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ORIGINAL PAPER

Inter-regional transportation and economic productivity: a case study of regional agglomeration economies in Japan

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Abstract This study investigates the benefit of agglomeration to regional productivity, highlighting the issue of accessibility with empirical data from Japan. We analyze empirically the impacts of agglomeration on regional economic return using an econometric approach, assuming three types of agglomeration economics: urbanization agglomeration, localization agglomeration, and mixed agglomeration. We estimate the agglomeration elasticities of 11 industries using inter-regional transportation network data and regional socioeconomic panel data for 1981, 1986, 1991, 1996, 2001, and 2006, covering 47 prefectures in Japan. Our results show that, on average, the indirect benefit of regional productivity improvement from localization agglomeration tends to be more significant than that from urbanization agglomeration. While the mining industry enjoys significant benefit from urbanization rather than localization agglomeration and the transportation/communication industry enjoys significant benefit from localization rather than urbanization agglomeration, finance/insurance and real estate can benefit from both agglomeration economies. We further find negative elasticities in the agriculture and service industries; this could be partly due to the industries' characteristics. A case study on Japan shows the importance of coordination between land-use and transportation investment for maximizing regional productivity through agglomeration.

JEL Classification C33 · D24 · O18 · R40

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1 Introduction

According to a UN report, 6.3 billion people, or 66% of the world population, will be living in urban areas by 2050 (United Nations 2014). Japan can be considered one of the most urbanized countries in the world. The World Bank estimated that roughly 93% of the Japanese population lived in urban areas in 2015. Huge populations settled in very small extents of habitable land in Japan, creating high-density cities along the country's plains and shorelines. This is the main factor that shaped the Japanese industry into a high-density agglomerated economy. Tabuchi and Yoshida (2000) suggested an expected 10% wage increase when the Japanese city population doubles. Because of its unique spatial distribution, Japan could be one of the most suitable candidates for case studies to investigate the relationship between regional agglomeration and productivity.

Furthermore, the rapid development of transportation in Japan after World War II, such as the development of the high-speed railways and extensive investments on expressway networks, can be regarded the main factor that induced agglomeration economies along the densely inhabited Japanese shorelines. From an economic perspective, such agglomeration benefits due to transportation investment can be treated as a technological growth. Christensen et al. (1947) estimated a total factor productivity (TFP) growth of 4.02% in Japan from 1943 to 1973 and a capital and labor growth of 3.28 and 2.21%, respectively. Although the Japanese economy faced its first economic crisis in the late 1980s, the contribution of TFP growth to the country's total economic growth is still significant. Despite the lower total growth after the economic crisis, the TFP growth contributed to up to around 30% of the total growth (Fukao 2013). However, Fukao (2013) showed a change in the trend of TFP growth among the industrial sectors, with an increasing trend in the service sector and a decreasing trend in the manufacturing sector. When investigating economic growth by considering agglomeration as one of the contributions to TFP, it would be interesting to investigate the agglomeration sensitivity of each industrial sectors, especially during the dynamic change from before the economic crisis to after the crisis in Japan.

1.1 Agglomeration economies: mechanism, scope, and empirical study

An agglomeration economy is typically defined as a benefit of firms staying close together. The concept of industrial scale of economies in Marshall (1890) has been further formulated into three factors leading to agglomeration economies, all closely related to transportation service. First, agglomeration creates clusters of firms wherein producers, suppliers, and customers are located together; this reduces the cost of goods, materials, and even services. Better transportation services can create more opportunities for firms to access better and cheaper input material. Second, this effect is observed in the case of workers as well. A larger pool of workers enables a better matching between firms and workers, and this improves productivity because skilled workers can better match their work with their skills. Since better accessibility inspires workers to work away from home, larger agglomeration can be attained in labor pooling through better transportation. Third, the so-called knowledge spillover can be expected in agglomerated areas. One of the most famous examples is the Silicon Valley; many firms including semiconductor manufacturers and IT firms are located together here, leading to an environment of mutual learning and assistance. Once again, better transportation encourages more meetings, discussions, or even workshops between firms, and this hastens the learning process, accelerates firms' technology, and results in better productivity.

To understand the mechanism of Marshall's economies of scale from an empirical perspective, past studies have categorized agglomeration in different ways. Rosenthal and Strange (2004) provided four types of categorization: industrial scope, temporal scope, geographical scope, and organization scope. As for organization scope, Thabet (2015) provides an investigation between agglomeration and organization-related variables such as competition, firm size, and foreign investment in a case of Tunisia. However, this study would like to focus on agglomeration with regard to the other three scopes. As for temporal scope, the key issue is to investigate whether the effect of agglomeration is static or dynamic. In other words, the agglomeration effect might require an accumulation of knowledge and its effect might develop over a period of years. By using the time lag of a number of plants in the area, Henderson (2003) concluded that high-tech firms also benefitted from the agglomeration level in the past. In a case study of Japan, Fukao et al. (2011) highlight the dynamic change of the manufacturing industry's structure into a technologically oriented one in Japan during the 1990s. As for geographical scope, the key issue is to investigate whether an agglomeration spillover effect exists across the geographical border or not. We provide an index to measure agglomeration by considering the transportation service to capture the spatial lag effects. For industrial scope, which is the main issue in this study, agglomeration is categorized into localization and urbanization agglomeration. In localization agglomeration, we can expect better productivity from agglomeration if the firms in a similar sector are located close to one another. From Marshall's economy of scale, firms benefit from supplier sharing or even technology transfer through localization. The concept of localized industries was proposed by Marshall (1890) and expanded into a growth model by Arrow (1962) and Romer (1986); the accumulation of knowledge spillover within the same industry is now known as the Marshall–Arrow–Romer externalities. On the other hand, in urbanization agglomeration, the firms' productivity level increases as the total market expands through urbanization, leading to larger labor pooling and cross-industry activities and further to productivity improvement. The benefits of urbanization agglomeration, as described in Jacobs (1969), emerge from different sectors' knowledge spillovers supporting one another. Moreover, innovation growth is believed to be stimulated by a variety of industrialization approaches, because different ideas and information can be synthesized through variety rather than specialization. Glaeser et al. (1992) showed that the economic growth of cities could be developed through the cross-fertilization of ideas in urbanization agglomeration. In other words, firms in large cities benefit from a variety of economies compared to those in small towns.

Empirical studies have reported the robust result of the importance of localization and urbanization agglomeration. For example, Henderson (1986) and Moomaw (1988) highlighted the significance of economies of scales in localization agglomeration in several production industries. Specifically, Henderson (2003) found that the high-tech industry benefits from more localization economies whereas the machinery industry does not, and the machinery industry benefits from more urbanization agglomeration whereas the high-tech industry does not. In contrast, Glaeser et al. (1992) claimed that industrial diversity promotes employment growth in cities, rather than specialization. As regards the study of Japan, where extensive agglomerated areas can be observed because of limited habitable land, Nakamura (1985) estimated the cross-section data for 1979. The result showed that localization agglomeration is more important for light industries, whereas urbanization agglomeration is more important for heavy industries. However, from these studies, it is still difficult to clarify whether localization agglomeration or urbanization agglomeration is more beneficial to the economies. Nevertheless, there are several insights that we can use from the existing studies. First, previous studies usually considered only the firm scale (number of workers, number of firms) or urban scale (population) to explain the agglomeration level. In this study, we provide an insight on the agglomeration effects from the regional scale. Second, previous studies highlighted only the manufacturing industry, but we would like to expand the scope by covering every industrial sector in the economy for the consideration of agglomeration. Finally, while previous studies discuss the importance of localization agglomeration and urbanization agglomeration, we propose another mechanism between the two agglomerations. Agglomeration does not have to be in a similar industry, as in localization agglomeration, or the absolute size of the agglomeration economies, as in urbanization agglomeration, but we investigate how to best match the different industries to locate together in a precise proportion to maximize the input–output matching process. We provide an index to measure these three types of agglomeration and analyze its impact on production in later sections.

Geographical distribution, as well as transportation services, can shape agglomeration activities. Transportation studies such as Graham (2007), Graham et al. (2009), and Melo et al. (2013, 2016) examined the contribution of transportation to productivity. Graham (2007), Graham et al. (2009), and Melo et al. (2013, 2016) consider transportation as one of the factors for agglomeration economies and showed that improvement in accessibility to transportation in term of “Effective Density” can create a better agglomeration environment. A significant contribution from agglomeration in the context of an urban rail project has been shown in Hensher et al. (2012) in a city scale as well. However, most of these studies investigate the firm- or urban-level effect of agglomeration and ignore the possibility that the spillover effect can spread across the region. Therefore, this study analyzes agglomeration in the regional scale. The case study of Japan can be one of the ideal regional scale case studies for two reasons. First, the firm- or urban-level data could be applied in other countries where the built-up area is distinctly separated and the cross-border effect is unlikely to be expected. However, the built-up area in Japan is highly connected, especially in the coastal area, and so the agglomeration effect can be expected to overflow across the region. Second, since Japan is an island nation, agglomeration across the national border is unlikely to occur. In other words, regional agglomeration can be fully observed without interfering with the agglomeration effect of other countries.

This paper is structured as follows. The next section presents the methodology used, including the formulation of regional production function and definition of agglomeration. Section 3 presents empirical data with uncontrolled relationships between agglomeration and economic development. Section 4 discusses our estimation methodology, the results of an econometric model and the interpretation of the agglomeration impact on regional economic productivity. Finally, Sect. 5 summarizes our conclusions and further issues.

2 Methodology

2.1 Production function

This paper empirically analyzes the impact of agglomeration on regional productivity by estimating the regional production function. We assume a generalized Cobb–Douglas function for the regional production function as follows:

$$GDP_{nit} = AK_{nit}^{\beta_k} L_{nit}^{\beta_l}, \tag{1}$$

where GDP_{nit} represents the GDP of zone i in industry n at time t; A represents the technology used (TFP); K_{nit} and L_{nit} represent, respectively, the capital and labor input of zone i in industry n at time t; and ρ, β_k, and β_l represent the elasticities of technology, capital, and labor, respectively.

Here, we assume that technology A is represented by the agglomeration index called effective density, ED, and the set of other independent variables, ϕ. We define the justification of the usage of effective density in the next subsection.

$$GDP_{nit} = A\left[ED, \phi\right] \cdot K_{nit}^{\beta_k} L_{nit}^{\beta_l}. \tag{2}$$

2.2 Effective density

In the research related to agglomeration economies, many variables have been applied to explain the agglomeration level. Raw data such as a number of firms or population are also used to determine the agglomeration level in studies such as Nakamura (1985), Beeson (1987), and Henderson (2003). Furthermore, several indices have been proposed to capture the effect of agglomeration as well. The Ellison and Glaeser agglomeration index (Ellison and Glaeser 1997) can be regarded as the most widely used index to measure agglomeration in view of its simplicity and unbiased estimation. Further to the Ellison and Glaeser agglomeration index, other discrete agglomeration indices have been proposed, such as the weighted agglomeration index by Maurel and Sédillot (1999) or the probability-based index by Mori et al. (2005). However, these indices compare the agglomeration activity in the zone with other activity outside the zone discretely without actual spatial consideration. Based on Ellison and Glaeser index, Duranton and Overman (2005) proposed an agglomeration index incorporating the distance between firms. In a comparison of the proposed index with the Ellison and Glaeser agglomeration index, Duranton and Overman (2005) concluded that the degree of agglomeration could be remarkably different when the spatial distribution is considered. By considering the distance between the sources of activity, the gravity model-based index as applied in Beeson (1987) is also one of the useful indices from its capability to consider the decay parameter along with the size of agglomeration. The agglomeration index in this study will be explained by *effective density*, one of the gravity model-based indices proposed by the Department for Transport (DfT), Wider Impact Guideline (Department for Transport 2014), for incorporating transportation into agglomeration.

For the selection of a suitable index for our study, two conditions need to be satisfied. First, our main objective is to investigate the impact of agglomeration through localization agglomeration and urbanization agglomeration. Therefore, the index used in this study must be applicable to these two types of agglomeration unbiasedly, while the Ellison and Glaeser agglomeration index and other earlier mentioned ones may satisfy only localization agglomeration. Second, we would like to consider the accessibility effect because Duranton and Overman (2005) pointed out the importance of the geographical distribution of activities. The gravity model-based index can satisfy both our conditions since the mass, which represents an activity, can be applied to both localization and urbanization agglomeration while the distance in this index can be represented by the accessibility factor. Thus, we can apply the *effective density* index to our study. The effective density of zone i is defined as the sum of the mass of employment in another zone j and the travel time between zone i and zone j. This formulation depicts agglomeration in two ways: The mass of employment gives a number of activities generated by a particular zone j, and travel time represents the attractiveness of zone j's activities from the viewpoint of zone i. This study assumes three types of effective densities to represent agglomeration. The first follows the concept of *urbanization agglomeration.* The economic scale in zone j will be explained by the total employment in zone j. The effective density under urbanization agglomeration can be formulated as

$$ED_{nit} = \sum_j \frac{E_{jt}}{g_{ijt}}, \tag{3}$$

where ED_{nit} represents the effective density of zone i in any industry n,E_{jt} represents the total employment in zone j, and g_{ijt} represents the travel time between zone i and zone j, all at time t.

The second type of effective density follows the concept of *localization agglomeration*. For regional productivity level in industry n, the economic scale of each zone j will be explained only by the employment of industry n in zone j. Effective density under localization agglomeration can be formulated as

$$ED_{nit} = \sum_j \frac{E_{njt}}{g_{ijt}}, \tag{4}$$

where ED_{nit} represents the effective density, and E_{njt}, the employment of zone i in industry n, at time t.

The third type of effective density follows *mixed agglomeration,* a format of agglomeration indicator in which we try to include the effect of both urbanization and localization. Under Marshall's proposal, more interaction between industries can lead to better returns for both parties. However, localization considers only the interaction between the same types of industry and ignores the interaction between different types of industries. On the contrary, urbanization considers the whole economy and ignores the economic structure. A city with the same worker level but different in structure would be considered to have the same effective density in the urbanization format. Zones with different industry types and industrial share can have different effects from agglomeration as well. For a better understanding of the whole agglomeration economy, we define the *weighted effective density* under mixed agglomeration by assuming a weight parameter of γ_{nmt} for each pair of industry as

$$ED_{nit} = \sum_{j} \sum_{m} \frac{\gamma_{nmt} E_{mjt}}{g_{ijt}}, \tag{5}$$

where γ_{nmt} is the effective density's weight parameter to explain the degree of industrial interaction between industry n and industry m at time t. From this formulation, we can explain agglomeration at a point between localization and urbanization through the weight γ_{nmt}, which roughly represents the productivity of joint activities and/or interactions between industries n and m; weight γ_{nmt} is the formulation modifying the co-agglomeration index proposed by Ellison and Glaeser (1997) as

$$\gamma_{nmt} = \exp\left[\frac{\sum_i (s_{nit} - x_{it})(s_{mit} - x_{it})}{1 - \sum_i x_{it}^2}\right], \tag{6}$$

where s_{nit} and s_{mit} are the respective shares of employment in industries n and m out of the total employment in zone i at time t, and x_{it} is the mean share of employment in zone i out of the national employment across all industries at time t. Note that Ellison and Glaeser's co-agglomeration index ignores the real spatial interaction agglomeration in terms of distance between firms (Duranton and Overman 2005). Thus, the co-agglomeration index in a spacious zone becomes the same as that in a smaller zone if both zones have the same number of firms, although in reality, the smaller zone can attain better agglomeration benefits from the shorter distance between firms. Despite such methodological disadvantages, our analysis uses this index for analytical simplicity.

3 Data

We use the inter-regional transportation data of Japan for our empirical analysis. Since inter-regional transportation connects one region with another, its impact on region-wide economic productivity can be felt across regions rather than within a region. Thus, we obtain data at the prefectural level (first-level administrative division in Japan,[1]

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[1] The administrative divisions of Japan can be divided into two levels. The upper tier is called "Prefecture"; this consists of 47 prefecture in Japan. The lower tier is called "Municipality"; there are several municipalities in one prefecture. Presently (2017), there are 1742 municipalities in Japan; this could be decreased due to

approximately equivalent to NUTS2[2] in the European Union) for our dataset, although, in reality, urbanization in the prefectural context might vary across prefectures. For instance, the built-up areas in megacities such as Tokyo and Osaka can cover multiple prefectures, whereas the built-up areas in less urbanized prefectures might cover only small towns in a single prefecture. Thus, agglomeration in our data may be regarded as a macroscopic approximation at the regional level. Our dataset covers 11 industries (agriculture; mining; manufacturing; construction; electricity, gas and water; retail; finance/insurance; real estate; transportation/communication; service; and government service) based on the classification of the Japanese Ministry of Economy, Trade, and Industry (METI). This classification reasonably distinguishes each industry so that localization agglomeration within the industry could be analyzed properly. The dataset covers 47 Japanese prefectures for six time frames at 5-year intervals: 1981, 1986, 1991, 1996, 2001, and 2006. Sociodemographic and socioeconomic data, such as prefectural population, GDP, employees, wage, capital, and investment stock data by industry, were derived from the Statistic Bureau and Cabinet office of Japan. Note that all economic data were adjusted to the year 2000. As for transportation data, the travel time between each prefecture pair was estimated as the shortest travel time for the six travel modes of high-speed rail, conventional rail, air, ferry, intercity bus, and private car. We used the National Integrated Transport Analysis System (NITAS) software developed by the Japanese Ministry of Land, Infrastructure, Transport, and Tourism (MLIT) to search for the shortest path. Also, note that the transportation network has over six variations across six time periods since the transportation infrastructure was developed gradually over time. Table 1 summarizes the statistics of the dataset used in this study. Note that the minimum value is usually obtained from the mining industry, where the geographical distribution is uneven, while the maximum value is distributed between the manufacturing industry during the early years and service industry during the later years.

Figure 1 illustrates the relationship between three types of prefectural effective density and the prefectural GDP. For the localization and mixed agglomeration cases, we present the prefectural GDP for the manufacturing industry as an example. Although the later years indicate less production, a comparison of the data for the same time period shows the prefectures with more effective density to have higher GDP, implying that agglomeration leads to higher overall production. This may be rather reasonable because effective density includes a number of workers and hence has a positive influence on the prefectural GDP. Plots in Fig. 1 clearly suggests a relationship between agglomeration and prefectural production. However, to find the return to productivity that can be expected from agglomeration, we present a controlled analysis in the next section.

Footnote 1 continued
depopulation in Japan. However, each prefecture and municipality may have different levels of autonomy based on its sub-classification. For example, Tokyo Prefecture, Osaka Prefecture, and Hokkaido Prefecture may have higher levels of autonomy than other prefectures. At the municipality level, a large municipality specified as "Designated City" has a higher level of autonomy than the other municipality sub-classifications.

[2] NUTS, or Nomenclature of Territorial Units for Statistics, is a subdivision code used in EU. The NUTS2 level indicates a population range of 800,000–3,000,000. The prefecture-level population of Japan has a range of 600,000–12,000,000.

Table 1 Descriptive statistics of dataset

	Total	1981	1986	1991	1996	2001	2006
Production (million JPY/industry/prefecture/year)							
Minimum	230	230	414	719	502	638	479
Median	378,414	273,240	323,247	396,046	456,916	449,022	446,210
Maximum	22,070,600	9,823,798	14,766,990	16,315,540	19,606,770	22,070,600	21,338,830
Mean	820,429	553,442	667,168	848,140	924,442	938,668	990,715
Standard deviation	1,605,935	948,974	1,271,036	1,617,179	1,728,182	1,864,892	1,937,460
Capital (million JPY/industry/prefecture/year)							
Minimum	1815	1936	1815	2226	2550	2845	3045
Median	854,233	364,181	595,462	862,513	1,092,411	1,277,283	1,349,462
Maximum	48,220,493	22,162,743	24,359,178	27,276,188	31,974,930	37,173,812	48,220,493
Mean	2,305,760	1,288,976	1,664,959	2,140,179	2,583,399	2,955,790	3,201,257
Standard deviation	4,145,113	2,503,369	3,004,524	3,630,910	4,305,946	4,908,843	5,418,859
Number of employee (person/industry/prefecture/year)							
Minimum	49	228	99	162	96	65	49
Median	41,587	39,882	41,593	42,934	44,193	42,333	38,430
Maximum	3,248,648	2,386,409	2,608,705	2,671,269	2,841,936	2,654,384	3,248,648
Mean	112,900	99,700	105,165	116,091	126,669	116,360	113,413
Standard deviation	234,242	202,944	216,547	237,327	258,192	241,460	244,809
Investment (million JPY/industry/prefecture/year)							
Minimum	115	115	141	225	127	133	208
Median	61,074	41,143	54,715	79,218	73,845	64,918	55,603
Maximum	11,917,150	4,989,108	7,560,264	10,917,420	8,846,604	8,958,830	11,917,150

Table 1 continued

	Total	1981	1986	1991	1996	2001	2006
Mean	248,229	152,166	197,865	315,386	262,008	247,909	314,037
Standard deviation	667,031	377,376	522,269	817,661	657,969	639,079	853,210
Urbanization agglomeration (person/minute/industry/prefecture/year)							
Minimum	147,188	147,188	170,714	191,491	198,151	192,470	202,194
Median	263,100	215,733	241,652	269,420	278,960	271,131	265,933
Maximum	631,467	504,171	542,392	609,558	631,467	608,729	604,423
Mean	296,137	254,866	273,723	310,319	322,163	310,647	305,103
Standard deviation	96,393	80,686	85,822	97,968	102,390	97,077	95,270
Localization agglomeration (person/minute/industry/prefecture/year)							
Minimum	118	411	335	262	222	163	118
Median	16,289	14,803	15,217	16,738	17,257	16,854	17,058
Maximum	216,685	149,714	163,562	175,887	189,490	181,887	216,685
Mean	27,121	23,171	24,881	28,208	30,497	28,237	27,735
Standard deviation	32,613	27,128	29,302	32,942	36,325	33,852	34,809
Mixed agglomeration (person/minute/industry/prefecture/year)							
Minimum	130,080	130,080	149,481	167,164	179,060	166,125	172,166
Median	429,163	384,356	402,143	442,870	468,439	448,376	436,988
Maximum	39,101,417	6,970,554	7,311,297	7,452,168	7,771,859	9,471,800	39,101,417
Mean	1,261,707	868,319	939,701	1,027,291	1,148,991	1,121,471	2,464,468
Standard deviation	2,675,939	1,134,532	1,203,867	1,250,391	1,397,458	1,487,553	5,724,662

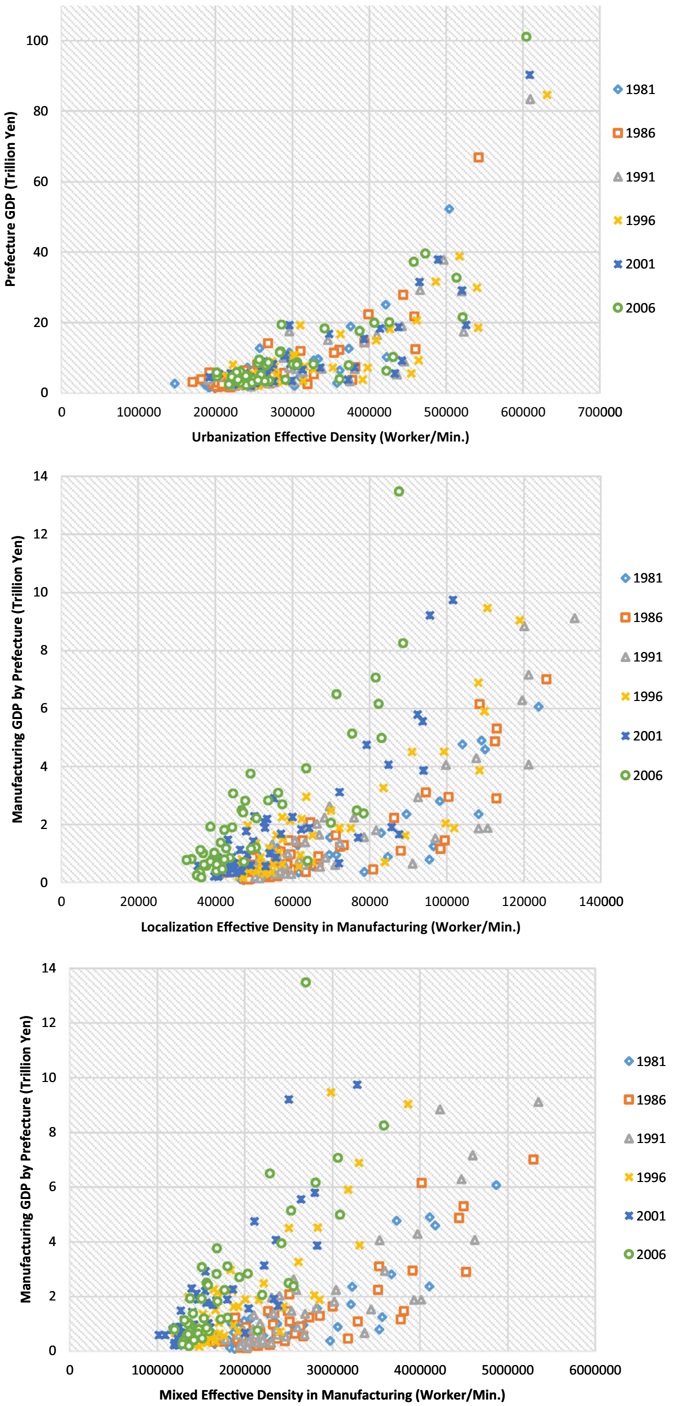

Fig. 1 Urbanization, localization, and mixed agglomerations versus prefectural GDP

4 Empirical analysis

4.1 Estimation method

The logarithmic transformation of the production function in Eq. (2) gives

$$gdp_{nit} = \rho ED_{nit} + \phi_{nit} + \beta_k k_{nit} + \beta_l l_{nit}, \tag{7}$$

where the alower case gdp_{nit}, ED_{nit}, ϕ_{nit}, k_{nit}, and l_{nit} represent the logarithmic GDP, logarithmic effective density, the set of other independent variables related to technological shocks, logarithmic capital, and logarithmic labor, respectively. ρ, β_k, and β_l represent the coefficients of effective density, capital input, and labor input, respectively. Effective density in the estimation refers to the specification of urbanization agglomeration, localization agglomeration, and mixed agglomeration (Eqs. 3, 4, 5).

One issue to be addressed in econometric estimation is the endogeneity effect. This could arise with reverse causality and omitted variables. This study assumes that agglomeration affects productivity. On the other hand, reverse causation, which can be reasonably expected when a region with higher productivity attracts more firms and workers, leads to further agglomeration. The most popular technique to deal with the endogeneity problem in regression analysis is the instrumental variable (IV) approach. By applying this approach to our estimation, agglomeration ED_{nit} is estimated by IVs in the first step, and the instrumented agglomeration is applied with other explanatory variables to explain production in the second step. Although we tried various IVs for our empirical analysis, including the generalized method of moments (GMM) technique (Arellano and Bond 1991), mainly with our agglomeration parameter, ED_{nit}, the IVs and the GMM model yielded unpromising results and we could not find any suitable IV/GMM model to our analysis. Several conditions might restrict the application of IV/GMM estimation to our dataset. For example, our dataset has only six time series observations, which might be too few to incorporate time series effect. Another possible reason is the rather stagnant growth in several variables such as labor and capital input in some prefectures. Because of these two reasons, the IV/GMM model can result in biased estimations due to inadequate lags and the small first-difference problem, eventually leading to the problem of the weak instrument (Alonso-Borrego and Arellano 1999; Arellano and Bover 1995; Blundell and Bond 1998).

Although we observe a stagnant growth of inputs in some prefectures and industries, constant production growth can be observed to a certain extent. This supports our assumption that besides input shocks, the TFP itself essentially affects the production level in Japan. Therefore, we assume productivity shocks apart from the agglomeration effect, and inputs are explained through a set of other independent variables, ϕ. We then expand the ϕ term using the semi-parametric approach, following the original work of Olley and Pakes (1996), which is one of the popular approaches applied in Graham et al. (2009) and Thabet (2015). With this method, we can assume that capital and investment are the proxy variables of TFP, apart from effective density:

$$gdp_{nit} = \rho ED_{nit} + \phi\left(k_{nit}, v_{nit}\right) + \beta_k k_{nit} + \beta_l l_{nit}, \tag{8}$$

where v_{nit} represents the investment of zone i in industry n at time t. In our regression process, $\phi\left(k_{nit}, v_{nit}\right)$ is assumed to be nonparametric and is specified as a third-order bivariate polynomial expansion of the Cobb–Douglas function. The estimated model can be written as follows:

$$\begin{aligned} gdp_{nit} = {} & \rho ED_{nit} + \beta_k k_{nit} + \beta_l l_{nit} + \beta_v v_{nit} + \beta_{kk}\left(k_{nit}\right)^2 + \beta_{vv}\left(v_{nit}\right)^2 + \beta_{kv} k_{nit} v_{nit} \\ & + \beta_{kkv}\left(k_{nit}\right)^2 v_{nit} + \beta_{kvv} k_{nit}\left(v_{nit}\right)^2 + \beta_{kkk}\left(k_{nit}\right)^3 + \beta_{vvv}\left(v_{nit}\right)^3. \end{aligned} \tag{9}$$

Note that in the analysis, zone i represents prefectures from the 47 prefectures in Japan, industry n represents the industrial categorization from 11 categories, and time t represents the time from six time periods as mentioned in the data section. We estimate three models in regression processes, the prefectural fixed-effect model ("prefecture controlled"), the time period fixed-effect model ("time controlled"), and the prefectural and time period fixed-effect model ("two-way controlled"). The panel data are estimated for each type of agglomeration assumption across the industrial categorization based on Eq. (9). Tables 2, 3, and 4 give the estimation results, highlighting the elasticities of effective density for each model.

4.2 Results

Table 2 summarizes the estimation results of the three regression models using urbanization agglomeration in 11 industries, assuming Eq. (3) for effective density. For all industries, model fitness is the highest in the time-controlled model, followed by the prefecture-controlled model and the two-way-controlled model. First, the prefecture-controlled model shows that effective density has significantly positive impacts on mining and finance/insurance and negative impacts on real estate and government service industries. Next, the time-controlled model shows that effective density has a significantly positive impact on real estate and negative impact on the agriculture industry. Finally, the two-way-controlled model shows that effective density has no impact on any industry.

Table 3 summarizes the estimation results of the three regression models using localization agglomeration in 11 industries, assuming Eq. (4) for effective density. First, the prefecture-controlled model shows that effective density has significantly positive impacts on construction, retailing, finance/insurance, and transportation/communication industries and negative impacts on manufacturing, electricity/gas/water, and service industries. Next, the time-controlled model shows that effective density has a significantly positive impact on real estate and negative impact on the agriculture industry. Finally, the two-way-controlled model shows that effective density has a significantly positive impact on the mining industry.

Table 4 summarizes the estimation results of the three regression models using mixed agglomeration in 11 industries, assuming Eq. (5) for effective density. Models assuming mixed effective density tend to perform better than those assuming urbanization agglomeration, although the results are generally the same as for earlier models. First, the prefecture-controlled model shows that effective density has significantly positive impacts on mining, finance/insurance, and transportation/communication and

Table 2 Estimated elasticities of regional productivity with respect to effective density based on urbanization agglomeration

	Prefecture control					
	Agriculture	Mining	Manufacturing	Construction	Elec, gas and water	Retail
ED	0.090	1.267***	−0.032	−0.011	0.175	−0.055
	(0.155)	(0.178)	(0.155)	(0.184)	(0.148)	(0.113)
l	0.195***	0.286***	0.411***	0.574***	−0.123	0.269***
	(0.041)	(0.033)	(0.123)	(0.050)	(0.076)	(0.025)
$Adj.\ R^2$	0.429	0.510	0.727	0.642	0.706	0.745

	Finance and insur	Real estate	Transport and comm	Service	Gov. service
ED	0.935***	−0.417**	−0.051	0.066	−0.195***
	(0.198)	(0.138)	(0.155)	(0.083)	(0.054)
l	0.548***	0.636***	0.220***	0.080*	0.549***
	(0.063)	(0.075)	(0.064)	(0.036)	(0.056)
$Adj.\ R^2$	0.699	0.730	0.721	0.771	0.747

	Time control					
	Agriculture	Mining	Manufacturing	Construction	Elec, gas and water	Retail
ED	−0.296***	0.011	0.095*	−0.101*	0.002	0.033
	(0.059)	(0.053)	(0.047)	(0.045)	(0.030)	(0.037)
l	0.331***	0.053	0.574***	0.253***	0.111***	0.212***
	(0.038)	(0.038)	(0.027)	(0.060)	(0.027)	(0.043)
$Adj.\ R^2$	0.777	0.885	0.928	0.915	0.927	0.930

	Finance and insur	Real estate	Transport and comm	Service	Gov. service
ED	0.062	0.292***	0.016	0.021	0.001
	(0.041)	(0.072)	(0.031)	(0.019)	(0.027)
l	0.194***	0.090	0.009	0.159***	0.963***
	(0.058)	(0.181)	(0.046)	(0.032)	(0.040)
$Adj.\ R^2$	0.926	0.893	0.930	0.936	0.929

	Two-way control					
	Agriculture	Mining	Manufacturing	Construction	Elec, gas and water	Retail
ED	−0.199	0.460	0.097	−0.298	0.062	0.057
	(0.230)	(0.286)	(0.201)	(0.191)	(0.149)	(0.115)
l	0.206***	0.158***	0.376***	0.172*	0.073	0.064
	(0.037)	(0.046)	(0.112)	(0.074)	(0.047)	(0.038)
$Adj.\ R^2$	0.185	0.611	0.330	0.295	0.617	0.557

Table 2 continued

	Finance and insur	Real estate	Transport and comm	Service	Gov. service
ED	0.064	0.164	0.222	0.005	0.095
	(0.116)	(0.188)	(0.118)	(0.076)	(0.068)
l	0.062	0.585***	0.098*	0.060*	0.710***
	(0.044)	(0.119)	(0.043)	(0.029)	(0.063)
Adj. R^2	0.537	0.284	0.490	0.630	0.372

The estimates in parenthesis represent standard errors; *** significance at the 0.1% level, ** significance at the 1% level, and * significance at the 5% level; for every model, number of observation = 282

negative impacts on the service industry. Next, the time-controlled model shows that effective density has a significantly positive impact on real estate and negative impact on the agriculture industry. Finally, the two-way-controlled model shows that effective density has a significantly positive impact on government service.

From Tables 2, 3 and 4, the best goodness of fit, as describe by the adjusted R^2, is in the time-controlled model, followed by the prefecture-controlled and two-way-controlled models. Furthermore, we observed poor significance for the two-way-controlled model. This could be due to misspecification in the two-way-controlled model because the prefecture-controlled and year-controlled parameters are correlated. For example, in early 1980s, when Japanese economy is still growing, we observed higher growth in the big prefecture. However, during 1990s where economic crisis occurred, such major prefectures may have lower growth than other small prefecture as the negative shock from the economic crisis is expected to be larger in major prefectures. In another word, prefecture control in the major prefecture and year control could be correlated while negative correlation is expected in the small prefecture and year control. Therefore, we would like to refrain our interpretation of results from the two-way-controlled model. Our major findings based on the prefecture- and year-controlled model results can be summarized as follows:

The prefecture-controlled model shows that

1. both urbanization and localization agglomerations have a positive influence on regional productivity in the finance/insurance industry;
2. urbanization agglomeration tends to have a positive influence on regional productivity in the mining industry;
3. localization agglomeration tends to have a positive influence on regional productivity in the transportation/communication industry; and
4. localization agglomeration tends to have a negative influence on regional productivity in the services industry.

   The time-controlled model shows that

5. both urbanization and localization agglomerations have a positive influence on regional productivity in the real estate industry; and
6. both urbanization and localization agglomerations have a negative influence on regional productivity in the agriculture industry.

Table 3 Estimated elasticities of regional productivity with respect to effective density based on localization agglomeration

	Prefecture control					
	Agriculture	Mining	Manufacturing	Construction	Elec, gas and water	Retail
ED	−0.121	0.060	−0.274***	0.532***	−1.324***	0.203***
	(0.212)	(0.091)	(0.067)	(0.107)	(0.151)	(0.058)
l	0.209***	0.180*	0.570***	0.321***	0.117	0.131**
	(0.050)	(0.078)	(0.112)	(0.069)	(0.072)	(0.043)
Adj. R^2	0.429	0.447	0.732	0.657	0.728	0.747

	Finance and insur	Real estate	Transport and comm	Service	Gov. service
ED	0.750***	0.153	0.520***	−0.478***	−0.207**
	(0.106)	(0.121)	(0.055)	(0.057)	(0.073)
l	0.256**	0.647***	0.141*	0.152***	0.563***
	(0.082)	(0.076)	(0.055)	(0.031)	(0.063)
Adj. R^2	0.709	0.728	0.742	0.776	0.745

	Time control					
	Agriculture	Mining	Manufacturing	Construction	Elec, gas and water	Retail
ED	−0.470***	0.142	0.109*	−0.106*	0.008	0.024
	(0.108)	(0.090)	(0.044)	(0.053)	(0.032)	(0.036)
l	0.401***	0.045	0.567***	0.262***	0.111***	0.217***
	(0.036)	(0.038)	(0.027)	(0.059)	(0.027)	(0.043)
Adj. R^2	0.773	0.886	0.928	0.915	0.927	0.930

	Finance and insur	Real estate	Transport and comm	Service	Gov. service
ED	0.061	0.244***	0.013	0.018	−0.007
	(0.040)	(0.066)	(0.031)	(0.020)	(0.029)
l	0.190**	0.083	0.007	0.161***	0.964***
	(0.057)	(0.182)	(0.046)	(0.032)	(0.040)
Adj. R^2	0.926	0.892	0.930	0.936	0.929

	Two-way control					
	Agriculture	Mining	Manufacturing	Construction	Elec, gas and water	Retail
ED	−0.575*	1.073***	0.274	−0.254	0.155	0.029
	(0.253)	(0.209)	(0.195)	(0.207)	(0.155)	(0.111)
l	0.267***	0.014	0.364**	0.177*	0.057	0.066
	(0.045)	(0.052)	(0.112)	(0.074)	(0.050)	(0.038)
Adj. R^2	0.197	0.627	0.333	0.293	0.618	0.557

	Finance and insur	Real estate	Transport and comm	Service	Gov. service
ED	0.060	0.292	0.221*	0.026	0.054
	(0.104)	(0.187)	(0.097)	(0.075)	(0.074)
l	0.060	0.570***	0.071	0.060*	0.711***

Table 3 continued

	Finance and insur	Real estate	Transport and comm	Service	Gov. service
	(0.044)	(0.118)	(0.045)	(0.029)	(0.063)
$Adj.\ R^2$	0.537	0.287	0.492	0.630	0.370

The estimates in parenthesis represent standard errors; *** significance at the 0.1% level, ** significance at the 1% level, and * significance at the 5% level; for every model, number of observation = 282

From the above findings, a significant result from both the urbanization and mixed agglomeration models implies influence from urbanization agglomeration, whereas a significant result from both the localization and mixed agglomeration models implies influence from localization agglomeration. Further, note that the prefecture-controlled model excludes the impacts of the unique prefecture-related factor by introducing constants to each prefecture whereas the time-controlled model excludes the impacts of the unique time-related factor by introducing constants to each time period. Findings (1)–(4) are based on observations of the prefecture-controlled model only, meaning that the results could hold true across prefectures but can be affected by the time factor. Findings (5)–(6) are based on observations of the time-controlled model only, meaning that the results could hold true across time but can be affected by the prefectural factor.

4.3 Discussion

From the results, the fitness of the estimated models assuming localization agglomeration tends to be higher than that for the other two models in any industries. The number of industries with significant estimates for agglomeration is also largest in the localization models. This could imply that localization agglomeration has a higher influence on economic production than urbanization agglomeration. However, the results also show that agglomeration has different effects for each industry.

First, the positive impacts of both urbanization and localization agglomeration on regional productivity in the finance/insurance and real estate industries, or the so-called FIRE industry, may be explained reasonably using Marshall's theory. Since the FIRE industry should have customers from many other industries, a higher density of potential customers from various industries can give more business opportunities to them; this may be one of the sources of external benefit from urbanization agglomeration. Because the FIRE industry particularly needs the latest information about local/regional/global markets, the social network of workers in the same industry can effectively contribute by sharing knowledge through meetings. Communication opportunities such as seminars and informal meetings attract businesspeople from across regions, and so a higher density of colleagues in the FIRE industry can provide more knowledge spillover through communication; this is one of the sources of external benefit from localization agglomeration. Localization agglomeration also affects the labor pool as well as the procurement of high-standard service, because the FIRE industry requires skillful labor and efficient business environment for attaining higher productivity. A significant impact can be found in the finance/insurance industry only with the prefecture-controlled model, probably because its impact con-

Table 4 Estimated elasticities of regional productivity with respect to effective density based on mixed agglomeration

	Prefecture control					
	Agriculture	Mining	Manufacturing	Construction	Elec, gas and water	Retail
ED	0.218	1.076***	−0.037	0.447**	−0.038	0.127**
	(0.134)	(0.164)	(0.057)	(0.135)	(0.137)	(0.039)
l	0.197***	0.244***	0.402***	0.444***	−0.126	0.169***
	(0.041)	(0.032)	(0.108)	(0.063)	(0.077)	(0.036)
$Adj.\ R^2$	0.433	0.502	0.728	0.649	0.706	0.747

	Finance and insur	Real estate	Transport and comm	Service	Gov. service
ED	1.214***	−0.362**	0.664***	−0.042***	−0.052
	(0.150)	(0.119)	(0.132)	(0.008)	(0.075)
l	0.355***	0.627***	0.198**	0.050	0.464***
	(0.065)	(0.075)	(0.061)	(0.033)	(0.053)
$Adj.\ R^2$	0.713	0.730	0.729	0.773	0.744

	Time control					
	Agriculture	Mining	Manufacturing	Construction	Elec, gas and water	Retail
ED	−0.297***	0.011	0.100*	−0.102*	0.002	0.031
	(0.059)	(0.053)	(0.046)	(0.044)	(0.030)	(0.036)
l	0.331***	0.053	0.572***	0.253***	0.111***	0.213***
	(0.038)	(0.038)	(0.027)	(0.060)	(0.027)	(0.043)
$Adj.\ R^2$	0.777	0.885	0.928	0.915	0.927	0.930

	Finance and insur	Real estate	Transport and comm	Service	Gov. service
ED	0.062	0.294***	0.016	0.021	0.000
	(0.041)	(0.072)	(0.031)	(0.019)	(0.026)
l	0.194***	0.089	0.009	0.159***	0.963***
	(0.058)	(0.181)	(0.046)	(0.032)	(0.040)
$Adj.\ R^2$	0.926	0.893	0.930	0.936	0.929

	Two-way control					
	Agriculture	Mining	Manufacturing	Construction	Elec, gas and water	Retail
ED	0.000*	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
l	0.181	0.040	0.151	0.173	0.262	−0.167
	(0.094)	(0.092)	(0.130)	(0.121)	(0.380)	(0.490)
$Adj.\ R^2$	0.005	0.485	0.253	0.125	0.114	0.017

	Finance and insur	Real estate	Transport and comm	Service	Gov. service
ED	0.000	0.000*	0.000	0.000	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
l	−0.029	0.372	−0.209	0.029	0.311*

Table 4 continued

	Finance and insur	Real estate	Transport and comm	Service	Gov. service
	(0.075)	(0.303)	(0.300)	(0.049)	(0.124)
Adj. R^2	0.372	0.070	0.163	0.426	0.191

The estimates in parenthesis represent standard errors; *** significant at the 0.1% level, ** significance at the 1% level, and * significance at the 5% level; for every model, number of observation = 282

siderably varies across prefectures. Similarly, a significant impact can be found in the real estate industry with the time-controlled model, probably because the real estate market in Japan was influenced by conditions in the national economic market rather than by each prefecture's unique condition, although the significance in the prefecture-controlled model is relatively strong as well. Note that the estimated elasticities in the finance/insurance industry with respect to urbanization, localization, and mixed agglomerations are 0.935, 0.750, and 1.214, respectively, and those in the real estate industry are 0.292, 0.244, and 0.294, respectively. This could mean that urbanization agglomeration may have a greater influence on productivity than localization agglomeration in those industries.

Second, the positive impact of urbanization agglomeration on regional productivity in mining may be explained from the market perspective. Although the intuition is, localization should be more vital in mining sector since mining products usually come directly from natural resources, which are typically located in limited areas based on geographical conditions of resource availability. By controlling the natural resources effect by the prefecture fixed effect, we observed the significant effect in urbanization agglomeration effect. This could be mainly due to the fact that the mining company is not only in the mine ore area, but our data reveals that company also establishes its office in the urban area in order to sell its product, especially in Japan, where there is higher share in rare metal and precious ore market, and the demand in this market is usually higher in the more urbanized area.

Third, the positive impact of localization agglomeration on regional productivity in transportation/communication may reflect regional market characteristics. For instance, when transportation firms are located closely, trucks/vans or drivers can be easily shared among them, thus reducing their potential business risk due to demand fluctuation in the transportation market. The network economy may also work in transportation/communication businesses that particularly use the physical network. In the case of Japan, multiple public transit operators working closely together can form a wider transportation network covering vast areas and thus enhance accessibility and the mobility of passengers; this could improve the productivity of public transit operators from the complementarity of services. A significant impact of agglomeration was found in the transportation/communication industry only with the prefecture-controlled model because its impact considerably varies over prefectures from the geographically uneven availability of natural resources.

Fourth, localization agglomeration negatively influences regional productivity in the service industry. Generally, negative elasticities of agglomeration to productivity are found when the centrifugal forces stemming from agglomeration are stronger than the centripetal forces (Fujita et al. 2001). The centrifugal force, or diseconomies from agglomeration, may arise from higher land rent, increased living expenses, or more congestion from a denser population. One possible reason for negative elasticity in the service industry is that agglomeration of the same service firms can cause serious market competition among them and lose the additional benefit of the imperfect competitive market. Agglomeration can even lead to over-competition, generating negative external effects such as weaker position in business contracts with their clients or customers, while less agglomerated firms can enjoy higher market power. The negative impact on some industries is supported by Combes et al. (2012), where the firm selection process[3] has no impact on spatial productivity difference.

Fifth, both urbanization and localization agglomerations have a negative influence on regional productivity in the agriculture industry. One possible explanation is that the economy of geographical scale works well in agricultural business because it typically requires larger land for better production. A larger area of land decreases the average cost of production, resulting in better productivity, and leads to less agglomeration. Another possible reason, particularly for the poor impact of localization agglomeration, is the negative external effect of agglomeration. For example, densely agglomerated agricultural businesses consume excessive natural resources such as water, wood, and fish, and thus reduce the performance of the agricultural production.

Finally, industries other than FIRE, transportation/communication, service, and agriculture may not have notable impacts from agglomeration. In particular, the poor significance of agglomeration in electricity/gas/water, retail, and government service industries could be explained by the characteristics of such services and/or goods. Because these are essential goods/services for people's daily life, the industries producing such commodities are required to be distributed evenly. Government service is a typical case, and retail and electricity/gas/water industries have to run their businesses even if their profit is near zero. More positively, these industries themselves distribute evenly based on the distribution of population, and so regional agglomeration may make less sense in these industries.

5 Conclusion

This study provided empirical evidence of the impacts of agglomeration on regional development using Japanese historical data. Although our study shares similar settings with Nakamura (1985), several contrasts can be found. Urbanization agglomeration is explained in Nakamura (1985) by the population in a densely inhabited district (DID). However, our study considers urbanization agglomeration with the total number of workers in the prefecture. In Japan, many towns near big cities serve as a residential area for workers in big cities. From the 2000 data, the daytime to night-time population ratio for Tokyo Prefecture is around 1.2, whereas that for the neighboring prefectures such as Saitama, Chiba, and Kanagawa is less than 0.9. We believe that the number of

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[3] The firm selection approach explains the better productivity from agglomeration resulting from the intensive competition in larger markets. Only the best firms can survive competition, resulting in better overall productivity in a large market compared to a smaller market.

workers is more reasonable for urbanization agglomeration because the worker is one of the contributors to firm productivity. Another difference is that the transportation factor is included in the agglomeration model. Agglomeration economies cannot be realized without communication between firms, and transportation can be considered as one of the barriers to communication level. Ideally, for panel data analysis, other communication variables such as level of Internet penetration or mobile phone usage should be included in the agglomeration model; this also depicts the accessibility level between firms across region and time. However, we would like to restrict our scope to transportation in this study.

Our results showed that on average, the indirect benefit from regional productivity improvement through localization agglomeration tends to be more significant than that through urbanization agglomeration although their robustness indicates that every industry utilizes agglomeration in different ways. From our results for Japanese industries, mining enjoys significant benefit from urbanization rather than localization, transportation/communication enjoys significant benefit from localization rather than urbanization, and FIRE benefits from both types of agglomeration economies. Negative elasticities were found for agriculture and service industries, but this could be partly due to the industries' characteristics. Furthermore, this study also discussed the factors that could lead to agglomeration. As in our discussions on the mining industry, the geographical distribution of natural resources is one of the factors considered. Although we tried to analyze the potential reverse causality and explain agglomeration with other factors, our attempts failed because of our limited dataset. This could be partly because of the unique policy implemented earlier in Japan by the national government in the 1980s and 1990s. Although the early stages following World War II saw a series of expressways and high-speed railways successfully introduced to expand the transportation network and meet the challenges of rapid economic growth, the government gradually shifted its policy goal from national economic development to regional economic development under the concept of "regionally balanced national development policy" in the 1980s and 1990s. During that period in Japan, the investment of inter-regional transportation infrastructure or development of regional industries may have been determined through political debates rather than a consistent decision-making process, thus making it difficult for us to interpret the mechanism of regional agglomeration in Japan. Note that the formal cost–benefit analysis guideline for transportation investment was introduced in Japan around 2000.

Although this study contributed to validating the assumption that improved regional accessibility promoted economic development through agglomeration, several further issues remain to be addressed. First, from a technical perspective, one of the issues is the rationale for using "effective density" to explain agglomeration. Kanemoto (2013) and Kidokoro (2015) explained the difference between an agglomeration economy and transportation investment through general equilibrium, mentioning that the concept of effective density might not be justified in some cases. For example, the effective density in Eq. (3) follows urbanization agglomeration, neglecting the industrial structure. Thus, a problem could arise. For example, a zone with 90% employment in industry n and 10% employment in industry m has the same effective density as another zone with 10% employment in industry n and 90% in industry m, although, obviously, the productivity between them should be different. This is the main reason we introduced the weighted effective density in our analysis to consider the whole economy within the zone, although the result could imply that the Ellison and Glaeser co-agglomeration index is not promising, at least with our specification and dataset. Further examination would be required for the definition of agglomeration. Yet, our finding can help the regional planner with regard to agglomeration to a certain extent. Nevertheless, we draw the first conclusion from our analysis: The relationship between transportation investment and the economy through agglomeration can be positive, negative, or not related, depending on the type and distribution of industrial activities. Many agglomeration-related studies focus only on the manufacturing sector, but we argue that the effect of inter-industrial agglomeration should be further investigated to reveal the real mechanism behind the cross-fertilization process proposed in urbanization agglomeration.

Finally, we emphasize the interest gain from the coordination between land-use and transportation service. Many practices can be explained using the results obtained in the case study of Japan. For example, the results show that the agglomeration productivity premium found in the real estate industry and in the transportation and communication industry are positively significant in several models. These results concur with the real situation in Japan, where transit-oriented development has been effectively established in large urban areas from the late twentieth century. The situation in Japan can explain the negative results in agriculture as well; the limited land available for cultivation in Japan is against the nature of the agricultural sector, where a larger land area decreases the average cost of production, implying that less agglomeration leads to higher productivity. However, we emphasize that these results can be unique for Japan, where limited habitable land is the main issue, forcing economic activities to agglomerate together. Nevertheless, another conclusion can be drawn from our findings: Transportation improvement significantly promotes the economy through agglomeration from better accessibility in many industries.

One policy implication drawn from the first conclusion is that the agglomeration effect should be treated industry by industry. For example, our result shows a negative impact of localization agglomeration in the service industry. While we continuously observed an increasing trend of employment in the service industry in Japan, we believe that the service industry in Japan should be expanded to the regions where an agglomeration of the service sector is still lagging behind in order to reduce the over-competition effect. As for the second conclusion, we believe that to maximize regional productivity from agglomeration, the land-use and transportation planning should consider whether, which, and where each sector should be allocated and transportation infrastructure invested. In Japan, huge infrastructure investment is criticized because the expected benefit might not be sufficient due to the declining population in Japan. However, we agree with the transportation project linking the major cities, such as the Chuo Shinkansen Maglev project. Despite its huge investment cost, we believe that this project will be able to generate sufficient indirect benefit through agglomeration along the most populated corridor in Japan.

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