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# Firm Agglomeration in Knowledge Intensive Business Service Sectors

**Shinya Fukui**

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# Firm Agglomeration in Knowledge Intensive Business Service Sectors*

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**Abstract**
We observe dense agglomerations of Knowledge-Intensive Business Services (KIBS) in large cities such as Tokyo and Osaka. Such urban features of KIBS stem from the fact that the main customers for KIBS are corporate headquarters (HQs), and KIBS's main input is highly skilled labor. We adhere to the model proposed by Redding and Venables (2004) and present a monopolistic competition model. Our results indicate that improving access to the agglomeration of HQs and KIBS and knowledge agglomeration will strengthen market access and supply access and that KIBS firms will be even more inclined to establish locations in those municipalities.

**Keywords**: Knowledge-Intensive Business Service; Headquarters; Monopolistic competition model; Japan; Municipalities
**JEL classification**: R12; L84; C21

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## 1 Introduction

In the last few decades, the business service sector has expanded enormously in economically developed economies, including Japan (Ministry of Economy, Trade and Industry 2002, OECD 2005a). The business service sector has become important for Japanese economic performance (Ministry of Economy, Trade and Industry 2017).

One prominent feature of business service activity is its high knowledge intensity. The OECD (2005b) classifies post and telecommunications, finance and insurance, business activities (not including real estate), education, and health as a knowledge-intensive business services (KIBS) at the two-digit ISIC/NACE level. Miles et al. (1995), who used the term KIBS originally, defined KIBS as

1. Relying heavily upon professional knowledge
2. Being themselves primary sources of information and knowledge, using their knowledge to produce intermediary services for their clients' production processes
3. Having competitive importance and supplied primarily to business.

Based on those earlier studies and the industrial classification used in the "*Economic Census*" of the Statistics Bureau, Ministry of Internal Affairs and Communications (MIC), our definition of KIBS corresponds to the following.

F: Finance and insurance

IT: Information services, Services incidental to the internet, Content industries, producing video picture information, sound information, character information production and distribution

P: Professional services, for which qualifications are needed, Professional services, providing design services and business consultants, Advertising

T: Technical services, such as commodity inspection and non-destructive testing services, engineering and architectural services, and mechanical design services

Following Miles et al. (1995), over the last few decades, the concentration, activity, and evolution of KIBS have garnered growing attention from numerous authors: Den Hertog (2000), Muller and Zenker (2001), Keeble and Nachum (2002), Wood (2002), Miles (2006), Koch and Stahlecker (2006), Wood (2006), Freel (2006), Doloreux and Muller (2007), Shearmur and Doloreux (2008), Johansson and Klaesson (2011), Doloreux and Shearmur (2012), Jacobs et al. (2014), Meliciani and Savona (2015), and Klaesson and Norman (2015).

The products of KIBS are characterized as intermediate supplier services rather than final goods for consumption. They supply services that are provided mainly to the other sectors. Additionally, KIBS is characterized as a knowledge-intensive sector. Therefore, the main customers for this sector are some pivotal corporate functions including headquarters (HQs). These customers tend to be agglomerated in larger cities (Fukui and Matsushita, 2018). Whereas KIBS demands highly skilled labor as input, highly skilled workers tend to reside in larger cities (Glaeser, 1999; Kox and Rubalcaba, 2007a, 2007b; Karlsson et al., 2009; and Schricke et al., 2012).

For instance, 37.9% of the KIBS labor force is in the 23 wards of Tokyo and Osaka city, the share of employees working for HQs in the 23 wards of Tokyo and Osaka city throughout Japan is approximately 10% (*"Economic Census for Business Activity 2012"* (*Keizai sensasu katsudo chousa*, Statistics Bureau, MIC, hereafter *ECBA2012*)). Additionally, the 23 wards of Tokyo and Osaka city have approximately 12% of all university graduates of all of Japan (*"National Census 2010"* from Statistics Bureau, MIC). That importance notwithstanding, the surface area of the 23 wards of Tokyo and Osaka city accounts for only about 0.2% of the entirety of Japan.

To analyze the KIBS market structure, we propose a monopolistic competition model. A wide variety of KIBS firms provide a diverse range of differentiated services demanded by HQs. This broad, various supply of services enables the production of a homogeneous set of services used by HQs. In addition, KIBS rely on highly skilled workers.

In a competitive market with free entry, higher wages attract laborers who work to provide KIBS. In fact, according to *ECBA2012*, 359,326 enterprises provide KIBS, whereas the total number of enterprises in KIBS with fewer than five employees is 203,179, with the share of 56.5%. Therefore, the market can be regarded as competitive, due to a large degree of small firms.

As a salient feature of KIBS, firms tend to locate in core cities such as Tokyo and Osaka, rather than in periphery cities. This agglomeration tendency is particularly stronger for KIBS than for other sectors such as manufacturing or retail sales. Therefore, KIBS is an important driving force of the economy in large cities (Ottaviano and Thisse, 2004; Proost and Thisse, 2017). This paper is designed to elucidate the causes of KIBS agglomeration.

Industrial agglomeration is a main subject of economic geography (e.g., Fujita et al. 1999; Fujita and Thisse, 2002). Larger cities tend to show agglomeration of firms and facilities because higher market potential or market accessibility associated with

larger cities generates scale economies, thereby enabling firms to obtain greater profits.

A Few empirical investigations of the location of KIBS firms can be found in the urban economics and economic geography literature. Jacobs et al. (2014) test the relations between location of birth of KIBS and multinational enterprises (MNEs). Meliciani and Savona (2015) examine the determinants of specialization of business service across EU-27. Klaesson and Norman (2015) explore the relation between spatial distribution and the growth of KIBS and market potential.

It is unsatisfactory, however, that all of these empirical studies are based on ad-hoc reduced-form equations but are not derived explicitly from a theoretical model of spatial economics. For instance, although Klaesson and Norman (2015) use market potential calculated using the size of the economy in the region as an explanatory variable, consideration of the actual situation calls for a calculation of KIBS' market potential based explicitly on the distribution of demand for agglomerated HQs and KIBS firms. Johansson and Klaesson (2011) present an empirical model that uses the demand function and pricing equation under the setting of increasing returns to scale. In spite of their explicit reference to the spatial economics theory, their analytical model is not derived from a clear description of the structural form.

Davis and Henderson (2008) and Strauss-Kahn and Vives (2009) examine the determinant factors affecting HQ location choice. Business services are used as one important factor to ascertain the HQ location. However, our study analyzes causality in the opposite direction: the demand by HQs to induce the location of KIBS firms.

From a theoretical perspective, Duranton and Puga (2005) explain the relations between trade cost and urban specialization in HQs and business services. They conclude that if the transmission cost of headquarter services is sufficiently low, then firms locate their headquarters away from their production plants and closer to other business service firms. This result is attributable to low intra-firm operating costs between HQs and the production site, while locating HQs proximate to concentrated business services in the city. Nevertheless, no empirical investigation has used this theoretical form.

In spite of the increasing importance of KIBS in economically developed countries, no research in the relevant literature describes a theory-based empirical study conducted to identify the agglomeration factor of KIBS. In fact, ours is the first study to estimate the agglomeration forces of KIBS derived from the spatial economic model setting.

As described herein, we seek the determinants of agglomeration of KIBS using data for Japan. Given that large cities such as Tokyo and Osaka represent the driving force

of the Japanese economy and given that they maintain great agglomerations of KIBS, investigating how KIBS agglomeration is created in the Japanese economy is important.

The remainder of the paper proceeds as follows. Following the Introduction, Section 2 outlines the related literature. Section 3 presents an explanation of the theoretical founding of our analysis. Section 4 presents a description of the empirical model and the data used in our estimation. Section 5 provides results and discussion. Section 6 presents conclusions.

## 2 Related literature

Several empirical studies have been conducted based on the theoretical background of economic geography. Redding and Venables (2004) are the first to suggest a structural framework of market access. They find the relation between per-capita income and distance to markets and supply access. The wage equation *à la* Fujita et al. (1999) plays a central role in their analysis. Hanson (2005) states that a strong relation exists between wages and market access across U.S. counties. Head and Mayer (2004, 2006) examine the link between the wage equation and market potential. Related to these, with increasing returns to scale and transport costs, some studies test the existence of home market effects (Davis and Weinstein, 1996, 1999, 2003).

Building on Helpman's research (1998), Redding and Sturm (2008) derive theoretically that the population increases with greater market access. They use the division of Germany after World War II as a natural experiment to examine the role played by market access. Amiti and Cameron (2007) estimate agglomeration benefits attributable to market access effects for firms in Indonesia. Hering and Poncet (2010) explain that individual wage differences arise from the geography of market access of Chinese cities. Another line of study based upon a natural experiment is that of Nakajima (2008) for Japan.

Several researchers examine the sectoral concentration of KIBS based on economic geography. Jacobs et al. (2014) test the relations between the location of birth of KIBS and multinational enterprises (MNEs) in Amsterdam in the Netherlands. After they assume the profit function of a firm, they conclude that KIBS tend to locate close to MNEs due to agglomeration externalities. Although they point out that HQs of MNEs are important for KIBS-birth, for the roles HQs play such as "command and control activities" and "concentrations of human capital and knowledge spillover," their inspection is not comprehensive: they only specifically examine MNEs. Meliciani and Savona (2015)

examine the determinants of specialization of business service across EU-27 using explanatory factors such as agglomeration economy, intermediate demand, and innovation in services. They treat the manufacturing sector and neighboring business services as intensive users of business services and treat information and communication technologies (ICTs) as an important determinant factor for specialization in business services. Klaesson and Norman (2015) explore the relation between spatial distribution and growth of KIBS and market potential in Sweden. The market potential of their paper is measured as in the total number of jobs in area. They find positive relations between the growth of KIBS and market potential.

## 3 Theoretical background

In this section, to derive our estimable specification form, we follow the model presented by Redding and Venables (2004), which is built on the spatial economic theory *à la* Fujita et al. (1999).

The economy consists of two sectors, HQs (sector *H*) and KIBS (sector *K*) and there are $i, j = 1, \cdots, R$ cities.

First, we describe the demand side of the economy. *H* sector in city $j$ has the production function in producing homogeneous HQ services represented as

$$H_j = \left[ \sum_i^R \int_0^{n_i} k_{ij}(z)^{\frac{\sigma-1}{\sigma}} dz \right]^{\frac{\sigma}{\sigma-1}} = \left[ \sum_i^R n_i k_{ij}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \qquad (1)$$

where $k(z)$ denotes the varieties of KIBS services with $z \in [0, n_i]$, $n_i$ represents the range of varieties produced in city $i$, and $\sigma > 1$ stands for the constant elasticity of substitution. The second equality holds because all services produced in city $i$ behave in a symmetric way. The price index for these HQs to purchase all variety of KIBS is defined as

$$P_j = \left[ \sum_i^R \int_0^{n_i} p_{ij}(z)^{1-\sigma} dz \right]^{\frac{1}{1-\sigma}} = \left[ \sum_i^R n_i {p_{ij}}^{1-\sigma} \right]^{\frac{1}{1-\sigma}}, \qquad (2)$$

where $p_{ij}(z)$ denotes the price of variety $z$ produced in city $i$ and sold in city $j$. $z$

can be dropped by assuming symmetry.

Using Shephard's lemma to the KIBS service price index, demand for a KIBS service in city $j$ produced in city $i$ is

$$k_{ij} = {p_{ij}}^{-\sigma} E_j {P_j}^{(\sigma-1)}, \qquad (3)$$

where $E_j = H_j q_j + \int_0^{n_j} k_j(z) p_j(z) dz$ represents the total expenditure on KIBS and HQs in city $j$ and $q_j$ expresses the price for the HQ service.

The profit function of a sector *K* firm in city $i$ is

$$\pi_i = \sum_j^R p_{ij} k_{ij} - P_i^{\alpha} w_i^{\beta} c \sum_j^R k_{ij} T_{ij} - P_i^{\alpha} w_i^{\beta} F, \qquad (4)$$

where $c$ represents a composite of KIBS and skilled labor required for one unit of *K* production, whereas fixed input is $F$ and $P_i^{\alpha} w_i^{\beta}$ gives a unit price of the composite input. Each KIBS firm employs all varieties of KIBS as input with price index $P$ and highly skilled labor with wage $w$, subject to input shares $\alpha$ and $\beta$, where $\alpha + \beta = 1$. For this study, $T_{ij} > 1$ represents the iceberg type transport cost and $T_{ij} - 1$ denotes the proportion of loss of service output produced in city $i$ to arrive in city $j$. This expression implies that $k_{ij} T_{ij}$ amount of service must be produced to sell a service to city $j$ that is produced in city $i$. Consequently, $\sum_j^R k_{ij} T_{ij}$ represents the total output of a sector *K* firm at city $i$ to attend to demand from all regions.

The price for each city where the service product is sold is $p_{ij} = p_i T_{ij}$. With profit maximization, the f.o.b. price $p_i$ has a constant markup as

$$p_i = \frac{\sigma}{\sigma - 1} \times unit\ cost, \qquad (5)$$

where $unit\ cost = P_i^{\alpha} w_i^{\beta} c$. Substituting equation (5) in (4), the profit of sector *K* in each city $i$ becomes

$$\pi_i = \frac{p_i}{\sigma} \left[ \sum_j^R k_{ij} T_{ij} - (\sigma - 1) F \right]. \qquad (6)$$

The free entry market equilibrium requires that $\pi_i = 0$. It follows from equation (6) that

$$\bar{k} = \sum_j^R k_{ij} T_{ij} = (\sigma - 1)F, \qquad (7)$$

where $\bar{k}$ represents equilibrium output of a sector *K* firm that is constant irrespective of the market size. Substituting the demand equation (3) to $\sum_j^R k_{ij} T_{ij}$, then using equation (5), the equation becomes

$$\bar{k}\left[\left(\frac{\sigma}{\sigma-1}\right) P_i^{\alpha} w_i^{\beta} c\right]^{\sigma} = \sum_j^R E_j P_j{}^{(\sigma-1)} T_{ij}{}^{(1-\sigma)}. \qquad (8)$$

Solving the equation (8) for $w_i$, the equation is rewritten as

$$w_i^{\beta\sigma} = \left(\frac{\sigma}{\sigma-1}\right)^{-\sigma} c^{-\sigma} \bar{k}^{-1} P_i^{-\alpha\sigma} \sum_j^R E_j P_j{}^{(\sigma-1)} T_{ij}{}^{(1-\sigma)},$$

$$w_i = constant \times P_i^{-\alpha/\beta} \left[\sum_j^R E_j P_j{}^{(\sigma-1)} T_{ij}{}^{(1-\sigma)}\right]^{1/\beta\sigma}, \qquad (9)$$

where $constant = \left(\frac{\sigma}{\sigma-1}\right)^{-1/\beta} c^{-1/\beta} \bar{k}^{-1/\beta\sigma}$. This calculation is the wage equation proposed by Fujita et al. (1999). The right-hand side (RHS) of the equation shows the "market access": the summation of market capacities under consideration of transport cost. The left-hand side (LHS) of the equation is the wage at which each firm in city $i$ can pay with zero profit.

We now turn to the supply side, where access to supply is measured as $n_i p_{ij}{}^{1-\sigma}$, where $n_i$ signifies the number of firms, and where $p_{ij}{}^{(1-\sigma)}$ stands for the price in which the trade cost is included.

From the demand equation (3), total service sold from city $i$ to city $j$ is

$$n_i p_i k_{ij} = n_i {p_i}^{1-\sigma} {T_{ij}}^{(1-\sigma)} \left( q_j H_j + \int_0^{n_j} k_j(z) p_j(z) dz \right) {P_j}^{(\sigma-1)}. \qquad (10)$$

This equation represents transaction between cities. The RHS of equation (10) gives both the market capacity $m_j \equiv \left(q_j H_j + \int_0^{n_j} k_j(z) p_j(z) dz\right) {P_j}^{(\sigma-1)}$ and the supply capacity $s_i \equiv n_i {p_i}^{1-\sigma}$ associated with trade cost ${T_{ij}}^{(1-\sigma)}$ between cities. Here, $m_j$ denotes the capacity of total sales in city $j$, which expresses the amount that the services sector *K* in city $i$ can sell. Here, $s_i$ represents the capacity of production, which consists of the number of firms $n_i$ and service price in sector *K* in city $i$.

Using $p_{ij} = p_i T_{ij}$, the price index becomes

$$P_j = \left[ \sum_i^R n_i \left( p_i T_{ij} \right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}} = \left[ \sum_i^R s_i \, {T_{ij}}^{(1-\sigma)} \right]^{\frac{1}{1-\sigma}}. \qquad (11)$$

The price index shows how severe the competition is in city $j$.

From equation (10), the market access of each city $i$ and the supply access of each city $j$ is defined as

$$MA_i \equiv \sum_j^R \left( q_j H_j + \int_0^{n_j} k_j(z) p_j(z) dz \right) {P_j}^{(\sigma-1)} \, {T_{ij}}^{(1-\sigma)}, \qquad (12)$$

$$SA_i \equiv \sum_j^R n_i {p_i}^{(1-\sigma)} {T_{ij}}^{(1-\sigma)}. \qquad (13)$$

In those expressions, $MA_i$ signifies market access, which is the distance-weighted sum of the market capacities of all partner cities. Also $SA_i$ denotes supply access, which is the distance-weighted sum of supplier capacities of all partner cities.

Finally, from equations (9), (10), (11), (12) and (13), we have the estimable function of

$$w_i = constant \times P_i^{-\alpha/\beta} \left[ \sum_j^R \left( q_j H_j + \int_0^{n_j} k_j(z) p_j(z) dz \right) P_j^{(\sigma-1)} T_{ij}^{(1-\sigma)} \right]^{1/\beta\sigma}$$

$$= constant \times SA_j^{\alpha/\beta(\sigma-1)} MA_i^{1/\beta\sigma}, \qquad (14)$$

where $constant$ is the same as that in equation (9).

Parameters are $\sigma > 1, \alpha < 1, \beta < 1$. Therefore, the following are true.

- High demand $\left(q_j H_j + \int_0^{n_j} k_j(z) p_j(z) dz\right)$ in city $j$ leads to high market access.
- If the price index $P_j$ increases, then sector *K* in city $i$ can sell much more of their services. This improvement corresponds to increased market access.
- Reduction in transport cost leads to increased market access.
- An increase in the number of firms $n_i$ and a decline of the price $p_{ij}^{(1-\sigma)}$ increase the supply access.
- Increased supply access reduces the price index, so the cost reduction in KIBS leads to reduced service production cost in city $i$ (from equation (11)).
- Similarly, reduction in transport costs will lead to an increase in supply access.

Market access expresses the benefit of proximity to a large market. Supply access indicates the benefit of proximity to suppliers. All in all, the higher the market access and higher the supply access, the higher a wage payment can be afforded.

## 4 Data description and econometric model

### *4.1 Data description*

The logarithm of equation (14) will be

$$\ln w_i = constant + \left[\frac{1}{\beta\sigma}\right] \ln MA_i + \left[\frac{\alpha}{\beta(\sigma-1)}\right] \ln SA_i. \qquad (15)$$

When defining parameters as $b_1 \equiv \left[\frac{1}{\beta\sigma}\right], b_2 \equiv \left[\frac{\alpha}{\beta(\sigma-1)}\right]$, this formation will be estimable.

We use a municipal unit of data for Japan for estimation because the inspection of spatial interaction is appropriate in such a small unit of aggregated data. Because wage data of KIBS are not available in municipal units, we substitute wages with share of the number of KIBS employees in municipality to the number of employees belonging to all

industries in that municipality. This substitution is plausible because it is more profitable for firms to locate in city $i$, which has a higher wage. The KIBS share corresponds to location probability, in a sense.

As defined by Nakajima (2008), we replace "market access" $MA_i$ with "market potential": $MP_i$. We follow Head and Mayer (2004) and use Harris (1954) type market potential in municipality $i$: $MP_i$. Here, $MP_i$ is derived as

$$MP_i = \sum_{i}^{R} \frac{Y_j}{d_{ij}}, \qquad i \neq j, \qquad (16)$$

where $Y_j$ denotes the size of the economy of the other municipality $j$ and $d_{ij}$ expresses the distance from municipalities $i$ to $j$. Distance is calculated according to the Euclidean distance between municipalities $i$ and $j$.[1] We use the number of the employees of HQs plus KIBS in municipalities for $Y_j$. For that reason, the variable is expressed as $MP(HQs + KIBS)_i$.

On the supply side, we replace "supply access" ($SA_i$) with "supply potential" and use specifications for market potential type. The equation for supply potential ($SP_i$) is as follows

$$SP_i = \sum_{i}^{R} \frac{L_j}{d_{ij}}, \qquad i \neq j, \qquad (17)$$

where $L_i$ is the number of highly skilled laborers in municipality $j$ and $d_{ij}$ continues to express the distance from municipalities $i$ to $j$.

For the KIBS share, we use *ECBA2012* for the data of KIBS employees in municipalities. The KIBS share of municipality $i$ is calculated as the share of the number of KIBS employees in municipality $i$ to the number of employees belonging to all industries in municipality $i$. The numbers of HQ employees and KIBS employees are

[1] Define longitude and latitude of municipality 1 for $x_1$, $y_1$, longitude and latitude of municipality 2 for $x_2$, $y_2$, and calculate the Euclidean distance as $d = 6378.137 \times \cos^{-1}(siny_1 siny_2 + cosy_1 cosy_2 \cos(x_2 - x_1))$. Longitude and latitude are computed using a "Geocoding Service" provided by the Center for Spatial Information Science of The University of Tokyo. When we input the names of municipalities, "Geocoding Service" returns the longitude and latitude of city offices of the municipalities. Therefore, we use these data.

taken from *ECBF2009* for calculating market potential. As a proxy for highly skilled labor, the population of university graduates is taken from the "*National Census 2010*" from Statistics Bureau, MIC.

We use some controls for municipalities. Population density ($POPdense_i$) is a proxy for congestion. This setting of the proxy is in line with a procedure used in an earlier study: Jacobs et al. (2014) state that population density represents crowding effects. For calculation of the population density, the population is taken from "*Basic Resident Register (Jyumin-kihon-daicho) 2010*" from Statistics Bureau, MIC. The land area of municipalities is from "*Statistical reports on the land area by prefectures and municipalities in Japan* (*Zenkoku-todoufuken-sikutyoson-betsu-mennski-no-shirabe*)" from the Geospatial Information Authority of Japan.[2]

Second, the number of enterprises ($ent_i$) is used because KIBS also sell their services to the other sector, irrespective of HQs and KIBS. Third, the manufacturing share of municipalities ($manu\ share_i$) is used because municipalities with high manufacturing shares show different activities for KIBS locations. For instance, Aichi prefecture is known to have high inclination of manufacturing, with many HQs related to manufacturing. However, KIBS activity is lower than in other large cities such as Tokyo, Osaka, or Kanagawa (Fukui and Matsushita, 2018). The number of enterprises and the manufacturing share based on the number of manufacturing employees in municipalities to the number of employees of the total sector in municipalities are from *ECBA2012*.

In addition to these, we use the cross term $Knowledge_i = Lshare_i \times POPdense_i$ to capture knowledge agglomeration in the municipalities. Population density is a proxy to the degree of urbanization. Therefore, if the share of highly skilled labor and population density is simultaneously high, then the concentration of highly skilled labor is apparent in large cities, so knowledge spillover occurs and agglomeration of knowledge is strong in that municipality. We calculate the market potential for knowledge agglomeration, otherwise knowledge agglomeration potential ($KP_i$), as

$$KP_i = \sum_{i}^{R} \frac{Knowledge_j}{d_{ij}}, \qquad i \neq j, \qquad (18)$$

where $Knowledge_i = Lshare_i \times \log POPdense_i$ and where $Lshare_i$ is calculated as the share of the number of highly skilled laborers in municipality $i$ to the number of highly

[2] Data for population density have been corrected by Professor Koji Yasuda for the purpose of analysis in another work. He kindly provided me with the correct data, and I appreciate his contribution.

skilled laborers in Japan total, and $d_{ij}$ expresses the distance from municipalities $i$ to $j$.

For cross-section, 1877 municipalities are used. The data pertain to private sectors (excluding public sector). *ECBA2012* and *ECBF2009* are exhaustive surveys about Japanese establishments and enterprises. Single-unit enterprises are excluded: we use only data of head office of multi-unit enterprises, for HQs because single-unit enterprises are presumed to demand KIBS in different way compared with head office of multi-unit enterprises. Demand for KIBS of head office of multi-unit enterprises is presumed to be more knowledge-intensive than for single-unit enterprises.

Descriptive statistics are presented in Table 1. The maximum and minimum values of *KIBS share* are 0.324 and 0.000, respectively. The *Market potential of HQs and KIBS* ranges from 8,466 to 1,376,398, and the coefficient of variation is 1.147. Additionally, the maximum and minimum values of the *Supply potential of highly skilled labor* are 10,154 and 548,180, respectively, and the coefficient of variation is lower than that of the *Market potential of HQs and KIBS* (0.851). The coefficient of variation of *Knowledge agglomeration potential* is 0.938. The maximum value of *Population density* is 19,444, and the minimum value of *Population density* is 1.555. *Number of enterprises* ranges from 70 to 952,499. *Manufacturing share* ranges from 0 to 0.678.

**Table 1** Descriptive statistics for variables used in estimation for the agglomeration of KIBS

| | Mean | Standard deviation | Median | Min | Max | Coefficient of variation |
|---|---|---|---|---|---|---|
| KIBS share | 0.037 | 0.030 | 0.030 | 0.000 | 0.324 | 0.811 |
| Market potential of HQs and KIBS | 93231 | 106926 | 63426 | 8466 | 1376398 | 1.147 |
| Supply potential of highly skilled labor | 105748 | 89971 | 77081 | 10154 | 548180 | 0.851 |
| Knowledge agglomeration potential | 0.048 | 0.05 | 0.033 | 0.004 | 0.282 | 0.938 |
| Population density | 1483 | 3003 | 252 | 1.555 | 19444 | 2.025 |
| Number of enterprises | 29731 | 59128 | 10868 | 70 | 952499 | 1.989 |
| Manufacturing share | 0.206 | 0.122 | 0.192 | 0.000 | 0.678 | 0.592 |

Note: *KIBS share* is the share of KIBS employees in municipalities, *Market potential of HQs and KIBS* is the market potential in municipality $i$, which can be calculated via equation (16) using the number of HQ employees plus the number of KIBS employees in municipalities $i$ and $j$ as well as the distance between them, *Supply potential of highly skilled labor* is determined via equation (17) using the number of highly skilled laborers in municipality $j$, and *Knowledge agglomeration potential* can be calculated via equation (18) using $Knowledge_i$, which is defined as $Knowledge_i = Lshare_i \times \log POPdense_i$. *Population density* is the population density in municipality $i$, *Number of enterprises* denotes the number of enterprises, and *Manufacturing share* stands for the manufacturing share based on the number of employees of

manufacturing in municipalities to the number of employees of all sectors in municipalities.

*4.2 Econometric model*

Our specification in estimating agglomeration of KIBS is using the Spatial Error model (SEM). Meliciani and Savona (2015) use the Spatial Durbin model (SDM) for the estimation of business service specialization. Actually, SDM is a general model that encompasses SEM or a Spatial Autoregressive model (SAR) (LeSage and Pace, 2009). In our spatial regression, spatial dependence for the independent variable and dependent variable are already included in specifications. These are market potentials of KIBS and HQs: $MP(HQs + KIBS)_i$ and the spatial lag of highly skilled labor share: $WLshare_i$. Therefore, in our case, spatial dependence between municipality $i$ and $j$ is summarized in the error term. Unobserved spatial dependence might appear in the error term. For instance, knowledge spillover or office supply in neighboring regions is conceivably unobserved spatial dependence. These variables are not available.

Specification for the estimation is

$$KIBSshare_i = constant + b_1 \ln MP(HQs + KIBS)_i + b_2 \ln SP_i + \gamma_1 \ln POPdense_i + \gamma_2 \ln ent_i + \gamma_3 manushare_i + u_i,$$
$$u_i = \lambda W u_i + e_i, \quad (19)$$

where the $KIBSshare_i$ is the share of the number of KIBS employees in municipalities, $\ln MP(HQs + KIBS)_i$ is the log of market potential in municipality $i$, which is defined in equation (16) using the number of the employees of HQs plus KIBS in municipalities and distances between municipality $i$ and $j$. Additionally, $SP_i$ is the log of supply potential in municipality $i$, which is defined in equation (17) using the number of highly skilled laborers in municipalities $i$ and $j$ as well as the distance between them. $\ln POPdense_i$ signifies log of population density in municipality $i$, $\ln ent_i$ denotes the log of the number of enterprises, $manushare_i$ expresses the manufacturing share based on the number of employees of manufacturing in municipalities to the number of employees of the total sector in municipalities, $u_i$ is the error component, $\lambda$ is a spatial parameter associated with the spatial weight matrix, and $e_i$ is the idiosyncratic error term.

$W$ is $R \times R$ spatial weight matrix, where $R$ represents the number of municipalities. Diagonal elements of $W$ are set to 0; off-diagonal elements are the inverse distance of 1,000 km unit between cities $i$ and $j$. This connection effect is thought to have distance decay so the off-diagonal elements of $W$ can be expressed as a

gravity-like model, following Anselin (2002), as

$$w_{ij} = \frac{1}{dist_{ij}^2}, \qquad i \neq j,$$

where $dist_{ij}$ expresses the distance between municipalities $i$ and $j$. As a convention, each row of $W$ is normalized to 1.

An alternative specification is

$$KIBSshare_i = constant + b_1 \ln MP(HQs + KIBS)_i + b_2 \ln KP_i + \gamma_1 \ln POPdense_i + \gamma_2 \ln ent_i + \gamma_3 manushare_i + u_i,$$
$$u_i = \lambda W u_i + e_i, \qquad (20)$$

where $\ln KP_i$ is the log of knowledge agglomeration potential in municipality $i$, which is defined in equation (18) using the share of the number of highly skilled laborers in municipality $i$ to the number of highly skilled laborers in Japan total and log of population density in municipalities $i$ and $j$ as well as the distance between them.

Correlation coefficients are presented in Table 2. High correlation coefficients (over 0.5) are apparent between *KIBS share* and *Market potential of HQs and KIBS* (0.549), *KIBS share* and *Number of enterprises* (0.681). The correlation coefficients of *KIBS share and Supply potential of highly skilled labor*, as well as of *KIBS share* and *Knowledge agglomeration potential,* are relatively low – 0.412 and 0.422, respectively – but positive. The correlation coefficients of explanatory variables are as follows: *Market potential of HQs and KIBS* and *Supply potential of highly skilled labor* (0.889), *Market potential of HQs and KIBS* and *Knowledge agglomeration potential* (0.897), *Market potential of HQs and KIBS* and *Population density* (0.781), *Supply potential of highly skilled labor* and *Knowledge agglomeration potential* (0.999), *Supply potential of highly skilled labor* and *Population density* (0.799), *Knowledge agglomeration potential* and *Population density* (0.808). Negative correlations are seen among *Manufacturing share* and all other variables.

Consequently, we can expect positive causality between our examined variables: *KIBS share*, *Market potential of HQs and KIBS*, *Supply potential of highly skilled labor,* and *Knowledge agglomeration potential.* Here, estimations have been conducted using the spatial generalized moments (GM) estimator proposed by Kelejian and Prucha (1999).

**Table 2** Correlation coefficients of variables used to estimate the agglomeration of KIBS

| | KIBS share | Market potential of HQs and KIBS | Supply potential of highly skilled labor | Knowledge agglomeration potential | Population density | Number of enterprises |
|---|---|---|---|---|---|---|
| Market potential of HQs and KIBS | 0.549 | | | | | |
| Supply potential of highly skilled labor | 0.412 | 0.889 | | | | |
| Knowledge agglomeration potential | 0.422 | 0.897 | 0.999 | | | |
| Population density | 0.493 | 0.781 | 0.799 | 0.808 | | |
| Number of enterprises | 0.681 | 0.664 | 0.466 | 0.472 | 0.481 | |
| Manufacturing share | -0.280 | -0.092 | -0.048 | -0.066 | -0.211 | -0.167 |

Note: *KIBS share* is the share of KIBS employees in municipalities, *Market potential of HQs and KIBS* is the market potential in municipality $i$, which can be calculated via equation (16) using the number of HQ employees plus the number of KIBS employees in municipalities $i$ and $j$ as well as the distance between them, *Supply potential of highly skilled labor* is determined via equation (17) using the number of highly skilled laborers in municipality $j$, and *Knowledge agglomeration potential* can be calculated via equation (18) using $Knowledge_i$, which is defined as $Knowledge_i = Lshare_i \times \log POPdense_i$. *Population density* is the population density in municipality $i$, *Number of enterprises* denotes the number of enterprises, and *Manufacturing share* stands for the manufacturing share based on the number of employees of manufacturing in municipalities to the number of employees of all sectors in municipalities.

## 5 Results and discussion

This section presents our estimation results. As in Redding and Venables (2004), correlation coefficients between *Market potential of HQs and KIBS,* which represents market access in equation (14), *Supply potential of highly skilled labor,* which represents supply access in equation (14), and *Knowledge agglomeration potential,* which is another form of supply access, are high. In Table 2, the correlation coefficient of *Market potential of HQs and KIBS* and *Supply potential of highly skilled labor* is 0.889, and that of *Market potential of HQs and KIBS* and *Knowledge agglomeration potential* is 0.897. The situation results in multicollinearity when we estimate using these two key explanatory variables simultaneously.

Because we adhere to the work of Redding and Venables (2004), first of all, we estimate using market access only; thus, we examine the *Market potential of HQs and KIBS*. The results of this estimation are presented in Table (3). The estimated coefficients are all found to be significant with magnitudes of about 0.01 to 0.02. If the *Market potential of HQs plus KIBS* increases 1%, then the *KIBS share* increases by 0.0001 points.

Next, we estimate the explanation for the KIBS share using our key explanatory variables, *Supply potential of highly skilled labor* and *Knowledge agglomeration potential.* Implied parameters for *Market potential of HQs and KIBS* are calculated using structural parameter values. Derived from equation (15), the estimated parameters are

$$b_1 = \left[\frac{1}{\beta\sigma}\right], b_2 = \left[\frac{\alpha}{\beta(\sigma-1)}\right]$$

and the relationship between them is as follows

$$b_1 = b_2 \frac{\sigma - 1}{\alpha\sigma}. \qquad (21)$$

In keeping with the work of Redding and Venables (2004), we set input share at $\alpha = 0.5$ and constant elasticity of substitution at $\sigma = 10$.

Results are displayed in Table 4 and the implied parameters of *Market potential of HQs and KIBS* are listed. Specification (1), which specifies that only structural variables are employed, demonstrates a significant and positive coefficient for *Supply potential of highly skilled labor*; however, under specifications (2)-(5), the coefficient of key variable *Supply potential of highly skilled labor* is not significant. Under specifications (6)-(10), which dictate an alternative variable for supply access, *Knowledge agglomeration potential*, the results change completely and key coefficients of estimation are all significant and positive. Coefficients range from 0.1 to 0.3; if *Knowledge agglomeration potential* increases 1%, then the *KIBS share* increases by 0.001 to 0.003 points. Additionally, implied parameters display values from 0.2 to 0.6, so if the *Knowledge agglomeration potential* increases 1%, then the *KIBS share* increases by 0.002 to 0.006 points. The values change drastically from the results shown in Table 3.

The results support our model. If the agglomeration of HQs and KIBS is strong in municipalities, then the market access will be high. If easy access to knowledge agglomeration increases, then supply access will increase in kind. Therefore, KIBS will be located in those municipalities. When we employ *Supply potential of highly skilled labor* for the structural variable supply access, the estimation results are insignificant. However, if we use *Knowledge agglomeration potential* for supply access, the results are all plausible. Therefore, the existence of knowledge agglomeration is more important than the share of highly skilled labor in municipalities.

**Table 3** Estimation results of the agglomeration forces of KIBS
(the effects of Market Access)

| Dependent variable: KIBS share | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Market potential of HQs and KIBS (log) | 0.0168 *** | 0.006 *** | 0.0071 *** | 0.005 *** | 0.005 *** |
| | (0.0018) | (0.0018) | (0.0016) | (0.0020) | (0.0019) |
| Population density (log) | | 0.0004 | | 0.0004 | 0.0061 *** |
| | | (0.001) | | (0.0006) | (0.0005) |
| Number of enterprises (log) | | 0.0085 *** | 0.0087 *** | 0.0089 *** | |
| | | (0.0005) | (0.0004) | (0.0005) | |
| Manufacturing share | | -0.064 *** | -0.063 *** | | -0.068 *** |
| | | (0.0049) | (0.0049) | | (0.005) |
| Intercept | -0.151 *** | -0.104 *** | | -0.110 *** | -0.044 ** |
| | (0.020) | (0.018) | | (0.021) | (0.020) |
| Lambda | 0.673 *** | 0.620 *** | 0.630 *** | 0.690 *** | 0.648 *** |
| Estimation method | Spatial GM | Spatial GM | Spatial GM | Spatial GM | Spatial GM |

Note: Parentheses show the standard error. The number of observations is 1877. *, **, and *** indicate statistical significance at the 10, 5, and 1 percent levels, respectively. “Lambda” corresponds to the spatial parameter in equations (19) and (20).

**Table 4** Estimation results of the agglomeration forces of KIBS
(the effects of Market Access and Supply Access)

| Dependent variable: KIBS share | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Market potential of HQs and KIBS (log, implied) | 0.020 | 0.000 | 0.004 | -0.004 | -0.004 |
| Supply potential of highly skilled labor (log) | 0.0114 *** | 0.000 | 0.0022 | -0.002 | -0.002 |
| | (0.0021) | (0.0019) | (0.0016) | (0.0021) | (0.0021) |
| Population density (log) | | 0.0015 ** | | 0.0016 ** | 0.0073 *** |
| | | (0.001) | | (0.0007) | (0.0005) |
| Number of enterprises (log) | | 0.0084 *** | 0.0092 *** | 0.009 *** | |
| | | (0.0005) | (0.0004) | (0.001) | |
| Manufacturing share | | -0.062 *** | -0.062 *** | | -0.067 *** |
| | | (0.0049) | (0.0049) | | (0.005) |
| Intercept | -0.095 *** | -0.038 * | -0.061 *** | -0.029 | 0.032 |
| | (0.023) | (0.020) | (0.017) | (0.023) | (0.022) |
| Lambda | 0.710 *** | 0.647 *** | 0.646 *** | 0.705 *** | 0.669 *** |
| Estimation method | Spatial GM | Spatial GM | Spatial GM | Spatial GM | Spatial GM |

| Dependent variable: KIBS share | (6) | (7) | (8) | (9) | (10) |
|---|---|---|---|---|---|
| Market potential of HQs and KIBS (log, implied) | 0.579 | 0.264 | 0.261 | 0.310 | 0.179 |
| Knowledge agglomeration potential (log) | 0.3216 *** | 0.147 *** | 0.1447 *** | 0.172 *** | 0.100 *** |
| | (0.0285) | (0.0291) | (0.0258) | (0.0321) | (0.0330) |
| Population density (log) | | -0.0002 | | -0.0006 | 0.0060 *** |
| | | (0.001) | | (0.0006) | (0.0005) |
| Number of enterprises (log) | | 0.0087 *** | 0.0086 *** | 0.0091 *** | *** |
| | | (0.0005) | (0.000) | (0.0005) | |
| Manufacturing share | | -0.061 *** | -0.0610 *** | | -0.067 |
| | | (0.0049) | (0.0049) | | (0.005) |
| Intercept | 0.020 *** | -0.038 *** | -0.038 *** | -0.053 *** | 0.012 *** |
| | (0.002) | (0.004) | (0.004) | (0.004) | (0.003) |
| Lambda | 0.616 *** | 0.588 *** | 0.610 *** | 0.629 *** | 0.630 *** |
| Estimation method | Spatial GM | Spatial GM | Spatial GM | Spatial GM | Spatial GM |

Note: Parentheses show the standard error. The number of observations is 1877. *, **, and *** indicate statistical significance at the 10, 5, and 1 percent levels, respectively. “Lambda” corresponds to the spatial parameter in equations (19) and (20).

## 6 Conclusion

With the increasing importance of the knowledge-intensive business service sector (KIBS) in Japan, we can observe dense agglomerations of KIBS in large cities such as Tokyo and Osaka. We attempt to identify the cause for dense agglomeration of KIBS. We take "market access" and "supply access" (Redding and Venables, 2004) as causes for agglomeration in KIBS because higher market access and higher supply access make higher wage payments for KIBS affordable. No study—building on spatial economic theory—has specifically examined the agglomeration force of KIBS.

We estimate several regression equations using Japanese municipal unit data. We use the KIBS share as the independent variable. The market potential for HQs and KIBS is used as a proxy for market access. Also, the population of university graduates is used as a proxy for supply access, highly skilled labor. Additionally, we use a cross term, the product of highly skilled labor share and log of population density, to express knowledge agglomeration potential in the municipalities.

We propose our monopolistic competition model for describing the agglomeration force of KIBS built on Redding and Venables (2004). A reduced form, based on the structural form, is driven. We conduct estimation for the whole KIBS sector.

Results obtained using the GM method proposed by Kelejian and Prucha (1999) demonstrate that knowledge agglomeration potential, which represents supply access in our model, displays significant and positive results. The results support our model. If the agglomeration of HQs and KIBS is strong in municipalities, then the market access will be high. If access to knowledge agglomeration increases, then supply access will increase as well. Therefore, KIBS will be located in those municipalities. Additionally, the magnitude of highly skilled labor agglomeration is relatively low, according to our empirics. This implies that improving access to the agglomeration of HQs and KIBS and knowledge agglomeration will strengthen market access and supply access and that KIBS firms will be even more inclined to establish locations in those municipalities. Thus, the effects of knowledge agglomeration on municipalities and neighboring municipalities are strongly supported by research.

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