas et al. (2003) showed that firms strategically consider infrastructure support as an important location variable.

(2002), local governments face a risk of "fiscal war" when they attempt to influence the location decisions of firms by making their own region more attractive by building infrastructure (Wasylenko, 1997). If neighboring regions respond by also increasing infrastructure support to attract the company of interest, the risk of fiscal failure increases (Dembour, 2008). This raises the question of whether infrastructure support is actually demanded by local firms and industries in the region, compared to neighboring regions. Unless governments are careful, fiscal spending might be completely wasted if it does not actually increase the attractiveness of the location (McCann and Shefer, 2004).

In addition, this survey study provides policy-related evidence that helps to explain the actual influence of location. Recently, economic geographers (see, for example, Markusen, 2001; Martin, 2001; and Massey, 2001), spurred by the controversial view of the World Development Report 2009 (WDR 2009), Reshaping Economic Geography, have advocated policy-focused research. Several economic geographers responded critically to the WDR 2009 (Harvey, 2009; Bryceson et al., 2009; Rigg et al., 2009; and Scott, 2009). For example, Rodriguez-Pose (2010) and other commentators recommended that economic geographers re-orient their work to policy application. In that vein, this survey-based study helps to elucidate the actual location decision process of new plants and contributes to this shift toward a focus on policy in economic geography.

This study applies exploratory factor analysis to the survey results. The application of exploratory factor analysis to a spatial study is by no means unusual, as the technique has become increasingly common in management studies as well as in economic geography (e.g., Marginson and Mcaulay, 2008; Galbraith et al., 2008; Zhou et al., 2008). There are two common advantages to this approach. First, it summarizes the numerous behavioral reasons for decisions by firm managers into a few latent reasons. Second, the resulting summated scale, such as a factor score, measures how much each latent reason affects the behavior of individual actors. Particularly for location decisions of firms, exploratory factor analysis provides a unique analytical advantage in that complex location reasoning is abstracted into a few theoretically meaningful factors, which are then independently transformed into a scale that differentiates regional features.

Recently, multivariate statistical approaches have been increasingly applied to a wide variety of studies of business strategies[3]. Govindarajan

[3] The application of exploratory factor analysis to social science studies has become common since Rummel (1970) and Harman (1976) published textbooks describing its use in evaluating socioeconomic data. Harrigan (1985) initially advocated multivariate statistical techniques, particularly exploratory factor analysis and cluster analysis, in management science[3]. Dorf and Emerson (1978) provided one of the earliest attempts to use exploratory factor analysis

and Praveen (2006) performed both exploratory and confirmatory factor analyses to investigate the disruptiveness of innovations[4]. Mani et al. (2007) used exploratory factor analysis to investigate the ownership structure of a foreign direct investment (FDI) portfolio with respect to the entry mode and equity level[5]. Marginson and McAulay (2008) also used exploratory factor analysis in an evaluation of short-terminism[6], and Reuer and Arino (2007) used the technique to uncover the incentives for a corporate alliance strategy and its various forms (e.g., M&A, non-equity agreements, and contractual provisions). Galbraith et al. (2008) focused on the location behavior of high-technology manufacturing companies. Zhou et al. (2008) used confirmatory factor analysis and found that the market orientation of firms improves product quality and job satisfaction of employees in China. Despite the popularity of multivariate techniques in management studies, these methods are rarely used in location studies[7]. Hence, this study takes advantage of the several benefits of exploratory factor analysis in the analysis of the survey results.

to explain the spatial transition of production locations from urban to rural sites. Agarwal and Ramaswami (1992) identified location factors that determine the choice of specific foreign market entry modes. Carter et al. (1994) and Stearns et al. (1995) included location among the six strategic factors they defined for venture firms. Lane et al. (2001) used a confirmatory exploratory factor analysis to examine the influence of knowledge acquisition on an international joint venture.

[4] The disruptiveness of innovation represents a situation in which large and historical market leaders struggle to develop and introduce new products and service innovations.

[5] Entry mode represents the dichotomous choice between either full or partial ownership control of FDI. Equity level is measured as a continuous span of ownership control from 0 to 100 percent.

[6] Short-termism is the idea, originally advocated by Porter (1992), that short-term performance is important for securing the long-term goals of a business.

[7] Recently, discriminant analysis has been used more frequently in the study of economic geography. Moreno and Casillas (2007) discriminated fast-growing SMEs from stagnant SMEs based on the features of firms and found that high-growth SMEs are characterized by smaller size, high accessibility to idle resources, and low availability of financial resources. Gellynck, Vermeire, and Viaene (2007) investigated the role of regional networks in the innovation process, and used discriminant analysis to discover the innovation potential of inter-firm networking within a region and intra-firm orientation toward international markets. Scott (2008) applied discriminant analysis to explore the spatial correlation between flexible production and design-intensive outputs. Borzacchiello, Nijkamp, and Koomen (2010) used discriminant analysis to identify the group characteristics of urban locations where better transport accessibility is available. Thus, multivariate techniques and discriminant analyses in particular have proven useful in location studies.

Data

The questionnaire data used in this study are published annually by the Japan Industrial Location Center (JILC), which is closely affiliated with the Ministry of Economy, Trade, and Industry (METI). The objective of this survey is to investigate the actual reasons behind the location choices of new manufacturing plants in Japan, and the results are used to reorganize land development and improve the efficiency of location decisions. The subjects (respondents) and the timing of the survey are described below:

- *Subject:* plants in two-digit SIC manufacturing industries
- *Scope:* all new plants (including research institutions) that bought or rented more than 1,000 m^2 of land from 1997 to 2004
- *Timing:* date of the contract between the owner of land and the buyer (debtor) of land

New plants include those initiated by both existing and start-up firms. Plants whose size is smaller than 1,000 m^2 are excluded from the study.

Table 1 lists the location reasons offered to respondents and the frequencies and shares of their choices. The frequency represents the total number of respondents making a particular choice, whereas the share represents the percentage of respondents. According to the table, the most important reason for a location choice is the availability of land, which is a precious resource in the Japanese manufacturing sector; 37% of respondents selected this as their primary reason. The survey found that firms emphasize the availability of an industrial zone, support from local government, and access to highways; all were common second reasons given by respondents for location choices. Among those reasons, infrastructure advantages are represented by access to highways, the availability of industrial zones, commuting convenience, and business and logistics services. These reasons are useful for investigating the positive role of infrastructure arrangements made by governments.

In addition, Figure 1 depicts a pie diagram of the industrial share of the surveyed plants. Almost the half of the plants belongs to food, general machinery, electrical machinery or fabricated metal industries. Therefore, the overall result is biased to the location preference of those industries. Also, Figure 2 represents the spatial distribution of the surveyed plants, and their density. The local number of new plants corresponds to the local number of respondents in the survey.

Methodology

This section describes the structure of the data set and discusses the advantages and disadvantages of exploratory factor analysis. The survey data set consists of cross-sectional data expressed in matrix form. We denote i and r as the identification number of an industry p and q stand for the number of industries and the location reason, respectively, with $i = \{1, 2, \cdots, p\}$

Table 1: Overview of the choice frequencies and shares.

	Primary reason		Secondary reason	
Location reason	freq.	share	freq.	share
Total	5495	100.0%	7581	100.0%
Access to airport	23 ○	0.4%	106	1.4%
Access to harbor	74 ○	1.3%	94 ○	1.2%
Access to highway	507 ◔	9.2%	999 ◑	13.2%
Access to railroad	6 ○	0.1%	71 ○	0.9%
Business and logistic service	178 ○	3.2%	472 ◔	6.2%
Availability of land	2038 ●	37.1%	1622 ●	21.4%
Availability of industrial zone	696 ◔	12.7%	1099 ◕	14.5%
Environment and neighborhood	372 ○	6.8%	1024 ◕	13.5%
Commuting convenience	388 ○	7.1%	903 ◑	11.9%
Support from local government	549 ◔	10.0%	682 ◔	9.0%
Manager's personal ties	225 ○	4.1%	225 ○	3.0%
Co-location with other firms	66 ○	1.2%	89 ○	1.2%
Others	373 ○	6.8%	195 ○	2.6%

Primary and secondary reason totals differ because respondents are allowed up to two choices for a secondary reason, whereas only one primary reason can be chosen.

and $r = \{1, 2, \cdots, q\}$. The frequency of choices in reason r by industry i can be represented by X_{ri} and the data set can be expressed in matrix form:

$$\boldsymbol{X} = \begin{pmatrix} X_{11} & \cdots & X_{1i} & \cdots & X_{1p} \\ \vdots & \ddots & \vdots & & \vdots \\ X_{r1} & \cdots & X_{ri} & \cdots & X_{rp} \\ \vdots & & \vdots & \ddots & \vdots \\ X_{q1} & \cdots & X_{qi} & \cdots & X_{qp} \end{pmatrix} \qquad (1)$$

There are two major advantages to exploratory factor analysis. First, exploratory factor analysis abstracts several reasons that are uniformly emphasized by industry into a few location factors. For instance, when the number of factors is limited to two, the frequency that reason r is chosen by industry i can be expressed by the following equation:

$$\boldsymbol{X_{ri} = f_{r1}s_{1i} + f_{r2}s_{2i} + u_r s^u_{ri}} \qquad (2)$$

The common factor consists of $f_{r1}\ s_{1i}$ and $f_{r2}\ s_{2i}$, where f_{r1} and f_{r2} are the factor loadings of the first and second factors, respectively, and s_{1i} and s_{2i} are the factor scores of the corresponding factors for industry i. The specific factor is represented by $u_r\ s_{ri}{}^u$ where $s_{ri}{}^u$ is the residual score of the specific factor. All industrial uniqueness that is not exhibited in the location reasons is assumed to be summarized in this specific factor.

Exploratory factor analysis is helpful for characterizing the unique impact of a location factor based on variation

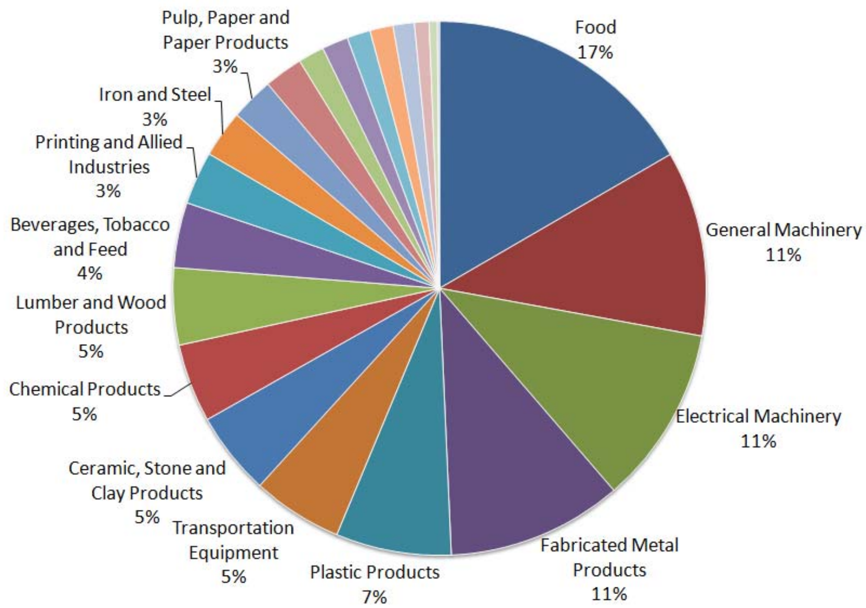

Figure 1: Pie diagram of the number of new plants in this survey

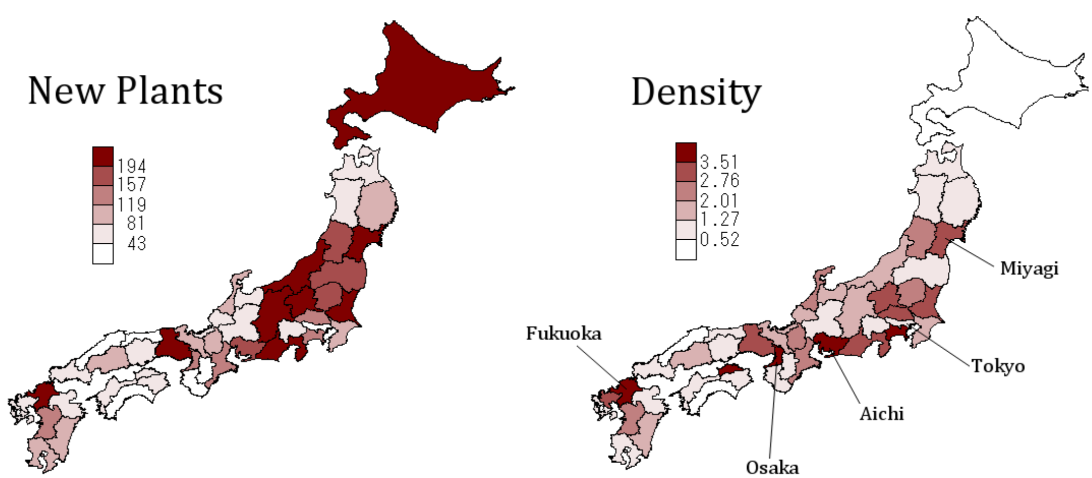

Figure 2: The number of new plants and their density (per 100 km^2).

in the factor scores. When a specific factor has no influence, X_{ri} is only dependent on f_{rk} and s_{ki}, where k is a unique identifier for a particular factor. Because f_{rk} is equally shared by all industries, the variance in the industry-specific variable X_{ri} is solely shaped by the variance in the industry-specific s_{ki}. Because the objective of this study is to characterize industrial variety in location reasoning, the industry-specific scores are crucial for measuring the differences in location choices among industries.

Hair et al. (2006) provided a useful definition of factor loadings and scores, describing factor loadings as the correlation of the original factors and variables (the frequency with which a particular reason is given for a location choice), and loadings as the degree of correspondence between the variable and the factor. Therefore, higher loadings make the variable more representative of the factor, and loadings allow an interpretation of the role of each variable in defining each factor. In addition, squared factor loadings indicate the percentage of the variance in an original variable that can be explained by a factor, which is represented by the value of communality. Besides, the factor score is a composite measure created for each observation (industry) on each factor. The factor score conceptually represents the degree to which each observation is significantly associated with the factor. Higher scores on variables with high loadings on a factor will result in a higher factor score. In this specific analysis, higher scores represent a greater number of new plants that choose their location because of the location factor.

Exploratory factor analysis is an appropriate technique for analyzing survey data related to location decisions because the location decisions of firms are highly complex and are influenced by many mutually interdependent factors. In this regard, it is quite difficult to isolate and measure the independent impact of the advantages of individual locations. This can be a methodological issue when variables are mutually correlated due to multi-colinearity. Exploratory factor analysis helps to minimize the influence of such problems by identifying a few latent location factors that affect a decision and summarizing similar location advantages into a factor; thus, all advantages are reduced to a few regional location factors.

It is important, however, to remember the limitations of exploratory factor analysis. Unlike principle component analysis, common exploratory factor analysis does not fully utilize the statistical information contained in data sets; rather, it summarizes the common variance among variables (location reasons) into factors. Therefore, the unique variance of each variable is not represented by common factors but instead resides within a specific factor. This means that specific characteristics not reflected in the common factor are summarized in the specific factor and cannot be controlled by the researcher. In other words, exploratory factor analysis only considers common variation shared among all samples (industries), and other diversity is disregarded. This incomplete use of statistical information is the major restriction of exploratory factor analysis. Therefore, it is important to remember that results derived from exploratory factor analysis only capture the common differences shared by all industries.

In processing the exploratory factor analysis, the maximum likelihood method, which is commonly used in this type of analysis, is applied to extract the factors. A promax rotation, which is appropriate when the goal of research is to derive theoretically meaningful factors (Hair et al., 2006), is used. The scores of factors are computed by the regression method. The number of factors is specified based on the latent root criterion that counts the number of eigenvalues greater than one. The result of χ^2 statistics is presented in each table to show that the location reasoning of a new plant is reasonably differentiated. In addition, the value of Cronbach's coefficient α is presented at the bottom of each analysis[8].

Exploratory factor analysis

This section introduces the results of the exploratory factor analysis[9]. Exploratory factor analysis is a data summarization technique that identifies latent factors (latent location reasons) by minimizing the variance among independent variables (location reasons). Exploratory factor analysis is also useful for characterizing an individual observation (industry) rather than groups of observations by latent factors. The data explored in this study are survey data; such categorical data are normally analyzed by multivariate statistical techniques. Exploratory factor analysis is particularly useful for summarizing the overall behavioral characteristics and the uniqueness of

[8] Cronbach's α measures the consistency of the questionnaire survey. More specifically, the value becomes larger when respondents' attitudes are parallel to the variables in a factor. For instance, if a respondent believes that market proximity is an important location reason, the respondent must also emphasize access to transport infrastructure to keep the survey consistent, because a transportation advantage improves market proximity and they mutually compensate one another. If this is not the case, the respondent has contradictory attitudes, and the questionnaire results are considered unreliable. Cronbach's α measures such consistency in exploratory factor analysis results; to guarantee consistency, the value should be higher than 0.7.

[9] There are two types of exploratory factor analysis: confirmatory factor analysis and exploratory factor analysis. Confirmatory factor analysis is performed to confirm an existing theory, and its typical approach is structural equation modeling. Due to the specificity of the objective, researchers are required, before performing the analysis, to specify the number of factors, to identify groups of variables that are expected to belong to specific factors, and to provide an a priori pattern of factor loadings. Exploratory factor analysis is adopted to evaluate an unknown structure of behavioral patterns that influence raw data and to identify a few key factors that are related to all measured variables. The crucial difference between these analyses is their objective: the goal of confirmatory factor analysis is to confirm an existing theory, whereas exploratory analysis explores a new theory. See Hair et al. (2006) for more discussion of the difference.

individual observation (industry).

Table 2 shows the factor loadings of the first and second factors for both primary and secondary reasons; their communalities are shown at the right column of each reason (see also figure 3). The latent root criterion specifies two factors, and the minor reasons are removed beforehand from the data[10]. $\chi 2$ statistics and p-values are sufficient to indicate significance. The values of the loadings are plotted in Figure 4.

Recall that factor loadings represent the correlation of the original variables (location reason) and the latent factors, and the loadings indicate the degree of correspondence between the variable and the factor. Therefore, higher loadings make the variable representative of the factor. The interpretation of a factor should begin with the first variable, and the checkout proceeds horizontally from left to right in search of the highest factor loadings; this horizontal comparison of factor loadings is repeated for all variables (location reason).

We will first address factor loadings of the primary reason. The first factor has lower factor loadings in access to highways and other transportation services, and the factor loadings of other items are generally higher than those of the second factor. Land availability is a physical constraint, industrial zoning is related to local industrial infrastructure, support from local government is an institutional matter, and a manager's personal ties are related to localized social capital. Therefore, the first factor seems to represent an overall location advantage aside from transportation. Because it is difficult to summarize these features using a few characteristics, we consider the first factor to be a *non-transportation advantage*.

Regarding the second factor of the primary reason, access to highways and other transportation services have particularly high factor loadings. Although the value of co-location with other firms is higher for the second factor, the difference between it and the first factor is negligibly small. Therefore, we specify the second factor as a *transportation advantage factor*.

An interesting feature of the first factor, the non-transportation factor, is its orientation toward relational reasons which is observed in the high loadings of support from the local government and the personal ties of managers. Doeringer and Terkle (1995) reviewed a series of survey studies and underscored the role of governmental partnership in the formation of clustering. In addition to investment in physical infrastructure such as highways and railroads, they stressed intangible institutional and cultural infrastructure that creates dynamic positive externalities. The examples of governmental support they mentioned include "business-education partnerships" for improving education through work experience and fostering research (Doeringer et al., 1987); "labor-management

[10] The minor reasons here are access to railroads, airports, and harbors, which are rarely chosen as important location reasons. See Table 1.

Table 2: Factor loadings of the first and second factors for primary and secondary reasons.

	Primary reason			Secondary reason		
	Factor 1	Factor 2		Factor 1	Factor 2	
Factor	Non-transportation	Transportation		Infrastructure	Non-infrastructure	
Access to highway	☐ 0.17	☑ 0.85	0.98	☑ 0.68	☐ 0.35	0.97
Business & logistic service	☐ -0.05	☑ 0.98	0.88	☑ 0.53	☑ 0.50	0.97
Land availability	☑ 0.70	☐ 0.34	0.99	☐ 0.58	☐ 0.46	0.99
Industrial zone	☑ 0.84	☐ 0.12	0.88	☑ 0.91	☐ 0.08	0.95
Environment and neighborhood	☑ 0.68	☐ 0.27	0.84	☐ 0.41	☑ 0.62	0.96
Commuting convenience	☑ 0.94	☐ 0.01	0.90	☑ 0.83	☐ 0.16	0.93
Support from local government	☑ 0.92	☐ 0.07	0.96	☑ 0.86	☐ 0.16	1.00
Manager's personal ties	☑ 0.90	☐ 0.07	0.92	☐ 0.35	☑ 0.66	0.93
Co-location with other firms	☐ 0.35	☐ 0.46	0.59	☐ -0.04	☑ 0.94	0.83
Cronbach's α	0.83[a]	0.79[a]		0.98[b]	0.82[c]	
	The χ^2 statistic is 36.18			The χ^2 statistic is 28.43		
	The degrees of freedom are 19			The degrees of freedom are 19		
	The p-value is 0.0100			The p-value is 0.0754		

In deriving Cronback's α in this table,

[a] Only checked reasons are included in the computation.
[b] Transportation service and land availability are not included in the computation.
[c] All checked items are included in the computation.

relations partnerships" for improving union management and recruiting efficiencies (Bartik, 1991; Doeringer and Terkle, 1992; Doeringer et al., 1998); and "civic capacity" for improving the civic climate to foster the public's cooperation with and understanding of local business and production (Gittell, 1992; Rosenfeld, 1997).

Additionally, several scholars have highlighted the role of informal elements of local society such as culture (institutions and common values and beliefs), social networks (kinship and personal ties), and the business climate (trust, informal ties, and cooperation). All of these facilitate and enable the development and evolution of industrial clusters (Saxenian, 1994; Roelandt and Den Hertog, 1999; Maskell, 2001; Rosenfeld, 2005). The higher loading of the personal ties of managers in the non-transportation factor implies that such informal networks can be powerful enough to influence the fate of a regional economy. This social orientation is also found in the factor such as the commuting convenience of employees and in attention to the environment and neighborhoods where plants are constructed.

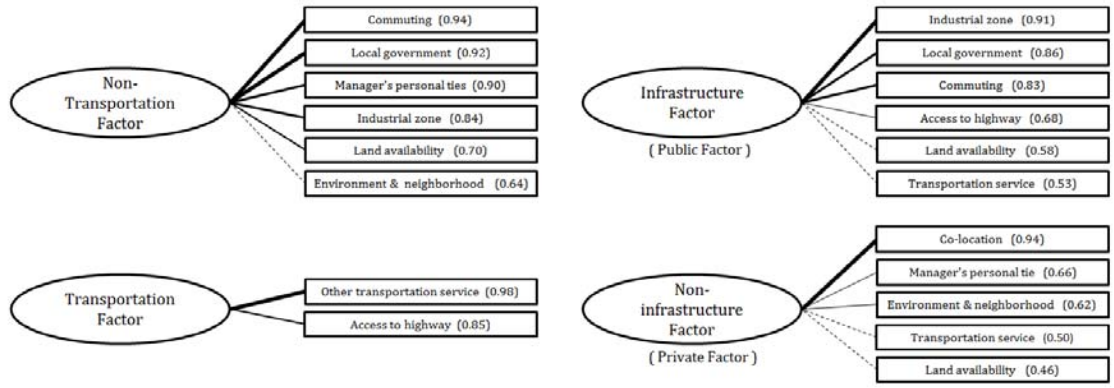

Figure 3: A portrayal of characterizations of the location factor.

Figure 4: Factor loading plots for primary and secondary reasons.

The factor loadings for the secondary reason are detailed in the same table. The loadings of the first factor are particularly high for industrial zoning, commuting convenience, and governmental support; the loadings of access to highways and other transportation services are also higher for the first factor[11]. These reasons are broadly associated with local infrastructure and regulation, which are controlled by public policy measures. Therefore, we identify the first factor as a public or

[11] Although the value of land availability is higher for the first than for the second factor, the difference is not significant.

infrastructure factor. The second factor offers higher loadings in co-location with other firms, the manager's personal ties, and less restriction from surrounding environment and neighborhoods. These factors are distinguished from policy-related reasons and are more associated with privately driven and policy independent characteristics that are inherently found in individual locations. Therefore, we summarize the second factor as a private or *non-infrastructure* factor.

Figure 4 illustrates this characterization of the factors. The loadings are mapped in scatter plots for the primary and secondary reasons. As seen in the plots, the factor loadings of one factor are inversely correlated with the loadings of another for both the primary and secondary reasons. Regarding the primary reason, the factor loadings of access to highways and other transportation services are higher for the second factor and those of the other reasons tend to be higher for the first factor. Therefore, we can convincingly identify the second factor as a transportation factor. For the secondary reasons, the factor loading of co-location with other firms is the highest in the second factor loadings, followed by personal ties of mangers and environment and neighborhoods. The availability of land and access to logistics services have intermediate importance, and governmental support, commuting convenience, and industrial zoning are valued higher in the first factor. While the first factor highlights physical as well as institutional infrastructure, which can be controlled by local policies, and the second factor emphasizes characteristics that are the consequence of private activity.

In essence, this exploratory factor analysis has identified two important location factors: the transportation factor in the primary reason and the infrastructure factor in the secondary reason. Both are associated with the role of infrastructure in the location decision. These location factors are significant because they are relevant to the spatial role of infrastructure support in the growth of manufacturing activity. Using these factors, we will characterize individual industries based on the variety of the factor scores.

The factor scores are presented in Table 3. The shaded pie graphs represent the relative differences in the scores; darker shading corresponds to higher scores. The scores are also plotted in Figure 5. The factor score, in this specific analysis, represents a greater number of new plants choosing their location because of the location factor. The absolute value of a score is correlated with the number of new plants. Therefore, the scores represent the growth rate of the industry, accelerated by the location factors.

The factor scores suggest some important implications. The food industry is an exceptional case. The growth of the food industry is particularly encouraged by the transportation factor in the primary reason. The impact of the

Table 3: Factor scores of primary and secondary reasons, by industry

		Primary reason		Secondary reason	
No.	Industry	Non-transportation	Transportation	Infrastructure	Non-infrastructure
1	Food	○ -2.33	● 5.65	◔ -1.40	● 4.61
2	Beverages	◔ 0.56	◔ -0.77	○ -1.61	◑ 1.63
3	Textile	◔ -0.81	◔ -0.12	◔ -0.54	◔ -0.45
4	Apparel	◔ -0.17	◔ -0.51	◔ -0.30	◔ -0.42
5	Lumber	◑ 0.76	◔ -0.79	◔ -0.36	◑ 0.48
6	Furniture	◔ -0.42	◔ -0.31	○ -1.66	◑ 0.99
7	Pulp	○ -1.06	◑ 0.72	◑ 0.58	◔ -1.12
8	Printing	○ -1.45	◑ 1.24	◔ -0.65	◑ 0.37
9	Chemical	◔ -0.76	◑ 0.69	◕ 2.40	○ -2.37
10	Petroleum	○ -1.28	◑ 0.45	◔ -1.22	◑ 0.31
11	Plastic	◔ 0.40	◑ 0.16	◕ 2.53	○ -1.95
12	Rubber	◔ -0.65	◔ -0.12	◑ 0.14	◔ -1.02
13	Leather	○ -1.24	◑ 0.24	◔ -0.42	◔ -0.68
14	Ceramic	◔ 0.59	◔ -0.60	○ -2.78	◕ 2.91
15	Iron	◔ -0.81	◑ 0.39	◔ -0.76	◑ 0.33
16	Non-Ferrous	◔ -0.61	◔ -0.11	◔ -1.24	◑ 0.53
17	Fabricated	◑ 1.40	◑ 0.04	◑ 0.93	◑ 0.38
18	General	◕ 3.50	◔ -2.00	◕ 2.34	◔ -0.85
19	Electrical	● 5.15	○ -3.95	● 4.03	○ -2.79
20	Transportation	◔ 0.25	◔ -0.15	◕ 1.50	◔ -1.15
21	Precision	◔ -0.19	◔ -0.54	◔ -0.77	◔ 0.04
22	Miscellaneous	◔ -0.83	◑ 0.38	◔ -0.75	◑ 0.22

transportation factor is quite reasonable because the sellable period of foods is quite limited by the limited shelf life of the products, which makes quick transportation essential. Moreover, high transportation factor scores are also found in the pulp, printing, chemical, and petroleum industries. Although these industries are more dependent on raw material inputs, their production is less dependent on complex supplier linkages than are the high-tech industries. Therefore, the importance of transportation factor is related to the properties of the products.

In contrast, a different pattern of scores is seen in the electric and general machinery industries. General location advantages (other than transportation) and infrastructure-based advantages help attract new plants in these types of high-tech industries. The scores can be interpreted ,to some extern, as they do not focus solely on transportation advantages; instead, infrastructure and relational advantages—such as support from local governments, industrial zones, and personal ties—are more important. This suggests that the destinations of high-tech industries are more dependent on public and private relationships and the production environment, and thus are associated with factors such as industrial zones, commuting conditions, and environmental regulations. In essence, the differences in factor scores illustrate

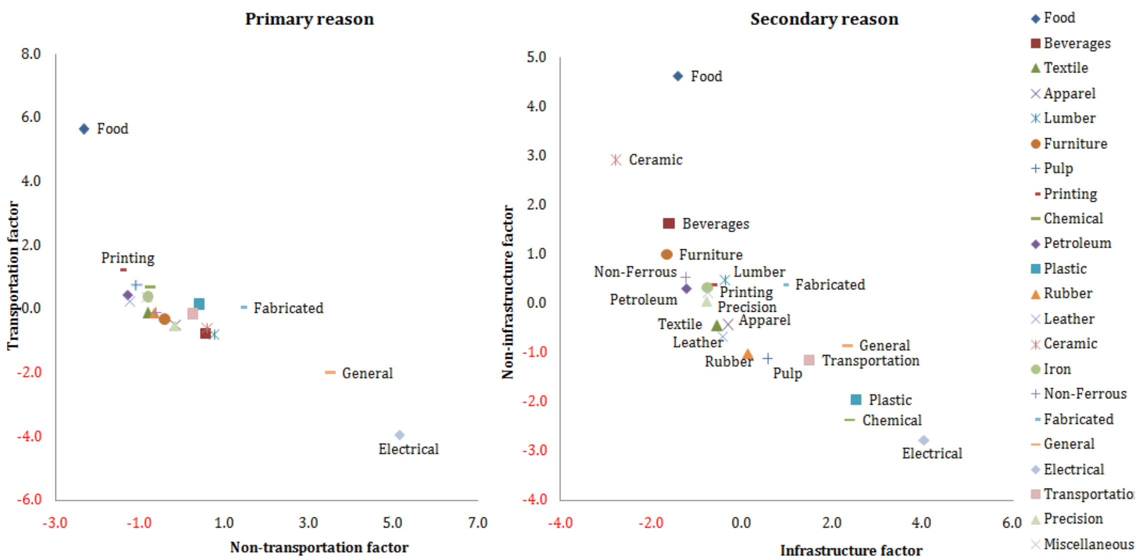

Figure 5: The plots of the scores of the first and second factors for primary and secondary reasons.

clear variation in the importance of transport infrastructure among manufacturing industries.

We next search for a correlation between the industry-specific location rationale and the location pattern. Figure 6 shows the proportion of new plants with positive factor scores for each region. Theoretically, the factor scores average zero; positive scores, therefore, are higher than average.

First, we compare the spatial patterns between the transportation and non-transportation factors for the primary location reason. We find two clear contrasting patterns. The proportion of industries with positive scores in the transportation factor generally become higher in urban centers and in suburban regions. Therefore, the transportation-related advantage tends to have a greater impact on the specialization of light manufacturing industries, such as food and printing industries, in urban and suburban regions.

The proportion of non-transportation industries is higher mostly in the periphery of urban regions, which includes many rural prefectures. The highest proportions are found in the middle of the mainland around Aichi prefecture, which is the core industrial area in Japan. Recall that the factor represents commuting convenience, support from local government, manager's personal ties, and industrial zone, and the location factor has a greater impact on the growth of high-tech industries in the core industrial region.

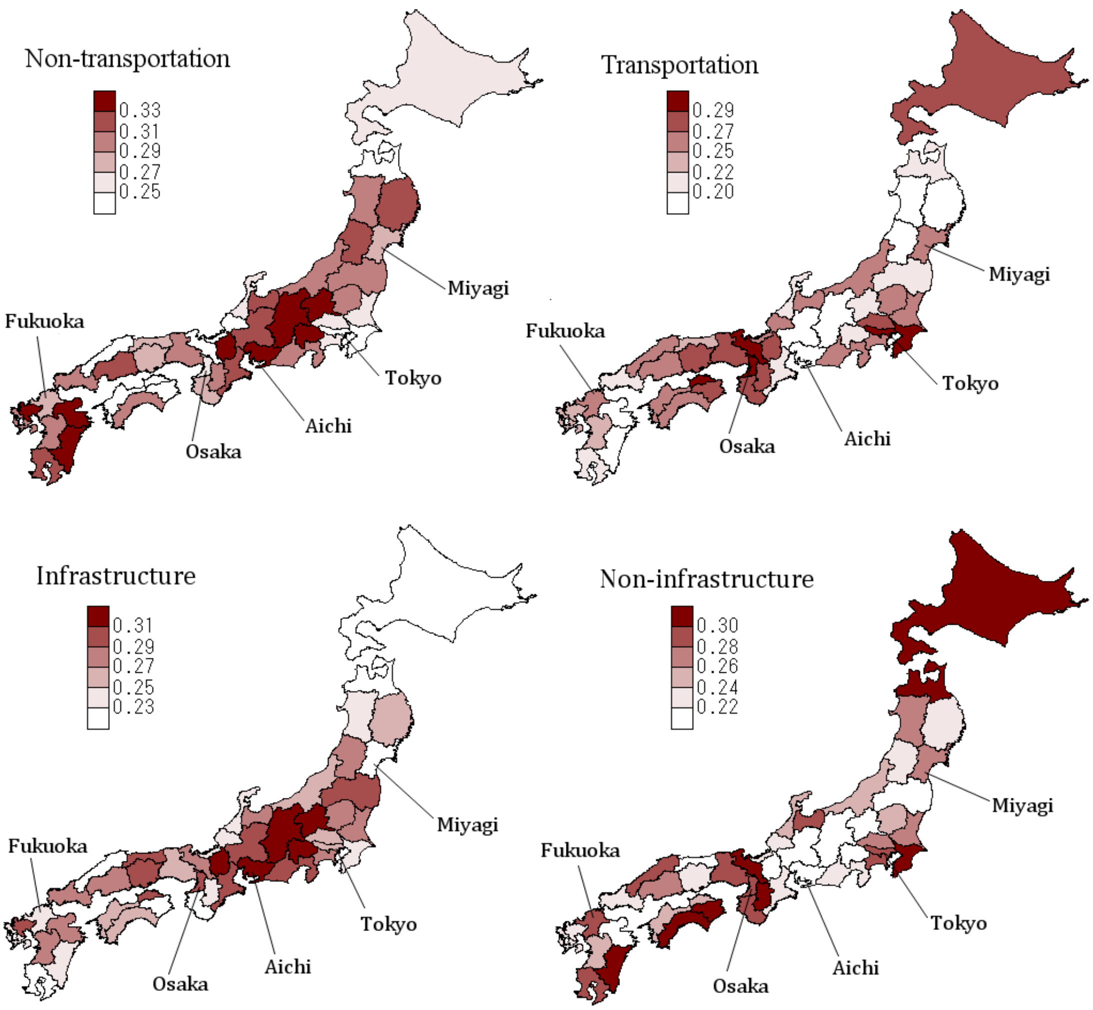

Figure 6: The proportion of industries that have positive factor scores.

Secondly, with respect to the secondary reason, the infrastructure factor mainly stands for industrial zone, support from local government, commuting convenience, and highway access. Plants in high-tech industries are more attracted to infrastructure support, and they tend to grow in the core industrial region. In contrast, non-infrastructure factor aggregates private reasons and exclude infrastructure-led advantages. The proportion of industries that emphasize location reasons is higher mainly in urban centers and in marginal areas. This might seem peculiar because it means that similar location advantages are found in both urban and rural areas. However, the factor includes co-location with other firms, manager's personal ties, and environmental restrictions, and the higher proportion in urban centers is probably due to a preference to co-locate, whereas the trend in marginal prefectures is most likely due to personal ties and unrestrictive environments.

It is interesting that the proportion of high-tech industries is higher in the core industrial area between Tokyo and Aichi, and that those high-tech industries emphasize the non-transportation and infrastructure factors. The non-transportation factor mostly consists of relational location reasons; support from the local government represents a firm's public linkages; a manager's personal ties are associated with social bonding; and commuting convenience is a matter of intra-firm labor relations. Thus, these are the most important location reasons of high-tech firms, and they well represent the relational aspects of the industrial cluster.

In addition, the infrastructure factor, which represents advantages such as industrial zones and highways, is found in the secondary reasons. Combined with the relational strength of high-tech plants, the core industrial region is also supported by infrastructure. McCann and Shefer (2004) mentioned that the local presence of infrastructure can be a catalyst for the creation of local agglomeration economies because infrastructure can be deemed as locally shared inputs (Marshall, 1920). Hence, it is easy to imagine that the high-tech agglomeration in the core area is maintained both by relational and infrastructure advantages and that infrastructure is also important for the formation of this industrial cluster.

In summary, the score analysis yields two characterizations of the industries: the location factors in terms of the primary and secondary reasons, and their spatial distributions regarding the core industrial region and other regions. The next section discusses these findings in more detail.

Results

To address the questions that were posed at the beginning of this paper, infrastructure does indeed play a significant role in directing the location of plants. This is clear from Table 1, which shows that, after land availability, highways, industrial zones, commuting convenience, and environmental restrictions are almost equally important reasons. Our findings also demonstrate that the location of new plants is in fact influenced by the spatial distribution of infrastructure. However, its importance differs across industries and regions.

Let us consider the industrial and regional variation in the impact of infrastructure support. Table 4 organizes the results of the empirical analyses discussed above. The columns denote the primary and secondary reasons, and the rows represent the two important regions: metropolitan areas such as Tokyo, Osaka, and their suburb prefectures, and the core industrial region in the middle of the main island. Other marginal regions are not considered here because the vast majority of new plants are concentrated in the two regions, and thus the analysis of these two areas is more meaningful, and because no straightforward characterization of other areas is possible due to the variation in their location characteristics.

Regarding the primary reason, although transportation advantages are reduced into a factor, there is variation in the impact of transport infrastructure across industries, as already suggested by Holl (2004a). The advantage works most favorably on food, pulp, printing, chemical, and petroleum industries. These types of industries are traditional and more dependent on raw material inputs than other industries such as high-techs, and they are attracted to metropolitan areas that are better equipped with transportation means; therefore, transportation infrastructure is important for these types of industries. However, the spatial range of the impact is rather limited to metropolitan areas.

Meanwhile, plants in high-tech industries such as the general machinery, electrical machinery, and transportation equipment industries are more attracted to non-transportation advantages. These include a manager's personal ties and support from the local government, which are more social and relational than physical infrastructure support. In addition, the spatial distribution of these industries tends to be concentrated near the core industrial cluster located in the middle of the mainland. Therefore, the high-tech cluster is supported by social and relational reasons rather than solely by better infrastructure conditions and the influence of infrastructure differs between the light manufacturing and high-tech industries.

Regarding the secondary reason, access to highways and other transportation services make up only part of the infrastructure factor and it seems that transportation infrastructure alone cannot be the sole secondary determinant of most

Table 4: A summary of location factors and regional characterizations.

	Primary Reason	Secondary Reason
Metropolitan region	*Transportation factor*	*Non-infrastructure factor*
	Food, pulp, printing, chemical, and petroleum	Food, ceramic, beverage, furniture
Core industrial region	*Non-transportation factor*	*Infrastructure factor*
	Electrical machinery, general machinery, fabricated metal	Electrical machinery, chemical, plastic, general machinery, transport equipment, fabricated metal

plants. The infrastructure factor has a larger impact on the growth of high-tech industries as well as some upstream industries such as the chemical, plastic, and fabricated metal industries. Moreover, non-infrastructure or privately driven factor is emphasized by light manufacturing industries, which include the food, beverage, lumber, furniture, ceramic, and printing industries. This leads us to speculate that infrastructure and policy supports influence the local growth of high-tech industries most favorably, as previously argued by Porter (Porter, 1998, 2000), but that the role of the factor is rather secondary for the industries. Thus, as shown in Table 4, the influence of infrastructure varies across industries.

Finally, in terms of the regional specialization of industry, the local proportion of light manufacturing industries is higher in metropolitan areas such as Tokyo and Osaka, whereas that of the high-tech industries increases on the periphery of these two urban prefectures and in the core industrial regions. Additionally, along the spatial axis, the location factors transition from transportation to non-transportation factor and from non-infrastructure to infrastructure factor. This infers that industries are attracted to particular advantages that are present in particular regions and that all location advantages, regions, and industries are connected and harmonized through the specific location behavior.

Conclusion

This study explored the spatial role of infrastructure and its variation across industries. The analysis revealed that transport infrastructure indeed influences the formation of industrial specialization, especially that of light manufacturing industries. However, infrastructure support is by no means the dominant factor shaping the industrial specialization of a region. High-tech specialization in the core industrial region, in particular, is more influenced by non-transportation factor related to location than by those related to infrastructure, such as highway access. This evidence is the antithesis of the conclusions of WDR 2009, which overemphasized the spatial roles of infrastructure and underestimated the impact of localized “relational assets” and “interdependency” (Amin and Thrift, 1994; Martine and Sunley, 1996; Storper, 1997; Amin, 1999; Harrington, et al., 2003; Gertler, 2005). This study discovered that the positive influence of infrastructure is rather limited and contingent on the nature of the industry in question and on the inter-regional geographical structure in which the firms and industries are embedded.

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