

# ENTREPRENEURIAL NETWORKS IN TOCHIGI PREFECTURE DURING THE MEIJI PERIOD: UNRAVELING REGIONAL DEVELOPMENT DISPARITIES FROM HUMAN CONNECTIONS

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**Abstract.** *As the world strives to reach new realms in sustainability, education and innovation, the topics of geopolitics, social impact and regional entrepreneurship have attracted attention globally, both in corporate and academic environments. This paper further explores these topics, while describing how some of these key elements have contributed to spatial economics, innovation, leadership and social impact in a Japanese organization.*

**Keywords:** *Social, Impact, Entrepreneurship, Japan, Geopolitics, Sustainability, Strategy*

## 1. INTRODUCTION

Fujita and Thisse (2013) attempted to explain the reasons for the concentration of population and wealth from the perspective of spatial economics. Toyoda (2013), from the perspective of economic geography, analyzed estimated values of population and income, stating that population movement expands regional disparities in economic scale. Both focus on people, but they view employees from the perspective of their proportion of the total population. Since executives determine a company's operating policies, it is necessary to focus on executives when considering their impact on the economy. Some executives hold positions in multiple companies, forming networks through these individuals. This study explores the causes of disparities in regional development by analyzing the human networks constructed by these executives.

Suzuki et al. (2009) and Minami (2016) focused on human connections and attempted to identify individuals who contributed to economic development using entrepreneurial networks. However, they only counted the number of concurrent executive positions.

Watahiki et al. (2023) conducted a centrality analysis of networks in Niigata Prefecture in 1897. By creating a heatmap based on executive addresses, they visualized the characteristics of executive connections on a map. As a result, they discovered that entrepreneurial networks in Niigata Prefecture have regional

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characteristics. However, since the analysis was for a single year, time-series analysis such as decline or development is insufficient.

This study visualizes connections in Tochigi Prefecture data, similar to Watahiki et al. (2023). Data from 1902, 1907, and 1912 will be analyzed to observe changes over a decade. This will investigate whether the regionality of entrepreneurial networks is a characteristic unique to Niigata Prefecture. Furthermore, the relationship between three types of centrality and their strengths and weaknesses will be examined in relation to economic development.

## **2. METHODS**

### **2.1. Data Sources and Processing**

The "Directory of Executives of Companies Nationwide in Japan" is treated as the data source. This document contains information such as company names, locations, capital, directors, and executive addresses for companies established throughout Japan during the Meiji period. Although there are typos and missing data, it is a valuable historical document that covers all of Japan during the Meiji period.

Regarding typos, if the Levenshtein distance was 1 or less and the person could not be confirmed as a different individual by referring to the official gazette, they were treated as the same person. However, if the Levenshtein distance was 1 or less but the two individuals belonged to the same company, they were treated as different individuals.

Among the listed individuals, there are not only executives but also staff members. In this study, to focus on the analysis of executives, it is necessary to distinguish them. According to Suzuki et al. (2009), directors, auditors, executive officers, advisors, presidents, supervisors, and consultants were treated as executives for joint-stock companies. After differentiation, staff data was excluded from the database.

### **2.2. Analysis Target**

For the Tochigi Prefecture portion of the data source, the 1902, 1907, and 1912 editions were put into a database to create entrepreneurial networks. Major events during this period include the outbreak of the Russo-Japanese War between 1902 and 1907, and the annexation of Korea between 1907 and 1912. Under these circumstances, industries related to import and export were greatly affected. At the same time, this was also a period when the center of transportation within Japan shifted from water transport to railways. Given that this was a transitional period for Japanese industry, the data from 1902, 1907, and 1912 were deemed suitable for time-series analysis.

### **2.3. Centrality Analysis**

As stated by Kanemitsu (2003), centrality analysis is highly practice-oriented and has yielded results in various organizational studies in politics and economics. Centrality analysis was performed on the network created in 2.1 to obtain three types of centrality. To ensure consistent conditions, the three types of centrality used were degree centrality, betweenness centrality, and eigenvector centrality, similar to Watahiki et al. (2023).

Degree centrality gives higher scores to nodes with more connections. In human networks, individuals with many acquaintances fall into this category. Betweenness centrality gives higher scores to nodes through which more shortest paths

pass when connecting all pairs of nodes. In human networks, individuals who bridge groups fall into this category. Eigenvector centrality considers the importance of connected nodes. That is, it gives higher scores for connections to important nodes with high degrees. In human networks, politicians often have strong eigenvector centrality.

The calculation methods for degree centrality and betweenness centrality followed Wasserman and Faust (1994), and the calculation method for eigenvector centrality followed Bonacich (1972).

#### **2.4. Increase and Decrease in the Number of Companies**

For time-series analysis, we define regional development and decline. Here, the number of companies is used as an evaluation index. We use data from 1902, 1907, and 1912 for municipalities in Tochigi Prefecture. Since dealing with all municipalities would be too extensive, municipalities with 4 or fewer companies in any given year were excluded. As mentioned later, Ujiie Town is an exception despite having a small number of companies. Regions with a small number of companies are almost always not displayed on the heatmap. Regions where the number of companies increased were considered developed regions, and regions where it decreased were considered declining regions.

### **3. HEATMAP**

A heatmap is a data visualization method that expresses the magnitude of numerical values using color intensity. In this study, we used QGIS (Quantum GIS), a geographic information system software, to create heatmaps of executive distribution, weighted by each centrality from 2.3.

The internal boundaries of each prefecture are based on administrative divisions in 1919, obtained from the National Land Numerical Information download site<sup>1</sup>. This is the oldest available data, and there were no significant changes from the 1912 boundaries, so the 1919 data was adopted.

To ensure comparability, each centrality was normalized.

#### **3.1. Heatmap (Degree Centrality)**

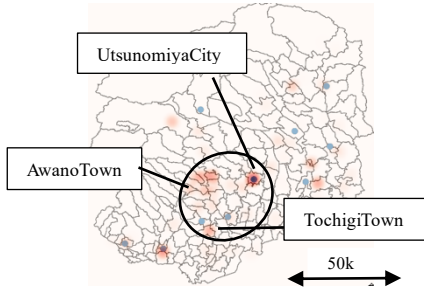
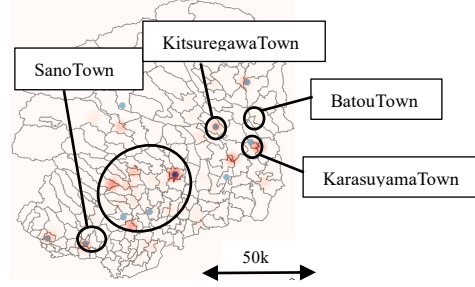
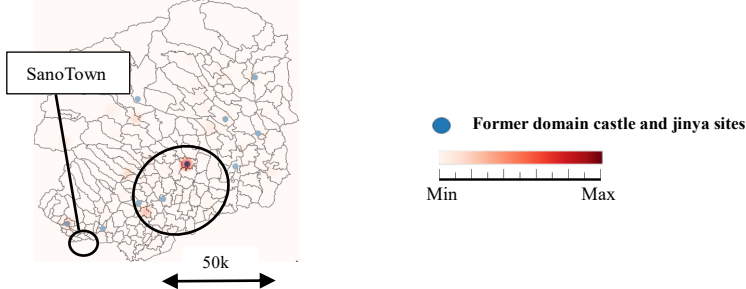
Figures 3.1.1 to 3.1.3 are heatmaps of executive distribution weighted by degree centrality, for 1902, 1907, and 1912, respectively.

From Figures 3.1.1, 3.1.2, and 3.1.3, it can be seen that degree centrality is strong in the central, western, and southern parts of the prefecture (within the black ellipse in the figures). This area included Utsunomiya City, Awano Town, and Tochigi Town.

As shown in Figures 3.1.1 and 3.1.2, Sano Town had high centrality in both 1902 and 1907. However, as shown in Figure 3.1.3, centrality is barely present in 1912. In 1912, centrality is weaker in most regions compared to previous years. This is also true for Awano Town and Tochigi Town within the ellipse. What is the difference between Awano Town and Tochigi Town, where centrality continues to appear weakly, and Sano Town, where centrality has almost disappeared?

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<sup>1</sup> National Land Information Division, National Spatial Planning and Regional Policy Bureau, MLIT of Japan (<https://nlftp.mlit.go.jp>) AccessDate 2025.05.07

**Figure 3.1.1.** 1902 Heatmap (Degree)**Figure 3.1.2.** 1907 Heatmap (Degree)**Figure 3.1.3.** 1912 Heatmap (Degree)

*Source:* author's own preparations based on data collected from internal materials and participatory observation.

### 3.2. Heatmap (Betweenness Centrality)

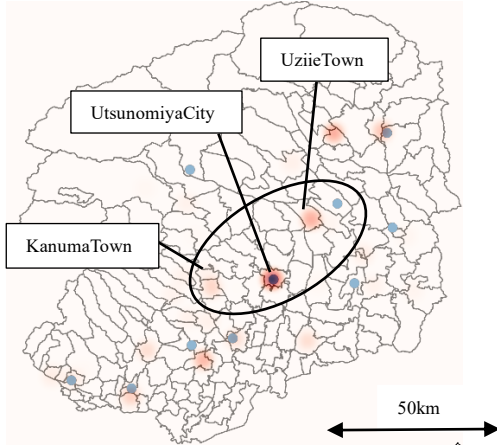
Figures 3.2.1 to 3.2.3 are heatmaps of executive distribution weighted by betweenness centrality, for 1902, 1907, and 1912, respectively.

From Figures 3.2.1, 3.2.2, and 3.2.3, it can be seen that betweenness centrality is strong in the central part of the prefecture (within the black ellipse in the figures). This area included Utsunomiya City, Kanuma Town, and Ujiie Town.

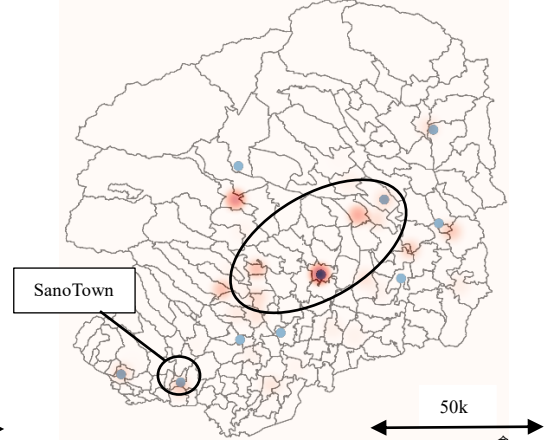
Ujiie Town has a small number of companies and resident executives, and its degree centrality is weak, but its betweenness centrality is strong. This is likely due to the presence of Kiheiiji Takizawa, a prominent businessman residing in Ujiie Town. He was known as a powerful businessman nationwide and was cited by Suzuki et al. (2009) as a person with many concurrent company positions.

Regarding Sano Town, similar to degree centrality, its centrality was strong in 1902 and 1907 but weak in 1912. While centrality in various regions weakens in 1912, the number of regions where it weakens is smaller compared to degree centrality.

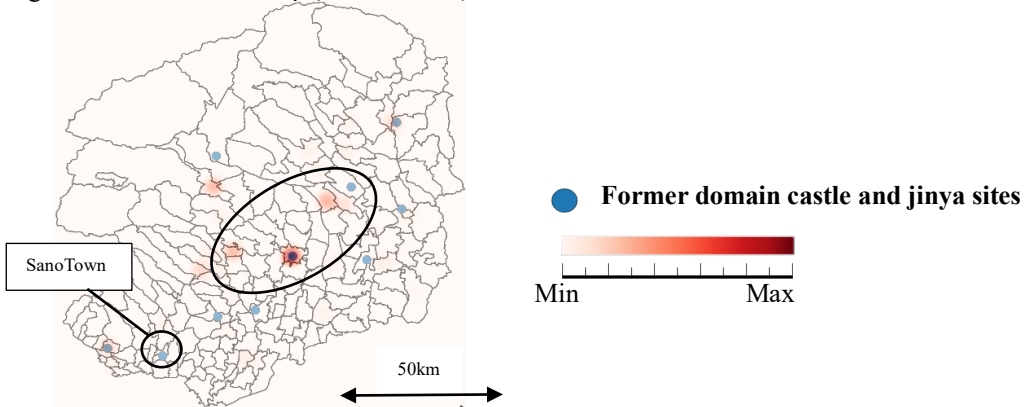
**Figure 3.2.1. 1902 Heatmap (Betweenness)**



**Figure 3.2.2. 1907 Heatmap (Betweenness)**



**Figure 3.2.3. 1912 Heatmap (Betweenness)**



*Source:* author's own preparations based on data collected from internal materials and participatory observation.

### 3.3. Heatmap (Eigenvector Centrality)

Figures 3.3.1 to 3.3.3 are heatmaps of executive distribution weighted by eigenvector centrality, for 1902, 1907, and 1912, respectively.

Eigenvector centrality shows a different pattern from the other two. In 1902, centrality was strong around Kanuma Town but weak in 1907 and 1912. In 1902, centrality was barely present in both Utsunomiya City and Ashikaga Town, but it was strong in 1907 and 1912.

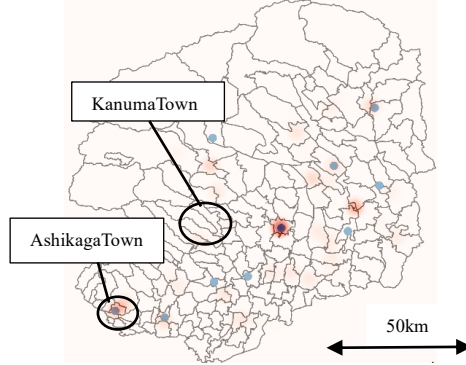
In 1902, eigenvector centrality was concentrated around Kanuma Town, but in 1907, it was scattered across various locations. In 1912, it concentrated again, but this time in Utsunomiya City instead of Kanuma Town.

The distribution of eigenvector centrality tends to appear most locally among the three types of centrality examined in this study.

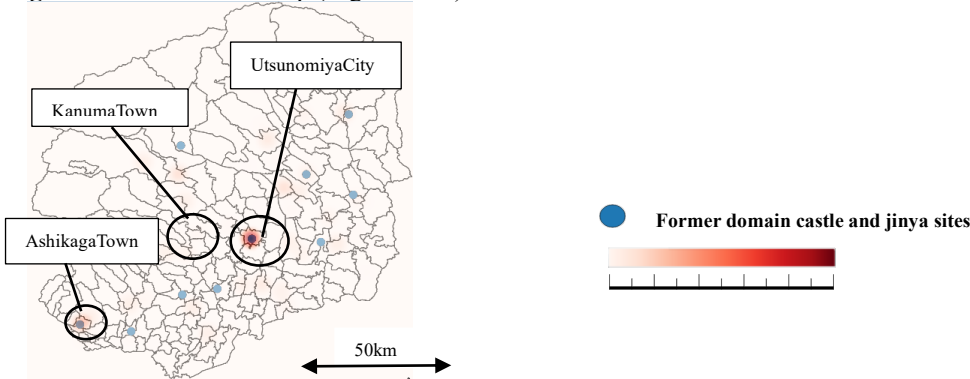
**Figure 3.2.1.** 1902 Heatmap (Eigenvector)



**Figure 3.2.2.** 1907 Heatmap (Eigenvector)



**Figure 3.2.3.** 1912 Heatmap (Eigenvector)



Source: author's own preparations based on data collected from internal materials and participatory observation.

Since each type of centrality shows a different pattern, it is clear that entrepreneurial networks in Tochigi Prefecture also have regional characteristics. Furthermore, the strong centrality that persists over the years varies by region. This indicates that the strength and weakness of centrality are not due to random distribution bias but are based on regional characteristics.

**4. TIME-SERIES ANALYSIS**

In 3.1 to 3.3, heatmaps were created from three years of data for each centrality to visualize changes over time. Here, we classify regions as developed or declining according to 2.4 and perform time-series analysis in conjunction with the heatmaps.

**Table 1.** Transition in the Number of Companies

	UtsunomiyaCity	TochigiTown	KanumaTown	SanoTown	OtawaraTown	KarasuyamaTown	AshikagaTown
In1902	15	6	6	5	5	3	2
In1907	24	9	5	5	5	7	6
In1912	31	17	6	8	5	6	11
	AwanoTown	BatouTown	MotegiTown	MokaTown	UjiiieTown	KitsuregawaTown	
In1902	2	2	1	1	1	0	
In1907	4	6	7	3	3	5	
In1912	6	5	11	5	4	2	

Source: author's own preparations based on data collected from internal materials and participatory observation.

Table 1 shows the number of companies in major municipalities in Tochigi Prefecture in 1902, 1907, and 1912. Between 1902 and 1907, the number of companies increased in all regions except Kanuma Town, Sano Town, and Otawara Town. Therefore, regions where the number of companies decreased between 1907 and 1912 are treated as declining regions. These are Karasuyama Town, Bato Town, and Kiguregawa Town. Regions where the number of companies continuously increased between 1902 and 1912 are treated as developed regions (Sano Town is also included here). These are Utsunomiya City, Tochigi Town, Sano Town, Ashikaga Town, Awano Town, Motegi Town, Moka Town, and Ujiie Town, a total of 8 regions. For Kanuma Town and Otawara Town, the change in the number of companies is small, and the number of companies remains the same between 1902 and 1912, so they are treated as stable regions here.

We compare the heatmaps from 1902 to 1912 for each centrality. In declining regions (see Figure 3.1.2 for locations), centrality strengthened between 1902 and 1907, then weakened towards 1912. Alternatively, it was too weak to appear in any year. In developed regions, Utsunomiya City shows strong centrality in all figures except Figure 3.3.1. As shown in 3.1 and 3.2, centrality in Tochigi Town and Sano Town weakened between 1907 and 1912.

## 5. DISCUSSION

Regions with strong centrality differ for each type of centrality, but Utsunomiya City consistently shows strong centrality, except for Figure 3.3.1. We considered that Utsunomiya City being the prefectural capital might be a factor, but in Watahiki et al. (2023), centrality was stronger in Nagaoka City than in Niigata City, suggesting that being the prefectural capital is not the sole determinant. Table 2 shows the population of Utsunomiya City, Tochigi Town, Kiguregawa Town, Ujiie Town, and Karasuyama Town in 1911. From Tables 1 and 2, it can be seen that Utsunomiya City has a larger population and number of companies compared to others. This might suggest an influence on the concentration in Utsunomiya City. However, there is a counterexample. Figure 3.1.2 shows that between Kiguregawa Town and Karasuyama Town, Karasuyama Town has stronger centrality. As shown in Table 1, Karasuyama Town has more companies, but as shown in Table 2, its population is about 55% of Kiguregawa Town's. Also, Utsunomiya City's population is about 10 times that of Karasuyama Town, but the difference in centrality strength does not appear to be equivalent. Regarding the number of companies, Tochigi Town has more than Karasuyama Town, but Karasuyama Town has stronger centrality. Therefore, regional characteristics cannot be explained solely by population or the number of companies.

**Table 2.** 1911 Population

Utsunomiya City	Tochigi Town	Kiguregawa Town	Ujiie Town	Karasuyama Town
50885	23528	8942	7368	4928

*Source:* Created by the authors based on data from “Tochigi Prefecture Statistical Report.”

Ujiie Town is not a large town in terms of both the number of companies and population. While its degree centrality and eigenvector centrality are both weak, only its betweenness centrality is strong. This is likely influenced by the presence of Kihei Takizawa, one of Tochigi Prefecture's leading businessmen during the Meiji period.

Kiheiji Takizawa resided in Ujiie Town and belonged to 11 companies within the prefecture in 1907, thus possessing a very strong influence. In fact, when ranking executives by centrality, he is among the top few in betweenness centrality. This suggests that regional characteristics are susceptible to the influence of highly influential individuals.

From the heatmaps, it is clear that most regions with strong centrality are located on or around the sites of former clan castles and jinya (administrative headquarters) from the feudal era. This suggests the influence of connections and urban functions accumulated during the former feudal period. The government may have been able to change municipal boundaries and the residents belonging to them, but it may not have been able to change their connections or their original sense of belonging to a community. Therefore, it is believed that the influence of the former feudal domains remained strong even more than 30 years after the abolition of the han system and establishment of prefectures.

In section 4, Tochigi Town was cited as an example of a developed region where centrality weakened. While the heatmaps indeed suggest a weakening of centrality, is this truly the case? Comparing the heatmaps of 1907 and 1912, centrality appears to weaken in all regions except Utsunomiya City across all types of centrality. However, considering that these heatmaps provide a relative assessment, another interpretation is possible. That is, Utsunomiya City's centrality is overwhelmingly strong, but other regions are not necessarily weak. This study used normalization to ensure comparability, performing a relative assessment. Based on these results, when considering regions with excessive concentration like Utsunomiya, the use of absolute assessments should also be considered.

## **6. CONCLUSION**

For entrepreneurial networks in Tochigi Prefecture, centrality analysis was conducted to determine three types of indicators. Heatmaps of executive distribution weighted by the obtained centralities revealed that each centrality had a different pattern of appearance. This indicates that each centrality has regional characteristics in its connection patterns, which is consistent with the results of Watahiki et al. (2023).

For time-series analysis, heatmaps were created and compared using data from 1902, 1907, and 1912. For each centrality, there were regions where centrality consistently appeared across multiple years. This implies that the regionality of the network is not due to accidental distribution bias. Furthermore, as shown in section 5, regionality cannot be explained by population or the number of companies alone.

To investigate the causes of disparities in regional development, we observed changes in heatmaps and the number of companies over a decade. As shown in section 4, in some regions, changes in the number of companies and changes in centrality strength were linked. While it was thought that the strength or weakness of centrality might affect regional development or decline, there were also regions like Tochigi Town where the number of companies increased but centrality weakened. From the current results, no relationship was found between the strength or weakness of centrality and economic development.

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