Discovering relation of railway route and national economy using statistical and remotely sensed dataset

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ABSTRACT: This study aims to find out the role of highways on economy in the surrounding areas in Japan. Even Among various transportations, focusing on highway network is important in most countries, because government invest a lot money on construct the infrastructure. To evaluate investment of governments on transport infrastructure cost effectiveness, investigating the impact of highways on economies to the surrounding area is necessary. Many researches were carried out to investigate the effect of highways on economy of city or on national economy using variety of methods. Difference in Difference analysis (DID) were to exclude endogenous effect without limiting our study area.
Target cities spread around all over in Japan, and highway cities were defined as cities in which highways were firstly constructed in 1980s. Depending on the location of highway, cities were labeled as highway cities, adjacent cities, and control cities. DID analysis was carried out with highway cities and control cities, adjacent cities and control cities to investigate the impact of highways on those areas. Several economic valuables including industry-based valuables were used for before and after comparison of construction. Here, four different time periods were selected to demonstrate the situation after construction for time-series analysis. The results show that the impact of highway on industries except for agriculture increases as longer time passes in highway cities, while highway construction has a negative impact on adjacent cities. More analysis using DTM to estimate a reasonable construction cost will be necessary for cost-benefit analysis for highway construction. As a future analysis, railway impact on economy will be studied to compare with the result of highways.

1. INTRODUCTION

1.1Background

Cities gave birth in long time ago where natural condition and trading condition was suitable. As for natural condition, close access to water, arable land, and residential place is necessary, while as for trading condition, being close to river or coastal area is necessary. Once city has emerged under those condition, it needs agglomeration effect to develop and expand its area. Agglomeration effect is a term used frequently in Spatial Economics and Economic Geography, which indicates people and stuff getting together. Krugman (2000) has made sure that transport is dominant factor for agglomeration. It is reported that depending on the industry type of the area, the type of transportation (freight / passenger) that plays an important role differs. Transportation is necessary for city to develop, but the type of transportation depends on the industry.

In this research, we focused on highway (intercity transportation) due to some reasons. Firstly, we wanted to know cost-effectiveness when investing for transportation infrastructure, which leads us to focus on highway since highway is usually constructed by government, unlike other transportation. Since the primary aim for constructing transportation is thought to be improving the economy (Chatman, Noland 2011), to look into the impact of highway investment to see whether or not the primary goal was achieved is quite important. Also, in government fund for public works, road construction and management occupies around 22% in year 2017 in Japan, which is 2nd biggest composition in the revenue (National Tax Agency 2017), meaning that road investment cannot be neglected. Second reason is that we did not want to separate freight and passenger transportation because it depends on industry type of the area that which type of transportation is more important. Lastly, interstate highway is highly developed in Japan and it is expected to have a big influence in the future as well.

There are several studies about how transportation infrastructure has affected the production of the area. Garcia- Mila, McGuire and Porter (1996), Ades and Glaeser (1999), and Fernald (1999) will be good examples. Garcia- Mia, McGuire and Porter (1996) tried to investigate the impact of public infrastructure on state-level in US using Cobb-Douglas production function concluding that there is no significant linkage between public capital and private output. Ades and Glaeser (1999) studies about US states and found out that there are strong correlation between growth and initial wealth of the area. Fernald (1999) found out the impact of road infrastructure will be bigger if the industry uses

car frequently. However, their analysis is state level, and state does not represent the economic impact of highway very well because state is way too big when considering the impact of highway. There are some other examples that targeted Japanese cities and investigated the impact of highways. Kameyama (2002) applied the model of Charlot and Duranton (2004) and differenciated inter-regional transport and intra-regional transport. He concluded that intra-regional transport will increase the number of employees with specialization of the industry of the area, while inter regional transport increase the number of employees in a specific industry with diversifying the industry, which might lead the spillover of the industry. Yodo and Yoshimura (2016) has tried to investigate the spillover effect after highway construction. They followed the approach of Chandra and Thompson (2000) and classify nation-wide municipals into adjacent and control groups. Since this method covers not only the effect on cities along or around highways, but also effects on surrounding area, it covers the comprehensive effect of highway, which is useful when trying to investigate the cost benefit analysis of highway investment. In their research, for the purpose of excluding endogenous effect, by using the method of Chandra and Thompson (2000), they excluded those cities which are already very urbanized and highway construction was carried out because of their size of cities.

Previous researches failed to target wide variety of cities when trying to know the impact of highways not only on suburban cities with highways and on adjacent cities of highways, but also on those urbanized cities with highways. They also lack the analysis on highway impact transition using the same highway to search for how the role of highway changes as time passes after the construction. In this study, we used wide variety of cities including highly populated urbanized area and investigated the impact transition for the same highways.

1.2 Objective

The objective of this research is to understand the impact of highways on city economics comprehensively so that we can use this result in the future studies when we are to investigate the cost benefit effectiveness. The significance of this study lies in that we used a wider variety of temporal and spatial dataset which was not used in a single paper in the past.

2. METHODOLOGY

2.1 Data Preparation

We prepared the following data for this study: a panel economic dataset for cities in Japan from 1980 to 2010, highway route and construction year, Urban Employment Area (UEA), and city level separation across Japan. These data were pre-processed so that it can be processed for DID analysis (Figure 1) Table 1 shows the data and the way of pre-processing. Panel data for cities in Japan consists of name of municipals, deviation value for economic status in total, manufacturing, retail, wholesale, and agriculture for years in 1980, 1990, 2000, and 2010. They have more data including the number of offices and financial power, but in this research, following the method that Yodo and Yoshimura (2016) has carried out, we will just focus on manufacturing, retail, wholesale and agriculture to identify the impact difference of highways on the area. Deviation value was used to indicate the economic status in this data, and it is calculated for each year, which enables us for inter-period comparison. This data was taken from Cabinet Office, Government of Japan (Cabinet Office Government of Japan 2014) and they explain how they calculated to create deviation value in the web page. Data of highway route and construction year for each highway was taken from Ministry of Land, Infrastructure and Transport (2017) in shapefile format. Urban Employment Area (UEA) is officially defined in the United States but it is not defined officially in Japan and researchers propose their own definition which will be suitable for them respectively until Kanemoto and Tokuoka (2002) tried to introduce a definition of UEA which can be wildly applied for various researchers. Defining UEA aims to improve the quality of economic analysis. Even though there is administrative boundaries, it doesn't always reflect the economic activities (Kurima, Ogawara 2001). Kanemoto (2017) improved UEA defined as Standard Metropolitan Employment Area by Yamada and Tokuoka, and we used UEA definition by Yoshimura and Yamane (2003). On the other hand, using the Central Place Theory (Christaller, Walter,, Baskin,Carlisle W., 1966), Japanese urban centers were classified into 10 levels using population and physical distance as a factor for size and location respectively. In defining the 10 levels, we followed the result of Yoshimura and Yamane (2003) because they also used the same UEA. In this study, UEAs of level 1, 2, and 3 will only be our target because 38 UEAs out of 284 belong to either level 1, 2, or 3, and considering that we want to look into the investment impact of highways, the impact might be too weak if we include level 4 UEAs (38+51=89 in total).

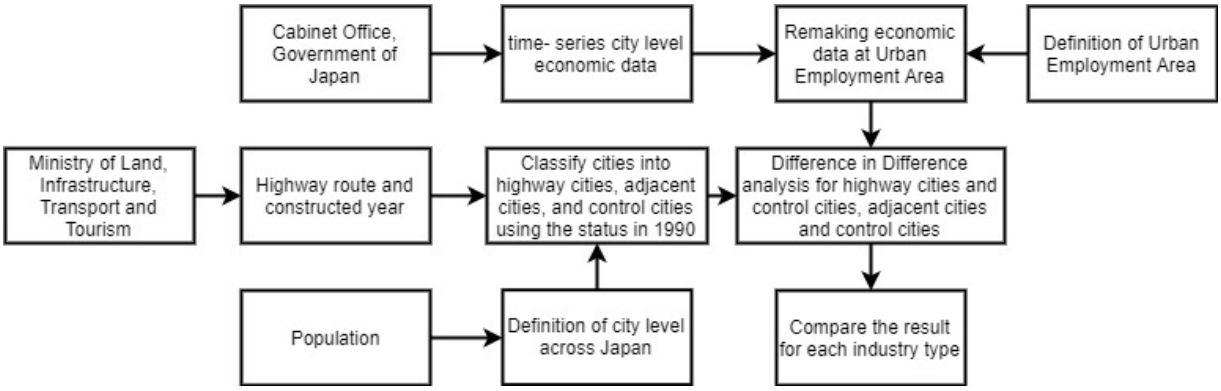

Figure 1. Flowchart of methodology to analyze the impact of highways on economy of UEAs.

Table 1. Data used in this study. Origin and the way of pre-processing data is shown in this table.

	Origin of data	Pre-processing data
Economic dataset for cities in Japan from 1980 to 2010	Cabinet Office, Government of Japan	Build an economic data using UEA
Highway route and construction year	Ministry of Land, Infrastructure, Transport and Tourism	Put the data into GIS for selecting city
Urban Employment Area (UEA)	Kanemoto and Tokuda, 2002	
City level separation across Japan	Yoshimura and Yamane, 2003	Put the data into GIS for selecting city

2.2 Pre-Processing

UEA data was used to remake the economic panel data into Geographic Information. Highway route data and UEA data were displayed in QGIS to define three groups of cities: highway cities, adjacent cities and control cities. Highway cities are the cities which possess highway in the UEA. Adjacent cities indicates the municipals which are adjacent to highway cities and don't possess highways. Control cities are those without highways and not adjacent to highway cities. Since we are to carry out Difference in Difference (DID) analysis, which is mentioned in the following section, we need to set the year of event, which, in here, construction of highways. We set the year 1990 as the year of construction because we are required at least two year datasets before and after the event for DID analysis and we have data of 1980, 1990, 2000, and 2010. For the reason above, UEAs whose highway was constructed between 1981 and 1990 were chosen for this study. Even though there are much more availability for UEAs with highway construction in 1980s, we chose only those UEAs whose highway was firstly constructed in 1980s for a better analysis. When choosing UEAs, we tried to pick up cities from different levels across level 1, 2, and 3 to compare the investment impact elasticity depending on the level of UEA, but due to the lack of UEA in which highway was firstly constructed in 1980s, UEAs from only level 3 were chosen in this study. Highway cities, adjacent cities, and control cities were shown in Figure 2.

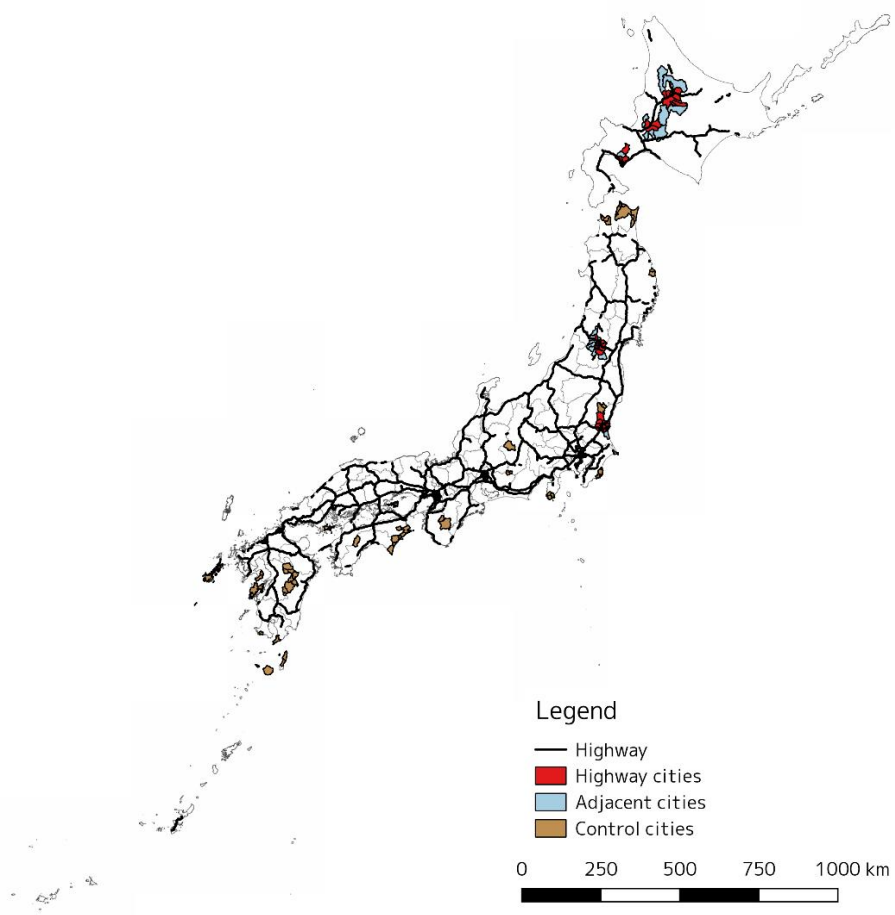

Figure 2. Test site. Highways and target cities are displayed in the map created by QGIS.

2.3 Difference in Difference (DID) Analysis

In order to extract the impact of highway construction, we used Difference in Difference (DID) analysis with the data mentioned above.
It is quasi- experiment which is quite useful in real life using the data of before and after some events to know the impact or effect of the event. In this analysis, two groups of treatment and control will be searched and its gap of value before and after the event will be compared. The estimation equation is as follows:

$$Y_{it} = \alpha_0 + \alpha_1 Treatment_i + \alpha_2 PostPeriod_t + \alpha_3 Treatment_i PostPeriod_t + \varepsilon_{it} \quad \textbf{(1)}$$

where i indicates the target area (municipality), t indicates the year. Y is dependent valuable, which is economic status in this research. $Treatment_i$ and $PostPeriod_t$ are dummy valuables for treatment group (if the municipality is treatment group, then 1, if not, 0) and for period after the event (if the year is after the event, then 1, if not, 0) respectively. In this research, using Ordinary Least Square (OLS) method, estimation for coefficients were carried out.

In our research, since we wanted to know the time series impact trend, analysis using four different time period was carried out. First one is comparing 1980 (before construction) and combined data of 1990, 2000, and 2010 (after construction). This will give us a general impact of highway construction. Second data period is comparing 1980 and 1990 (just after construction). This will tells us the direct impact of highway on the economy. Third one is comparing 1980 and 2000 (about 10 years after the construction). And final one is comparing 1980 and 2010.

3. RESULT AND DISCUSSIONS

Results of DID analysis are shown in Table 2 and Table 3. Table 2 shows the summary of the result and Table 3 shows the data of the result. Table 3, Panel A shows the result for highway cities and Table 3, Panel B shows the result for

adjacent cities. First row of Panel A tells us that construction of highway gives a positive impact on total economy, retail, and wholesale in 1% of significance in general 20 years from construction. Even though the impact on manufacturing is not significant, highway construction have a positive impact on manufacturing on the area. On the other hand, highway construction seem to have a negative impact on agriculture though it is not significant statistically. It seems that since those level 3 cities which we targeted were rather urbanized and agglomerated area and due to the highway construction, agglomeration effect has a big impact on this area. As Krugman (2001) and Kameyama (2006) has pointed out, agglomeration effects becomes really dominant as face to face communication is crucial for the region industry. In agriculture, face to face communication is not important for a better productivity, which leads the result of agriculture showing different trend. Since agglomeration effects are more significant in industries other than agriculture (Kurugman, 2001), the result can be assumed as a result of agglomeration which was caused by highway construction. A glance at time series analysis gives us a more in detail impact trend analysis of highway construction. In total economy, retail, and wholesale, the impact of highway increases as longer time passes after the construction and all of these trend is trustful at least 10% of significance. This result looks very interesting when comparing to the study by Nakazato (2001). He concluded that the impact of highway decreases as the analysis year gets newer. However, his analysis doesn't differenciate year of highway construction, he used the data of highway length at each year. He mentions two reasons for the result. First one is that since highway infrastructure has developed enough and marginal productivity has decreased. Second reason is that since highway came to be constructed not-so-good places in terms of cost and benefit effectiveness, their investment became ineffective. Here in our research, we focused on the area in which highway was newly constructed and we followed the economic status of the area, so in terms of the impact of the same highway, its impact increases as more time passes. We need the same analysis for those area where highway was constructed before 1980s and compare the result to see whether we can see the same trend of decreasing impact of highway in newer year as is discussed in the paper of Nakazato (2001). Positive impact on manufacturing can be seen in comparison of 1980 and 2000 at level of 10%, while impact of highway on agriculture is displayed as negative in all of the comparison even though they are all insignificant statistically. All the results of Panel B is insignificant statistically, but we can see the trend of negative impact of highway construction on total economy, retail, and wholesale in the adjacent cities. Even though they are not significant, coefficient of all the comparison show negative value in total economy, retail, and wholesale. This result seems somewhat different to the study of Yodo and Yoshimura (2016), which revealed that adjacent cities have more positive impact of highway compared to highway cities, and adjacent of adjacent cities have negative impact of highway. However, since their definition of highway cities is the municipals which have highway and our definition of highway cities is the UEA which have highway, and UEA is composed of several municipals. It means that our highway cities are bigger and corresponds their highway cities and adjacent cities, and our adjacent cities corresponds their adjacent to adjacent cities. This tells us that even though the values shown in Table 1 are not significant statistically, it is worth to conclude that adjacent cities get negative impacts from highway construction and this trend can be seen using both DID (our analysis) and fixed effect model (Nakazato's analysis).

Table 2. Summary of the results. Discussion from the results of highway cities and adjacent cities.

Highway cities	Adjacent cities
-positive impact on economy (agglomeration effect) -negative impact on agriculture (agglomeration of other industries) -impact increases as time passes (takes time to adjust the change)	-not significant statistically (other stronger factors) -negative impact on economy (industries moving into agglomerated area)

Table 3. Results for DID analysis of highway cities and adjacent cities. ***, **, *: significant at 1%, 5%, and 10%. Panel A: Results for highway cities using OLS, with observations of 452, number of municipals is 113. The first row shows the result of comparison of economic status in 1980 and combined status of 1990, 2000, and 2010. Second, third, and fourth row shows the comparison of 1980 and 1990, 1980 and 2000, and 1980 and 2010 respectively. Panel B: Results for adjacent cities using OLS, with observations of 428, number of municipals is 107. The first row shows the result of comparison of economic status in 1980 and combined status of 1990, 2000, and 2010. Second, third, and fourth row shows the comparison of 1980 and 1990, 1980 and 2000, and 1980 and 2010 respectively.

Highway cities	Total economy	Total economy	Manufacturing	Manufacturing	Retail	Retail	Wholesale	Wholesale	Agriculture	Agriculture
Panel A: Economic impact on highway cities										
Treatment× PostPeriod	3.8964*** (0.00183)		3.2521 (-0.22765)		5.8330*** (-0.00251)		7.3357*** (-0.00628)		-0.01887 (-0.996)	
Treatment× PostPeriod (1990)		2.5114** (0.0312)		1.5629 (0.558)		4.6455** (0.012382)		5.3847* (0.08975)		-4.2182 (0.250152)
Treatment× PostPeriod (2000)		4.2356*** (0.00117)		5.9184* (0.05772)		5.6227*** (0.004492)		8.2441*** (0.00521)		-4.9721 (0.219)
Treatment× PostPeriod (2010)		4.9423*** (0.00074)		2.2751 (0.4664)		7.2308*** (0.000268)		8.3782*** (0.00373)		-3.3871 (0.425)
Adjacent cities	Total economy	Total economy	Manufacturing	Manufacturing	Retail	Retail	Wholesale	Wholesale	Agriculture	Agriculture
Panel B: Economic impact on adjacent cities										
Treatment× PostPeriod	-0.5698 (0.682)		0.4234 (-0.8835)		-3.09E-01 (-0.874421)		-1.498 (-0.5879)		-0.01887 (-0.996)	
Treatment× PostPeriod (1990)		-0.3151 (0.813)		1.49991 (0.611)		-1.845e-01 (0.921)		-1.607 (0.64638)		0.8294 (0.841970)
Treatment× PostPeriod (2000)		-0.7012 (0.626)		0.1868 (0.95412)		-8.073e-01 (0.687)		-0.8006 (0.7956)		-1.052 (0.818)
Treatment× PostPeriod (2010)		-0.6930 (0.669)		-0.4157 (0.9026)		6.500e-02 (0.974)		-2.0870 (0.491)		0.1664 (0.972)

4. CONCLUSIONS AND FUTURE WORKS

4.1 Conclusion

This study provided empirical evidence of impacts of highway on city economics and the spillover effect and its transition by time. Even though our study focus on very similar target compared to the one done by Yodo and Yoshimura (2016), we introduced statistical method of DID to exclude endogenous effect, which enabled us to expand our target cities which also includes urbanized cities. The impact of highways are not limited to a certain area, it expands not only to the area on the highway, but also the adjacent area for highways both in urban and rural area. We revealed that highway construction can cause a positive impact on cities which have highways and negative impact on cities which are adjacent to the highway cities in general. However, this trend is not true for certain industries including agriculture. This results show that agglomeration effect was caused due to the highway construction in highway cities. The impact of highways gets bigger as longer time passes from the construction in highway cities. It might be because it takes time for private sectors to adjust to the change, which is to agglomerate more firms and offices closer to the highway. But in this research, since we picked up the construction year of 1980s, we only had data up to 20 years from construction, but since highway has a longer life period, we need to investigate the impact transition of highways constructed earlier than 1980s to study a longer time period impact of highways. Our analysis has failed statistically in adjacent cities. The possible reasons for this is that in adjacent cities, there are stronger different factors that drives those cities, and highway impact itself is not significant either it is negative or positive. To solve this problem, we need to make clear of other possible factors that can have an effect on those adjacent cities including other transportation, industry structure, and geography and policy. However, even though the result is not significant, we still see the negative impact of highway on adjacent cities. This matches the assumption of previous research done by Yodo and Yoshimura (2016).

4.2 Future Works

This research is aimed as a first step to investigate the cost-effectiveness of highway investment. As a second step, we need to focus not only on cities of level 3, but also on cities from other levels. Also, since in this research, deviation value was used as a representative for economic status for each year, this value is difficult to convert to production, which we need when investigating the cost-benefit analysis. Some other datasets with valuables that can be converted to production value is needed. Finally, cost for highway construction will be necessary. Even though we have general data for construction cost, when we want to carry out a municipal level analysis, we need construction cost at municipal level. At the moment, we are considering to use DTM to demonstrate the difficulty for highway construction, which seem to have close relation with construction cost. Also, using the similar method, relation of railway construction on the economy of the area will be studied in the future.

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