RIETI Discussion Paper Series 25-E-069

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RIETI Discussion Paper Series 25-E-069

July 2025

Disentangling Economies of Density: Evidence from micro-geographic data *

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Abstract

This study utilizes micro-geographic data to examine wage premiums across different residential and employment agglomerations. In the existing literature on economies of density, the distinction between residents and workers is often addressed without a clear differentiation between the two. This oversight hinders the formulation of practical policy recommendations for compact urban planning and industrial location strategies. Amid Japan's ongoing population decline, certain regions retain the capacity to attract industrial activity despite their waning appeal as residential areas. However, when policy discussions focus exclusively on residential agglomeration, regions with substantial potential to revitalize local industrial clusters may be overlooked. To bridge this gap, the study integrates manufacturing establishment data with regional mesh data on both residents and workers. This study finds that employment concentration, rather than residential concentration within compact geographic areas accounts for wage premiums, thereby highlighting the critical role of spatial locality of employment in shaping industrial location strategies.

JEL classification: F14, R12

Keywords: Wage Premium, Productivity, Economies of Density, Agglomeration, Geocoding

* I thank Shota Araki, Nobuaki Hamaguchi, Seiichiro Inoue, Arata Ito, Eiichi Tomiura, Akira Yamaguchi, and the participants of the RIETI DP Seminar for their helpful comments and suggestions. Any remaining errors are my own. This study uses microdata (questionnaire information) from the Census of Manufacture (Ministry of Economy, Trade and Industry) and Economic Census for Business Activity (Ministry of Internal Affairs and Communications and Ministry of Economy, Trade and Industry) with permission under the Statistics Act of Japan. This study uses the regional mesh grid statistics of Economic Census and Population Census provided by the Ministry of Internal Affairs and Communications. This study is an outcome of the research conducted under the RIETI Project "Evidence-Based Policy Making for Regional Revitalization." This research uses the establishment-level panel converter table developed by the project mentioned above. This study was supported by JSPS KAKENHI Grant Numbers 21K01497.

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1. Introduction

Larger cities attract more people. Urbanization is a global phenomenon that accompanies economic growth. As such, one of the dimensions shaping the cities is the density (World Bank, 2009). Along with the new geographic information system (GIS) technology and increasing availability of micro-geographic data, the density is creating a new trend in the literature on urban economics (Ahlfeldt et al., 2015; Ahlfeldt and Pietrostefani, 2019; Donovan et al., 2024; Duranton and Puga, 2020; Grover et al., 2023).

There is a vast amount of literature on the economies of density showing that the density plays an important role on both consumer and production sides (Duranton and Puga, 2020). Consumers benefit from close access to a larger variety of goods and services in denser cities (Handbury and Weinstein, 2015). Workers can earn higher wages in larger cities (Baum-Snow and Pavan, 2012; Combes et al., 2008; Fu and Ross, 2013; Kondo, 2017a). Firms benefit from agglomeration economies in terms of productivity and innovation (Combes et al., 2012).

This study emphasizes the importance of differentiating between the agglomerations of residents and workers and solves the three issues raised by Duranton and Puga (2020)., who pointed out that the density should be carefully used in terms of 1) choice of scale, 2) using a single index measure of density, and 3) appropriate variable of interest for measuring density. In the existing literature on economies of density, the distinction between residents and workers is often discussed without making a clear distinction between the two, which hinders the discussion of policy implications regarding compact urban planning and industrial location policies.

In the context of regional development, place-based policy attracts policymakers (Moretti, 2024), and this study newly discusses the trade-off between compact urban planning and industrial location policies. Urban policymakers consider urban planning in terms of residence (Ahlfeldt and Pietrostefani, 2017). In India, bad city shape prevents faster city growth (Harari, 2020). Industrial policymakers promote industrial clusters for regional development, which also affects the city's shape. These two types of policies may face geographical trade-offs in terms of locations. The manufacturing sector produces tradable goods and tends to be located far from residential areas, along with decreasing trade costs. Firms may relocate their establishments depending on the production process (Duranton and Puga, 2001).

In Japan, facing a population decline, compact urban planning is being implemented to maintain urban infrastructure. The Japanese government promotes the concept of compact cities by Location Rationalization Plan (Ministry of Land, Infrastructure, Transport and Tourism, 2015). Figure 1 shows the Location Rationalization Plan for Toyama city, Toyama prefecture. There are two types of areas: guided urban facility zone and guided dwelling zone. The guided urban facility zone is an area into which livelihood services are guided, along with the facilities to be guided into that area. The guided dwelling zone is an area into which a dwelling is guided to maintain a given population density. As the circle of a 2 km radius is depicted based on the location of JR Toyama station, the government considers local population concentration in terms of residence. However, there remain areas that possess the potential to attract industry despite their declining appeal as residential areas. If policy discussions are based exclusively on the concentration of residents, the areas with the greatest potential for revitalizing the local industrial clusters may be underestimated.

[Figure 1]

With the objective of informing policy implications concerning the nexus between compact urban planning and industrial location, this study uncovers how different local population and employment density affect wages. Using the household dataset in six Sub-Saharan African countries, Henderson et al. (2021) found that the economic density measure and choice of scale changes the density impact on income and wage. An important finding is that population density works when the wages are compared across cities. However, local population density is nuanced when wages are compared within the city. This gap may arise when workers commute long distances between residential location and workplace. Distinguishing between population and employment, this study provides clear evidence for better understanding of the economies of density.

This study makes a significant contribution to the existing literature by revealing that the local density within a confined geographical area is a crucial factor in determining wage increases. The novel approach employed in this study involves integrating manufacturing establishment data with micro-geographic data on residents and workers, utilizing a 500-meter by 500-meter mesh grid. The findings of this study indicate that local employment density, rather than local population density, is a pivotal factor influencing regional wage increases. This elucidates the mechanisms underlying the economy of density and provides significant policy implications for both urban compact and industrial location policies.

The remainder of this study is organized as follows: Section 2 describes the empirical methods. Section 3 summarizes the panel dataset of Japanese manufacturing establishments and the geocoding process. Section 4 discusses the estimation results. Finally, Section 5 concludes.

2. Method

2.1. Measuring Local Density

Figure 2 shows the geographical distributions of employed workers and population based on 500 m by 500 m mesh grids in Tokyo prefecture, and Figure 3 shows the estimation results of the hot spot analysis using the Getis–Ord $G_i^*(d)$ statistic, which detects hot spots (Getis and Ord, 1992; Kondo, 2016a). Based on Figure 2, there is a clear statistical correlation between both distributions from a global perspective. However, the local aspect between both distributions is not necessarily the same. Based on the hot spot analysis in Figure3, a stylized fact is that employment is locally concentrated in the central business districts, while the population is geographically widely distributed to suburbs, as workers reside outside the central business districts and commute. Another salient fact is that hot spots of employed people are also observed even in the suburbs (e.g., Tachikawa, Hachioji, Fuchu, and Machida cities). This stylized fact suggests that the business locations show local agglomeration aside from population concentration.

[Figures 2–3]

This study constructs local geographical variables on employment and population densities using 500 m × 500 m regional mesh grid statistics. The local employment and population density for establishment i located in mesh grid a is calculated as follows:

$$\log\left(\text{Dens}_{at}^{k,d\text{km}}\right) = \sum_{b\in\mathcal{M}} \text{Size}_{bt}^{k} \times 1(D_{ab} \leq d \text{ km}), \tag{1}$$

where $\text{Dens}_{at}^{k,d\text{km}}$ is local density of mesh grid a in year t within the circle of d km radius for type $k \in \{\text{Employment, Population}\}$, and Size_{bt}^{k} is the number of employed persons or the population size, D_{ab} is the distance between mesh grids a and b, $\mathcal{M}$ is the set of mesh grids, and $1(\cdot)$ is the indicator function that takes the value of 1 if D_{ab} is less than d km and 0 otherwise. The bilateral distance between the mesh grids, D_{ab}, was calculated as the great circle distance using the latitude and longitude of the centroid of each mesh grid by the spgen in Stata (Kondo, 2017b).

Figure 4 illustrates the geographical range of local area in Tokyo. The base point of the red color mesh grid is the Tokyo Metropolitan Government Office. The crucial aspect of the local density is the geographical range of local area (Duranton and Puga, 2020). Therefore, this study sets four threshold distance as $d = \{500 \text{ m}, 2 \text{ km}, 4 \text{ km}, 8 \text{ km}\}$ to investigate the impact of local population concentration and differentiate it from local employment concentration. Corresponding to Equation (1), the red, blue, and green color circles indicate the geographic range of 2, 4, 8 km radius, respectively.

[Figure 4]

2.2. Impact of Local Density on Wage

To estimate the impact of local density on wage, this study estimates the following wage equation:

$$\log(\text{Wage}_{iasrt}) = \alpha^{k,d\text{km}} \log\left(\text{Dens}_{at}^{k,d\text{km}}\right) + \boldsymbol{X}_{it}\boldsymbol{\beta} + \eta_s + \psi_r + \pi_t + u_{iasrt}, \tag{2}$$

where Wage_{iasrt} is the average hourly wage for all workers in establishment i in year t, $\boldsymbol{X}_{i,t-1}$ is the vector of control variables including total factor productivity (TFP), establishment size, financial capital at the firm level, and the dummy of multi-establishment, η_s is the industry fixed effect, ψ_r is the prefecture fixed effect, π_t is the year effect, and u_{iasrt} is the error term.

The parameter of interest is $\alpha^{k,d\text{km}}$ that captures the impact of local density on wages. The main concern is to compare the parameters $\alpha^{k,d\text{km}}$ between local employment and population densities. In other words, this study uncovers which type of local concentration increases the average hourly wage.[1]

3. Data

This study uses confidential establishment-level microdata from the Japanese manufacturing sector as surveyed by the Census of Manufacture (CM) and the Economic Census for Business Activity (ECBA). The Ministry of Economy, Trade and Industry conducted the CM annually until 2020 (the survey year was 2019), including the 2012, 2016, and 2021 ECBA (Joint with Ministry of Internal Affairs and Communications). The study covers the period from 2012 to 2020 and uses the CM and ECBA to construct establishment-level panel data.

The CM includes two questionnaires: Form A (Kou) for establishments with 30 or more employees and Form B (Otsu) for establishments with 29 or fewer employees. Data on capital stock are only available for Form A, which is essential for estimating TFP at the establishment level. Thus, this study only used Form A datasets for regression analysis.

Wages are measured at the establishment level. The CM provides the total wage payments and the total number of workers. Therefore, this study calculates the average wage per worker at the establishment level. The deflator is constructed from the consumer price index (2020=100).

The TFP estimation is proposed in several ways in the literature (Olley and Pakes, 1996; Levinsohn and Petrin, 2003; Ackerberg et al., 2015; De Loecker and Warzynski, 2012). This study employs the approaches proposed by Ackerberg et al. (2015) and De Loecker and Warzynski (2012). It assumes a value-added translog productivity function. The estimation procedure follows the same approach as Kondo (2016b, 2018, 2023) using the same dataset as the CM in Japan.

Regarding the output variable, value added is used, which is calculated as total production minus total materials, fuel, and energy consumed, as well as the subcontracting expenses for production outsourcing.

[1] The baseline estimation is based on the ordinary least squares (OLS). However, the parameter $\alpha^{k,d\text{km}}$ might be estimated biased. As discussed by Martin et al. (2011) and Duranton and Puga (2020), firms and workers tend to concentrate in attractive areas with higher advantages. Some studies use a fixed effect estimation to deal with the spatial selection of establishments. Contrary to the OLS estimation, this approach omits the size effect across areas. In other words, the parameter is estimated as a statistical relationship from changes in local density on the changes in wages regardless of the initial size of local density.

Regarding the inputs, two factors are considered: labor and capital stock. Labor is defined as the total number of hours worked per year. Using the average hours worked in a year in the manufacturing sector, which are obtained from the Monthly Labour Survey (Ministry of Health, Labour and Welfare), the total annual hours worked are calculated by multiplying the annual number of workers by the hours worked. Capital stocks are measured as end-of-year book values using the perpetual inventory method. Energy consumption is used as a proxy for material demand for productivity shocks, which are unobserved by econometricians but observable to each establishment. All nominal values of outputs, intermediate inputs, energy consumption, and capital stocks are deflated by each price index. Finally, the deflators of the output price (2011=100), input price (2011=100), and investment price (2010=100) are constructed using the price indices available from the Bank of Japan, and all monthly price indices are averaged yearly.

Each establishment location was identified on a 500 m × 500 m grid square map using geocoding software (Address Matching Tool, MAPPLE). The geocoding process was conducted offline to protect the confidentiality of the establishment-level microdata. After obtaining the mesh code for each establishment, this study merges the 500 m × 500 m regional mesh grid statistics with the establishment dataset.

The 500 m × 500 m regional mesh grid statistics are based on the 2012, 2014, 2016, and 2021 Economic Censuses and the 2010, 2015, and 2020 Population Censuses, offered by the Ministry of Internal Affairs and Communications. Each mesh grid includes the 10-digit mesh code for the case of 500 m × 500 m regional mesh grid statistics. The lacking information between the survey years is linearly interpolated.

Table 1 presents the descriptive statistics for the variables used in the empirical analysis, which includes both establishment-level and mesh-level variables. From 2012 to 2020, the number of observations ranges from approximately 30,000 to 40,000. Although this study uses establishment-level microdata, capital is defined at the firm level. Note that the mesh-level variables are constructed by aggregating the surrounding mesh grids to capture local density. Based on the great circle distance using the latitude and longitude of the centroid of each mesh grid, local employment and population density variables within the circle of 2 km, 4 km, and 8 km radius are constructed by the spgen in Stata (Kondo, 2017b).

[Table 1]

4. Results and Discussion

Table 2 presents the estimation results of the wage equation (2). Columns (1)–(4) of Table 2 present the impact of local employment density, while Columns (5)–(8) of Table 2 present that of local population density. Figure 5 illustrates the density elasticity of wages with respect to employment and population densities in Table 2.

Columns (1)–(4) of Table 2 show that local employment density has statistically significant, positive coefficients. The density elasticities on wages within 500 meters, 2 km, 4 km, and 8 km are 0.0106, 0.0179, 0.0201 and 0.0227, respectively. However, Column (5) of Table 2 shows that local population density within a 500-meter mesh grid is statistically significant but negative. Figure 5 demonstrates that as the geographical range expands, the density elasticity of wages approaches the value of local employment density.

[Table 2 and Figure 5]

Tables 3–6 present the geographical heterogeneity in the impact of local employment and population density on wages by introducing the cross term of the local density with the prefecture dummy. Figures 6–9 illustrate the density elasticity of wages with respect to employment and population densities, respectively.

Column (1) of Table 3 shows that local employment density within a 500-meter mesh grid shows a significant and positive coefficient in 26 of the 47 prefectures, with an estimated elasticity ranging from approximately 0.0093 to 0.0328. However, Column (2) of Table 3 shows that local population density within a 500-meter mesh grid shows a significant and positive coefficient in 3 of the 47 prefectures (Tokyo, Kyoto, and Osaka). Furthermore, the local population density shows significantly negative estimates in some prefectures.

Table 4 presents the estimation results of the impact of local density within 2 km on wages. Column (1) of Table 4 shows that local employment density within 2 km has a significant, with an estimated elasticity ranging from 0.0100 to 0.0415. In contrast to Table 3, Column (2) of Table 4 shows that local population density within 2 km has a significant at the 10 % level and positive coefficient in 19 of the 47 prefectures, with an estimated elasticity ranging from 0.0095 to 0.0346.

Tables 5–6 present the estimation results of the impact of local density within 4 km and 8 km on wages, respectively. As the geographical range increases, the wage premium values converge toward equal values between employment and population density. Figure 9 compares the wage elasticity within 8 km, and the two premiums are nearly identical.

[Tables 3–6 and Figures 6–9]

Tables 7–10 present the geographical heterogeneity in the impact of local employment and population density on wages by introducing the cross term of the local density with the industry dummy. Figure 10 illustrates the density elasticity on wages between employment and population densities in Tables 7–10, respectively.

Column (1) of Table 7 shows that local employment density within 500-meter mesh grid shows a significant at the 10 % level and positive coefficient in 13 of the 16 industries, with an estimated elasticity ranging from approximately 0.0092 to 0.0292. However, Column (2) of Table 7 shows that local population density within a 500-meter mesh grid shows a significant and positive coefficient only in 2 of the 16 industries. Rather, five industries show significantly negative elasticities.

Tables 8–10 present the estimation results of the impact of local density within 2 km, 4 km, and 8 km on wages, respectively. As before, wage premium values converge toward equal values for employment and population densities as the geographic range increases. Table 10, for example, presents the estimation results of the impact of local density within 8 km on wages. In Column (1) of Table 10, local employment density shows a significant and positive coefficient in 15 of the 16 industries, and the estimated elasticity ranges from approximately 0.0080 to 0.0588. In Column (2) of Table 10, local population density shows a significant and positive coefficient in 15 of 16 industries, and the estimated elasticity ranges from approximately 0.074 to 0.0630.

[Tables 7–10 and Figure 10]

In summary, as pointed out by Duranton and Puga (2020), the geographical scale for density matters for better understanding of the economies of density. This study finds that the vastness of geographical scale makes it difficult to understand differences between local employment and population density. The impact of employment agglomeration on wages is only observed within geographically narrow areas (e.g., 500 meters). These findings suggest that employment density, rather than population density, in small geographic areas is important for increasing regional wages and provides important clues for understanding the mechanism of urban wage premiums.

5. Conclusion

This study has conducted an empirical analysis of agglomeration wage premium by differentiating between the agglomerations of residents and workers. In the extant literature on economies of density, the difference between residents and workers is often discussed without making a distinction between the two, which hinders the discussion of sufficient policy implications regarding compact urban planning and industrial location policies. This study aimed to address this gap by integrating manufacturing establishment data with micro-geographic data on residents and workers.

Using microdata of manufacturing establishments by integrating the regional mesh grid statistics in Japan, this study found that local employment density, rather than local population density, matters for increase in regional wage. An important finding is that, as geographical scale increases, the wage premium between employment and population density approaches equivalently. This study also found heterogeneity in the impact of local employment and population density on wages across prefectures and industries, in accordance with geographical scale of density.

This study has important implications for industrial location policy for the manufacturing sector. Urban compact policy seeks population concentration in terms of residence. However, industrial location policy seeks industrial clusters in terms of employment. Since these policies are not necessarily connected, policymakers may face a trade-off between them. In other words, the current policy direction toward urban compactness hinders industrial location policy outside urban planning zones. Industrial location policy is also an important factor in regional revitalization.

In the context of declining population in Japan, there are regions that possess the potential to attract manufacturing industry despite their declining appeal as residential areas. However, if policy discussions emphasize the agglomeration of residents exclusively from the perspective of urban compactness policy, areas with the greatest potential to revitalize local industrial clusters may be overlooked. As a place-based policy, industrial location policy is a potential driver of regional economic development. The manufacturing sector produces tradable goods. As transport costs decrease, geographical restrictions on industrial location are decreasing as well. A key takeaway from this study is that industrial clusters should be concentrated in narrow geographic areas. Policymakers must seek the nexus between compact urban planning and industrial location simultaneously.

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Table 1. Descriptive Statistics

Variable	Obs.	Mean	S.D.	Min	P1	P25	P50	P75	P99	Max
Establishment-Level										
log(Wage)	308,719	7.828	0.344	6.751	6.982	7.605	7.849	8.069	8.558	8.715
log(TFP)	305,689	8.187	0.626	4.512	6.394	7.838	8.181	8.542	9.800	10.937
log(Establishment Size)	308,711	0.872	0.302	−0.878	0.358	0.634	0.836	1.076	1.646	2.141
log(Firm Capital)	306,423	8.941	2.161	0.000	5.704	7.570	8.505	9.210	16.001	18.932
Dummy of Multiple Establishment	308,719	0.392	0.488	0.000	0.000	0.000	0.000	1.000	1.000	1.000
Mesh-Level										
log(Employment Density within 500 m)	303,045	5.814	1.356	0.000	0.000	5.083	5.966	6.722	8.277	10.800
log(Employment Density within 2 km)	303,034	9.053	1.341	0.000	5.668	8.209	9.095	9.987	11.969	14.150
log(Employment Density within 4 km)	303,045	10.224	1.371	2.708	6.778	9.358	10.233	11.185	13.313	15.000
log(Employment Density within 8 km)	303,045	11.449	1.396	4.615	7.943	10.571	11.436	12.363	14.633	15.632
log(Population Density within 500 m)	303,045	4.753	2.483	0.000	0.000	3.434	5.332	6.629	8.589	9.332
log(Population Density within 2 km)	302,644	9.691	1.405	0.000	6.198	8.796	9.734	10.683	12.317	12.709
log(Population Density within 4 km)	303,039	11.006	1.321	0.000	7.710	10.155	10.999	11.941	13.596	13.926
log(Population Density within 8 km)	303,045	12.253	1.327	5.257	8.945	11.378	12.245	13.163	14.854	15.125

Note: The establishment-level panel dataset covers the period from 2012 to 2020.

Table 2. Estimation Results of Wage Premium for Employment and Population Density

	Dependent Variable: log(Establishment-level Average Wages)							
	Employment Density				Population Density			
Explanatory Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log(Density within 500 m)	0.0106***				−0.0026***			
	(0.0008)				(0.0004)			
Log(Density within 2 km)		0.0179***				0.0098***		
		(0.0009)				(0.0008)		
Log(Density within 4 km)			0.0201***				0.0178***	
			(0.0009)				(0.0009)	
Log(Density within 8 km)				0.0227***				0.0228***
				(0.0009)				(0.0010)
Log(TFP)	0.1325***	0.1323***	0.1322***	0.1319***	0.1323***	0.1330***	0.1325***	0.1320***
	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0016)
Log(Establishment Size)	0.0963***	0.1000***	0.1013***	0.1020***	0.1023***	0.1020***	0.1019***	0.1020***
	(0.0039)	(0.0039)	(0.0039)	(0.0039)	(0.0039)	(0.0039)	(0.0039)	(0.0039)
Log(Firm Capital)	0.0453***	0.0452***	0.0454***	0.0456***	0.0446***	0.0455***	0.0456***	0.0457***
	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)
Dummy of Multiple Establishment	−0.0053**	−0.0051**	−0.0051**	−0.0053***	−0.0049**	−0.0047**	−0.0050**	−0.0053**
	(0.0021)	(0.0021)	(0.0021)	(0.0021)	(0.0021)	(0.0021)	(0.0021)	(0.0021)
Establishment Fixed-Effect	No	No	No	No	No	No	No	No
Industry Fixed-Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Prefecture Fixed-Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed-Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	300,777	300,766	300,777	300,777	300,777	300,378	300,771	300,777
Number of Establishments	64,961	64,961	64,961	64,961	64,961	64,875	64,961	64,961
Adjusted R^2	0.4369	0.4388	0.4395	0.4403	0.4358	0.4364	0.4383	0.4397

Notes: Heteroskedasticity-consistent standard errors clustered by establishments are in parentheses. * denotes statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 3. Estimation Results of Wage Premium for Employment and Population Density within 500m by Prefecture

	Dependent Variable: log(Establishment-level Average Wages)			
	Employment Density		Population Density	
Explanatory Variables	(1)		(2)	
Log(Density within 500 m) × Prefecture 1	−0.0107**	(0.0049)	−0.0130***	(0.0023)
Log(Density within 500 m) × Prefecture 2	−0.0057	(0.0078)	−0.0162***	(0.0042)
Log(Density within 500 m) × Prefecture 3	0.0114**	(0.0056)	−0.0115***	(0.0038)
Log(Density within 500 m) × Prefecture 4	0.0229***	(0.0064)	−0.0066*	(0.0034)
Log(Density within 500 m) × Prefecture 5	0.0117	(0.0077)	−0.0082*	(0.0045)
Log(Density within 500 m) × Prefecture 6	0.0071	(0.0065)	−0.0073**	(0.0035)
Log(Density within 500 m) × Prefecture 7	0.0057	(0.0045)	−0.0109***	(0.0028)
Log(Density within 500 m) × Prefecture 8	0.0125***	(0.0040)	−0.0068***	(0.0024)
Log(Density within 500 m) × Prefecture 9	0.0097**	(0.0045)	−0.0106***	(0.0028)
Log(Density within 500 m) × Prefecture 10	0.0061	(0.0044)	−0.0054*	(0.0028)
Log(Density within 500 m) × Prefecture 11	0.0072**	(0.0036)	−0.0004	(0.0018)
Log(Density within 500 m) × Prefecture 12	0.0098**	(0.0042)	−0.0061***	(0.0023)
Log(Density within 500 m) × Prefecture 13	0.0328***	(0.0021)	0.0133***	(0.0012)
Log(Density within 500 m) × Prefecture 14	0.0169***	(0.0044)	−0.0041**	(0.0018)
Log(Density within 500 m) × Prefecture 15	0.0054	(0.0044)	−0.0012	(0.0023)
Log(Density within 500 m) × Prefecture 16	0.0128**	(0.0058)	−0.0034	(0.0033)
Log(Density within 500 m) × Prefecture 17	0.0116*	(0.0063)	0.0025	(0.0030)
Log(Density within 500 m) × Prefecture 18	−0.0017	(0.0054)	−0.0106***	(0.0038)
Log(Density within 500 m) × Prefecture 19	0.0063	(0.0100)	−0.0008	(0.0051)
Log(Density within 500 m) × Prefecture 20	0.0060	(0.0043)	−0.0016	(0.0028)
Log(Density within 500 m) × Prefecture 21	0.0103**	(0.0042)	−0.0024	(0.0027)
Log(Density within 500 m) × Prefecture 22	0.0043	(0.0038)	−0.0075***	(0.0020)
Log(Density within 500 m) × Prefecture 23	0.0030	(0.0026)	−0.0040***	(0.0014)
Log(Density within 500 m) × Prefecture 24	0.0087**	(0.0041)	−0.0056*	(0.0029)
Log(Density within 500 m) × Prefecture 25	0.0272***	(0.0057)	0.0001	(0.0029)
Log(Density within 500 m) × Prefecture 26	0.0256***	(0.0059)	0.0101***	(0.0027)
Log(Density within 500 m) × Prefecture 27	0.0185***	(0.0031)	0.0029**	(0.0013)
Log(Density within 500 m) × Prefecture 28	0.0099***	(0.0033)	−0.0019	(0.0017)
Log(Density within 500 m) × Prefecture 29	0.0040	(0.0094)	−0.0002	(0.0050)
Log(Density within 500 m) × Prefecture 30	0.0051	(0.0084)	0.0034	(0.0054)
Log(Density within 500 m) × Prefecture 31	0.0128	(0.0086)	−0.0109**	(0.0050)
Log(Density within 500 m) × Prefecture 32	0.0186**	(0.0083)	−0.0085	(0.0054)
Log(Density within 500 m) × Prefecture 33	0.0027	(0.0048)	−0.0061**	(0.0027)
Log(Density within 500 m) × Prefecture 34	0.0093**	(0.0041)	0.0000	(0.0023)
Log(Density within 500 m) × Prefecture 35	0.0179***	(0.0063)	−0.0001	(0.0038)
Log(Density within 500 m) × Prefecture 36	0.0263***	(0.0090)	−0.0015	(0.0061)
Log(Density within 500 m) × Prefecture 37	0.0149**	(0.0076)	−0.0046	(0.0043)
Log(Density within 500 m) × Prefecture 38	0.0195***	(0.0067)	−0.0059	(0.0042)
Log(Density within 500 m) × Prefecture 39	0.0039	(0.0101)	0.0076	(0.0077)
Log(Density within 500 m) × Prefecture 40	0.0012	(0.0044)	−0.0050**	(0.0023)
Log(Density within 500 m) × Prefecture 41	0.0064	(0.0068)	−0.0064	(0.0056)
Log(Density within 500 m) × Prefecture 42	0.0292***	(0.0075)	−0.0022	(0.0053)
Log(Density within 500 m) × Prefecture 43	0.0177***	(0.0066)	−0.0008	(0.0042)
Log(Density within 500 m) × Prefecture 44	−0.0070	(0.0088)	−0.0114**	(0.0052)
Log(Density within 500 m) × Prefecture 45	0.0189**	(0.0080)	0.0054	(0.0059)
Log(Density within 500 m) × Prefecture 46	0.0292***	(0.0083)	−0.0218***	(0.0048)
Log(Density within 500 m) × Prefecture 47	−0.0303**	(0.0144)	0.0029	(0.0056)
Control Variables, Industry, Prefecture, and Year FE	Yes		Yes	
Number of Observations	300,777		300,777	
Number of Establishments	64,961		64,961	
Adjusted R^2	0.4382		0.4377	

Notes: Heteroskedasticity-consistent standard errors clustered by establishments are in parentheses. * denotes statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 4. Estimation Results of Wage Premium for Employment and Population Density within 2km by Prefecture

	Dependent Variable: log(Establishment-level Average Wages)			
	Employment Density		Population Density	
Explanatory Variables	(1)		(2)	
Log(Density within 2 km) × Prefecture 3	0.0096	(0.0074)	−0.0045	(0.0076)
Log(Density within 2 km) × Prefecture 4	0.0235***	(0.0056)	0.0138**	(0.0064)
Log(Density within 2 km) × Prefecture 5	0.0238***	(0.0083)	0.0191**	(0.0093)
Log(Density within 2 km) × Prefecture 6	0.0165**	(0.0070)	0.0121*	(0.0074)
Log(Density within 2 km) × Prefecture 7	0.0100*	(0.0051)	0.0051	(0.0056)
Log(Density within 2 km) × Prefecture 8	0.0189***	(0.0060)	0.0061	(0.0059)
Log(Density within 2 km) × Prefecture 9	0.0110**	(0.0056)	0.0042	(0.0059)
Log(Density within 2 km) × Prefecture 10	0.0072	(0.0066)	−0.0014	(0.0070)
Log(Density within 2 km) × Prefecture 11	0.0195***	(0.0040)	0.0124***	(0.0036)
Log(Density within 2 km) × Prefecture 12	0.0249***	(0.0049)	0.0095**	(0.0039)
Log(Density within 2 km) × Prefecture 13	0.0415***	(0.0021)	0.0346***	(0.0021)
Log(Density within 2 km) × Prefecture 14	0.0323***	(0.0049)	0.0118***	(0.0043)
Log(Density within 2 km) × Prefecture 15	0.0061	(0.0055)	0.0012	(0.0058)
Log(Density within 2 km) × Prefecture 16	0.0088	(0.0087)	0.0134	(0.0092)
Log(Density within 2 km) × Prefecture 17	0.0088	(0.0070)	0.0061	(0.0066)
Log(Density within 2 km) × Prefecture 18	−0.0062	(0.0078)	−0.0099	(0.0078)
Log(Density within 2 km) × Prefecture 19	0.0024	(0.0105)	−0.0012	(0.0121)
Log(Density within 2 km) × Prefecture 20	0.0079	(0.0056)	0.0035	(0.0061)
Log(Density within 2 km) × Prefecture 21	0.0196***	(0.0053)	0.0179***	(0.0050)
Log(Density within 2 km) × Prefecture 22	0.0023	(0.0044)	−0.0049	(0.0045)
Log(Density within 2 km) × Prefecture 23	0.0098***	(0.0036)	0.0003	(0.0031)
Log(Density within 2 km) × Prefecture 24	0.0155**	(0.0069)	0.0010	(0.0071)
Log(Density within 2 km) × Prefecture 25	0.0234***	(0.0067)	0.0233***	(0.0066)
Log(Density within 2 km) × Prefecture 26	0.0338***	(0.0054)	0.0313***	(0.0051)
Log(Density within 2 km) × Prefecture 27	0.0336***	(0.0029)	0.0109***	(0.0027)
Log(Density within 2 km) × Prefecture 28	0.0183***	(0.0033)	0.0144***	(0.0032)
Log(Density within 2 km) × Prefecture 29	0.0188**	(0.0090)	0.0164**	(0.0081)
Log(Density within 2 km) × Prefecture 30	0.0243***	(0.0091)	0.0241**	(0.0105)
Log(Density within 2 km) × Prefecture 31	0.0159*	(0.0090)	0.0164	(0.0108)
Log(Density within 2 km) × Prefecture 32	0.0243***	(0.0085)	0.0172*	(0.0102)
Log(Density within 2 km) × Prefecture 33	0.0164***	(0.0048)	0.0058	(0.0051)
Log(Density within 2 km) × Prefecture 34	0.0175***	(0.0042)	0.0124***	(0.0042)
Log(Density within 2 km) × Prefecture 35	0.0299***	(0.0083)	0.0137	(0.0083)
Log(Density within 2 km) × Prefecture 36	0.0400**	(0.0174)	0.0419**	(0.0189)
Log(Density within 2 km) × Prefecture 37	0.0010	(0.0082)	−0.0099	(0.0101)
Log(Density within 2 km) × Prefecture 38	0.0215***	(0.0080)	0.0125	(0.0090)
Log(Density within 2 km) × Prefecture 39	0.0062	(0.0093)	0.0132	(0.0104)
Log(Density within 2 km) × Prefecture 40	0.0063	(0.0051)	−0.0049	(0.0038)
Log(Density within 2 km) × Prefecture 41	0.0085	(0.0122)	0.0083	(0.0123)
Log(Density within 2 km) × Prefecture 42	0.0353***	(0.0095)	0.0302**	(0.0120)
Log(Density within 2 km) × Prefecture 43	0.0219***	(0.0079)	0.0135	(0.0083)
Log(Density within 2 km) × Prefecture 44	0.0048	(0.0095)	−0.0034	(0.0094)
Log(Density within 2 km) × Prefecture 45	0.0180*	(0.0102)	0.0102	(0.0120)
Log(Density within 2 km) × Prefecture 46	0.0273***	(0.0091)	0.0208**	(0.0105)
Log(Density within 2 km) × Prefecture 47	−0.0345	(0.0223)	−0.0286	(0.0229)
Control Variables, Industry, Prefecture, and Year FE	Yes		Yes	
Number of Observations	300,766		300,378	
Number of Establishments	64,961		64,875	
Adjusted R^2	0.4405		0.4380	

Notes: Heteroskedasticity-consistent standard errors clustered by establishments are in parentheses. * denotes statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 5. Estimation Results of Wage Premium for Employment and Population Density within 4km by Prefecture

	Dependent Variable: log(Establishment-level Average Wages)			
	Employment Density		Population Density	
Explanatory Variables	(1)		(2)	
Log(Density within 4 km) × Prefecture 1	−0.0022	(0.0041)	−0.0036	(0.0039)
Log(Density within 4 km) × Prefecture 2	0.0012	(0.0078)	−0.0057	(0.0082)
Log(Density within 4 km) × Prefecture 3	0.0106	(0.0074)	0.0054	(0.0081)
Log(Density within 4 km) × Prefecture 4	0.0315***	(0.0066)	0.0311***	(0.0071)
Log(Density within 4 km) × Prefecture 5	0.0181**	(0.0084)	0.0189*	(0.0097)
Log(Density within 4 km) × Prefecture 6	0.0257***	(0.0074)	0.0236***	(0.0082)
Log(Density within 4 km) × Prefecture 7	0.0133**	(0.0054)	0.0121**	(0.0061)
Log(Density within 4 km) × Prefecture 8	0.0256***	(0.0068)	0.0169**	(0.0075)
Log(Density within 4 km) × Prefecture 9	0.0160***	(0.0061)	0.0133*	(0.0069)
Log(Density within 4 km) × Prefecture 10	0.0100	(0.0069)	0.0071	(0.0076)
Log(Density within 4 km) × Prefecture 11	0.0235***	(0.0040)	0.0190***	(0.0038)
Log(Density within 4 km) × Prefecture 12	0.0241***	(0.0050)	0.0182***	(0.0049)
Log(Density within 4 km) × Prefecture 13	0.0424***	(0.0020)	0.0444***	(0.0022)
Log(Density within 4 km) × Prefecture 14	0.0372***	(0.0049)	0.0333***	(0.0046)
Log(Density within 4 km) × Prefecture 15	0.0059	(0.0059)	0.0028	(0.0067)
Log(Density within 4 km) × Prefecture 16	0.0092	(0.0086)	0.0139	(0.0097)
Log(Density within 4 km) × Prefecture 17	0.0040	(0.0074)	0.0060	(0.0079)
Log(Density within 4 km) × Prefecture 18	0.0060	(0.0079)	0.0036	(0.0088)
Log(Density within 4 km) × Prefecture 19	0.0017	(0.0105)	0.0010	(0.0114)
Log(Density within 4 km) × Prefecture 20	0.0094	(0.0061)	0.0068	(0.0070)
Log(Density within 4 km) × Prefecture 21	0.0232***	(0.0053)	0.0253***	(0.0054)
Log(Density within 4 km) × Prefecture 22	0.0054	(0.0047)	0.0036	(0.0049)
Log(Density within 4 km) × Prefecture 23	0.0102***	(0.0037)	0.0042	(0.0037)
Log(Density within 4 km) × Prefecture 24	0.0217***	(0.0074)	0.0113	(0.0078)
Log(Density within 4 km) × Prefecture 25	0.0274***	(0.0072)	0.0290***	(0.0073)
Log(Density within 4 km) × Prefecture 26	0.0323***	(0.0048)	0.0324***	(0.0051)
Log(Density within 4 km) × Prefecture 27	0.0341***	(0.0027)	0.0297***	(0.0033)
Log(Density within 4 km) × Prefecture 28	0.0206***	(0.0033)	0.0205***	(0.0033)
Log(Density within 4 km) × Prefecture 29	0.0191**	(0.0091)	0.0206**	(0.0086)
Log(Density within 4 km) × Prefecture 30	0.0242**	(0.0095)	0.0213*	(0.0111)
Log(Density within 4 km) × Prefecture 31	0.0212**	(0.0091)	0.0239**	(0.0109)
Log(Density within 4 km) × Prefecture 32	0.0311***	(0.0097)	0.0318***	(0.0108)
Log(Density within 4 km) × Prefecture 33	0.0167***	(0.0050)	0.0119**	(0.0052)
Log(Density within 4 km) × Prefecture 34	0.0185***	(0.0042)	0.0161***	(0.0044)
Log(Density within 4 km) × Prefecture 35	0.0228***	(0.0088)	0.0218**	(0.0094)
Log(Density within 4 km) × Prefecture 36	0.0389**	(0.0152)	0.0432**	(0.0180)
Log(Density within 4 km) × Prefecture 37	−0.0017	(0.0084)	−0.0080	(0.0102)
Log(Density within 4 km) × Prefecture 38	0.0207**	(0.0087)	0.0187*	(0.0098)
Log(Density within 4 km) × Prefecture 39	0.0141	(0.0092)	0.0180*	(0.0104)
Log(Density within 4 km) × Prefecture 40	0.0091*	(0.0053)	−0.0005	(0.0064)
Log(Density within 4 km) × Prefecture 41	0.0076	(0.0131)	0.0120	(0.0135)
Log(Density within 4 km) × Prefecture 42	0.0404***	(0.0102)	0.0426***	(0.0118)
Log(Density within 4 km) × Prefecture 43	0.0219***	(0.0082)	0.0205**	(0.0085)
Log(Density within 4 km) × Prefecture 44	0.0098	(0.0087)	0.0063	(0.0095)
Log(Density within 4 km) × Prefecture 45	0.0141	(0.0110)	0.0133	(0.0131)
Log(Density within 4 km) × Prefecture 46	0.0212**	(0.0097)	0.0214**	(0.0106)
Log(Density within 4 km) × Prefecture 47	−0.0304	(0.0230)	−0.0301	(0.0245)
Control Variables, Industry, Prefecture, and Year FE	Yes		Yes	
Number of Observations	300,777		300,771	
Number of Establishments	64,961		64,961	
Adjusted R^2	0.4412		0.4401	

Notes: Heteroskedasticity-consistent standard errors clustered by establishments are in parentheses. * denotes statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 6. Estimation Results of Wage Premium for Employment and Population Density within 8km by Prefecture

	Dependent Variable: log(Establishment-level Average Wages)			
	Employment Density		Population Density	
Explanatory Variables	(1)		(2)	
Log(Density within 8 km) × Prefecture 1	−0.0006	(0.0039)	−0.0011	(0.0039)
Log(Density within 8 km) × Prefecture 2	0.0059	(0.0088)	−0.0014	(0.0094)
Log(Density within 8 km) × Prefecture 3	0.0284***	(0.0072)	0.0319***	(0.0081)
Log(Density within 8 km) × Prefecture 4	0.0374***	(0.0065)	0.0380***	(0.0072)
Log(Density within 8 km) × Prefecture 5	0.0208**	(0.0100)	0.0245**	(0.0111)
Log(Density within 8 km) × Prefecture 6	0.0308***	(0.0084)	0.0325***	(0.0091)
Log(Density within 8 km) × Prefecture 7	0.0188***	(0.0061)	0.0197***	(0.0068)
Log(Density within 8 km) × Prefecture 8	0.0207***	(0.0077)	0.0194**	(0.0086)
Log(Density within 8 km) × Prefecture 9	0.0236***	(0.0071)	0.0239***	(0.0080)
Log(Density within 8 km) × Prefecture 10	0.0170**	(0.0078)	0.0175**	(0.0087)
Log(Density within 8 km) × Prefecture 11	0.0270***	(0.0041)	0.0242***	(0.0038)
Log(Density within 8 km) × Prefecture 12	0.0240***	(0.0054)	0.0204***	(0.0050)
Log(Density within 8 km) × Prefecture 13	0.0420***	(0.0020)	0.0463***	(0.0021)
Log(Density within 8 km) × Prefecture 14	0.0373***	(0.0047)	0.0358***	(0.0046)
Log(Density within 8 km) × Prefecture 15	0.0085	(0.0069)	0.0083	(0.0079)
Log(Density within 8 km) × Prefecture 16	0.0215**	(0.0092)	0.0238**	(0.0103)
Log(Density within 8 km) × Prefecture 17	0.0066	(0.0072)	0.0100	(0.0080)
Log(Density within 8 km) × Prefecture 18	0.0241***	(0.0092)	0.0254**	(0.0102)
Log(Density within 8 km) × Prefecture 19	0.0054	(0.0104)	0.0059	(0.0114)
Log(Density within 8 km) × Prefecture 20	0.0094	(0.0068)	0.0089	(0.0076)
Log(Density within 8 km) × Prefecture 21	0.0307***	(0.0056)	0.0314***	(0.0057)
Log(Density within 8 km) × Prefecture 22	0.0091	(0.0056)	0.0079	(0.0058)
Log(Density within 8 km) × Prefecture 23	0.0102***	(0.0037)	0.0083**	(0.0042)
Log(Density within 8 km) × Prefecture 24	0.0305***	(0.0085)	0.0266***	(0.0090)
Log(Density within 8 km) × Prefecture 25	0.0381***	(0.0085)	0.0408***	(0.0088)
Log(Density within 8 km) × Prefecture 26	0.0319***	(0.0045)	0.0332***	(0.0047)
Log(Density within 8 km) × Prefecture 27	0.0323***	(0.0026)	0.0372***	(0.0029)
Log(Density within 8 km) × Prefecture 28	0.0210***	(0.0032)	0.0226***	(0.0033)
Log(Density within 8 km) × Prefecture 29	0.0183*	(0.0097)	0.0201**	(0.0092)
Log(Density within 8 km) × Prefecture 30	0.0259**	(0.0108)	0.0241**	(0.0122)
Log(Density within 8 km) × Prefecture 31	0.0156	(0.0107)	0.0200	(0.0130)
Log(Density within 8 km) × Prefecture 32	0.0411***	(0.0095)	0.0441***	(0.0109)
Log(Density within 8 km) × Prefecture 33	0.0179***	(0.0051)	0.0152***	(0.0054)
Log(Density within 8 km) × Prefecture 34	0.0198***	(0.0044)	0.0189***	(0.0047)
Log(Density within 8 km) × Prefecture 35	0.0221**	(0.0091)	0.0241**	(0.0103)
Log(Density within 8 km) × Prefecture 36	0.0410***	(0.0136)	0.0443***	(0.0158)
Log(Density within 8 km) × Prefecture 37	−0.0126	(0.0108)	−0.0170	(0.0123)
Log(Density within 8 km) × Prefecture 38	0.0202**	(0.0102)	0.0147	(0.0111)
Log(Density within 8 km) × Prefecture 39	0.0253**	(0.0101)	0.0275**	(0.0109)
Log(Density within 8 km) × Prefecture 40	0.0139**	(0.0063)	0.0110	(0.0076)
Log(Density within 8 km) × Prefecture 41	0.0002	(0.0147)	0.0055	(0.0162)
Log(Density within 8 km) × Prefecture 42	0.0458***	(0.0118)	0.0508***	(0.0132)
Log(Density within 8 km) × Prefecture 43	0.0235***	(0.0081)	0.0255***	(0.0086)
Log(Density within 8 km) × Prefecture 44	0.0151	(0.0097)	0.0137	(0.0108)
Log(Density within 8 km) × Prefecture 45	0.0128	(0.0134)	0.0150	(0.0148)
Log(Density within 8 km) × Prefecture 46	0.0166	(0.0109)	0.0155	(0.0115)
Log(Density within 8 km) × Prefecture 47	−0.0325	(0.0256)	−0.0343	(0.0275)
Control Variables, Industry, Prefecture, and Year FE	Yes		Yes	
Number of Observations	300,777		300,777	
Number of Establishments	64,961		64,961	
Adjusted R^2	0.4419		0.4413	

Notes: Heteroskedasticity-consistent standard errors clustered by establishments are in parentheses. * denotes statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 7. Estimation Results of Wage Premium for Employment and Population Density within 500m by Industry

	Dependent Variable: log(Establishment-level Average Wages)			
	Employment Density		Population Density	
Explanatory Variables	(1)		(2)	
Log(Density within 500 m) × Sector 1	−0.0145***	(0.0021)	−0.0085***	(0.0011)
Log(Density within 500 m) × Sector 2	0.0292***	(0.0043)	−0.0014	(0.0026)
Log(Density within 500 m) × Sector 3	0.0069*	(0.0041)	−0.0022	(0.0022)
Log(Density within 500 m) × Sector 4	0.0033	(0.0036)	−0.0041**	(0.0021)
Log(Density within 500 m) × Sector 5	0.0273***	(0.0030)	0.0030*	(0.0017)
Log(Density within 500 m) × Sector 6	0.0017	(0.0029)	−0.0060***	(0.0017)
Log(Density within 500 m) × Sector 7	0.0211***	(0.0026)	−0.0013	(0.0013)
Log(Density within 500 m) × Sector 8	0.0129***	(0.0033)	−0.0027	(0.0021)
Log(Density within 500 m) × Sector 9	0.0099***	(0.0029)	0.0014	(0.0016)
Log(Density within 500 m) × Sector 10	0.0092**	(0.0040)	−0.0033	(0.0024)
Log(Density within 500 m) × Sector 11	0.0121***	(0.0021)	−0.0006	(0.0011)
Log(Density within 500 m) × Sector 12	0.0129***	(0.0018)	0.0017*	(0.0010)
Log(Density within 500 m) × Sector 13	0.0246***	(0.0043)	0.0075***	(0.0024)
Log(Density within 500 m) × Sector 14	0.0275***	(0.0024)	−0.0059***	(0.0013)
Log(Density within 500 m) × Sector 15	0.0124***	(0.0021)	−0.0023*	(0.0012)
Log(Density within 500 m) × Sector 16	0.0213***	(0.0054)	−0.0019	(0.0031)
Control Variables, Industry, Prefecture, and Year FE	Yes		Yes	
Number of Observations	300,777		300,777	
Number of Establishments	64,961		64,961	
Adjusted R^2	0.4397		0.4365	

Notes: Heteroskedasticity-consistent standard errors clustered at the establishment level are in parenthesis. * denotes statistical significance at the 10 % level, ** at the 5 % level, and *** at the 1 % level.

Table 8. Estimation Results of Wage Premium for Employment and Population Density within 2km by Industry

	Dependent Variable: log(Wage)			
	Employment Density		Population Density	
Explanatory Variables	(1)		(2)	
Log(Density within 2 km) × Sector 1	−0.0077***	(0.0020)	−0.0141***	(0.0020)
Log(Density within 2 km) × Sector 2	0.0473***	(0.0037)	0.0434***	(0.0041)
Log(Density within 2 km) × Sector 3	0.0210***	(0.0040)	0.0152***	(0.0039)
Log(Density within 2 km) × Sector 4	0.0087**	(0.0038)	0.0040	(0.0036)
Log(Density within 2 km) × Sector 5	0.0311***	(0.0026)	0.0260***	(0.0031)
Log(Density within 2 km) × Sector 6	0.0180***	(0.0039)	0.0050	(0.0031)
Log(Density within 2 km) × Sector 7	0.0216***	(0.0024)	0.0137***	(0.0024)
Log(Density within 2 km) × Sector 8	0.0213***	(0.0042)	0.0164***	(0.0036)
Log(Density within 2 km) × Sector 9	0.0197***	(0.0039)	0.0099***	(0.0033)
Log(Density within 2 km) × Sector 10	0.0230***	(0.0048)	0.0126***	(0.0044)
Log(Density within 2 km) × Sector 11	0.0177***	(0.0022)	0.0099***	(0.0020)
Log(Density within 2 km) × Sector 12	0.0242***	(0.0019)	0.0181***	(0.0018)
Log(Density within 2 km) × Sector 13	0.0355***	(0.0042)	0.0312***	(0.0041)
Log(Density within 2 km) × Sector 14	0.0299***	(0.0022)	0.0179***	(0.0022)
Log(Density within 2 km) × Sector 15	0.0225***	(0.0025)	0.0137***	(0.0023)
Log(Density within 2 km) × Sector 16	0.0250***	(0.0048)	0.0151***	(0.0049)
Control Variables, Industry, Prefecture, and Year FE	Yes		Yes	
Number of Observations	300,766		300,378	
Number of Establishments	64,961		64,875	
Adjusted R^2	0.4418		0.4394	

Notes: Heteroskedasticity-consistent standard errors clustered by establishments are in parentheses. * denotes statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 9. Estimation Results of Wage Premium for Employment and Population Density within 4km by Industry

	Dependent Variable: log(Establishment-level Average Wages)			
	Employment Density		Population Density	
Explanatory Variables	(1)		(2)	
Log(Density within 4 km) × Sector 1	−0.0056***	(0.0020)	−0.0098***	(0.0021)
Log(Density within 4 km) × Sector 2	0.0515***	(0.0034)	0.0545***	(0.0036)
Log(Density within 4 km) × Sector 3	0.0258***	(0.0039)	0.0249***	(0.0041)
Log(Density within 4 km) × Sector 4	0.0088**	(0.0038)	0.0077**	(0.0038)
Log(Density within 4 km) × Sector 5	0.0330***	(0.0025)	0.0354***	(0.0031)
Log(Density within 4 km) × Sector 6	0.0194***	(0.0038)	0.0155***	(0.0038)
Log(Density within 4 km) × Sector 7	0.0225***	(0.0024)	0.0214***	(0.0025)
Log(Density within 4 km) × Sector 8	0.0280***	(0.0040)	0.0265***	(0.0041)
Log(Density within 4 km) × Sector 9	0.0205***	(0.0037)	0.0181***	(0.0039)
Log(Density within 4 km) × Sector 10	0.0250***	(0.0047)	0.0229***	(0.0047)
Log(Density within 4 km) × Sector 11	0.0199***	(0.0021)	0.0192***	(0.0022)
Log(Density within 4 km) × Sector 12	0.0270***	(0.0019)	0.0257***	(0.0020)
Log(Density within 4 km) × Sector 13	0.0417***	(0.0040)	0.0409***	(0.0042)
Log(Density within 4 km) × Sector 14	0.0311***	(0.0022)	0.0281***	(0.0023)
Log(Density within 4 km) × Sector 15	0.0238***	(0.0025)	0.0213***	(0.0025)
Log(Density within 4 km) × Sector 16	0.0283***	(0.0045)	0.0249***	(0.0049)
Control Variables, Industry, Prefecture, and Year FE	Yes		Yes	
Number of Observations	300,777		300,771	
Number of Establishments	64,961		64,961	
Adjusted R^2	0.4429		0.4420	

Notes: Heteroskedasticity-consistent standard errors clustered by establishments are in parentheses. * denotes statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 10. Estimation Results of Wage Premium for Employment and Population Density within 8km by Industry

	Dependent Variable: log(Establishment-level Average Wages)			
	Employment Density		Population Density	
Explanatory Variables	(1)		(2)	
Log(Density within 8 km) × Sector 1	−0.0046**	(0.0020)	−0.0069***	(0.0021)
Log(Density within 8 km) × Sector 2	0.0588***	(0.0032)	0.0630***	(0.0035)
Log(Density within 8 km) × Sector 3	0.0285***	(0.0038)	0.0297***	(0.0041)
Log(Density within 8 km) × Sector 4	0.0080**	(0.0038)	0.0074*	(0.0039)
Log(Density within 8 km) × Sector 5	0.0372***	(0.0026)	0.0414***	(0.0031)
Log(Density within 8 km) × Sector 6	0.0182***	(0.0037)	0.0176***	(0.0038)
Log(Density within 8 km) × Sector 7	0.0269***	(0.0024)	0.0280***	(0.0025)
Log(Density within 8 km) × Sector 8	0.0316***	(0.0041)	0.0320***	(0.0042)
Log(Density within 8 km) × Sector 9	0.0238***	(0.0036)	0.0267***	(0.0038)
Log(Density within 8 km) × Sector 10	0.0269***	(0.0046)	0.0264***	(0.0048)
Log(Density within 8 km) × Sector 11	0.0246***	(0.0021)	0.0263***	(0.0023)
Log(Density within 8 km) × Sector 12	0.0304***	(0.0019)	0.0315***	(0.0020)
Log(Density within 8 km) × Sector 13	0.0446***	(0.0039)	0.0462***	(0.0041)
Log(Density within 8 km) × Sector 14	0.0333***	(0.0021)	0.0340***	(0.0022)
Log(Density within 8 km) × Sector 15	0.0273***	(0.0026)	0.0279***	(0.0027)
Log(Density within 8 km) × Sector 16	0.0313***	(0.0046)	0.0316***	(0.0049)
Control Variables, Industry, Prefecture, and Year FE	Yes		Yes	
Number of Observations	300,777		300,777	
Number of Establishments	64,961		64,961	
Adjusted R^2	0.4444		0.4441	

Notes: Heteroskedasticity-consistent standard errors clustered by establishments are in parentheses. * denotes statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

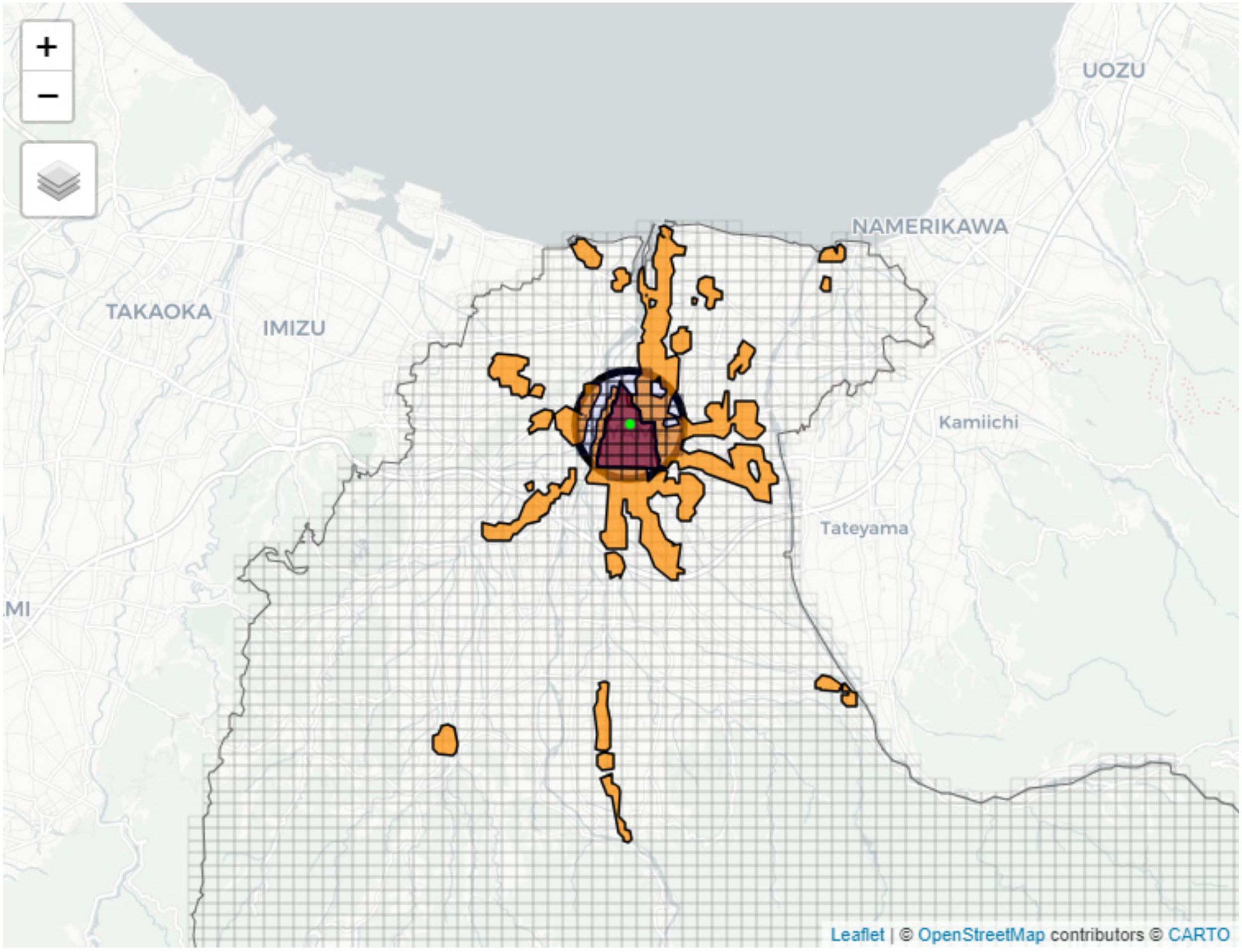


Figure 1. Urban Compact Planning by Location Rationalization Plan in Toyama city, Japan

Note: Author's creation. Red colored area represents the guided urban facility zone, which is an area into which livelihood services are guided, along with the facilities to be guided into that area. Yellow colored area represents the Guided dwelling zone, which is an area into which dwelling is guided to maintain a given population density. The circle of 2 km radius is depicted based on the location of JR Toyama station. Mesh Grid is based on the 500 m by 500 m.

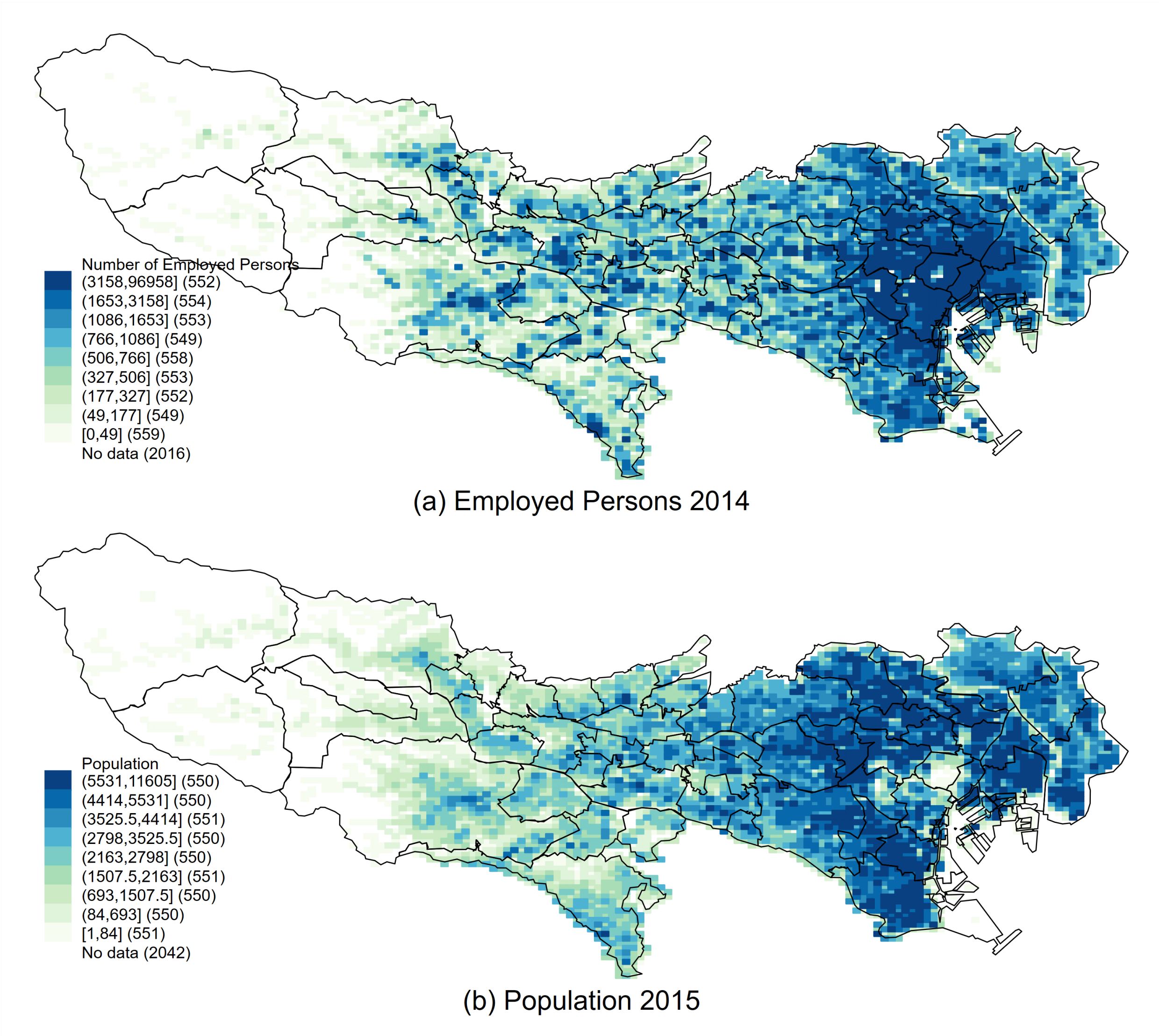


Figure 2. Employment and Population Distributions in Tokyo Prefecture

Note: Author's creation based on Regional Mesh Statistics based on 500 m by 500 m mesh grids of 2014 Economic Census for Business Activity (MIC and METI) and 2015 Population Census (MIC).

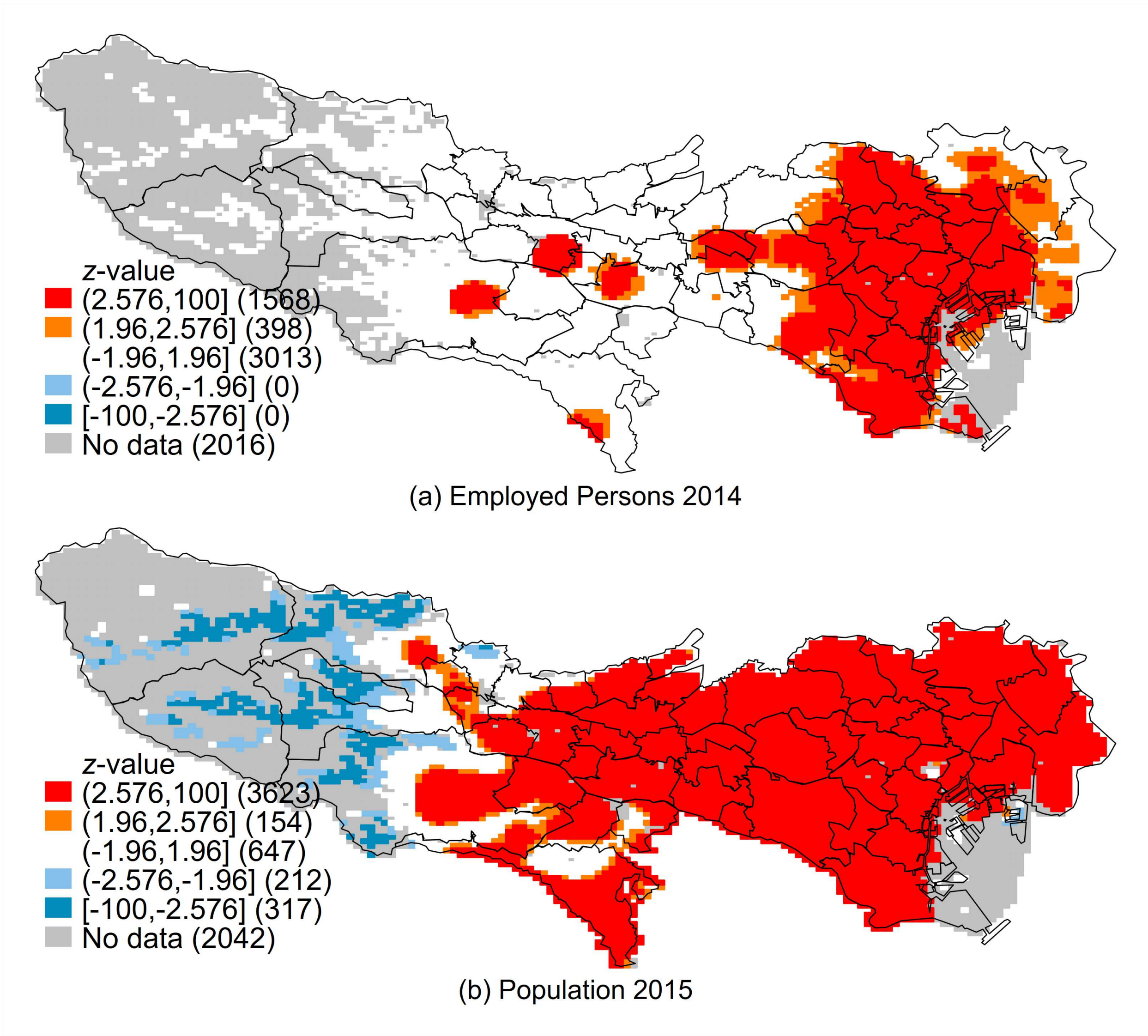


Figure 3. Hot Spot Analysis of Employment and Population Distributions in Tokyo Prefecture

Note: Author's creation based on Regional Mesh Statistics based on 500 m by 500 m mesh grids of 2014 Economic Census for Business Activity (MIC and METI) and 2015 Population Census (MIC). The hot spot analysis was conducted by the Getis–Ord $G_i^*(d)$ statistic. The spatial weight matrix is based on the binary indicator that takes the value of 1 for neighboring regions located within $d = 2$ km and 0 otherwise. The z-value of the Getis–Ord $G_i^*(d)$ statistic indicates the statistical significance. Although only the Tokyo prefecture is shown, the hot spot analysis included the surrounding prefectures (Saitama, Chiba, and Kanagawa prefectures) in order to avoid border discontinuity.

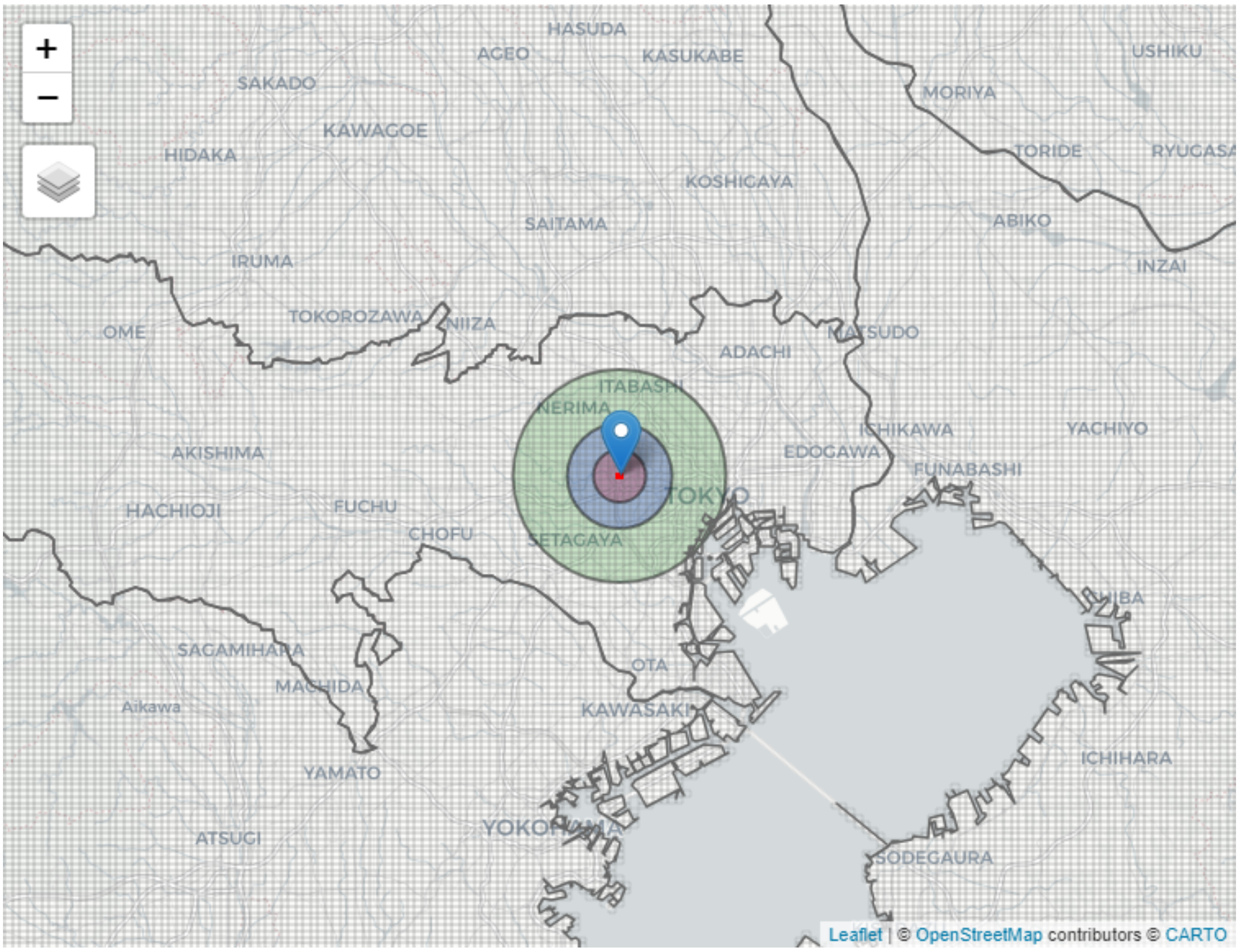
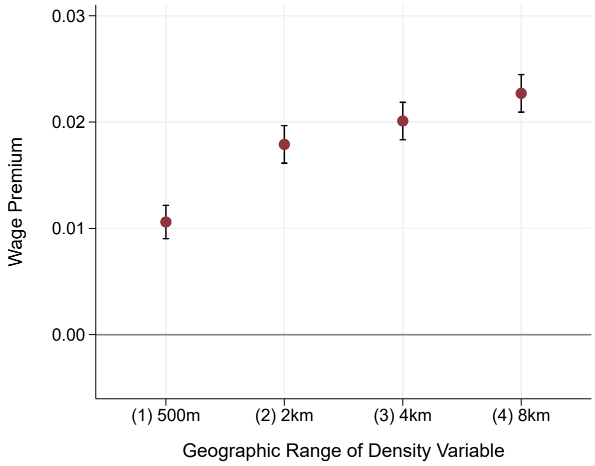
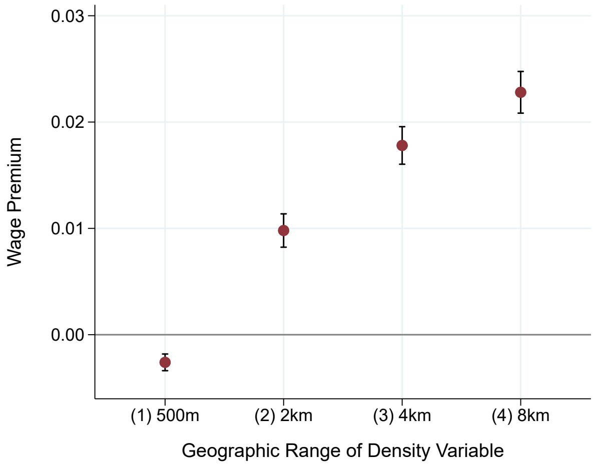


Figure 4. Geographic Range of Local Density Variables

Note: Author's creation. Each Mesh grid is based on about 500 m by 500 m. The red, blue, and green color circles indicate the geographic range of 2, 4, 8 km radius, respectively. The base point is the Tokyo Metropolitan Government Office.



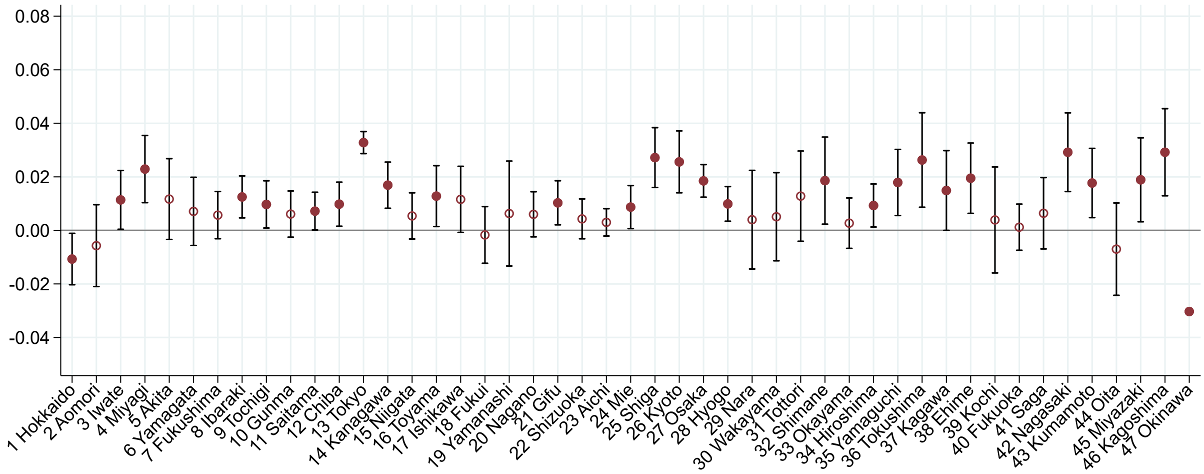
(a) Employment Density



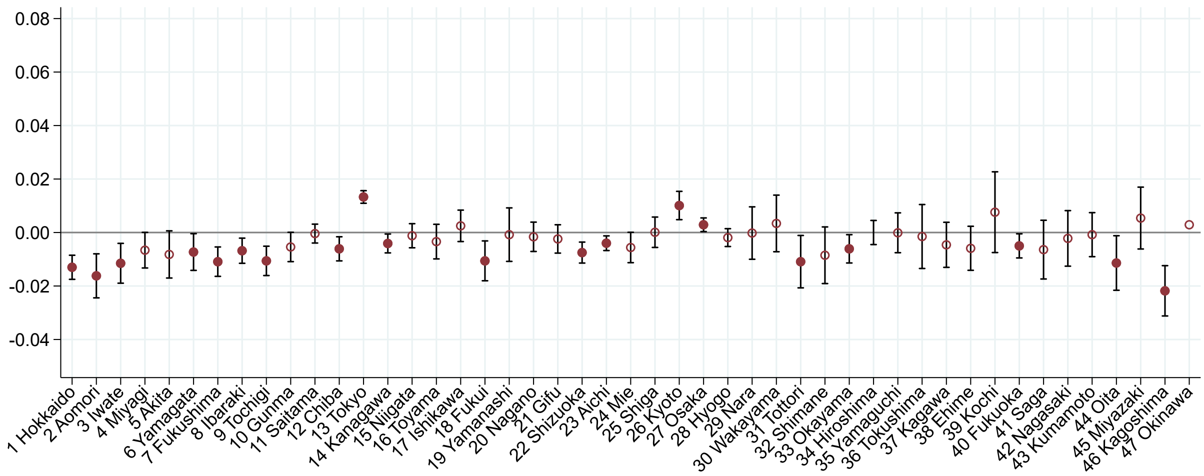
(b) Population Density

Figure 5. Wage Premium for Employment and Population Density

Note: Author's creation. The marker indicates the point estimates. The bar indicates the 95% confidence intervals.



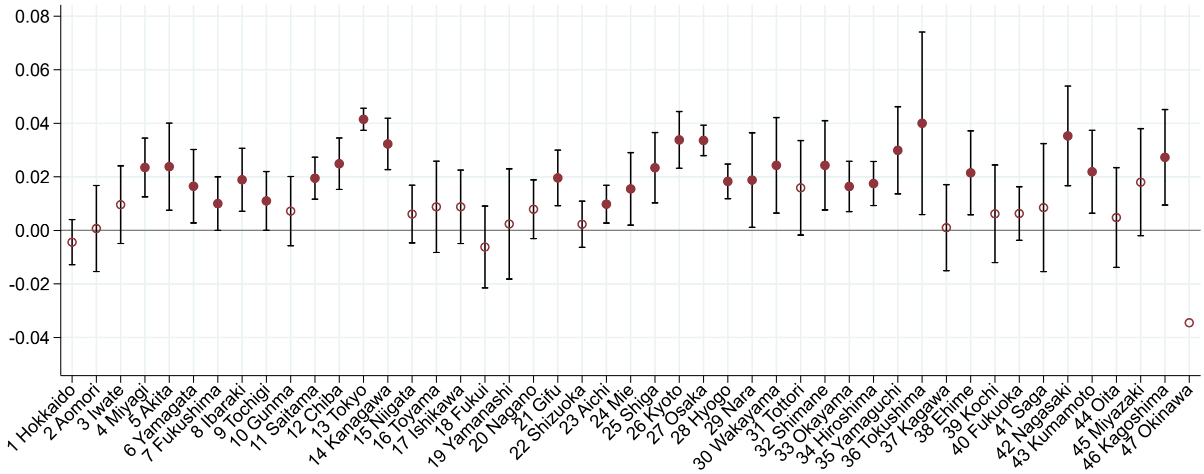
(a) Employment Density



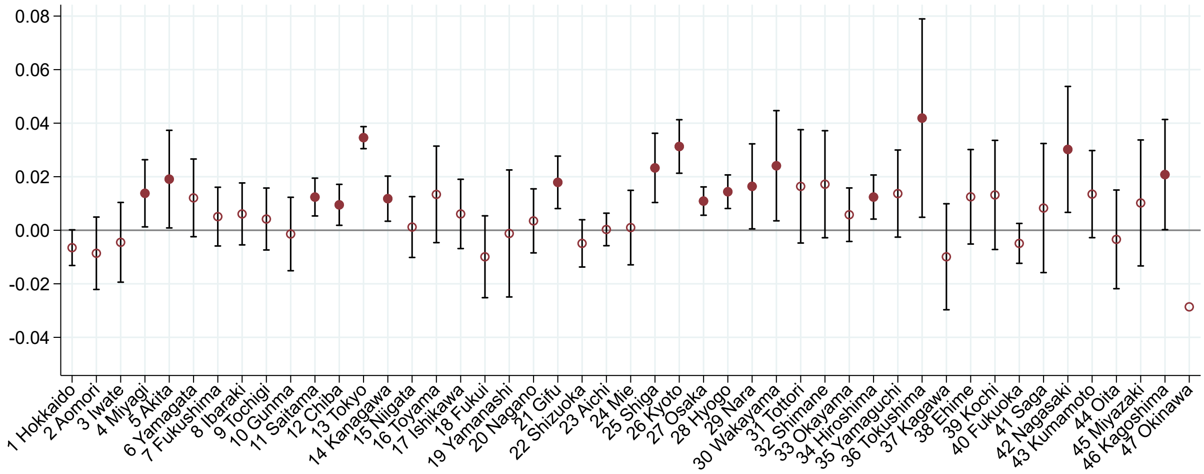
(b) Population Density

Figure 6. Wage Premium for Employment and Population Density within 500m by Prefecture

Note: Author's creation. The marker indicates the point estimates. The bar indicates the 95% confidence intervals.



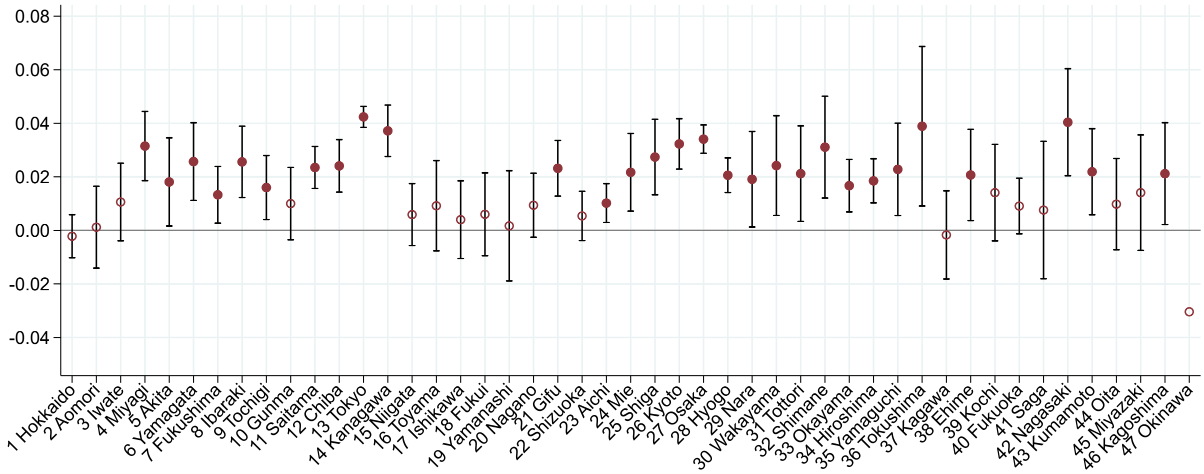
(a) Employment Density



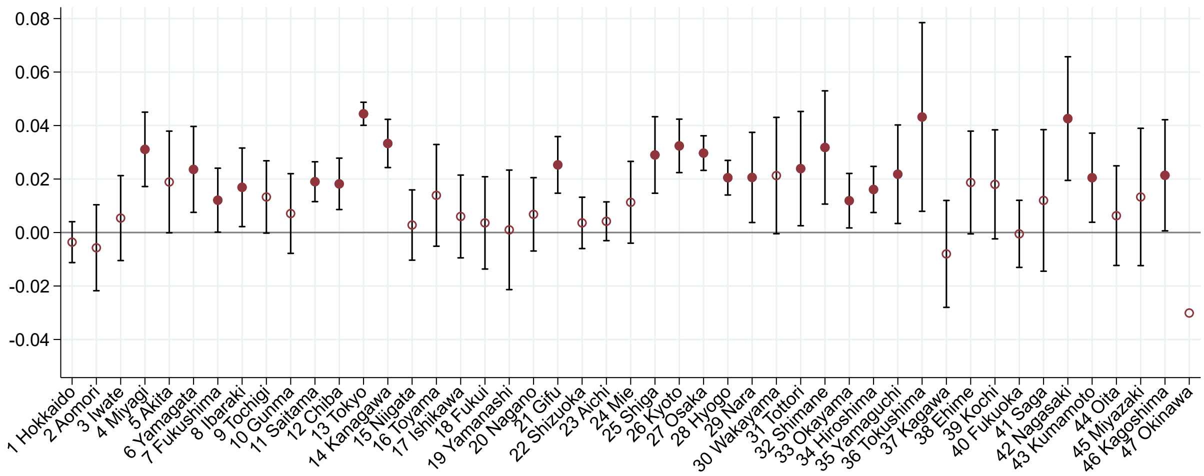
(b) Population Density

Figure 7. Wage Premium for Employment and Population Density within 2km by Prefecture

Note: Author's creation. The marker indicates the point estimates. The bar indicates the 95% confidence intervals.



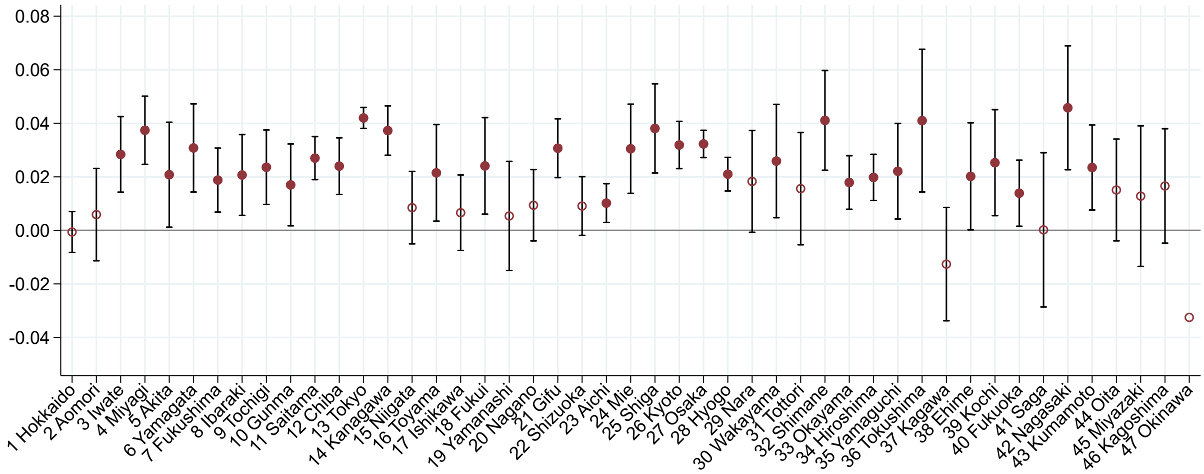
(a) Employment Density



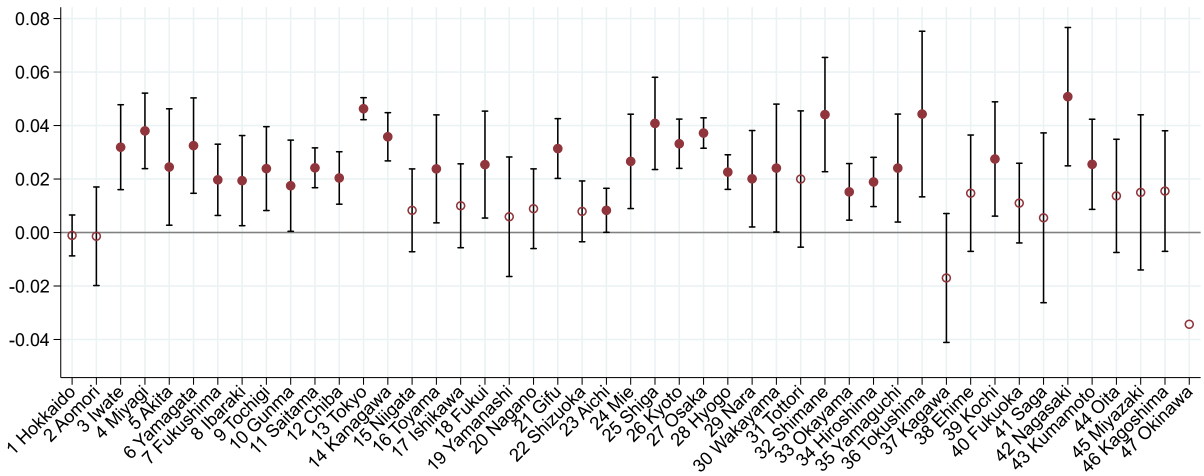
(b) Population Density

Figure 8. Wage Premium for Employment and Population Density within 4km by Prefecture

Note: Author's creation. The marker indicates the point estimates. The bar indicates the 95% confidence intervals.



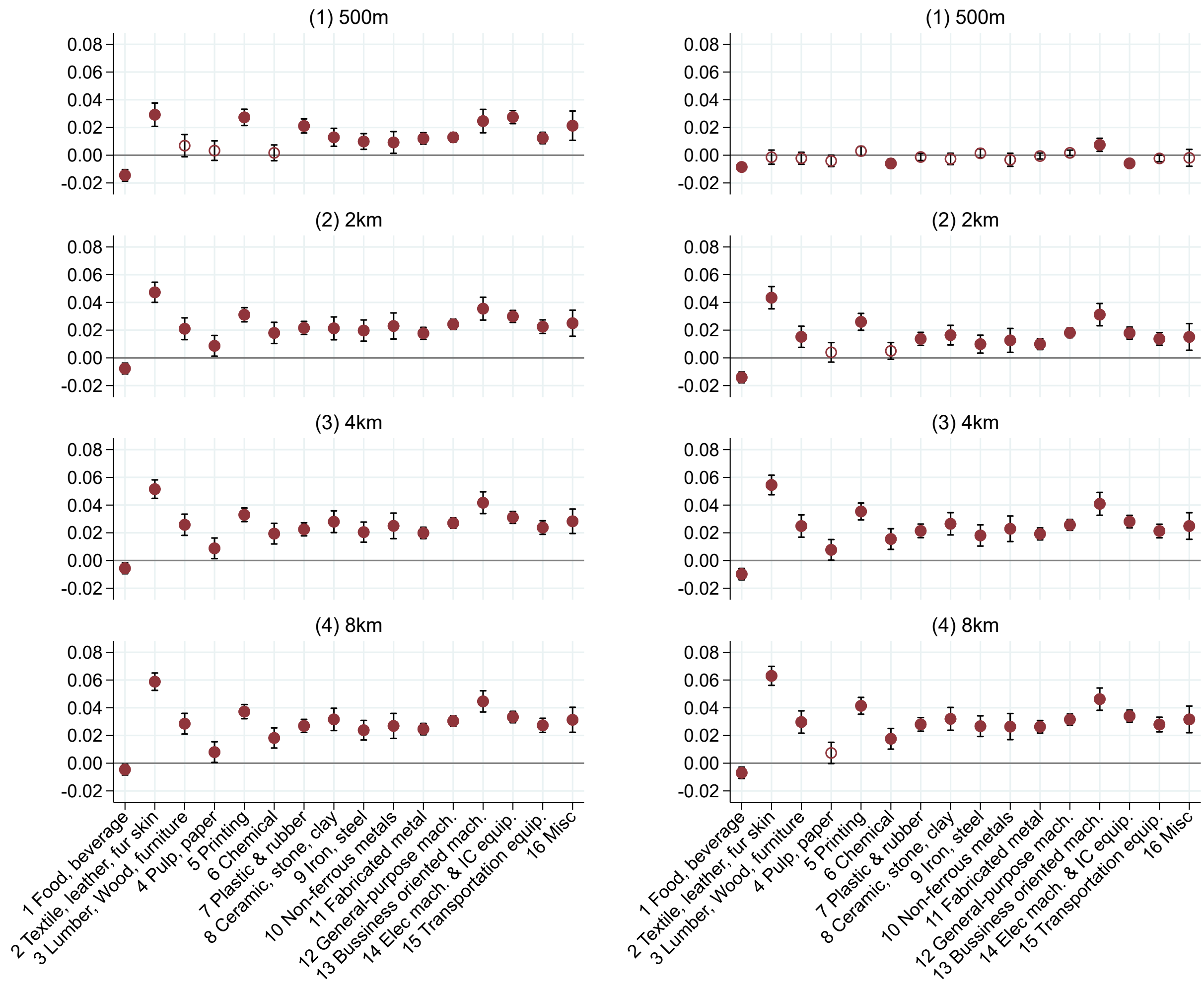
(a) Employment Density



(b) Population Density

Figure 9. Wage Premium for Employment and Population Density within 8km by Prefecture

Note: Author's creation. The marker indicates the point estimates. The bar indicates the 95% confidence intervals.



(a) Employment Density **(b)** Population Density

Figure 10. Wage Premium for Employment and Population Density by Industry

Note: Author's creation. The marker indicates the point estimates. The bar indicates the 95% confidence intervals.

Online Appendix for

Disentangling Economies of Density: Evidence from Micro-Geographic Data

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Table of Contents

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Appendix A TFP Estimation

The theoretical background of productivity and markup estimation is based on the study by Ackerberg et al. (2015) and De Loecker and Warzynski (2012). Suppose that firms demand two factors (labor and capital) for production. Firm i minimizes costs of labor and capital inputs to produce output.

Consider the value added trans-log production function as follows:

$$\log v_{it} = \beta_t + \beta_\ell \log \ell_{it} + \beta_k \log k_{it} + \beta_{\ell\ell}(\log \ell_{it})^2 + \beta_{kk}(\log k_{it})^2 + \beta_{\ell k} \log \ell_{it} \log k_{it} + \omega_{it} + e_{it}, \quad \text{(A.1)}$$

where v_{it} is the value-added of establishment i in year t, ℓ_{it} is the labor, and k_{it} is the capital stock. The error term is assumed to consist of two components: ω_{it} is a productivity shock which is unobserved by the econometricians but observable to the establishment i, and e_{it} is a sequence of idiosyncratic shock which is not observable by the establishment i before the input decision-making.

Obtaining consistent parameter estimates $(\hat{\beta}_t, \hat{\beta}_\ell, \hat{\beta}_k, \hat{\beta}_{\ell\ell}, \hat{\beta}_{kk}, \hat{\beta}_{\ell k})$ of the trans-log production function by the Ackerberg-Caves-Frazer approach, this study estimates the logarithm of TFP as follows:

$$\log\left(\widehat{\mathrm{TFP}}_{it}\right) = \log v_{it} - \hat{\beta}_\ell \log \ell_{it} - \hat{\beta}_k \log k_{it} - \hat{\beta}_{\ell\ell}(\log \ell_{it})^2 - \hat{\beta}_{kk}(\log k_{it})^2 - \hat{\beta}_{\ell k} \log \ell_{it} \log k_{it}. \quad \text{(A.2)}$$

Labor and capital elasticities in the trans-log production function are calculated as follows:

$$\theta_{it}^{\ell} = \frac{\partial \log v_{it}}{\partial \log \ell_{it}} = \hat{\beta}_\ell + 2\hat{\beta}_{\ell\ell} \log \ell_{it} + \hat{\beta}_{\ell k} \log k_{it}. \quad \text{(A.3)}$$

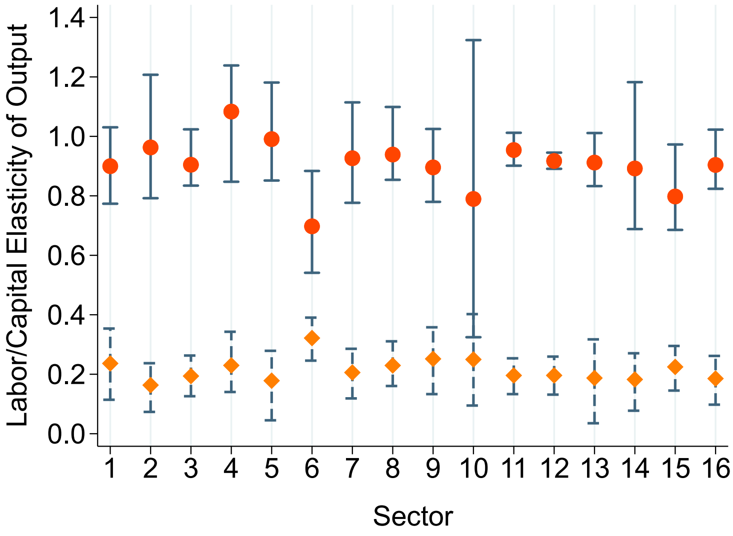
and

$$\theta_{it}^{k} = \frac{\partial \log v_{it}}{\partial \log \ell_{it}} = \widehat{\beta}_k + 2\widehat{\beta}_{kk} \log k_{it} + \widehat{\beta}_{\ell k} \log \ell_{it}. \quad \text{(A.4)}$$

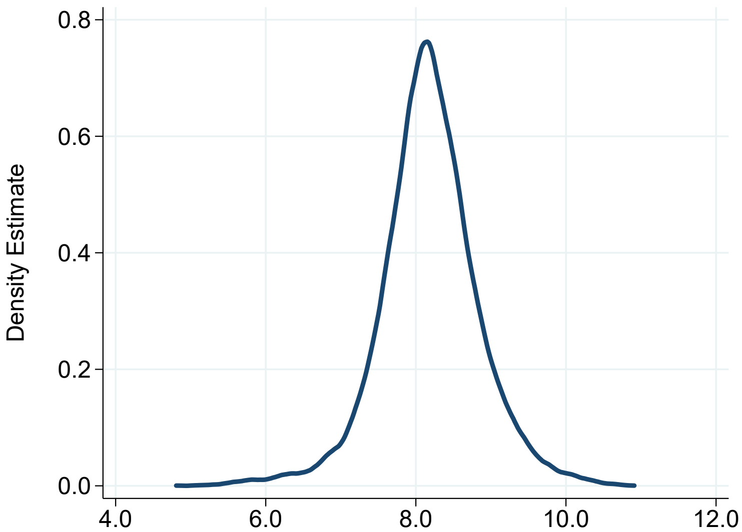
Unlike the Cobb–Douglas production function, labor and capital elasticities in the trans-log production function vary across the establishments. See (Kondo, 2018, 2023) for details of TFP estimation using the Census of Manufacture in Japan.

Figure A.1 shows the labor and capital elasticities of output based on the trans-log production function by industry and the TFP distribution.

[Figure A.1]



(a) Labor and Capital Elasticity of Output



(b) TFP Distribution

Figure A.1. TFP Estimation

Note: Author's creation. The labor and capital elasticity of output are $\partial \log v_{it} / \partial \log \ell_{it}$ and $\partial \log v_{it} / \partial \log k_{it}$ of Equation (A.1). The circle and diamond markers represent the average labor and capital elasticities of output, respectively. The lines represent the 5–95 percentile interval of the estimated elasticities.

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