Geography and Reorganization of Municipal Borders: the Case of Japanese Municipal Mergers

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November 20, 2024
KEO Discussion Paper No. 183

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GEOGRAPHY AND REORGANIZATION OF MUNICIPAL BORDERS: THE CASE OF JAPANESE MUNICIPAL MERGERS*

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ABSTRACT. This study investigates the role of geography in shaping the spatial borders of municipalities, focusing on Japan's municipal mergers. Specifically, it examines whether the geographic integration between municipalities influence the efficiency of public good provisions after mergers, thereby encouraging the merger decision. While fiscal challenges often drive mergers, the post-merger efficiency in delivering public goods is crucial. The study analyzes the factors that determine the likelihood of municipal pairs merging by examining their geographic and fiscal characteristics. Our empirical results, derived from bivariate probit analyses, demonstrate that both first- and second-nature geography significantly influence merger probabilities, in terms of the magnitude of the effects, more so than financial variables. Furthermore, the impact of various factors varies depending on the fiscal conditions of the municipalities, possibly reflecting the differing motives and expected outcomes following the merger.

*The authors would like to thank Takaaki Takahashi and the seminar participants at the University of Tokyo Center for Spatial Information Science (CSIS) Days 2024 for their helpful comments. Any remaining errors are the authors' own.

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1 Introduction

Geography plays an important role in the formation of cities. In particular, Bosker and Buringh (2017) and Henderson et al. (2018) show evidence that the first-nature geography such as the access to water and agricultural resources plays an important role in determining the spatial distribution of economic activities.[1] Whether in urban or rural settings, most human production activities expand or are sustained through the use of public goods, which are either managed by or dependent on political or jurisdictional authority. Alesina et al. (2000) argue that nations benefit from economies of scale of Public good provisions (PGP) until the nation size reaches a certain level, at which the congestion and coordination costs become dominant. A similar concept has been applied to understand the optimal size of cities, municipalities, and school districts (Miceli, 1993; Brasington, 2003; Gordon and Knight, 2009). The literature highlights the broader significance of jurisdictional borders and the spatial extent of PGP. This raises the question of what shapes the spatial distribution of national and jurisdictional borders, which define the spatial limits of PGP. While various factors influence border placement, natural features like seas, rivers, and mountains frequently align with them. To what extent is geography important to the efficiency of PGP?

In this paper, we shed light on the role of geography in determining PGP efficiency by empirically testing how geographic factors relate to the spatial redistribution of jurisdictional borders due to municipal mergers in Japan. Since the 19th century, Japan has experienced several merger waves of municipalities mostly involving the local government known as shi-ku-cho-son[2]. The most recent wave of mergers during the Heisei era[3] was driven by a government merger-promotion policy, though municipalities retained autonomy in deciding whether, and with whom, to merge, as further described in Section 2. This wave, referred to as the Heisei-no-dai-gappei or the Heisei Municipal Amalgamation[4], reduced the number of municipalities (shi-ku-cho-son) from 3,306 to 1,905 between 2001 and 2011.

We take advantage of this drastic rearrangement of municipal borders to empirically examine the extent to which geographic features—particularly those relevant to the spatial integration of two municipalities—are associated with PGP efficiency. We test to what extent these geographic characteristics have influenced merger decisions, controlling for various

[1]Henderson et al. (2018) find that a parsimonious set of 24 physical geography attributes explains 47% of worldwide variation and 35% of within-country variation in economic activities represented by night lights. Bosker and Buringh (2017) address the roles of geography such as water- and land-based transportation in determining today's European city system.

[2]Shi-ku-cho-son are the basic units of local government under the prefecture (ken) in Japan, consisting of cities (shi), towns (machi or cho), and villages (mura or son). Municipalities vary widely in size and population.

[3]The Heisei era spanned from 1989 to 2019.

[4]This term is used in Weese (2015).

other factors related to municipal mergers.

The Heisei municipal amalgamation has been studied from various perspectives, and several papers have reported important factors on the municipal mergers, including population, area, fiscal conditions, heterogeneity in income and culture (Hirota, 2007; Miyazaki, 2014; Weese, 2015; Hirota and Yunoue, 2022). In his structural estimation assessing the efficiency of municipal size and number after the merger wave, Weese (2015) incorporates a geographic factor tied to individual utility within a municipality. Specifically, he uses the population-weighted average distance (using 1km grid squares) to the optimal public goods location for both existing and potentially merged municipalities.

As our focus is on the role of geography in municipal mergers, we examine the effects of geography more closely by including various variables that characterize geographic factors related to the spatial integration of municipalities. In particular, we test the separate effects of first-nature geography, which refers to the features of terrain, such as altitude and ruggedness, and second-nature geography, which pertains to human-made or economic factors, such as transportation infrastructure and population distribution. We also compare these effects with the effects of fiscal variables.

Even in locations with first-nature geographic advantages that could facilitate future spatial integration between municipalities, constructing the necessary infrastructure can incur significant costs. This contrasts with areas that already feature established second-nature infrastructure, where transportation access—characterized by the presence of road and rail networks—ensures better connectivity. By including these variables, we gain insights into the distinct roles of actual and potential level of spatial integration between municipalities.

In our empirical analysis, we use a bivariate probit framework suggested in Poirier (1980) to examine the likelihood of a municipal pair to merge. Most observed mergers involve two municipalities, though some include three or more. We consider the outcome of merger waves as the result of pairwise evaluations. For each municipality pair in our sample, we compare their fiscal distress indices and identify the relatively distressed and sound municipalities. We consider that the motive and purpose of a merger, and thus the effects of covariates, could differ depending on their fiscal conditions, following the findings of Hirota and Yunoue (2017). Our specification allows the effect of covariates to differ between distressed and sound municipalities.

To measure the first-nature geographic characteristics at and around the border, we use Japanese grid-square statistics as well as geocoded information of municipal borders (MLIT, 2021). As we demonstrate later, geographic attributes such as altitude and ruggedness are associated with the spatial distribution of existing transportation infrastructure, including roads and railways, which is thought to play a crucial role in the spatial integration of two areas. We use these variables to capture the characteristics of first-nature geography at and around the border prior to the merger wave.

Included in our study as a second-nature geographic variable is the spatial dispersion of the population. A municipality with a spatially concentrated population is considered to have higher PGP efficiency (Bergstrom and Goodman, 1973; Buchholz and Sandler, 2021). Spatial dispersion of population would reduce PGP efficiency by increasing the costs of providing public goods, such as transportation infrastructure, education, and healthcare services. We also include transportation coverage at and around municipal borders and for each municipality.

In addition to geographic factors, we control for the fiscal condition of municipalities, which is considered to play a crucial role in their decision to merge. Hirota and Yunoue (2017) provides evidence, based on a sample from Japan, that subordinate merger partners are typically municipalities facing adverse fiscal conditions. Similarly, Hinnerich (2009) suggests that both long-term and short-term debts drive municipalities to merge.As we describe in Section 2, maintaining the level of government transfer is considered as an important motivation for municipal mergers in Japan.

Our empirical results indicate that both first- and second-nature geography play significant roles in determining the probability of a municipal pair merging. By estimating the effects of those variables on unobserved net value from a municipal merger separately for relatively distressed and sound municipalities of the municipal pairs in our sample, we also found that the effects of many variables vary depending on the relative level of fiscal distress in the pair.

2 Heisei Municipal Amalgamation in Japan

The Heisei Municipal Amalgamation refers to a wave of municipal mergers in Japan, which involves the smallest administrative units known as shi-ku-cho-son (cities, wards, towns, and villages). These entities operate under larger jurisdictions called to-do-fu-ken (prefectures). While Japan's central government establishes national policies and oversees prefectural administration, shi-ku-cho-son(s) also have considerable autonomy, managing local priorities such as education, public health, waste management, and infrastructure development.(Ministry of Internal Affairs and Communications, 2002)

Municipal mergers in Japan are governed by a voluntary process, as emphasized in the Government of Japan (2004).[5] The process involves multiple approvals: (i) municipal as-

[5] The Japanese New Municipal Merger Law (Shichōson no Gappei no Tokurei ni Kansuru Hōritsu) is the currently effective law concerning municipal mergers. See https://laws.e-gov.go.jp/law/416AC0000000059.

semblies vote to form a merger consultation committee, which drafts a merger plan; (ii) the plan is voted on again in both assemblies; and (iii) upon approval, the prefectural assembly conducts a final vote. If a municipal assembly rejects the proposal, the mayor may call a voter referendum within ten days. If the majority supports establishing the merger council, the rejecting assembly is deemed to have approved it. This process ensures a democratic approach to mergers by involving representatives and residents.[6]

Though voluntary, the central government promotes mergers through fiscal incentives tied to the Local Allocation Tax (LAT) system, which redistributes funds to ensure equitable access to public services across regions. LAT transfers are calculated as the difference between a municipality's standard fiscal needs (SFN), which account for essential expenditures including debt servicing, and its discounted standard revenues (DSR), which incentivize tax collection by considering 75% of estimated revenue.[7]

Under the Trinity Reform policy,[8] the central Japanese government plans to reduce LAT transfers as part of addressing national fiscal challenges. Under this policy, municipalities undergoing mergers may benefit from maintained transfer levels for up to five years after the merger, as outlined in Government of Japan (2004).[9] This policy promotes fiscal stability during the transition period by maintaining LAT transfers at pre-merger levels, encouraging municipalities to merge. This aligns with broader decentralization reforms discussed in Government of Japan (2024). For further insights into government strategies and fiscal mechanisms influencing mergers, see Hirota and Yunoue (2017), which highlights the balance between local autonomy and central government support.

3 Empirical Model

3.1 Theoretical background

To motivate our empirical specifications, we provide an outline of the theoretical model based on previous literature, including Brasington (2003) and Miyazaki (2014). Consider two municipalities $\{d, s\}$, with population $N \in \{N_d, N_s\}$ respectively, choosing to merge or

[6] The administrative process includes two municipal assembly votes, before and after drafting the merger plan, and one prefectural assembly vote.

[7] LAT: chihō kōfu zei. For a detailed explanation of the LAT in Japanese, see `https://www.soumu.go.jp/main_sosiki/c-zaisei/kouhu.html`. For English, see `https://www.chihousai.or.jp/english/03/public08.html`.

[8] The Trinity Reform (2003) continues the efforts of Government of Japan (1999) to repeal the delegation system that subordinates local governments to the central government. For details, see `https://www.soumu.go.jp/main_sosiki/jichi_zeisei/czaisei/czaisei_seido/zeigenijou.html`.

[9] The exceptions for calculating the amount of Local Allocation Tax are specified in the Local Allocation Tax Act (Act No. 211 of 1950). See `https://laws.e-gov.go.jp/law/416AC0000000059`.

to stay independent.[10] Since the merger decision is voted on in municipal assemblies, we assume a median voter in each municipality representing all municipal residents.We write the utility function of the median voter as:

$$U = v(x) + u(g), \tag{1}$$

where $v(x)$ and $u(g)$ are, respectively, the utility of private good consumption, x, and that of public good consumption, g.[11] We denote the median voter's income by y and tax rate by τ. Then the median voter's budget constraint is written as:

$$y(1 - \tau) = x, \tag{2}$$

Municipal governments tax resident's income to provide for public goods. The unit cost function of PGP is $c(N, G, \tilde{G})$, which we assume is a function of population N, first-nature geography G and, second-nature geography $\tilde{G}$. Hence, we write a municipal government's budget constraint as:

$$c(N, G, \tilde{G}) \times g = \tau y F N, \tag{3}$$

where F is the fiscal efficiency of local government that are independent of $c(\cdot)$.

Using equations (2), (3), and utility function (1), we can write that the median voter of municipality k maximizes:

$$U = u(g_k) + v(y - \frac{c(N_k, G_k, \tilde{G}_k)}{F_k N_k} g_k), \tag{4}$$

which shows that a median voter's utility changes by her income allocation to private goods and public goods provided by the local government through taxation. Solving the first-order condition of the utility maximization problem with respect to g_k leads to an equilibrium level of g_k, g_k^*, such that $\frac{\partial u(g)}{\partial g_k^*} = \frac{\partial v}{\partial x} \frac{c(N_k, G_k, \tilde{G}_k)}{F_k N_k}$. Assuming a log-utility specification with $u(g) = a\ log(g)$ and $v(x) = b\ log(x)$, the utility is maximized at $g_k = g_k^* = \frac{a}{a+b} \cdot \frac{y F_k N_k}{c(N_k, G_k, \tilde{G}_k)}$, within the support $g_k \in [0,\ \frac{y F_k N_k}{c(N_k, G_k, \tilde{G}_k)}]$.

Thus, for the median voter in a municipality $k \in \{d, s\}$, the net utility of becoming a

[10] In our empirical specification, d refers to a relatively more fiscally distressed municipality, and s refers to a relatively more financially sound municipality.

[11] In Alesina et al. (2000) and Brasington (2003), $u(g)$ is determined by a cultural- and/or social- heterogeneity. Our focus, however, is the role of geography.

member of municipality $d \cup s$, Y_k^* is:

$$\begin{aligned} Y_k^* &= u(g_{d,s}^*) + v\left(y - \frac{c(N_{d,s}, G_{d,s}, \tilde{G}_{d,s})}{F_{d,s}N_{d,s}} g_{d,s}^*\right) \\ &- u(g_k^*) - v\left(y - \frac{c(N_k, G_k, \tilde{G}_k)}{F_k N_k} g_k^*\right). \end{aligned} \tag{5}$$

By substituting $g_k^* = \frac{a}{a+b} \cdot \frac{yF_kN_k}{c(N_k,G_k,\tilde{G}_k)}$ and $g_{d,s}^* = \frac{a}{a+b} \cdot \frac{yF_{d,s}N_{d,s}}{c(N_{d,s},G_{d,s},\tilde{G}_{d,s})}$ into equation (5), Y_k^* is written as:

$$\begin{aligned} Y_k^* &= a\ log(\frac{F_{d,s}}{F_k} \cdot \frac{N_{d,s}}{N_k} \cdot \frac{c(N_k, G_k, \tilde{G}_k)}{c(N_{d,s}, G_{d,s}, \tilde{G}_{d,s})}) \\ &= a\ log(\frac{F_{d,s}}{F_k}) + a\ log(\frac{N_{d,s}}{N_k}) + a\ log(\frac{c(N_k, G_k, \tilde{G}_k)}{c(N_{d,s}, G_{d,s}, \tilde{G}_{d,s})}) \end{aligned} \tag{6}$$

We consider that if Y_k^* is positive, municipality k has an incentive to merge with the other. Equation (6) motivates the specification of our reduced form analyses.

3.2 Empirical Specification

With the above theoretical framework, we base our empirical model on Poirier's bivariate probit model, as adopted by Brasington (2003) in his study on school district mergers. Our sample consists of all pairwise combinations of municipalities, $\mathcal{A}$, that are geographically adjacent and within the same prefecture. For each pair, we define d as the municipality that is *relatively* more fiscally distressed and s as the relatively sound municipality. We then estimate the coefficients of the variables determining the unobserved net value for a distressed (sound) municipality to merge with a sound (distressed) municipality.

While our focus is on the role of geography, the Heisei municipal amalgamation highlights distinct differences in the motives and purposes of mergers based on the fiscal conditions of the municipalities. Empirical findings by Hirota and Yunoue (2017) and Hinnerich (2009) point to potential free-rider problems among fiscally distressed municipalities. Although mergers require mutual agreement, the motivations and objectives seem to differ. Hirota and Yunoue (2017) highlight that distressed municipalities aim to shift their debt burden to fiscally sound ones, consistent with Miyazaki (2014). However, the motivations of fiscally sound municipalities remain underexplored. Our specification distinguishes these motivations, offering insights into their incentives.

Let Y_d^{*s} represent the net value for municipality d to merge with municipality s, and Y_s^{*d} represent the net value for municipality s to merge with municipality d, both corresponding to the median voter's utility as defined in equation (5). We write

$$Y_d^{*s} = f(G_d^s, \tilde{G}_d^s, F_d^s, X_d^s) + \epsilon_d^s$$
$$Y_s^{*d} = h(G_s^d, \tilde{G}_s^d, F_s^d . X_s^d) + \epsilon_s^d,$$

where G_d^s, $\tilde{G}_d^s$, F_d^s, and X_d^s are vectors representing first-nature geography, second-nature geography, fiscal, and control variables associated with Y_d^{*s}, respectively, and G_s^d, $\tilde{G}_s^d$, F_s^d, and X_s^d are the corresponding vectors for Y_s^{*d}. ϵ_d^s and ϵ_s^d are correlated random components that follow a bivariate normal distribution.

We assume that each municipality has an incentive to merge with the other in the pair if the net value of merging exceeds zero. We define indicators of this incentive, denoted by Y_d^s and Y_s^d, as follows:

$$Y_d^s = 1 \quad \text{iff} \quad Y_d^{*s} > 0 \tag{7}$$
$$Y_s^d = 1 \quad \text{iff} \quad Y_s^{*d} > 0 \tag{8}$$

As mentioned above, during the Japanese Heisei municipal amalgamation, municipalities were required to form a joint committee to negotiate merger plans and fulfill the administrative requirements necessary for completing the merger. However, the final decisions were made through referendums in each municipality, requiring unanimous approval. Specifically, the two municipalities voted anonymously on the merger in their respective town assemblies, and the plan could proceed to the prefectural assembly only if both assemblies approved it.

When a pair of municipalities merges, it implies that both d and s had an incentive to merge under our assumption (i.e., $Y_d^s = 1$ and $Y_s^d = 1$). However, when a merger is unsuccessful, it is unclear whether neither municipality had an incentive or which one lacked the incentive. Thus, Y_d^s and Y_s^d are only partially observed. To address this, we adopted the bivariate probit model by Poirier (1980), which enables the estimation of parameters associated with the net value of each party in the pair under partial observation. This model has been applied in various contexts, including Brasington (2003).

Let $Z_{d,s}$ denote an indicator variable for the actual merger. Then, we can write $Z_{s,d}$ as a product of Y_d^s and Y_s^d:

$$Z_{d,s} = Y_s^d Y_d^s, \quad \{d, s\} \in \mathcal{A}. \tag{9}$$

$Z_{d,s} = 1$ if and only if both municipality d and municipality s vote in favor of the merger; otherwise, $Z_{d,s} = 0$. We can write $Pr(Z_{d,s} = 1)$ as $\Phi(R_d^{s\prime}\beta_d, R_s^{d\prime}\beta_s, \rho)$, where $R_d^{s\prime} \equiv [G_d^s\ \tilde{G}_s^d\ F_d^s\ X_d^s]$ and $R_s^{d\prime} \equiv [G_s^d\ \tilde{G}_d^s\ F_s^d\ X_s^d]$. β_d and β_s are parameter vectors, and $\rho \in [-1, 1]$ is the correlation coefficient between ϵ_d^s and ϵ_s^d, and $\Phi(\cdot)$ denotes the cumulative distribution function of the bivariate standard normal distribution. Poirier (1980) provides an estimation based on maximum likelihood method:

$$L(\beta_d, \beta_s, \rho) = \sum_{\{d,s\} \in \mathcal{A}} Z_{d,s} \log[\Phi(R_d^{s\prime}\beta_d, R_s^{d\prime}\beta_s, \rho)] + (1 - Z_{d,s}) \log[1 - \Phi(R_d^{s\prime}\beta_d, R_s^{d\prime}\beta_s, \rho)], \quad (10)$$

where $L(\cdot)$ is the log-likelihood function of the sample.

4 Data

4.1 Our sample of municipal pairs for bivariate probit analyses

Using Japan's municipal administrative borders, we identify first-degree adjacency for each municipality. First-degree adjacency is defined as two municipalities sharing a common border. This yields a total of 8,783 pairs from 3,306 municipalities, with each municipality having an average of 5.31 adjacent municipalities.

However, pairs involving municipalities in different prefectures are unlikely to merge due to administrative constraints, as merger plans must be approved by the respective prefectural assembly. Only one counterexample exists across all periods. Therefore, we excluded 1,031 pairs where the municipalities are located in different prefectures. Additionally, there are 12 ordinance-designated cities[12], which serve as prefectural administrative hubs, take on greater prefectural responsibilities, and are generally excluded from mergers. Following conventional practices in the literature, such as Brasington (2003), we removed 469 pairs involving ordinance-designated cities.

Lastly, we excluded pairs with extreme geographic values for the boundary or municipalities containing only one population mesh. After these adjustments, our sample consists of 6,967 pairs. Of these, 27.4% underwent mergers between January 1, 2001, and December 31, 2011.[13]

[12] As of 2001, these are Sapporo, Sendai, Chiba, Yokohama, Kawasaki, Nagoya, Kyoto, Osaka, Kobe, Hiroshima, Kitakyushu, and Fukuoka.

[13] The number of mergers (counted by the number of merged adjacent pairs) in each year was as follows: 3 (2001), 9 (2002), 45 (2003), 349 (2004), 1,023 (2005), 379 (2006), 21 (2007), 16 (2008), 9 (2009), 49 (2010), and 9 (2011).

4.2 Variables

First-nature Geography Variables, G

To capture the geographic integration between a pair of municipalities, we use the GIS dataset from the National Land Information Division, Ministry of Land, Infrastructure, Transport and Tourism (MLIT) of Japan[14]. Using the shapefile of municipal borders, we first calculate the border length for each pair of municipalities using ArcGIS software. A municipality pair sharing a longer border could be considered more geographically integrated than one with a shorter border, *ceteris paribus*.

We use the 250m mesh dataset that comprise over 7 million meshes and record the minimum, average, and maximum values of altitude and ruggedness within each mesh.[15] We identify all meshes containing the border and calculate the average altitude and ruggedness for each municipal pair's border. Figure 1 shows that the kernel density of mesh-level altitude and ruggedness index is left-skewed for borders with transportation facilities.[16] This indicates that lower altitude and less ruggedness are generally associated with better transportation access.

Lastly, we also include the Euclidean distance between the geographic centroids of each municipality. This measure serves as an additional factor to account for the spatial distance between the municipalities.

Second-nature Geography Variables, $\tilde{G}$

Transportation: As highlighted by Bosker and Buringh (2017), transportation serves as a vital means of enabling access and a fundamental factor in uniting two distinct geographic regions. While first-nature geography, such as physical proximity and natural terrain, provides the foundational conditions, transportation acts as a key component of second-nature geography, shaping how these regions are connected and integrated through human-made infrastructure.

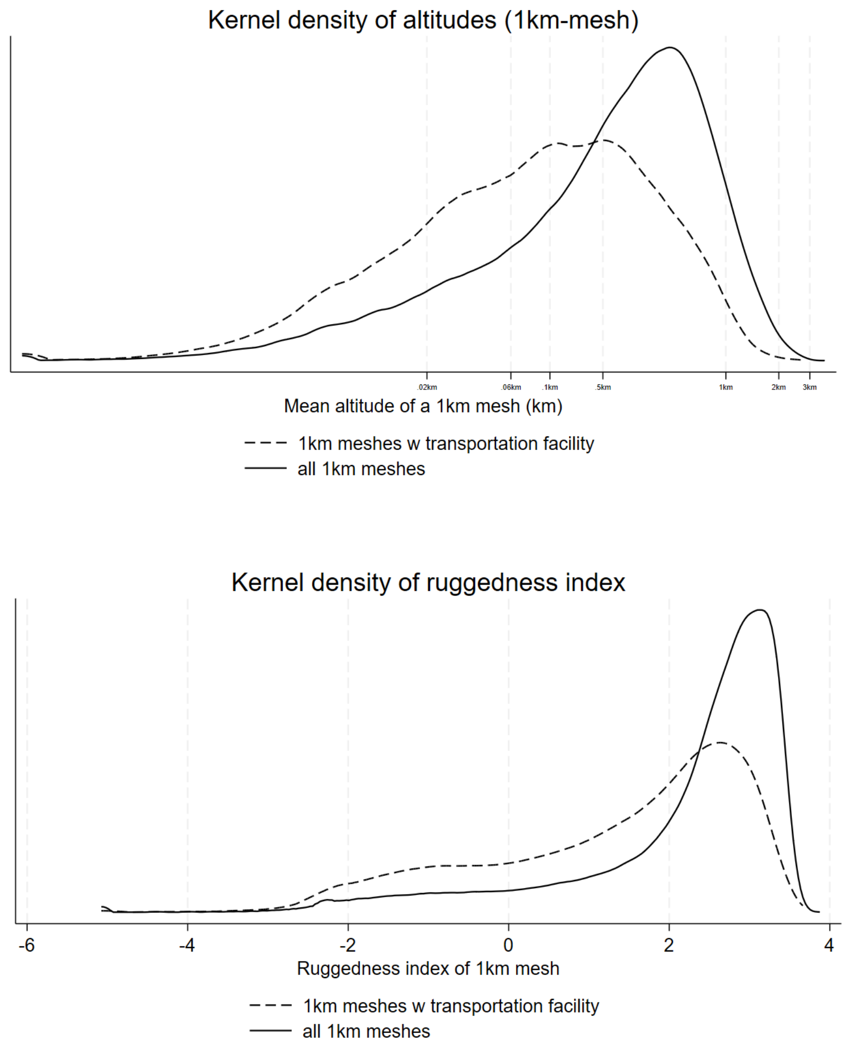
The GIS land-use data (MLIT, 2021)[17] informs us, for each 1km mesh, the presence and/or area of various geographic features, among which is the area of roads, railway tracks, and rail yards combined (2-dimensional). Taking advantage of this data set, we construct a

[14] https://nlftp.mlit.go.jp/ksj/index.html.

[15] The 250m mesh data are based on finer geographic units. For example, altitude is measured using 10m meshes, and the ruggedness index follows Nunn and Puga (2012)'s method. While Henderson et al. (2018) note potential bias in Nunn and Puga (2012)'s method due to latitude-based mesh differences, Japan's limited range (20° to 45° north latitude) minimizes this bias.

[16] Transportation data are based on 1km-mesh land-use data from MLIT (2021).

[17] Detailed information about the land-use data can be found at https://nlftp.mlit.go.jp/ksj/gml/datalist/KsjTmplt-L03-a-2016.html.



Notes: Authors' calculations based on MLIT data of Japan and other official Japanese government statistics.

Figure 1: Geographic attributes of 1km meshes with transportation facilities

dummy variable, $D^T_{d,s} = 1$, which indicates the presence of transportation infrastructure in any of the 1km meshes consisting the border of a pair of municipalities. When transportation facilities are located near the border, they are more likely to extend and link both sides of the municipalities. Among the 6,967 municipal borders in our sample, 45% include some form of transportation infrastructure. Table 1 shows that such a percentage is higher for the municipal borders of the pairs that underwent merger.

As a measure of transportation coverage for each municipality, we also calculate the share of the meshes with transportation infrastructure out of all meshes of the municipality. With greater transportation coverage in a municipality, the access to public services would be, in general, better within the municipality, which would also influence an incentive for a municipality to merge.

Population Dispersion: As addressed in Ladd (1992), Gordon and Knight (2009), Buettner and Holm-Hadulla (2013) and Weese (2015), the population distribution also affects the access to the public services and thus PGP efficiency. In particular, the spatial dispersion of population would hinder centralized resource allocation and management, reducing economies of scale of the PGP.

To measure population dispersion, we utilize mesh-level population data from Statistics Bureau of Japan (2024) and calculate two metrics. First, for a pair of municipality, we obtain the distance between the population weighted centroids.[18] As another measure for population dispersion, we also use the average pairwise distance between all 1km meshes weighted by mesh-population, which we represent by R_k, where $k \in \{d, s, d \cup s\}$:

$$R_k = \frac{\sum_{i \neq j} \sum_j \pi_i \pi_j d_{ij}}{\sum_{i \neq j} \sum_j \pi_i \pi_j}, \tag{11}$$

where i and j represent a 1km mesh of a municipality k. Figure 2 shows that, for the set of municipality pairs that were actually merged during the Heisei municipal amalgamation, the kernel density of the measures is relatively left-skewed compared to that of all municipality pairs in our sample.

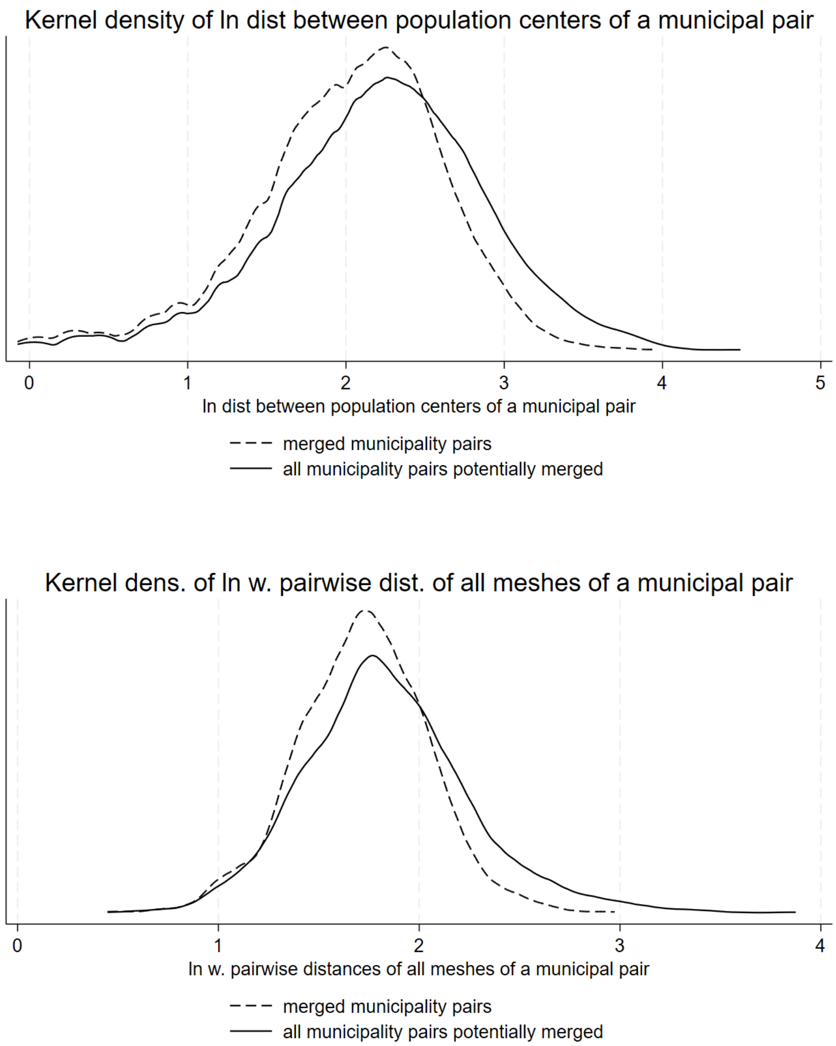
Fiscal Variables, F

We obtain fiscal variables from the MIC budget and account data,[19] which provides a comprehensive range of municipal fiscal data from 1975 to the present, available at an annual frequency. Following the literature (Hinnerich, 2009; Weese, 2015; Hirota and Yunoue, 2022), we include two fiscal variables: government transfer and fiscal distress index, the latter calculated by dividing fiscal debt by the municipal fiscal scale. Since the initial year in our study is January 1, 2001, and municipal fiscal reports are typically recorded at the end of the year, we use the 2000 cross-sectional data in our fiscal panel to represent the fiscal status of each municipality at the beginning of 2001. From Table 1, we observe that municipalities in the merger sample are more fiscally distressed than those in the full sample.

We also collect other fiscal variables, such as a municipality's tax income, long-term debt, and short-term debt. However, these variables are highly correlated with population and the fiscal distress index.

[18]This is obtained by taking the average of longitude and latitude of each 1km mesh of a municipality with mesh-population as a weight.

[19]For MIC budget and account, see: https://www.soumu.go.jp/menu_yosan/kesan.html.



Notes: Authors' calculations based on MLIT data of Japan and other official Japanese government statistics.

Figure 2: Population Distribution in Merger Sample and Full Sample.

Other Control Variables, X

Included as municipality- and prefecture-level control variables are population and area,[20] which account for factors related to a municipality's population density and spatial resources.

5 Results

Table 2 presents the results of the Poirier bivariate probit analyses. In specification [1], as a measure of population dispersion of the municipal pairs that can potentially merge, we

[20]These variables are created using Japan's municipal administrative borders (https://nlftp.mlit.go.jp/ksj/index.html).

Table 1: Descriptive Statistics of Variables.

Number of municipa pairs in our sample: 6967.

Dependent Variable	**Freq.**	**Percent (%)**
$Z_{d,s} = 0$	5,058	72.60
$Z_{d,s} = 1$	1,909	27.40

		Full Sample		**Merger Sample**	
Variable^{+}	Unit	Mean	Std. Dev	Mean	Std. Dev
First-nature Geography Variables, G					
border length (ln, km)	(d, s)	8.91	1.05	9.10	0.836
border altitude (ln, m)	(d, s)	-1.89	1.56	-1.89	1.46
border ruggedness (ln)	(d, s)	1.83	1.57	1.96	1.47
distance between geographic centroids (ln, km)	(d, s)	2.30	0.503	2.20	0.445
Second-nature Geography Variables, $\tilde{G}$					
distance between population centroids (ln, km)	(d, s)	2.22	0.663	2.02	0.601
D^T=1 if any border meshes contain transportation facilities	(d, s)	0.447	0.497	0.487	0.500
transportation coverage	d	0.224	0.188	0.194	0.169
	s	0.221	0.195	0.197	0.171
avg. pairwise distance among all 1km-meshes (weighted by pop.) (ln, km)	(d, s)	1.84	0.417	1.72	0.322
	d	1.33	0.375	1.30	0.347
	s	1.28	0.390	1.25	0.363
Municipal Fiscal Variables, F					
fiscal distress index	d	1.95	0.562	2.00	0.534
	s	1.51	0.476	1.57	0.463
government transfer (ln, million yen)	d	7.89	0.791	7.81	0.643
	s	7.71	0.926	7.70	0.605
Control Variables, X					
population (ln)	d	9.67	1.42	9.32	1.34
	s	9.57	1.20	9.29	1.06
area (ln, km^2)	d	7.40	0.882	7.27	0.78
	s	7.30	0.944	7.15	0.848
prefecture population (ln)	d/s	10.2	0.546	10.1	0.378
prefecture area (ln, km^2)	d/s	7.53	0.539	7.49	0.397

Notes: Authors' calculations based on MLIT data of Japan and other Japanese government statistics. prefecture population and prefecture area refer to the average municipal population and average municipal area within a prefecture. $^{+}$ Variables represent values prior to mergers.

include the distance between population centroids of a municipality pair, and in specification [2], we include $R_{d \cup s}$ as well as R_d and R_s. Table 3 presents the marginal effects on $\Pr(Z_{d,s} = 1)$. The average marginal effects (AME) are calculated by first estimating the marginal effect for each observation using the Delta method and then averaging these values.

5.1 Overall Results

First-nature geography, G

Let us first examine the coefficients of the first-nature geography variables. In Table 2, under specification [1], border length yields positive and significant coefficients in both the equations for Y_d^{s*} and Y_s^{d*}, with similar values. This suggests that sharing a longer border increases the net value of a municipal merger for both sides of a pair by nearly the same amount. In specification [2], however, the coefficient for border length is not significant, possibly because its effect is absorbed by the inclusion of pairwise distance between municipalities as a second-nature geography variable. As shown in Table 3, however, in both [1] and [2], the marginal effect of border length on the probability of a merger, $\Pr(Z_{d,s} = 1)$, remains positive and significant.

Border altitude shows negative coefficients in both [1] and [2], though the significance varies between the specifications. As shown in Table 3, the marginal effect of altitude on $\Pr(Z_{d,s} = 1)$ is negative and significant. This suggests that higher border altitude may limit the scale economies of PGP and act as a potential barrier to integration.

Border ruggedness obtained the positive and significant coefficient in the equation for Y_d^{s*}, which is opposite from our initial conjecture. While the significance disappears in [2], the marginal effect of border ruggedness on $\Pr(Z_{d,s} = 1)$ is also positive and significant. While the lower degree of ruggedness would reduce the construction costs for some transportation means if necessary, the development of such terrain especially at a border would require the municipalities of the both side to cooperate. It is possible that the municipal merger would ease the development of such geographic area.

The distance between the geographic centroids obtained a positive coefficient in the equation for Y_d^{s*}, suggesting that greater geographic separation increases Y_d^{s*}. Again in [2], the coefficient is not significant, but the marginal effects shown in Table 3 shows the positive and significant effect of the distance between the geographic centroids on $\Pr(Z_{d,s} = 1)$, which is opposite from our initial conjecture. When the geographic centroids of adjacent municipalities are farther apart, it is possible that each municipality is also relatively distant from other neighboring municipalities under certain conditions. Our current empirical approach does not explicitly account for the effects of other neighboring municipalities, which is a limitation of this study and a potential direction for future research.

Second-nature geography, $\tilde{G}$

Our results indicate that the second-nature geography variables also impact the net value of mergers between distressed and sound municipalities. As Table 2 shows, the presence of the transportation facilities represented by D^T obtained positive and significant coefficient in the equation for Y_d^{s*} in specification [1]. Once a municipality pair is merged, it is possible that a distressed municipality relies more on the existent public good in a sound municipality than the sound municipality does on that in a distressed municipality. That could be reflected in the result. Again, in specification [2], the coefficients are not significant, but the marginal effect of D^T is positive and significant in both [1] and [2].

Looking at the effects of transportation coverage in each municipality in Table 2 and Table 3, higher transportation coverage in a fiscally sound municipality appears to decrease the net value for a sound municipality to merge with a distressed one. The coefficient of transportation coverage is negative and significant in the equation for Y_s^{d*} in both specifications [1] and [2], and its marginal effect is negative and significant in [2]. With a better transportation system, particularly in fiscally sound municipalities, even peripheral areas might already be satisfied with their current access to public goods, which likely reflects the level of fiscal soundness. Consequently, such municipalities would be less inclined to pursue a merger.

Let us now discuss the effect of the population distribution. First, in specification [1], the distance between population centroids has the negative and significant effect on Y_s^{d*}. The access to the population centroid of the neighboring municipality might be more important for a fiscally distressed municipality than for a fiscally sound municipality, as the financially distressed municipality might expect to benefit from the PGP of the fiscally sound municipality. Based on the point estimates, an increase in the distance between population centroids by one unit reduces the net value for a distressed municipality to merge with a sound municipality by 19.4 times the effect on a sound municipality. This finding aligns with the theory and the empirical results presented in Weese (2015), which suggest that PGP efficiency increases when the shortest possible distance to the public good (weighted by population of each mesh) in a municipality, if provided at a single location, is reduced.

In specification [2], as a measure of population dispersion, we use average pairwise distance between all 1km-meshes (weighted by population), $R_{d \cup s}$, as defined in equation 11. The coefficient is negative but not significant, while as Table 3 shows the marginal effects is negative and significant, indicating the same tendency as that of the distance between population centroids. In this specification, we also control for population dispersion of each municipality represented by the same measure (i.e.R_d, R_s). As shown in Table 2, the coefficient of R_s is significant in the equation for Y_s^{d*}. It is possible that the more dispersed population distribution would make a fiscally sound municipality to seek for PGP efficiency and might seek for greater scale by merging, where distressed municipality might seek for a merger for PGP efficiency regardless of its level of dispersed population.

Table 2: Results of Poirier Bivariate Probit Analyses.

Dependent variable =1 if a pair of distressed and sound municipality is merged between 2001 and 2011.

Variable$^+$	**Unit**	**[1]**		**[2]**	
		Distress	**Sound**	**Distress**	**Sound**
First-nature Geography Variables, G					
border length	(d, s)	0.330***	0.315***	0.122	0.287***
border altitude	(d, s)	-0.138**	-0.0845	-0.00652	-0.140*
border ruggedness	(d, s)	0.111*	0.000949	-0.0501	0.133
distance between geographic centroids	(d, s)	0.593***	0.305	0.165	0.618
Second-nature Geography Variables, $\tilde{G}$					
D^T=1 if any border meshes contain transportation facilities	(d, s)	0.100	0.307	0.212	0.0802
transport coverage	d/s	-0.442	-0.629*	-0.213	-0.452**
distance between population centroids	(d, s)	-0.658**	0.0414	-	-
avg. pairwise distance among all 1km-meshes (weighted by pop.) R_d, R_s	d/s	-	-	1.80	1.08***
avg. pairwise distance among all 1km-meshes (weighted by pop.) $R_{d\cup s}$	(d, s)	-	-	-0.741	-1.66
Municipal Fiscal Variables, F					
fiscal distress index	d	0.653**	-0.725	-0.753	0.550
fiscal distress index	s	1.06***	-0.0928	-0.0930	0.847
fiscal distress index × fiscal distress index	(d, s)	-0.352***	0.138	0.172	-0.296*
government transfer	d	-1.08*	2.81	3.60	-1.57
government transfer	s	-1.10*	2.58	3.32	-1.49
government transfer × government transfer	(d, s)	0.158**	-0.337	-0.451	0.216
Control Variables, X					
population	d	1.15***	-0.0395	-0.570	0.382
population	s	1.16***	0.260	-0.251	0.344
population × population	(d, s)	-0.137***	-0.0361	0.0236	-0.0539
area	d	-0.152	-0.812	-0.596	0.619
area	s	-0.236	-1.03	-0.120	0.0932
area × area	(d, s)	-0.192	0.132	0.0259	-0.0962
prefecture population	d/s	0.351	-0.448	-0.719*	0.553
prefecture area	d/s	-0.448**	0.719	0.993*	-0.487
Constant	d/s	-3.86	-17.1*	-17.7	2.25
Correlation ρ		0.740		-0.148	
Wald test $\chi^2(1)$		1.15		0.02	
Log pseudolikelihood		-3445.4		-3368.4	

Notes: Authors' calculations based on MLIT data of Japan and other Japanese government statistics. Number of observations is 6967. Cluster-robust standard error is used (clustered by prefecture). $^+$ Variables represent values prior to mergers. Significance levels: * p<0.10, ** p<0.05, *** p<0.01.

Fiscal Variables, F

Consistent with the findings in Hirota and Yunoue (2017, 2020) and Hinnerich (2009), a municipality's fiscal distress level appears to influence the net value of a merger. Based on the coefficients of the fiscal-distress index of both municipalities of a pair and that of their interaction term, the results from specification [1] of Table 2 indicate that the fiscal distress level of the distressed municipality increases Y_d^{s*} only when the fiscal distress level of the relatively sound municipality in the pair is below a certain threshold ($1.96 = \frac{0.653}{0.352}$). However, when the fiscal distress level of the sound municipality exceeds this threshold, the fiscal distress level of the distressed municipality appears to reduce Y_d^{s*}. This suggests that while the distressed municipality views the merger as beneficial under favorable fiscal conditions of the other party, it may perceive the merger as detrimental when the counterpart's fiscal condition is also poor. In specification [2], the coefficient is significant only for the interaction term, and its negative sign suggests that, regardless of the fiscal distress index value, the net utility for a relatively sound municipality in a pair to merge with the other, Y_s^{d*}, decreases as the other municipality becomes more financially distressed. This is further reflected in the marginal effects in Table 3, which indicate that the probability of a municipal merger increases with the fiscal distress index of the sound municipality but decrease with that of the distressed municipality.

Now, let us examine the coefficients for government transfers. The results from specification [1] indicate that the amount of government transfer received by the distressed municipality negatively affects Y_d^{s*} as long as the government transfer to the other municipality in the pair remains below a certain threshold ($6.86 = \frac{1.08}{0.158}$). However, once the government transfer to the other municipality exceeds this threshold, its effect on Y_d^{s*} becomes positive. Marginal effects in Table 3 show the positive effect of the government transfer for both distressed and sound municipalities. We find that the government transfer of both sides of a municipality pair increases the probability for the pair to merge, possibly reflecting the dominant preference for a municipality to keep the current level of government transfer even for a short term, facing the Japanese government' merger promotion policy.

Control variables, X

The effect of the population of each municipality of a pair on the net value of a municipal merger is positive, when the population of the other municipality is below a certain level, which is below the sample average based on our calculation. The merger of two large municipalities seems to decrease the net value of a municipal merger for both sides. The Marginal effects of population on $\Pr(Z_{d,s} = 1)$ shown in Table 3 are negative for both municipalities of the pair.

The results for the municipal area in the bivariate probit model are mixed, but the marginal effects of the municipal area on $\Pr(Z_{d,s} = 1)$ are negative. While these results should be interpreted in conjunction with the coefficients for the prefecture area, they at least suggest that there are costs associated with the merger of two large municipalities.

Table 3: Average of marginal effects on $\Pr(Z_{d,s} = 1)$

Variable^{+}	Unit	[1]	[2]
First-nature Geography Variables, G			
border length	(d, s)	0.0933***	0.0768***
border altitude	(d, s)	-0.0353***	-0.0317***
border ruggedness	(d, s)	0.0230**	0.0242**
distance bw geographic centroids	(d, s)	0.147***	0.155***
Second-nature Geography Variables, $\tilde{G}$			
D^T=1 if any border meshes contain transportation facilities	(d, s)	0.0452***	0.0404**
transport coverage	d	-0.0911	-0.0227
transport coverage	s	-0.0506	-0.100*
distance bw population centroids	(d, s)	-0.132***	-
avg. pairwise distance among all 1km-meshes (weighted by pop.), R_d	d	-	0.191**
avg. pairwise distance among all 1km-meshes (weighted by pop.), R_s	s	-	0.240***
avg. pairwise distance among all 1km-meshes (weighted by pop.), $R_{d \cup s}$	(d, s)	-	-0.448***
Municipal Fiscal Variables, F			
fiscal distress index	d	-0.0225	-0.0346*
fiscal distress index	s	0.0870***	0.0812***
government transfer	d	0.0500**	0.0377
government transfer	s	0.0230*	0.0194
Control Variables, X			
population	d	-0.0570***	-0.0639**
population	s	-0.0322***	-0.0379***
area	d	-0.0550***	-0.0624**
area	s	-0.0878***	-0.130***
prefecture population	d	0.0723*	-0.0766
prefecture population	s	-0.0360*	0.123
prefecture area	d	-0.0923***	0.106
prefecture area	s	0.0578**	-0.108

Notes: Authors' calculations based on MLIT data of Japan and other Japanese government statistics. Cluster-robust standard error is used (clustered by prefecture). $^{+}$ Variables represent the value before mergers. Significance levels: * p<0.10, ** p<0.05, *** p<0.01.

5.2 Comparison of Marginal Effects

In this section, we compare the magnitude of the effects of each variable on the probability of a merger, $\Pr(Z_{d,s} = 1)$. Table B.1 shows the average magnitude of the effect of a 1 standard deviation (s.d.) increase of each variable on $\Pr(Z_{d,s} = 1)$ that are first evaluated for each observation. To highlight the comparison in such magnitude effects between geography and financial variables, here we discuss those of selected variables.

Specifically, a 1 s.d. increase in border length increases $\Pr(Z_{d,s} = 1)$ by 9.80 percentage points (pp) in specification [1] and 8.06 pp in [2]. Considering that the percentage of merged pair is 27.5%, the magnitude effects of a 1 s.d. increase in the border length increase the merger probability almost by one third. Notably, its magnitude is more than twice that of the fiscal distress index in [1] and nearly three times that of government transfers.

Looking at the effects of border altitude, a 1 s.d. increase in border altitude decreases $\Pr(Z_{d,s} = 1)$ by 5.51 pp in specification [1] and 4.95 pp in [2], suggesting that higher altitudes may act as a natural barrier to merging. The magnitude of the effect is again much stronger than those of fiscal distress index and of government transfer.

Turning to the second-nature geography variables, in specification [1], a 1 s.d. increase in the distance between population centroids decreases $\Pr(Z_{d,s} = 1)$ by 8.75 pp, showing that closer population centroids would facilitate a municipal merger.In specification [2], the average pairwise distance among all 1km-meshes within the combined area of a municipality pair, $R_{d \cup s}$, also has a negative impact on the probability of a merger. A one-standard-deviation increase in $R_{d \cup s}$ reduces the probability by 18.68 percentage points, indicating that greater internal population dispersion within a potentially merged area strongly discourages municipal mergers, possibly due to reduced perceived efficiency gains. This effect is the largest among all variables and may have contributed to the insignificance of the coefficients of other variables in the bivariate probit model under specification [2]. These findings highlight that population dispersion plays a crucial role in influencing municipal merger decisions. To further investigate the roles of first- and second-nature geography, future research should examine how much of this population dispersion can be attributed to first-nature geographic factors.

The fiscal variables do have influences on $\Pr(Z_{d,s} = 1)$, while the magnitude of the effects is much smaller than some of the first- and second- nature geography variables. Looking at the effect of government transfers, a 1 s.d. increase raises $\Pr(Z_{d,s} = 1)$ by 3.96 percentage points (pp) for distressed municipalities and 2.13 pp for sound municipalities in specification [1].Again the magnitude of the effects is smaller than those of first- and second- nature geography variables.

6 Conclusion

The Heisei municipal amalgamation, which took place in Japan from the late 1990s to the mid-2000s, significantly reduced the number of municipalities, cutting them to nearly half. The merger of municipalities significantly change the spatial distribution of municipal borders, as nearly 30% of municipal borders disappeared as a result of the Heisei municipal amalgamation. This provides an opportunity to examine the factors that determine which municipal borders persist and which ones vanish.

Focusing on testing the role of geography in the PGP, we utilize geographic variables available at fine spatial unit (i.e., 1km and 250m meshes). We quantify the geographic attributes of each municipality and its borders, classifying them into first-nature and second-nature geographic variables. Our study complements existing research on municipal and school-district mergers (Weese, 2015; Brasington, 2003; Alesina et al., 2000, 2004) by incorporating various geographic attributes to examine their role in the PGP, alongside the commonly studied demographic, social, and fiscal characteristics of municipalities.

While a merger could be motivated by fiscal issues or policies, the PGP efficiency following the merger should be critical. Moreover, the decision to merge inherently involves determining which municipality to merge with. For our empirical examination, we construct a sample of pairwise combinations of municipalities that are geographically adjacent to each other and located within the same prefecture, and we examine the determinants of their likelihood of merging. Our results indicate that both first- and second-nature geography play significant roles in determining the probability of a municipal pair merging. By estimating the coefficients for relatively distressed and sound municipalities within each pair, we also found that the effects of many variables vary depending on the relative level of fiscal distress in the pair.

To assess the role of first- and second-nature geography in greater detail, it would be necessary to investigate how second-nature geographic attributes are determined, particularly in relation to first-nature geography.[21] It is also possible that geographic disintegration across areas has led to spatial cultural differences, which may be partially captured by the effects of first-nature geography identified in our analyses. Despite the relatively small geographic scale, cultural resistance to mergers may still exist in modern Japan. The investigation of these aspects is left for future work.

[21] As highlighted in the human geography literature, including Iyigun (2005), the spatial distribution of population is considered often shaped by geographic factors.

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Appendix

A Regulations Regarding Municipal Merger

The laws on which the merger is based: the Local Autonomy Law (Chihō Jichihō), the Old Municipal Merger Law (Kyū Shichōson Gappeihō), and the New Municipal Merger Law (Shin Shichōson Gappeihō or Shichōson no Gappei no Tokurei ni Kansuru Hōritsu). The New Municipal MergerLaw can be found on on the e-GOV law searching system (See https://laws.e-gov.go.jp/law/416AC0000000059).

To initiate a merger request, a representative of the municipal assembly members must petition the mayor, obtaining at least one-fifth of the signatures. If the municipal assembly of the requesting municipality rejects the merger proposal, the mayor can initiate a voter referendum within ten days. If more than half of the valid votes support the establishment of the merger council, it is considered that the municipal assembly of the requesting municipality has approved the request.

Then, two municipalities establish a merger consultation committee composed of representative members from both. The committee consults the prefecture governor to draft the basic merger plan, including the new name of the municipality, the location of the government office, etc. During this negotiation process, the committee frequently interacts with the prefectural government.

After the basic plan is approved by the prefecture government, the plan needs to be voted again in the assemblies of the two municipalities separately. If the plan is accepted by both municipal assemblies, then the merger plan is required to be voted again at the prefecture assembly until reaching a decision at the prefectural level.

Finally, the prefecture-level decision is considered at the national government, Minister of Internal Affairs and Communications. If the application is accepted, the merger will be finally announced publicly.

B Magnitude of Effects

Table B.1: Change in $\Pr(Z_{d,s} = 1)$ by a 1 s.d. increase of each variable.

Variable (represent value before mergers)	Unit	[1]	[2]
First-nature Geography Variables, G			
border length	(d, s)	0.0980	0.0806
border altitude	(d, s)	-0.0551	-0.0495
border ruggedness	(d, s)	0.0361	0.0380
distance bw geographic centroids	(d, s)	0.0739	0.0780
Second-nature Geography Variables, $\tilde{G}$			
D^T=1 if any border meshes contain transportation facilities	(d, s)	0.0225	0.0201
transport coverage	d	-0.0171	-0.00427
transport coverage	s	-0.00987	-0.0195
distance bw population centroids	(d, s)	-0.0875	-
avg. pairwise distance among all 1km-meshes (weighted by pop.), R_d	d	-	0.0716
avg. pairwise distance among all 1km-meshes (weighted by pop.), R_s	s	-	0.0936
avg. pairwise distance among all 1km-meshes (weighted by pop.), $R_{d \cup s}$	(d, s)	-	-0.187
Municipal Fiscal Variables, F			
fiscal distress index	d	-0.0126	-0.0194
fiscal distress index	s	0.0414	0.0387
government transfer	d	0.0396	0.0298
government transfer	s	0.0213	0.0180
Control Variables, X			
population	d	-0.0809	-0.0907
population	s	-0.0386	-0.0455
area	d	-0.0485	-0.0550
area	s	-0.0829	-0.123
prefecture population	d	0.0395	-0.0418
prefecture population	s	-0.0197	0.0672
prefecture area	d	-0.0497	0.0571
prefecture area	s	0.0312	-0.0582

Notes: Authors' calculations based on MLIT data of Japan and other Japanese government statistics. The calculations are based on the average marginal effects of each variable, as shown in Table 3.