



The determinants of airline networks in the island regions of Japan

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ABSTRACT

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This study aims to show the determinants of the airline's networks in Japanese island regions. Transportation systems are generally needed for residents in island regions to maintain their livelihood. Meanwhile, it is also necessary for people who live in outside regions such as tourists. Therefore, the transportation systems would be significant to maintain both tourism industries and the social situations in many of islands in Japan. This study, first, applied the network analysis to verify the nexus of connections among the transportation network in island regions in Japan. Degree centrality was calculated, and the result shows that some islands which is well-known as the tourism destinations located in southern part of Japan obtained many of connections to other places including other islands, as well as the mainland. Then regression model with the result of network analysis was composed and estimated by maximum likelihood method. The outcome shows that the situations of island society such as aged problem and economy in the islands would be influenced to maintain the airlines, as well as the amount of tourism demand. From these results, this paper concluded that both internal situations of island society and the tourism demand would be important to maintain island's transportation system.

Contribution/Originality: This study aims to focusing on the airline networks in Japanese island regions with quantitative approach. This study would be contributed as the literature for policy making of small regions such as islands.

1. INTRODUCTION

The transportation system has been considered critical for island regions' economic and social sustenance. Briguglio (1995) highlights that island face disadvantages in economic development, with remoteness being a key factor. While Briguglio's research focused on small, developing island states, this concept is applicable to all island regions of Japan.

Japan has several island regions. According to the Center for Research and Promotion of Japanese Islands, there are more than 400 inhabited islands in the country. Of them, five, namely, Hokkaido, Honshu, Shikoku, Kyusyu, and Okinawa, are generally referred as the Japanese mainland. Kakazu (2014) considers the definition of islands in Japan to be influenced by the Remote Island Development Act of 1953. The act has designated the 258 islands where people reside and promoted the livelihoods of these targeted areas. Furthermore, other special acts have designated the Okinawa, Ogasawara, and Amami islands as other island areas. Following the development acts that have promoted the growth of infrastructure or transportation systems in most Japanese islands, the standard of living and economic disparity between these islands and the mainland have been found to have improved.

This study seeks to examine the relationships between airline networks in Japanese island regions and social factors such as internal situations or tourism demand. Accessibilities in these islands are related to tourism, which is a significant sector, as well as the livelihood.

As Suzuki (2019) mentioned, the promotion of the movement of population is regarded as a common agenda in most of the islands. Since airplane networks are a key driver in the promotion of population movement within the transportation system, this study focused on airplanes networks to measure the accessibility of these islands.

2. LITERATURE REVIEW

Previous studies of accessibilities that have utilized network analysis have primarily focused on urban transportation. For example, Kuzuya (1980) and Ogata (1980) applied network analysis to determine urban transportation systems, such as bus and train accessibilities, in Japan. In contrast, Murayama (1982) analysis of accessibility shifts in air passenger flow in Canadian urban areas found that the number of air passengers had gradually increased with the development of urban systems. Conversely, network analysis has been used to consider the effect of zoning on tourism flows (Yabe, 2013).

In this study, the destinations in Japanese prefectures were divided into two or three regions using the community clustering method. The study primarily examined the transportation systems of urban areas to determine their spatial structures and development using network analysis, which, in turn, shed light on the spatial structures, key areas of transportation, and accessibility.

Transportation in island areas is significant because of their regional characteristics. Spilanis, Kizos, and Petsioti (2012) argue that islands in Greece that have assignments, particularly in small islands, use calculated indicators to measure their accessibility. In addition, Karampela, Kizos, and Spilanis (2014) revealed that accessibility is not related to geographical distances, and that transport modal choices are necessary for island regions in Greece, although small islands still have accessibility issues. Moreover, taking advantage of network techniques, Makkonen, Salonen, and Kajander (2013) found that despite the existing transportation networks in the Finnish archipelago, there were spatial mismatches between population distributions and transport opportunities. These studies argue that geographical distance is one of characteristics that demonstrates the transportation network issues in the island regions of these countries.

Accessibility and transportation issues are also crucial themes in the islands of Japan (Miyauchi, 2007). They are directly affected to the livelihoods of residents. According to Miyauchi (2001), while the most of residents in the islands could return to their homes within a day when they visited nearby cities, residents of 33 islands (out of 255) could not commute to nearby cities.

This study highlights the fact that Japanese islands also face disadvantages related to transportation systems, although the frequency of these issues is low. Accessibility to nearby cities is also an important issue to address in order to help societies develop their internal economies. Furthermore, transportation systems are significant for the promotion of tourism. Ozawa (2015) discussed the tourism policy of the island regions of Japan using a regression model. His study found that accessibility is one of the key factors that enable the development of tourism in island regions.

This study aims to demonstrate the nexus of air transportation networks with regard to social situations and tourism demand in Japanese islands. First, this paper uses network analysis to calculate centrality and indicate which islands are importance in airline networks. Following this, the regression model that was composed using network analysis results was carried out to estimate the relationships between the island's social situations and tourism demand. This was done to identify the significance of the transportation systems.

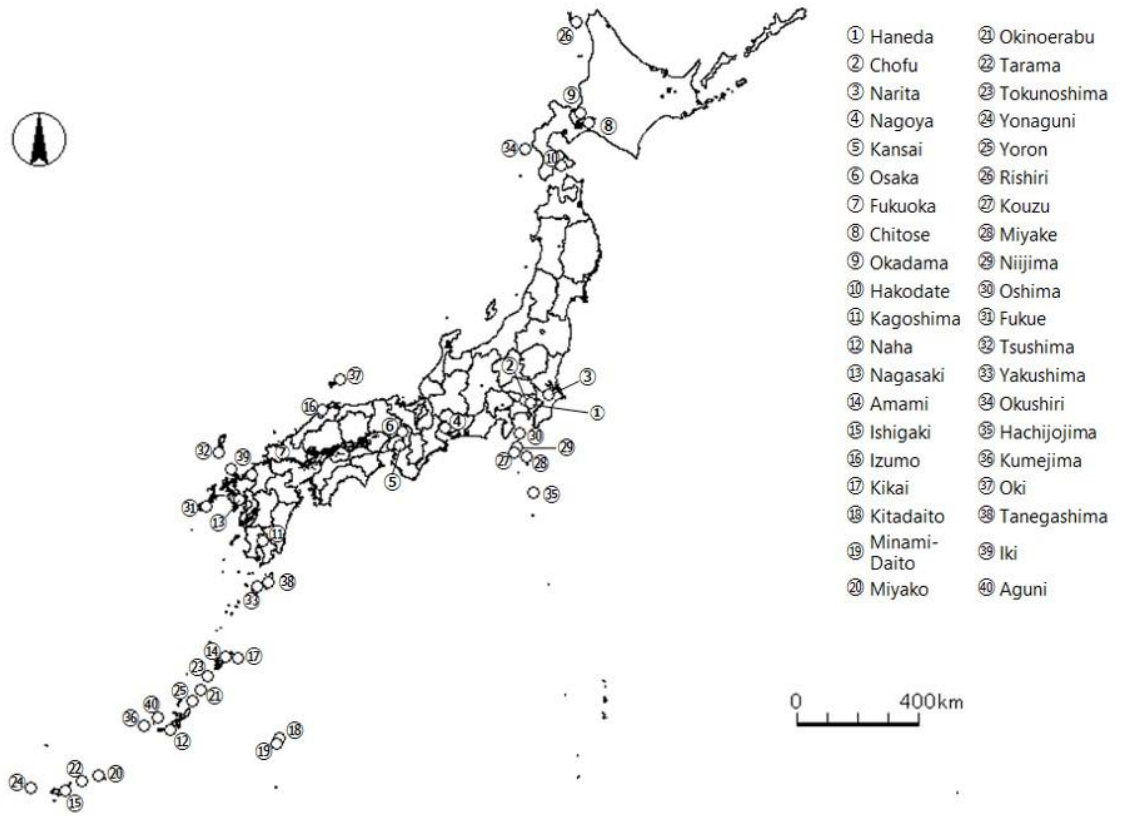


Figure 1. The map of airport.

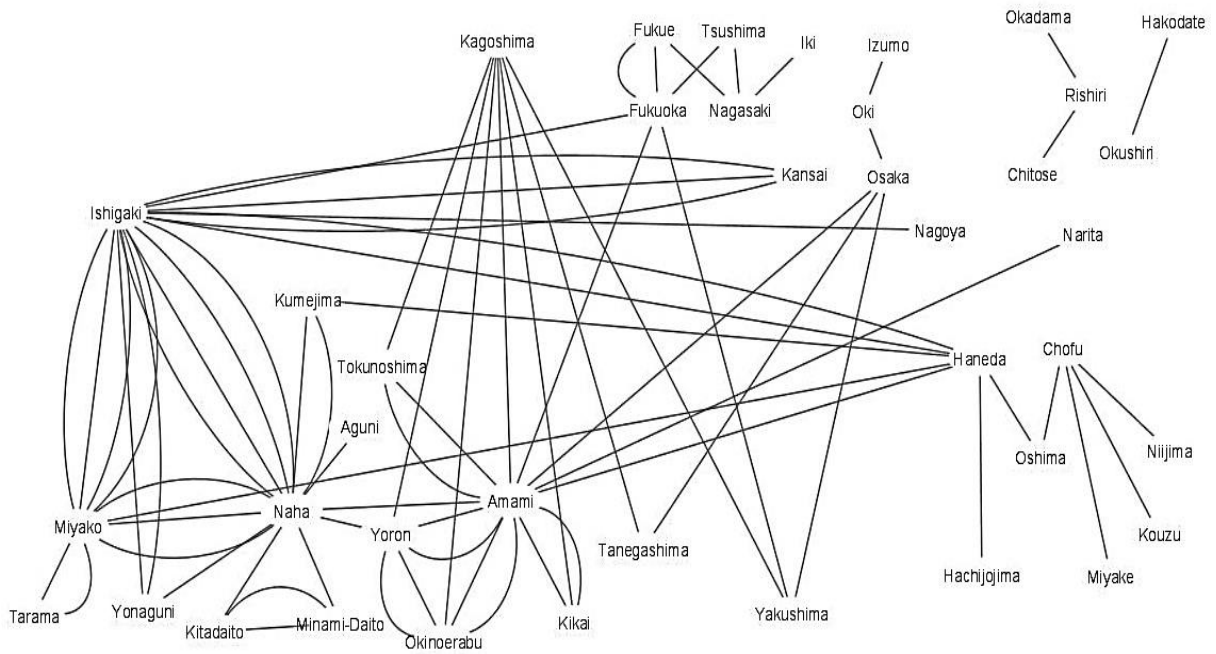


Figure 2. The network of airlines.

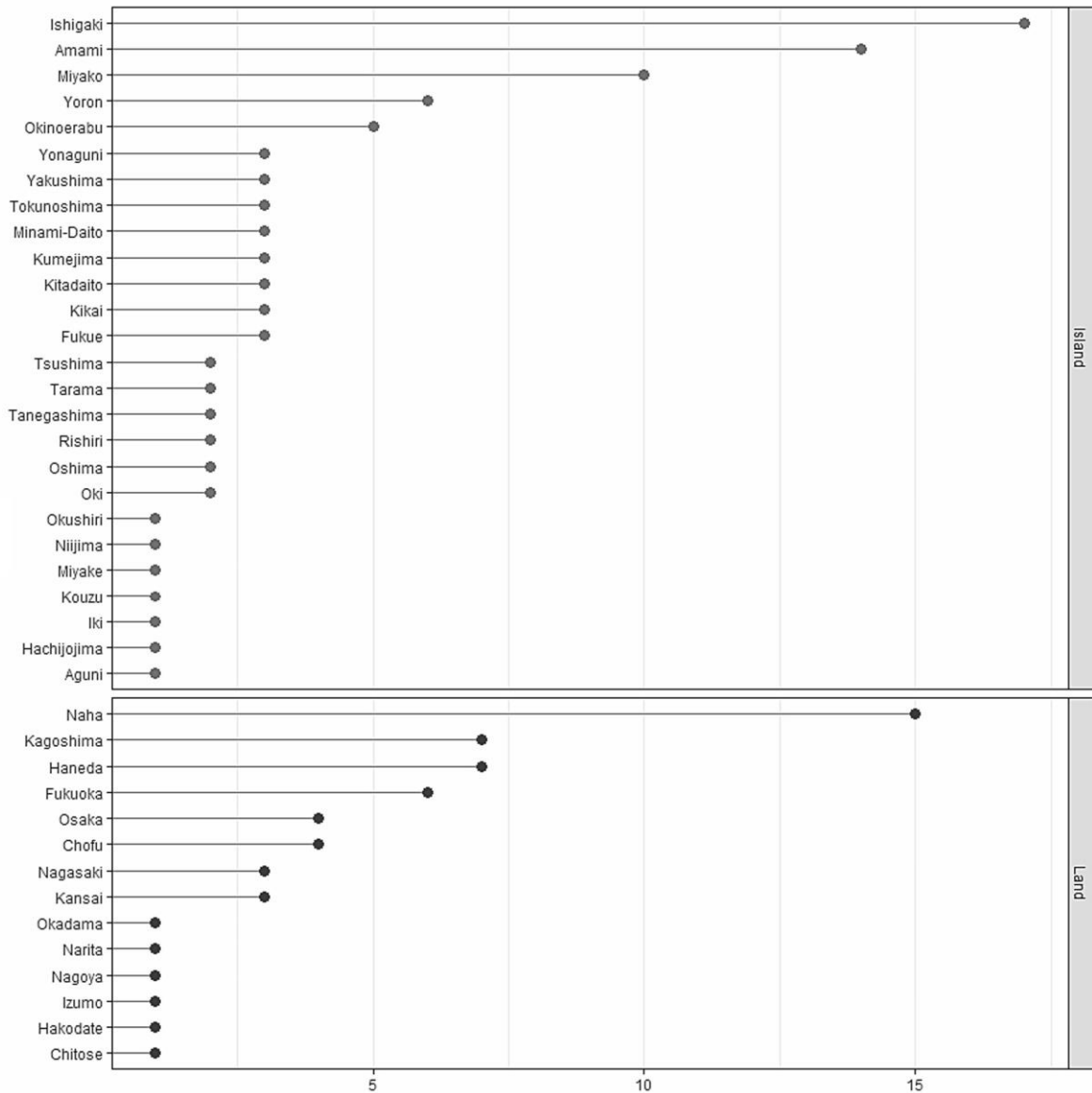


Figure 3. The result of degree centrality.

2.1. Data Description of Airline Networks in Japan

This study used statistical data published by the Center for Research and Promotion of Japanese Islands (2019). This collection of public statistics data from the island regions in Japan is called the Ritou Toukei Nennpou (Annual Report of Statistics in Islands). The data also included the location of airports and air transportation data from 2015 to 2016.

Figure 1 presents the locations of the airports targeted by this study, and Figure 2 demonstrates the network of airlines. The locations are classified into two—the airports in the islands, and the mainland. The figures that illustrate Amami, Ishigaki and Miyako demonstrate a significant number of connections. These islands are located in southern regions such as Kagoshima and Okinawa, prefectures that are made up of a large number of islands. These islands are primarily connected to urban areas, such as Tokyo (Haneda) or the Okinawa mainland (Naha). Figure 3 summarized the degree centrality to demonstrate the number of the connections and importance of the networks. The graph is divided into two groups—the airports in the islands, and those in the mainland—as origin points. The number of the connections in Amami-Oshima was 14. Besides, Ishigaki and Miyako in Okinawa prefecture had 17 and 10 of each. Meanwhile, Naha in Okinawa mainland had 15 and Haneda and Kagoshima had 7

as origin points. These airports connect several regions, and they are considered significant points for the Japanese island airplane network.

The islands with degree centralities that obtained high values were popular tourism destinations. Meanwhile, those that had several connections between urban areas and nearby islands were indicated as the result of the network analysis. Many of tourists traveling from urban areas were considered, as well as those traveling for business purposes or logistics. For example, people who live in the close islands may be used these airlines for logistics and business purpose because that islands may have any market for them. Thus, it is considered that the airlines are utilized for several purposes because of the regional characteristics, such as size of the economy or social situations.

2.2. Regression Model

A regression model was composed to demonstrate the determinants of the degree centrality, which demonstrates the importance of island airline networks across Japan. The number of connections to other places was interpreted as accessibility for residents and tourists. As indicated by the network analysis, several customers used the airlines for several purposes, that ranged from tourism to business. Thus, this paper considers the estimation model as below.

$$\text{Degree} = f(\text{Tourism Demand}, \text{Population Density}, \text{Aged Rate}) \dots 1$$

'Degree' is the response variable and indicates the degree of centralities, which is the number of the connections to other places in each of islands. Although the number of the nodes in the airline networks was 40 in total, this analysis targeted 26 islands for this model.

This paper selected three explanation variables to estimate the relationships to the degree of centralities. First, 'Tourism Demand' comprised of variables for tourism demand in each of the islands. Accessibilities could be significant for many tourists on the basis of their choice of destination. Therefore, many of airlines may be connected to the islands if there was more tourism demand. Island regions were generally considered disadvantageous because of their locational conditions; however, high tourism demand was influenced by transportation networks.

Meanwhile, 'Population Density' was used as an alternative variable to indicate the level of urbanization. Airlines are not only utilized for tourism, but also for business and logistics. If several industries were accumulated, airlines would be increased since people who used by these purposes exists more. Meanwhile, 'Aged Rate' indicates the variables for social situations in islands. Although an ageing society is an issue that encompasses all of regions in Japan, the situation in islands is also significant. It is considered that society in many of the islands may weaken if this rate increased. This negative impact may influence the airline networks since both economy and people's attraction to islands would decline.

These explanation variables were also referred to in the Annual Report of Statistics in Islands published in 2019. The tourism data was drawn from 2015 to 2016. Additionally, data for population densities and rate of aged citizens were drawn from the 2015 national population census.

The response variable of this model included a count data, which was composed by counting numbers. In count data, it is considered that normal distribution, such as ordinary least squares would be unsuitable for estimation. Therefore, the estimation method for a regression analysis was carried out with maximum likelihood estimation, whereby the probability distribution for error structure of response variable was assumed. This paper carried out two types of probability distributions; the Poisson distribution, and the negative binomial distribution. Poisson distribution is generally used to estimate the count data of response variables. However, the estimation method with discrete data, such as count data, could be concerned of overdispersion, which is more variance than assumptions. In Poisson distribution, the assumption of variance equals to the expectation values on the estimation model. Thus, this paper also demonstrates the result of the negative binomial distribution, which assumed that variance was more

than the Poisson distribution. To indicate the robustness of the results, this paper estimates two types of probability distributions.

Table 1. The result of regression model.

	Poisson	Negative binomial
(Intercept)	-1.024 1.094	-0.997 1.128
log(Tourist)	0.209*** 0.07	0.206*** 0.072
log(POP_DEN)	0.387** 0.186	0.391** 0.193
Rouka_Rate	-0.062*** 0.016	-0.062*** 0.017
logLik	-47.935	-47.889
AIC	103.87	105.778
Num.obs	26	26

Note: Standard errors shown in parentheses.
Num. obs: Number of observations.
Significance level *** $p < 0.01$, ** $p < 0.05$.

2.3. Result of Regression Model

Table 1 demonstrates the result of the estimation model. Both the Poisson and negative binomial models obtained similar results. Both log likelihoods were -47.94, as assumed by Poisson distribution, and -47.89 in assumed by negative binomial distribution, respectively. Akaike Information Criteria (AIC) indicated similar values as 103.87 in the Poisson model and 105.78 in the negative binomial, respectively.

The coefficients also indicate similar results. 'Tourism', which includes variables for tourism demand, was statistically significant, and the coefficient was positive in both models. This implied that airline connections would increase if the tourism demand increased. Furthermore, 'POP_DEN', which is the variable for population densities, was also significant and positive. This result indicates that airline networks would affect the accumulation of industries. Meanwhile, 'Aged Rate', which was indicated the rate of the aged population (those over 65), was statistically significant but had negative coefficients. Hence, the airline networks would decrease when the aged rate in islands was increased. From these results, social and economic factors were also important perspectives for airline networks, as well as tourism factors.

3. DISCUSSION

The network analysis results demonstrate that islands with several airline connections tend to be popular tourism destinations. Therefore, the regression model also demonstrates that the variable for tourism demand was significant statistically and increased the possibilities that several airlines connected. These results may indicate that the promotion of tourism demand for islands was related to their transportation systems, and it could also be necessary to maintain the transportation systems in island regions.

In the meantime, airlines were used for several purpose, such as business and logistics. From this viewpoint, this paper considers that airline is not only influenced by social and economic situations in islands, but also tourism. Thus, variables for economy and social situations were added to the regression model to estimate the effect to the degree centralities of airline networks in island regions. Population density, which indicated the variable of economic degree, was statistically significant, and indicated the tendency to increase the importance for airline networks. This result inferred that other economic sectors that did not comprise tourism were also important in the maintenance of airline networks, since the expansion of the industries would promote the population movement and

logistics. Although it is difficult to open up large-scale industries in island regions, it might be possible to develop manufacturing sectors such as food sectors, since, for instance, some islands have own resources for food processing.

Meanwhile, the aged population, which is for the variable of social situations was also significant, but the coefficient was negative. From this result, it may be noted that the increase of aged population would decrease airline linkages. Hence, it is considered that social decline influenced the transportation systems of island regions. It is not easy to prevent depopulation and fertility decline, which are issues faced not only by the island regions. However, population movements, which are not only for the purpose of tourism, might have a possibility to keep up the communities. For example, some regions try to drive migration policies, such as the U-turn or the I-turn, especially for young generations. Generally, they work for a few years in the community and prepare their own businesses in order to settle down during that period. The result of the estimation model indicate that these policies might be affected by the transportation system.

4. CONCLUSION

This study considered the transportation systems network of the island regions of Japan. Using network analysis, this paper found that islands that are well known as tourism destinations have a lot of connections to other places in urban areas and other nearby islands. Thus, this paper composed a regression model to demonstrate the relationships between airline networks and tourism demand. Furthermore, social and economic factors, such as population density and aged population, were also included in the estimation model, since these factors could be influenced to the transportation systems in island regions.

The regression model that used the maximum likelihood method demonstrated the significance of all the variables. The variables of tourism demand and population densities indicate positive coefficients. Thus, it was found that the number of airlines increased, and that the accessibilities would be improved when both factors increased. Several purpose users utilized the airline for islands, and the market size or economic level of the area would be influenced by the situation of transportation. Hence, these factors might be improvement to maintain accessibility for these islands. Meanwhile, the issue of the aged population is not significant to transportation systems since the variable was negative. Although it is difficult to prevent the growth of the ageing society, migration policies, such as the U-turn and I-turn, might be helpful for communities, since it is considered that the maintenance of community in island regions is related to the transportation system. Better accessibility would affect the lives of residents and tourism promotion. Hence, this paper considered that the maintenance of the transportation system is crucial agenda for island regions.

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