Accessibility to the nearest urban metropolitan area and rural poverty in Japan

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Abstract

The study examines the effects of accessibility to the nearest urban metropolitan area on rural poverty by using Japanese municipality-level data. We conduct nationwide cross-sectional analyses, and find that a larger time distance to the nearest urban metropolitan area significantly increases regional poverty rates. In addition, the study focuses on opening of new commuting train, Tsukuba Express (TX), connecting Tokyo and Ibaraki prefecture, a suburban area of Tokyo. We conduct municipality-level panel analyses, and the results suggest that opening TX reduced rural poverty rates of the surrounding areas, but the effects required 6–10 years to be observed. Therefore, regional policy makers might need to consider that transportation investments that improve inter-regional accessibility do not affect regional economic performance for several years.

JEL classification: R11, R12, R13, R41, and R42

1. Introduction

Even in developed countries, poverty is still a serious problem. Candy and Smith (2014) compare ten different definitions of absolutely poverty rates in the case of the United States, and point out that one of the indexes of absolute poverty rates reaches about five percent.[1] In Japan, the government provides public assistance to people in poverty who cannot earn minimum costs of living, and the share of people receiving public assistance increased from 0.70% in 1995 to 1.70% in 2015.[2] From the fact, we consider that there are still many poor people who cannot subsist themselves without assistance, and the number tends to increase recently. Therefore, we should investigate factors which affect poverty still existing in developed countries to improve the poverty situation.

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1 Although absolutely poverty rate is officially defined as the share of people living with an income of less than 1.90 dollars per day, the amount is less than 2.00 dollars per day in Candy and Smith. The index of absolute poverty rate reached about 5% correspond the definition of absolute poverty in Shaefer and Edin (2013). The index focuses only on households with children, and excludes the effects of government assistances such as food stamps. As the source, the estimation adopts the Survey of Income and Program Participation.

2 There were about 2,140,000 people receiving public assistance in 2015 according to Ministry of Health, Labor and Welfare.

ILO (2016) announces that improving income levels is crucial for reducing poverty. As empirical evidence of the relationship between income level and poverty, Förster and d'Ercole (2005) examine the case of OECD countries in the second half of the 1990s and find that their poverty rates and income levels strongly correlate. From those discussions, there is a possibility that factors affecting regional income levels also have impacts on regional poverty situations.

As an important factor that affects regional economic performance, we consider agglomeration spillover effects. Marshall (1920) mentions the possibility that firms tend to concentrate to get advantages such as rich labor markets, low transportation costs of inputs and outputs, and knowledge spillover. Those benefits of agglomeration increase the productivity of firms in urban metropolitan areas, and the effects are known to spill over to surrounding regions.

The magnitude of agglomeration spillover effects is known to shrink by distance from urban metropolitan areas. Rosenthal and Strange (2003, 2006) empirically investigate six kinds of industries in the United States. They suggest that the amount of employment rapidly decreased by distance from agglomeration in five out of six industries.

The above discussions suggest that regional economic performance could diminish with the distance from urban metropolitan areas. In terms of poverty, Partridge and Rickman (2008) investigate the relationship between regional poverty rates and distance from the nearest urban metropolitan areas by using county-level data from the United States, showing that larger linear distance from a nearby urban metropolitan areas causes higher poverty rates in counties. Partridge and Rickman interpret the heterogenous distribution of poverty as the result of decreases in regional labor demand and wage level by distance from economic agglomeration.

In this study, we estimate the effects of accessibility to the nearest urban metropolitan area on regional poverty by using Japanese municipality-level data. From our nationwide cross-sectional analyses, we find that a larger time distance to the nearest urban metropolitan area significantly increases regional poverty rates. The monetary magnitude is such that a one-minute increase of time distance to the nearest urban metropolitan area increased the number of households in poverty by about 0.78 and the annual expenditure of regional governments for public assistance by about 1.75 million yen on average in 2014.

In addition, we focus on the case of a new commuting train that opened in 2005, the Tsukuba Express (TX), which connects Tokyo and suburban areas, and we conduct panel analyses to understand the impacts of changing accessibility to closely located urban metropolitan areas on rural poverty. From our panel analyses, we find that improvements in accessibility to the nearest urban metropolitan area significantly decrease poverty rates, even controlling for municipality fixed effects. We also find that the effects of reducing regional poverty are observed in municipalities located close to TX. The result is consistent with our hypothesis that improvement in accessibility to the nearest urban metropolitan area will spread the range of positive spillover effects from urban metropolitan areas, stimulate their economic performance, and reduce poverty.

In a related study, Partridge and Rickman (2008) investigate the relationship between regional poverty rates and distance from the nearest urban metropolitan areas in the United States. They show that larger linear distance from a nearby urban metropolitan areas causes higher poverty rates in counties. However, there are two issues that are not considered in their study. First, Partridge and Rickman use linear distance as a distance variable, which cannot measure accurate inter-regional accessibility.[3] To solve the problem, we adopt time distance, which can measure actual transportation costs as an inter-regional accessibility variable, as well as linear distance. From our estimations, a larger time distance to the nearest urban metropolitan area causes higher regional poverty rates, while linear distance to the nearest urban metropolitan area does not explain rural poverty. Second, Partridge and Rickman (2008) only conduct a cross-sectional analysis, and their results may contain biases from neglecting unobservable regional characteristics. Against this background, we conduct a panel analysis to understand the effects of changing transportation costs to closely located urban metropolitan areas on rural poverty rates, controlling for time invariant regional characteristics, and find that the opening of a new commuting train reduces poverty in regions located close to the commuting train.

In another related study about location of poverty, Glaeser, Kahn and Rappaport (2008) investigate the distribution of poverty in areas close to CBD within about 16 kilometers in the US, and find that people in poverty tend to locate in central areas of cities to receive the advantage of better public transportation. They also point out that regional median income decreases by distance to CBD. However, Clark, Huang and Withers (2003) find that more than one quarter of employees in the Seattle labor market have commute distance larger than 16 kilometers from their residences in 1990s. Since commutable areas have expanded by progress of public transportation and residential development specifically in developed countries, there is possibility that the range used by Glaeser, Kahn and Rappaport are not sufficient to consider distribution of poverty in surrounding areas of urban metropolitan areas.

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[3] Boscoe et al. (2012) focus on the relationship between housing prices and distance to the nearest hospital in the case of the United States and Puerto Rico. They find that linear distance does not work appropriately as a measure of accessibility if there are geographic barriers that prevent people from traveling.

The structure of this paper is as follows. The next section describes the mechanism of the relationship whereby access to urban metropolitan areas affects rural poverty, in reference to previous studies. Section 3 explains our estimation models and variables. Section 4 describes the results of the cross-sectional analysis. Section 5 describes the configuration of the panel analysis and its results. Section 6 is the conclusion.

2. Background mechanism

This section describes the mechanism whereby regional accessibility to closely located urban metropolitan areas affects rural poverty, referring to previous studies. The seriousness of the poverty situation in a region depends on the regional wage and employee level, which is determined as an equilibrium of regional labor demand and labor supply. Partridge and Rickman (2008) formulate the relationship whereby regional employment and wage rates affect regional poverty, which can be written as the following function.

$$\mathrm{Poverty}_i = \mathrm{f}_i^{pov}(er_i, wr_i, \boldsymbol{other}_i^{pov}), \quad (1)$$

where er_i is the employment rate of region i and wr_i is its wage rate. $\boldsymbol{other}_i^{pov}$ is the vector of other variables that affect the poverty situation of region i. To understand how $\mathrm{Poverty}_i$ exerts influence, we consider how er_i and wr_i exert influence.

The employee and wage rates of a region depend on the interaction between regional labor demand and labor supply. The relationships are written as the following functions.

$$er_i = \mathrm{f}_\mathrm{i}^{\mathrm{er}}(l_i^d, l_i^s), \quad (2)$$

$$wr_i = \mathrm{f}_\mathrm{i}^{\mathrm{wr}}(l_i^d, l_i^s), \quad (3)$$

where l_i^d is the labor demand of region i, and l_i^s is the labor supply. If other factors are given, an increase in l_i^d increases er_i or wr_i, and an increase in l_i^s decreases er_i or wr_i. Then, we consider factors that determine the level of regional labor demand and labor supply.

On the labor demand side, agglomeration economy spillovers and increases in the labor demand of the surrounding regions occur, and the spillover effects are known to diminish by distance. Audretsch et al. (2005) focus on the location of high technology-based firms in the United States, and find that high technology-based firms strongly concentrate within 50 kilometers of universities. The above discussions suggest that the amount of regional labor demand decreases by distance from economic agglomeration.

On the labor supply side, rural workers are known to have difficultly accessing urban labor markets across regions. Lucas (2001) introduces evidence suggesting that rural workers stay in their own areas in spite of higher income levels in urban metropolitan areas. Molho (1995) provides one of the evidences referenced in Lucas (2001), suggesting that rural workers tend to stay in rural areas because of their attachment to the culture or human relations in areas in which they live. In addition, Lucas (2001) identifies costs of information about urban labor markets, which become larger by distance from urban metropolitan areas, as a reason why rural workers stay in the areas in which they live.

The above discussions suggest that whereas labor demand concentrates in urban metropolitan areas and the amount rapidly diminishes by distance from economic agglomeration, rural workers' mobility is at a low level, and they have difficulty migrating to urban metropolitan areas across regions in pursuit of higher wages. This causes the amount of labor demand to diminish by distance from economic agglomeration with a larger slope than that of the labor supply. We can express the relationships as the following functions:

$$l_i^d = \mathrm{f}^{\mathrm{ld}}\left(Distance_i^{UA},\ \boldsymbol{other_i^{ld}}\right), \qquad \frac{\partial l_i^d}{\partial Distance_i^{UA}} < 0, \tag{4}$$

$$l_i^s = \mathrm{f}^{\mathrm{ls}}\left(Distance_i^{UA},\ \boldsymbol{other_i^{ls}}\right), \qquad \frac{\partial l_i^s}{\partial Distance_i^{UA}} < 0, \tag{5}$$

$$\frac{\partial l_i^d}{\partial Distance_i^{UA}} < \frac{\partial l_i^s}{\partial Distance_i^{UA}}, \tag{6}$$

where $Distance_i^{UA}$ is the distance to the nearest urban metropolitan area of region i. From functions (2) and (3), increases of $Distance_i^{UA}$ decrease regional wages or employee level through changes in l_i^d and l_i^s, and from function (1), the increases in $Distance_i^{UA}$ worsen the regional poverty situation. The relationship can be written as the following function:

$$\mathrm{poverty}_i = \mathrm{f}_{\mathrm{i}}^{\mathrm{pov}}\left(Distance_i^{UA},\ \boldsymbol{other_i}\right), \qquad \frac{\partial \mathrm{poverty_i}}{\partial Distance_i^{UA}} > 0, \tag{7}$$

where $\mathrm{poverty}_i$ is the poverty rate of region i.

From the above discussion, we assume that better accessibility to closely located economic agglomeration improves the regional poverty situation. We examine the impact of distance to the nearest urban metropolitan area on rural poverty rates with Japanese municipality level data.

3. Cross-sectional analysis

3.1. Empirical strategy

Based on the theoretical background, this section describes the estimation model that explains the level of municipalities' poverty rates. The estimation model is as follows:

$$\text{Pov}_i = \alpha_i + \beta\text{Distance}_i + \delta\mathbf{X}_i + \theta\text{Prefecture}_i + \text{u}_i. \quad (8)$$

Pov_i is municipality i's poverty rate. Distance_i is municipality i's distance to the nearest urban metropolitan area. According to the above discussion, we expect that β is negative.

$\mathbf{X}_i$ is the vector that contains variables relating to municipality i's poverty rate. It contains three types of variables, explaining municipality i's population structure, economic activity, and education level.

Prefecture_i is a prefecture dummy in which municipality i is contained. We adopt it to control for the heterogeneity that comes from the prefecture of municipality i. u_i is the error term.

3.2. Data

This section describes the data we use. First, we clarify the definition of municipalities and urban metropolitan areas.

The Japanese government defines a *municipality* as the smallest unit of administrative districts, and it is composed of cities, towns, villages, and specified districts.[4] We define urban metropolitan areas as municipalities with populations of over 300,000; this is a condition of the *core city,* which is a legal urban metropolitan area determined by article 252 of the Local Autonomy Law.[5] In Japan, there were 71 urban metropolitan areas in 2012. In addition, we regard 23 specified districts in the Tokyo metropolitan area as one urban metropolitan area. In this study, each municipality has a nearest urban metropolitan area. The nearest urban metropolitan area of a municipality is defined as the urban metropolitan area that has the closest linear distance to the rural municipality.

Since we cannot observe the distribution of poverty in each municipality and the distance between each household in urban areas and the center of urban metropolitan area, we except municipalities that are urban metropolitan areas themselves from our sample. In this study, we focus on the distribution of poverty in suburban and rural areas.

Distance_i is municipality i's distance to the nearest urban metropolitan area. In our cross-sectional analysis, we adopt linear distance, time distance by car, and time distance by public transport as accessibility variables to the nearest urban metropolitan area.

Linear distance is measured as the linear distance by kilometer between the government offices of a rural municipality and the municipality's nearest urban metropolitan area. We calculate the linear distance

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[4] In 2012, there were 1,747 municipalities composed of 786 cities, 754 towns, 184 villages, and 23 specified districts in the Tokyo metropolitan area.

[5] In 2016, the definition of core city changed to cities with population of over 200,000. However, we adopt the previous definition used in 2012, when our sample was observed.

between municipalities using a location-based service and coordinate conversion service from the Geospatial Information Authority of Japan.

Time distance by car measures how long people would spend to travel between two government offices by car. This variable is calculated using Google Maps.[6] Time distance by public transport is the time people spend to travel between the municipality in which they live and its nearest urban metropolitan area by train and bus.[7] We calculate this variable using the Timetables published by the Japan Travel Bureau (JTB), which is a representative timetable of public transportation in Japan. In the case of municipalities that contain stations, we measure the time distance between their representative station, which is defined in the Timetables, and the representative station of its nearest urban metropolitan area.[8] In the case of municipalities that do not contain stations, we add the time distance between their government offices' nearest bus stop and the nearest station to the time distance from the rural station to the representative station of the nearest urban metropolitan area. We calculate the optimal path between a rural municipality and its nearest urban metropolitan area for commuters.[9] The unit of time distance is one minute.

As the measure of regional poverty rates, we adopt a municipality's share of households receiving public assistance. This is defined as the ratio of households receiving public assistance to 100 households in each municipality. The requirement for receiving public assistance is that a household lives under the poverty line, which is determined by the standards created by the Ministry of Health, Labour and Welfare (MHLW). Each municipality's income threshold for providing public assistance controls for each municipality's price level determined by MHLW. We assume municipalities' share of households receiving public assistance work as a proxy for the absolute poverty rate, which is defined as "*the inability to meet basic needs of health and nutrition*" (Deaton, 2004, pp11). As an additional reason that we adopt public assistance, there are few municipality-level data about poverty in Japan. To calculate the public assistance rate of each municipality, we use the Prefectural Statistic Manuals (2012).[10]

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6 We obtain the data in 2016.

7 Each municipality's principal station is defined by its government.

8 In cross-sectional analysis, we refer the Timetables (2010) records time distance by public transports on April 1st, 2010.

9 The optimal path is calculated as the fastest path from a rural station to the representative station of the nearest urban metropolitan area, but we except limited express trains and bullet trains, which require additional fare as commuting methods.

10 The Prefectural Statistic Manuals (2012) records each data for 2011.

Table 1 shows the number and share of reasons for discontinuing public assistance by households in Japan as whole between 2012 and 2016. In all types of households, the share of discounting public assistance because of increasing or deriving income by job is not a huge, between 13.9 and 16.0%. The largest reason in the category is death of receiver (28.6-34.0%), but the reason is mostly occupied by elderly households and households with handicapped members who do not have labor force. Without them, in fatherless households and other households, the largest reason for discontinuing public assistance is increasing or deriving income by job (29.5-36.0% in other households). From the fact, we consider that there are many households receiving public assistance because of their low, or no, income even they hold labor force, and improvement of municipal wage level or employee level could reduce the share of households receiving public assistance.

Table 1. The Number and Share of Households Discontinuing PA in Japan as whole

	2012	2013	2014	2015	2016
All Tyepes of Households					
All	13,986	11,901	11,710	13,333	11,474
Death	4,002	3,639	3,670	4,342	3,900
	(28.6)	(30.6)	(31.3)	(32.6)	(34.0)
Increasing or Deriving Income by Jobs	1,974	1,659	1,878	2,127	1,826
	(14.1)	13.9	16.0	16.0	15.9
Elderly Households					
All	4,895	4,430	4,524	5,550	5,104
Death	2,810	2,600	2,752	3,398	3,110
	(57.4)	(58.7)	(60.8)	(61.2)	(60.9)
Increasing or Deriving Income by Jobs	85	83	102	110	122
	(1.7)	(1.9)	(2.3)	(2.0)	(2.4)
Fatherless Households					
All	972	717	719	888	665
Death	40	7	5	7	7
	(4.1)	(1.0)	(0.7)	(0.8)	(1.1)
Increasing or Deriving Income by Jobs	224	164	189	271	214
	(23.0)	(22.9)	(26.3)	(30.5)	(32.2)
Households with Handicapped Membetrs					
All	4,061	3,168	2,858	3,236	2,648
Death	933	823	744	760	636
	(23.0)	(26.0)	(26.0)	(23.5)	(24.0)
Increasing or Deriving Income by Jobs	368	353	361	417	380
	(9.1)	(11.1)	(12.6)	(12.9)	(14.4)
Other Households					
All	4,058	3,586	3,609	3,659	3,057
Death	219	209	169	177	147
	(5.4)	(5.8)	(4.7)	(4.8)	(4.8)
Increasing or Deriving Income by Jobs	1,297	1,059	1,226	1,329	1,110
	(32.0)	(29.5)	(34.0)	(36.3)	(36.3)

Percentages of the reasons are in parentheses.

Partridge and Rickman (2008) use county-level poverty rate based on the poverty standard defined by the U.S. Census Bureau. The standard aims to identify whether a household is in an absolute poverty situation, and it controls for states' price levels and the number of household members; it has similar requirements to those of the Japanese income threshold for receiving public assistance. The similarity between the two poverty standards is convenient for us to compare our estimation results with those of Partridge and Rickman (2008).

Using $\mathbf{X}_i$, we control for factors relating to municipality i's poverty rate. It contains three types of variables. (I) The variables that explain municipality i's population structure are the number of households and age structure (share of population under 15 and share of population over 65). (II) The variables about municipality i's economic performance are industrial structure (share of laborers in the primary sector and in the manufacture sector) and municipality i's unemployment rate. (III) The variables reflecting municipalities' education level are the share of people who graduate from a university and the share of high school graduates. To obtain those variables, we use the Statistical Observations of Prefectures, constructed by the Ministry of Internal Affairs and Communications Statistics Bureau (2010).[11]

Table 2 displays the summary statistics. We use 33 prefectures, from a total of 47, which announced the share of households receiving public assistance at the municipality level.[12] We can find from the table that the mean of municipal linear distance to the nearest urban metropolitan area is about 35 kilometers, and time distance is about 50 minutes. It indicates that we focus on the distribution of poverty in suburban areas and that is different with the geographical range focused by Glaeser, Kahn and Rappaport (2008), investigate the distribution of the poor in urban metropolitan area. The table also shows that the mean of poverty rate is about 2.3%. It is considerably low compared to relative poverty rate in Japan, about 16% in 2012, announced by OECD. That indicate that we focus on just households in serious poverty situation which is hard to live in the minimum standard without receiving public

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11 The Statistical Observations of Prefectures (2010) records each data in 2010.

12 The 33 available prefectures are Aichi, Chiba, Fukui, Fukuoka, Fukushima, Gifu, Hiroshima, Hokkaido, Hyogo, Ibaraki, Iwate, Kagawa, Kagoshima, Kanagawa, Kochi, Kumamoto, Kyoto, Miyazaki, Nagasaki, Nara, Oita, Okinawa, Osaka, Saga, Saitama, Shiga, Shimane, Tochigi, Tokyo, Tottori, Toyama, Wakayama, and Yamaguchi.

assistance.

Table 2. Summary Statistics

	Mean	Std. Dev.	Min	Max
DISTANCE to the Nearest Urban Metropolitan Area				
Linear Distance (km)	35.6	39.8	4	412
Time Distance by Car (min)	50.3	37.2	9	338
Time Distance by Public Transport (min)	52.7	53.0	3	510
POVERTY				
Household Receiving PA	873	1,008	35	9,384
Poverty Rates (%)	2.3	1.5	0	9
Other Regional Characteristics				
Population	92,182	61,673	4,387	290,959
Household	36,664	25,682	2,000	126,180
Share of Population Under 15	13.1	1.9	6	20
Share of Population Over 65	26.2	5.2	14	46
Share of Workers in Primary Sector	26.6	29.5	0	80
Share of Workers in Industry Sector	25.5	7.1	11	49
Share of Unemployed	3.4	0.8	2	7
Share of High School Graduates	36.0	7.1	17	97
Share of University Graduates	11.9	5.0	3	33
N = 378				

4. Cross-sectional results

This section describes the results of our cross-sectional estimation. Table 3 shows the estimation results. Column (1) uses linear distance as Distance_i, and its coefficient is positive and insignificant. This result suggests that linear distance to the nearest urban metropolitan area does not have significant effects on rural poverty rates. Column (2) adopts time distance by car as Distance_i. The coefficient is positive with a 10% statistical significance. The magnitude is that one-minute increases of time distance by car to the nearest urban metropolitan area increase the rural poverty rates by about 0.003 percentage point. Column (3) shows the estimation of time distance by public transport, and its coefficient is positive with a 5% statistical significance. This result shows basically the same result as estimation (2). One-minute increases of time distance by public transport to the nearest urban metropolitan area increase rural poverty rates by about 0.002 percentage point.

Columns (1)–(3) are fundamentally consistent with the results of Partridge and Rickman (2008) in suggesting that a larger distance to the nearest urban metropolitan area will worsen the rural poverty situation. However, our results also show that there is difference between the significance of linear distance and time distance. From columns (1)–(3), we find that, whereas a municipality's linear distance to the nearest urban metropolitan area does not have significant effects on rural poverty rates, time distance significantly affects rural poverty rates. These results suggest that, whereas linear distance does not precisely capture inter-regional accessibility in regions such as Japan that have many geographical barriers, time distance could measure accessibility.

We consider the monetary impact of distance to the nearest urban metropolitan area on rural governments. From column (3)'s result, the magnitude of a one-minute increase of time distance is about a 0.002 percentage point increase in rural poverty rates. These results show that, for instance, an increase of 10 minutes of time distance to the nearest urban metropolitan area causes municipalities' annual expenditures for public assistance to increase by about 17.5 million yen on average.[13]

Table 3. Result of the Cross-Sectional Analysis

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Baseline Sample			*Urban Metropolitan Areas with Populations Larger than 500,000*			*Urban Metropolitan Areas with Populations Smaller than 500,000*		
Log(Linear Distance)	0.078 (0.071)	–	–	0.23 (0.22)	–	–	0.066 (0.074)	–	–
Time Distance by Car	–	0.0032* (0.0012)	–	–	0.0020 (0.0012)	–	–	0.0018* (0.00075)	–
Time Distance by Public Transport	–	–	0.0018** (0.00086)	–	–	0.0015 (0.00085)	–	–	0.0018* (0.00075)
Population (thousand)	0.0020*** (0.00059)	0.0019** (0.00055)	0.0021*** (0.00058)	0.00079 (0.00060)	0.00079 (0.00062)	0.00088 (0.00060)	0.0011** (0.00038)	0.0011** (0.00038)	0.0011** (0.00038)
Share of Population Under 15	-0.062 (0.039)	-0.051 (0.038)	-0.06 (0.038)	-0.082 (0.053)	-0.068 (0.054)	-0.072 (0.052)	-0.048 (0.034)	-0.038 (0.034)	-0.039 (0.034)
Share of Population Over 65	-0.017 (0.018)	-0.010 (0.018)	-0.016 (0.017)	-0.067** (0.025)	-0.060* (0.024)	-0.064** (0.024)	-0.022 (0.015)	-0.019 (0.015)	-0.020 (0.015)
Share of Workers in Primary Sector	-0.0029 (0.0017)	-0.0043* (0.0017)	-0.0036* (0.0018)	-0.0016 (0.0018)	-0.0032 (0.0019)	-0.0028 (0.0019)	-0.0030** (0.0011)	-0.0026* (0.0011)	-0.0026* (0.0011)
Share of Workers in Industry Sector	-0.0040 (0.0070)	-0.0058 (0.0066)	-0.0039 (0.0067)	-0.017* (0.0080)	-0.019* (0.0079)	-0.017* (0.0078)	-0.012* (0.0052)	-0.010* (0.0051)	-0.010* (0.0051)
Unemployed Rates	0.15* (0.062)	0.15* (0.062)	0.14* (0.062)	-0.016 (0.060)	-0.023 (0.053)	-0.029 (0.052)	0.083* (0.038)	0.075* (0.036)	0.075* (0.036)
10 Years' Lag of Poverty Rates	0.80*** (0.076)	0.78*** (0.075)	0.79*** (0.075)	1.34*** (0.10)	1.36*** (0.10)	1.34*** (0.10)	1.08*** (0.053)	1.11*** (0.047)	1.11*** (0.047)
Share of High School Graduates	0.0037 (0.0082)	0.0057 (0.0080)	0.0052 (0.008)	0.019* (0.0087)	0.023* (0.0093)	0.023* (0.0092)	-0.0018 (0.0065)	0.00049 (0.0062)	0.00049 (0.0063)
Share of University Graduates	-0.010 (0.012)	-0.0074 (0.012)	-0.0078 (0.012)	-0.011 (0.018)	-0.019 (0.014)	-0.017 (0.014)	-0.027** (0.0093)	-0.023* (0.0092)	-0.023* (0.0092)
Intercept	1.33 (1.05)	0.93 (1.06)	1.25 (1.05)	2.77 (1.61)	2.75 (1.47)	2.83 (1.45)	1.92 (1.00)	1.57 (0.98)	1.57 (0.98)
Prefecture	Y	Y	Y	Y	Y	Y	Y	Y	Y
Adjusted R^2	0.76	0.77	0.77	0.92	0.92	0.92	0.93	0.93	0.94
N	372	368	372	171	170	171	197	194	194

Signif. codes: 0 '***' 0.01 '**' 0.05 '*' 0.1. We adopt a cluster robust standard error.

Cluster robust standard errors are in parentheses.

There is a possibility that the scale of economic agglomeration affects the magnitude of spillover effects on surrounding regions. In analyses (4)–(9), we divide municipalities by the scale of population of their nearest urban metropolitan area. We define the threshold of municipalities as whether their nearest

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13 In 2014, there were about 56.4 million households in Japan, and about 1.6 million households received public assistance; thus, the share of households receiving public assistance was about 2.38%. There were 1,718 municipalities in 2014, and each municipality has about 931 households receiving public assistance on average. The total expenditure of the Japanese government for public assistance was about 3,843 billion yen, and, dividing the amount of total expenditure by the number of municipalities, a municipality's average expenditure for public assistance was about 2.2 billion yen. From the average number of households receiving public assistance and the amount of the expenditure, the average amount of public assistance for each household was about 2.4 million yen. From the results of (2) and (3), an increase of 10 minutes of time distance increases the share of public assistance by about 0.02; thus, it adds about 7.82 households receiving public assistance. In this result, a municipality's annual expenditure for public assistance increases by about 17.5 million yen on average.

urban metropolitan area has a population over 500,000; this is one of the requirements to be an ordinance designated city, which is a representative system to define metropolises in Japan. Columns (4)–(6) present the results of estimations using the municipalities whose nearest urban metropolitan area has a population larger than 500,000. Columns (7)–(9) only use municipalities with a population smaller than 500,000.

As distance variable, linear distance is used in column (4), time distance by car is adopted in column (5), and time distance by public transport is used in column (6). The results of (4)–(6) suggest that distance to the nearest urban metropolitan area does not have significant effects on rural poverty rates in municipalities whose nearest urban metropolitan area has a population larger than 500,000. From columns (7)–(9), we can observe qualitatively similar results to those of columns (1)–(3) in that the coefficient of linear distance is positive and insignificant, and the coefficients of time distance by car and by public transport are positive and statistically significant. Column (7) uses linear distance as $\mathrm{Distance}_i$, and its coefficient is positive and insignificant. Column (8) adopts time distance by car as $\mathrm{Distance}_i$. The coefficient is positive with 10% statistical significance. The result shows that one-minute increases of $\mathrm{Distance}_i$ increase the rural poverty rates by about 0.002 percentage point. Column (9) provides the estimation with time distance by public transport, and its coefficient is positive with 10% statistical significance. This result suggests that one-minute increases of $\mathrm{Distance}_i$ cause rural poverty rates to increase by about 0.002 percentage point. Columns (4)–(9) show that whereas distance to the smaller urban metropolitan areas impacts rural poverty rates, accessibility to larger urban metropolitan areas does not have significant effects.

We consider the reason why only municipalities closely located to a smaller urban metropolitan area experience the significant effects from distance to urban metropolitan areas. From columns (5) and (8), we find that in municipalities close to a larger urban metropolitan area, the magnitude of the coefficient (about 0.002) is larger than that of municipalities close to a smaller urban metropolitan area (about 0.0018). However, the coefficient for municipalities close to a larger urban metropolitan area has a considerably higher standard error (about 0.0012) than that of municipalities close to a smaller urban metropolitan area (about 0.00075), and that causes the insignificance of time distance in column (5). From columns (5), (6), (8), and (9), we can observe that municipalities close to larger urban metropolitan areas consistently have a larger standard error of time distance to the nearest urban metropolitan areas than municipalities close to smaller urban metropolitan areas do. This suggests that there are larger heterogeneities of the impact of agglomeration economies from the nearest urban metropolitan area among municipalities close to larger urban metropolitan areas than among those close to smaller urban metropolitan areas; for example, only some of the municipalities receive a large benefit from good accessibility to the nearest urban metropolitan area, and the others do not receive it. We consider that the heterogeneities are caused by urban shadow effect, tendency that urban metropolitan area resorbs economic activities of surrounding regions and cause their economic declines. There is possibility that larger metropolitan area presents more serious urban shadow effect to its surrounding areas, and it caused insignificant effects of accessibility to the nearest urban metropolitan area with more than 500,000 population on surrounding areas' poverty situations.

5. Panel analysis

Although our estimation model includes all the possible variables to control for municipality heterogeneity, there is a possibility that our model still misses unobservable characteristics that cannot be controlled by these variables, and the results may include some biases. To control for unobservable time invariant heterogeneities of municipalities, we conduct a panel analysis and estimate the impact of improving accessibility to the nearest urban metropolitan area on rural poverty rates.

5.1. Opening of TX

To control for unobservable and time invariant characteristics of municipalities, we focus on opening of new commuting train between Tokyo and its surrounding cities, Tsukuba Express (TX), in 2005. TX connects Tsukuba city in Ibaraki prefecture, a northern suburban area of Tokyo, to Akihabara area located in the CBD of Tokyo. Opening TX shortened the time distance between Tsukuba and Akihabara from 60 minutes to 40 minutes. The drastic change in accessibility to urban metropolitan areas might affect the geographic ranges of spillover effects from economic agglomeration on the surrounding regions of the railroad. For instance, households' job selecting behavior or firms' decision of location could reflect the impacts of changing accessibility in surrounding municipalities of the railway. Since the railway also contains Kashiwa (an urban metropolitan area in Chiba prefecture) as its passing station, the opening of TX might have impacts that come from the change in accessibility to other, smaller urban metropolitan areas as well as to Tokyo. Figure 1 shows the routes of TX and the Joban line, which is an existing railway connecting municipalities in Ibaraki to Tokyo. The route of TX is colored red, and the Joban line is colored blue. Each circle represents a station of the railways.

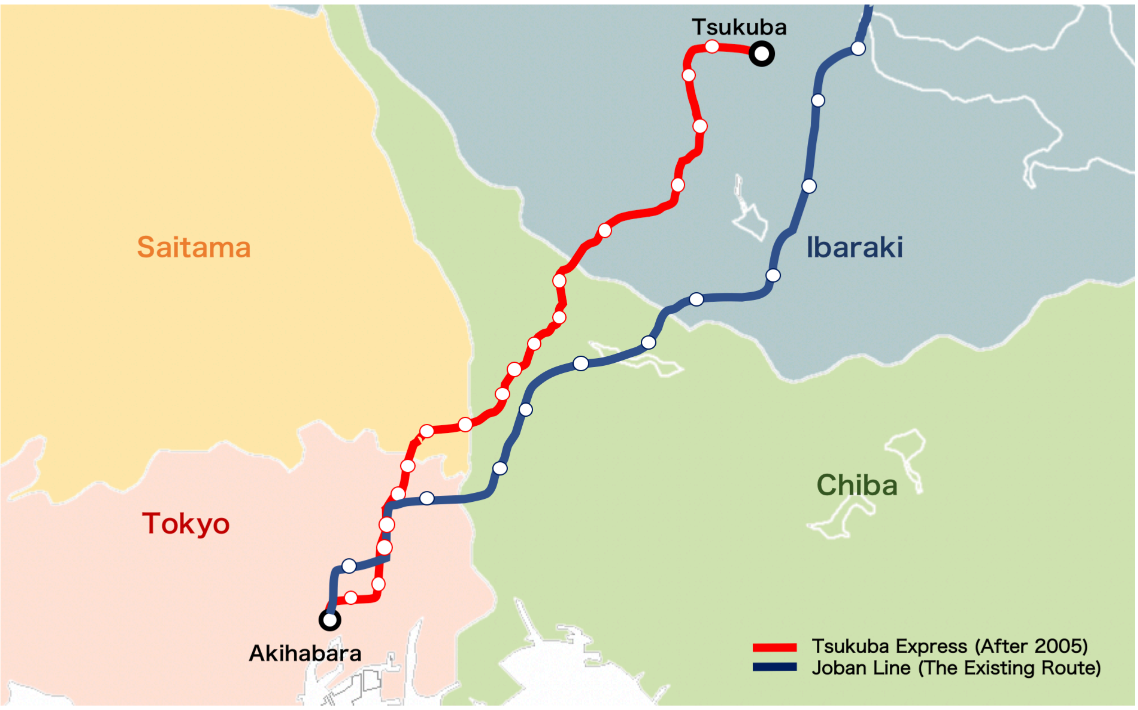

Figure 1: Routes of the Tsukuba Express and Joban Line.

5.2. Panel analysis

We create panel data and estimate the impacts of accessibility to urban metropolitan areas on municipalities' poverty rates, controlling for the time invariant characteristics of municipalities. To create the panel data, we use JTB's Timetables (JTB, 2000, 2005, 2010, 2015) and calculate the time distance among stations using the appropriate commuting route. The estimation model is as follows:

$$\mathrm{Pov}_{it} = \alpha_{it} + \beta \mathrm{TimeDistance}_{it} + \delta \mathbf{X}_{it} + \eta_i + \varepsilon_{it}. \quad (9)$$

η_i indicates the municipality fixed effects. ε_{it} is the error term, which comes from the time invariant characteristics of municipality i.

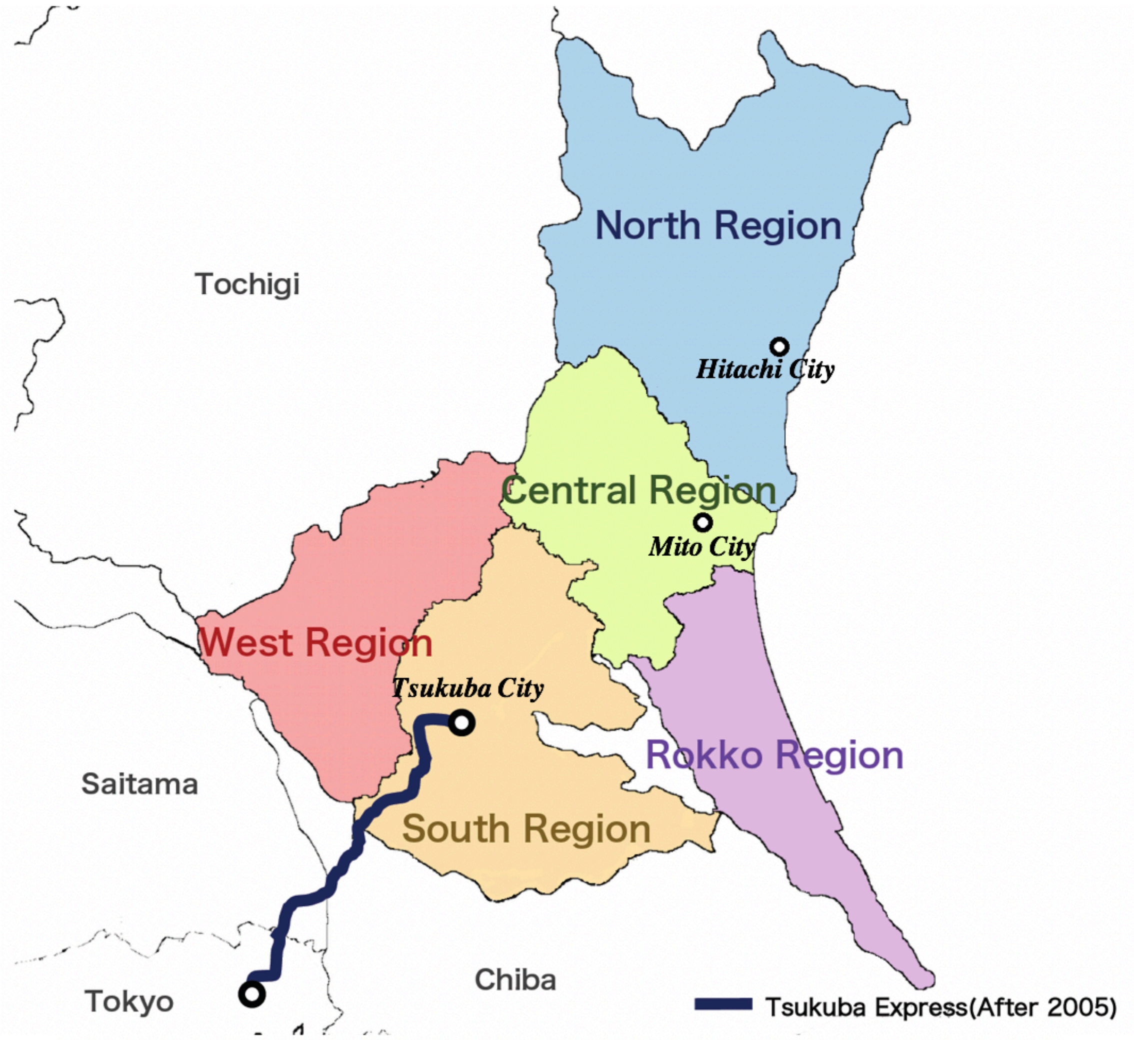

Figure 2: Regions of the Ibaraki Prefecture and the Route of the Tsukuba Express

In our panel analysis, only the time distances by public transport are used as distance variables, since linear distance cannot identify changes of inter-regional accessibility. Additionally, we cannot observe the previous time distance by car.

Ibaraki prefecture is divided into five regions: Central, South, West, North, and Rokko regions.[14] TX terminates at Tsukuba city in the South region. Figure 2 shows the main suburban cities, Mito, Hitachi

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[14] Each region is composed of municipalities as follows: Central (Kasama, Mito, and Omitama cities; and Ibaraki, Oarai, and Shirosato towns), South (Inashiki, Ishioka, Kasumigaura, Ryugasaki, Thukubamirai, Toride, Tsuchiura, Tsukuba, and Ushiku cities; Miho village; and Ami and Kawachi towns), West (Bando, Chikusei, Joso, Koga, Sakuragawa, Shimotsuma, and Yuki cities; and Yachiyo town), North (Hitachi, Hitachinaka, Hitachiomiya, Hitachiota, Kitaibaraki, Naka, and Takahagi cities; and

and Tsukuba city, and five regions of Ibaraki prefecture, and the route of TX. Since there is a difference in proximity to the new commuting train among the municipalities, the impact of opening TX might affect only municipalities that have better accessibility to the new railway.

We consider that Tsukuba city containing Tsukuba terminal, the terminus of TX, and its surrounding areas are independent from the other area of Ibraki prefecture. Kanemoto and Tokuoka (2002) define Japanese core metropolitan area as areas composed by a core city containing Density Inhabited District (DID) with more than 10 thousand population and suburban municipalities whose more than 10% of workers commuting to the core city. Ibaraki prefecture contain three core metropolitan areas in it, Mito metropolitan area, Hitachi metropolitan area and Tsukuba metropolitan area according to National Census (2010). Although each municipality can be contained in multiple metropolitan areas in the definition by Kanemoto and Tokuoka, there is no municipalities overlapping among Mito, Hitachi and Tsukuba metropolitan areas. From the fact, we assume that the metropolitan areas are strongly independent from each other. Since TX passes Tsukuba metropolitan area but does not pass Mito and Hitachi Metropolitan area, opening TX would especially affect municipalities contained in Tsukuba metropolitan area.

In Japan, there was the boom in mergers of municipalities, known as the big merger of Heisei. The peak was in 2005; on March 31th, 2004, there were 3,132 municipalities in Japan, then the number became 1821 on March 31th, 2006. Also in Ibaraki, the number of municipalities decreased from 85 to 44 in the period we focus on in the study. To control these municipal mergers, we add each variables of municipalities to the variables of the municipalities what they were merged with in the period before the merger.

To observe the effectss of proximity to TX on the magnitude of the impact of opening TX, we introduce a cross-term of $\mathrm{TimeDistance}_{it}$ and an indicator that identifies whether a municipality is close to TX. The estimation model is as follows:

$$\mathrm{Pov}_{it} = \alpha_{it} + \beta\mathrm{TimeDistance}_{it} + \gamma\mathrm{TimeDistance}_{it} \times \mathrm{ClosetoTX}_{i} + \delta\mathbf{X}_{it} + \eta_{i} + \varepsilon_{it}. \quad (10)$$

We define the regions closer to TX as the West and South regions; if a municipality is included in the regions, the indicator becomes one.

Table 4 shows the summary statistics of the case of our panel analysis. We can find from the table that time distance to the nearest urban metropolitan area of municipalities closely TX dramatically decreased

Daigo town; and Tokai village), and Rokko region (Hokota, Itako, Kamisu, Kashima, and Namekata cities).

after opening TX. On the other hands, in municipalities not closely TX, time distance to the nearest urban metropolitan area of municipalities slightly decreased. We consider the decreases in accessibility to urban metropolitan area could improve poverty situation in municipalities close to TX.

Table 4. Summary Statistics of the Case of Our Panel Analysis

	Municipalities Not Close to TX				Municipalities Close to TX			
	mean	sd	min	max	mean	sd	min	max
Before Opening TX (year<=2005)								
DISTANCE to the Nearest Urban Metropolitan Area								
Time Distance by Public Transport	73.0	27.3	28	151	42.3	17.7	10	68
POVERTY								
Poverty Rates (%)	0.43	0.17	0.13	0.98	0.29	0.10	0.09	0.46
Other Regional Characteristics								
Population	61,226	53,748	9,873	262,603	89,874	51,627	18,024	200,528
Share of Population Under 15	14.6	1.3	10.8	17.2	14.3	1.8	9.9	17.2
Share of Population Over 65	20.1	4.1	12.6	34.2	16.0	3.2	10.4	20.9
Share of High School Graduates	37.7	2.5	31.3	42.3	35.0	4.2	24.9	41.2
Share of University Graduates	6.7	2.5	3.2	13.9	13.3	4.3	5.7	20.3
Share of Workers in Primary Sector	5.5	3.5	0.7	15.7	3.9	1.7	1.4	7.2
Share of Workers in Industry Sector	30.4	6.3	16.5	45.1	30.0	5.8	16.4	39.1
	N=30	Municipality=15			N=58	Municipality=29		
After Opening TX (year>=2010)								
DISTANCE to the Nearest Urban Metropolitan Area								
Time Distance by Public Transport	69.2	25.0	26	139	27.1	18.5	5	67
POVERTY								
Poverty Rates (%)	0.69	0.35	0.18	2.07	0.50	0.22	0.17	0.95
Other Regional Characteristics								
Population	59,193	54,301	8,786	270,783	93,081	55,426	16,313	226,963
Share of Population Under 15	12.3	1.6	8.5	16.8	13.0	1.8	8.7	16.2
Share of Population Over 65	26.5	4.2	16.7	40.4	23.8	5.5	14.3	38.2
Share of High School Graduates	40.8	4.7	29.2	50.7	35.2	6.9	20.1	47.2
Share of University Graduates	8.7	2.8	4.5	16.1	16.5	5.1	7.5	26.6
Share of Workers in Primary Sector	11.1	7.0	2.9	31.9	11.2	6.5	3.5	30.7
Share of Workers in Industry Sector	30.2	6.0	19.4	45.9	28.7	4.4	19.2	35.9
	N=30	Municipality=15			N=58	Municipality=29		

5.3. The results

Table 5 describes the results of our panel analysis. Columns (1)–(2) show the results of the analysis using all of the sample (2000, 2005, 2010, and 2015). In column (1), the coefficient of $\mathrm{TimeDistance}_{it}$ is positive and insignificant. This result shows that time distance to the nearest urban metropolitan area does not affect rural poverty rates. Then, we include the interaction term between $\mathrm{TimeDistance}_{it}$ and

$\mathrm{ClosetoTX}_i$ in our model, as well as $\mathrm{TimeDistance}_{it}$. In column (2), the coefficient of $\mathrm{TimeDistance}_{it}$ is negative and insignificant, and the coefficient of the cross-term is positive with 10% significance. The magnitude of the interaction term is that one-minute decreases of $\mathrm{TimeDistance}_{it}$ reduce rural poverty rates by about 0.006 percentage point.

From columns (1) and (2), we find that accessibility to the nearest urban metropolitan area does not have significant impacts on rural poverty rates overall in the Ibaraki prefecture. However, column (2) suggests that time distance to urban metropolitan areas has impacts on rural poverty in municipalities that are closer to TX. From the results, we find that the opening of TX affected only municipalities that have better accessibility to TX. Although time distance to the nearest urban area also changed in regions that are not close to TX, their poverty rates did not reflect the changes in accessibility. We consider that a slight change in accessibility to urban metropolitan areas cannot spread or strengthen agglomeration spillover effects enough to cause the rural poverty situation to be improved, but that the opening of TX caused a significant improvement of accessibility to urban metropolitan areas, which was enough to improve the poverty rates of areas peripheral to TX.

Table 5. Results of the Panel Analysis

	(1)	(2)	(3)	(4)	(5)	(6)
	Baseline Sample		***2005 and 2010***		***2005 and 2015***	
Time Distance to the Nearest Urban Metropolitan Area	0.0015 (0.0017)	-0.0020 (0.0026)	-0.00023 (0.0013)	0.00014 (0.0029)	0.0025 (0.0035)	-0.0056 (0.0034)
Time Distance to the Nearest Urban Metropolitan Area × Municipality Close to TX	–	0.0057* (0.0030)	–	-0.00045 (0.0032)	–	0.012** (0.0052)
Intercept	7.56 (6.78)	5.34 (6.88)	6.52 (6.61)	6.24 (7.20)	6.74 (10.37)	2.78 (9.89)
Xi	Y	Y	Y	Y	Y	Y
Municipality Fixed Effect	Y	Y	Y	Y	Y	Y
Adjusted R^2	0.70	0.71	0.41	0.41	0.67	0.70
Municipality	44	44	44	44	44	44
N	176	176	88	88	88	88

Signif. codes: 0 '***' 0.01 '**' 0.05 '*' 0.1. We adopt a cluster robust standard error.

Cluster robust standard errors are in parentheses.

From Table 4, we find that whereas municipalities close to TX decrease their time distance to the nearest urban metropolitan area by about 15.2 minutes on average (from 42.3 to 27.1), municipalities far from TX decrease their time distance by only about 3.8 minutes (from 73.0 to 69.2). We consider that the difference of magnitude reflects the municipalities' accessibility to TX, and poverty situation of municipalities close to TX might more sensitively receive the impact of opening TX than municipalities far from TX. Roberto (2008) empirically investigates the case of the United States and finds that the working poor have a larger burden of commuting costs than the national median in eight metropolitan cities. Their result suggests that people living in poverty have lower price elasticity of commuting costs than people not in poverty. If improved commuting costs to the nearest urban metropolitan area are still too expensive for people in poverty, the municipalities' poverty situations might not reflect the changing accessibility to urban areas. From this discussion, we consider that a slight change of accessibility to urban areas could not affect rural poverty rates significantly.

From column (4) and (6) in table 5, we can find there is time lag between the opening of TX and changes of regional poverty situation. Chandra and Thompson (2000) focus on the lag of firms' relocation after improvements of interstate transportation in the United States. They find that the impacts of the new interstate highways on suburban regions' labor demand do not appear significantly until several years later. Their results suggest that improvement in accessibility to a closely located urban metropolitan area will spread ranges of agglomeration spillover effects and increase labor demand in surrounding regions, but lags occur before the effects appear. Providing that the lags occur in cases of opening commuting trains, there is a possibility that an improvement in poverty rates will not be observed until several years after the opening of TX in the surrounding areas.

To observe the lags of effects appearing after the TX opening, we conduct panel analyses (3)–(6). Columns (3)–(4) indicates the results of analyses using periods 2005 and 2010 as the sample. On the other hand, columns (5)–(6) adopt years 2005 and 2015 as the sample. Columns (3) and (5) adopt time distance to the nearest urban metropolitan area as the distance variable. In addition, columns (4) and (6) adopt the cross-term between $\mathrm{ClosetoTX}_i$ and $\mathrm{TimeDistance}_{it}$, as well as $\mathrm{TimeDistance}_{it}$.

In column (3), the coefficient of $\mathrm{TimeDistance}_{it}$ is negative and insignificant. In column (4), the coefficient of $\mathrm{TimeDistance}_{it}$ is positive and insignificant, and one of the cross-terms is negative and insignificant. In column (5), the coefficient of $\mathrm{TimeDistance}_{it}$ is positive and insignificant. In column (6), the coefficient of $\mathrm{TimeDistance}_{it}$ is negative and insignificant, and one of the cross-terms is positive with 5% statistical significance.

Columns (3)–(4) show that time distance to urban metropolitan areas does not have significant effects on rural poverty rates in 2005 and 2010. However, from columns (5) and (6), we find that one-minute increases of time distance to the nearest urban metropolitan area cause rural poverty rates to increase about 0.012 percentage point in municipalities close to TX. The results show that the economic effects of opening TX on the peripheral regions did not appear until 6–10 years later. We consider that our results are consistent with the findings of Chandra and Thompson (2000), which suggest that the effects of improvement in accessibility to urban metropolitan areas take some years to be observed.

However, as another explanation of our results of panel analyses, there is possibility that opening TX caused inflows of not poor people to municipalities closely located to TX, the effect is called gentrification. If opening TX attracted people not in poverty to Tsukuba metropolitan area, it could apparently decrease regional poverty rates even the number of the people in poverty did not change. To check whether opening TX decreases the number of people with low income in areas closely located to TX, we conduct panel analyses focusing on the impacts of opening TX on the number of households in each income level. If improvements of accessibility to the nearest urban metropolitan area by opening TX increased regional labor demand in municipalities closely located to TX, the number of households earning low income would decrease in the municipalities after opening TX, and it would decrease rural poverty in the areas.

Table 6 shows the summary statistics of the number of households classified by their annual income, less than 3,000,000 yen, between 3,000,000 - 5,000,000 yen, between 5,000,000 - 10,000,000 yen and more than 10,000,000 yen.[15] The data are also classified by before or after opening TX, and location of municipalities, close to TX or not close to TX. From the table, we can observe that the number of households earning less than 3,000,000 yen, between 3,000,000 - 5,000,000 yen, and between 5,000,000 - 10,000,000 yen increased after opening TX in both groups of municipalities. On the other hands, the

[15] We obtain the municipality-level data of the number of households divided by income level by The House and Land Statistics Survey by Ministry of Internal Affairs and Communications Statistics Bureau.

number of households earning more than 10,000,000 yen decreases after opening TX in both groups.

Table 6. Summary Statistics of the Case of Our Panel Analysis

	Municipalities Not Close to TX				Municipalities Close to TX			
	mean	sd	min	max	mean	sd	min	max
Before Opening TX (year<=2005)								
The number of Households Earning less than 3,000,000 yen	5,506.0	7,072.1	0	31,060	5,200.7	4,727.7	0	23,590
The number of Households Earning between 3,000,000-5,000,000 yen	5,156.0	6,211.4	0	24,940	5,269.5	4,236.3	0	18,150
The number of Households Earning between 5,000,000-10,000,000 yen	6,332.4	7,391.2	0	28,500	7,185.2	5,887.8	0	22,670
The number of Households Earning more than 10,000,000 yen	1,792.4	2,347.1	0	10,120	2,356.9	2,160.9	0	9,320
	N=30	Municipality=15			N=58	Municipality=29		
After Opening TX (year>=2010)								
The number of Households Earning less than 3,000,000 yen	8,456.9	8,766.6	2,280	41,140	7,615.7	5,876.5	1,360	26,210
The number of Households Earning between 3,000,000-5,000,000 yen	6,886.7	6,907.2	1,510	30,650	6,793.6	4,902.2	1,380	22,070
The number of Households Earning between 5,000,000-10,000,000 yen	7,450.5	7,316.7	1,330	31,210	7,861.4	6,525.3	1,560	31,010
The number of Households Earning more than 10,000,000 yen	1,618.8	1,605.4	240	6,780	1,736.7	1,486.5	320	6,820
	N=30	Municipality=15			N=58	Municipality=29		

We conduct a panel analysis to investigate the impacts of opening TX on the number of households in each income level. The estimation models are as follows:

$$\ln\text{Households}_{it} = \alpha_{it} + \beta\text{TimeDistance}_{it} + \gamma\text{TimeDistance}_{it} \times \text{ClosetoTX}_i + \eta_i + \varepsilon_{it}. \quad (11)$$

In estimation model (11), $\ln\text{Households}_{it}$ is the natural logarithmic of the number of municipality i's households classified by their income level in year t.

Table 7 describes the results of our panel analyses using estimation model (11). Columns (1) shows the results of the analysis adopting the natural logarithm of the number of households earning less than 3,000,000 yen as the explained variable. In column (1), the coefficient of time distance to the nearest urban metropolitan area is negative with one percent significance. The magnitude is that one-minute increases in TimeDistance_{it} reduce the number of households earning less than 3,000,000 yen by about 0.007 percentage point. Then, the coefficient of the cross-term is positive with five percent significance. The magnitude of the interaction term is that one-minute decreases of TimeDistance_{it} reduce the number of households earning less than 3,000,000 yen by about 0.008 percentage point in municipalities closely located to TX.

Columns (2) is the result of the estimation adopting the natural logarithm of the number of households earning between 3,000,000 and 5,000,000 yen as the dependent variable. In column (2), the coefficient of TimeDistance_{it} is negative with five percent significance. The magnitude is that one-minute increases in TimeDistance_{it} reduce the number of households earning between 3,000,000 and 5,000,000 yen by about 0.009 percentage point. The coefficient of the cross-term is positive with 10% significance. The magnitude of the interaction term is that one-minute decreases of TimeDistance_{it} reduce the number of households earning between 3,000,000 and 5,000,000 yen by about 0.007 percentage point in municipalities closely located to TX.

Columns (3) uses the natural logarithm of the number of households earning between 5,000,000 and 10,000,000 yen as the explained variable, and shows the similar results to column (1) and (2) in the points of coefficients of TimeDistance_{it} and the cross-term. The coefficient of time distance to the nearest urban metropolitan area is negative with one percent significance. The magnitude is that one-minute increases in TimeDistance_{it} reduce the number of households earning between 3,000,000 and 5,000,000 yen by about 0.009 percentage point. Then, the coefficient of the cross-term is positive with 10% significance. The magnitude of the interaction term is that one-minute increases of TimeDistance_{it} increase the number of households earning between 5,000,000 and 10,000,000 yen by about 0.005 percentage point in municipalities closely located to TX.

Columns (4) describes the result of the analysis adopting the natural logarithm of the number of households earning more than 10,000,000 yen as the dependent variable. In column (4), the coefficient of TimeDistance_{it} is negative and insignificant. Then, the coefficient of the cross-term is positive and insignificant. The result show that time distance to the nearest urban metropolitan area does not affect the number of households earning more than 10,000,000 yen.

In terms of TimeDistance_{it}, the results of columns (1), (2) and (3) show that increases in time distance to the nearest urban metropolitan area decrease the number of households earning less than 3,000,000 yen, between 3,000,000 and 5,000,000 yen, and between 5,000,000 and 10,000,000 yen in all over Ibaraki prefecture. From the results, we consider that households with income less than 10,000,000 yen tend to relocate to the areas with better accessibility to the nearest urban metropolitan area to receive the benefits of smaller commuting costs. Moreover, we can observe the tendency that households with higher income sensitively react to smaller time distance to the nearest urban metropolitan area. This is consistent to our above discussion that shows households with smaller income have lower mobility than households with larger income. From the above discussions, we consider that improvement of accessibility to the nearest urban metropolitan areas attract households with less than 10,000,000 income, and the scale of impacts depend on the households' income level. But column (4) suggests that the number of households earning more than 10,000,000 yen, the richest class in our sample, was not affected by time distance to the nearest urban metropolitan area. As interpretation of the result, we consider that since households with income more than 10,000,000 yen have sufficient income to locate on places they want, they do not react to improvements of accessibility to the nearest urban metropolitan area by relocation.

With respect to the cross-term, columns (1) – (3) show that increases in time distance to the nearest urban metropolitan area increase the number of households with income less than 3,000,000 yen, between 3,000,000 and 5,000,000 yen, and between 5,000,000 and 10,000,000 yen in municipalities closely located to TX. The results consistent to our assumption that improvements of accessibility to the nearest urban metropolitan area increases regional income level and reduce the number of households with lower income, less than 3,000,000 yen in the sample. The result also shows that the number of households earning between 3,000,000 and 5,000,000 yen, and between 5,000,000 and 10,000,000 decrease by improvements of accessibility to the nearest urban metropolitan area. Since there is the tendency that households with lower income are strongly affected by time distance to the nearest urban metropolitan area, we consider that the reduction of households with income between 3,000,000 and 5,000,000 yen, and between 5,000,000 and 10,000,000 would be partly canceled out by households who were in lower income class before opening TX and increased their income after opening TX.

The above results show that opening TX decreased the number of households with small income in municipalities closely located to TX. We also observe that improvements of accessibility to the nearest urban metropolitan area attract households earning less than 10,000,000 yen. The results suggest that improvement of accessibility to the nearest urban metropolitan area decreases regional poverty by increasing regional income level, and activate the areas' economy through inflows of households from other areas.

Table 7. The Result of Opening TX on the Number of Households Divided by their Income

	(1)	(2)	(3)	(4)
	ln (Households Earning less than 300 thousand yen)	ln (Households Earning between 300-500 thousand yen)	ln (Households Earning between 500-1,000 thousand yen)	ln (Households Earning more than 1,000 thousand yen)
Time Distance to the Nearest Urban Metropolitan Area	-0.00727***	-0.00853**	-0.00885***	-0.00278
	(-3.690)	(-2.677)	(-4.018)	(-1.375)
Time Distance to the Nearest Urban Metropolitan Area × Municipalities Close to TX	0.00782**	0.00738*	0.00486*	0.00355
	(2.581)	(1.993)	(1.686)	(1.603)
Municipality Fixed Effects				
Year Fixed Effect				
Constant	8.287***	8.416***	8.826***	7.486***
	(198.8)	(152.1)	(175.1)	(86.76)
Observations	157	157	157	157
R2	0.780	0.563	0.313	0.340
N	42	42	42	42

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

However, there is still a possibility that the decreases in the number of households with lower income is just a result of driving out people in poverty by increases in housing rent caused by gentrification. If gentrification caused increases in housing rent in the areas closely located to TX and the areas' rent level became too expensive for the poor, the people in poverty would relocate to another area with lower housing rent, and we would observe the decreases in the number of households with lower income in Tsukuba metropolitan area.

We consider that people in poverty situation before opening TX were not driven out from their residences even after opening TX. There are two main reasons. First, as a legally condition protecting people in poverty from being driven out, there is Leased Land and House Lease Law in Japan. The law provides that owners could increase rent only when "*the building rent becomes unreasonable, as a result of the increase or decrease in tax and other burden relating to the land or the buildings, as a result of the rise or fall of land or building prices or fluctuations in other economic circumstances, or in comparison to the rents on similar buildings in the vicinity, the parties may, notwithstanding the contract conditions*".[16] Moreover, the law also provides that residents could negotiate with the owner by civil conciliation and deposit their rent which is same amount before the rent changing. Therefore, we consider that people in poverty situation were not immediately driven out even after gentrification.

[16] Article 32 (1) of Leased Land and House Lease Law.

Second, since relocation costs are more serious burden for people in poverty than for people not in poverty, the poor tend to stay in their residence for a longer time. Table 8 shows the number and share of households classified by their monthly housing rent and their duration of residence in Ibaraki prefecture in 2013.[17] We can find that in the groups whose housing rent is between 0 - 10,000 yen and 10,000 – 20,000 yen, more than 30% of households living in current residences for 13 or more years. In the group whose housing rent is between 20,000 – 40,000 yen, the share of living their residence for more than 13 years is about 24.6%, and the share decreases by increases in housing rent. Since housing rent has strongly positive correlation with household income, we can interpret that the mobility of households in poverty is lower than ones not in poverty.

Table 8. The Number and Share of Households Divided by Monthly Rent and their Duration of Residence in 2013

	All	0 yen	0-10,000 yen	10,000-20,000 yen	20,000-40,000 yen	40,000-60,000 yen	60,000-80,000 yen	80,000-100,000 yen	100,000-150,000 yen	150,000-200,000 yen
All	209,400	4,900	10,900	13,800	46,800	78,900	43,500	7,500	2,900	200
	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)
0-2 years	86,100	1,900	4,100	5,200	17,300	33,300	19,900	3,100	1,200	100
	(41.1)	(38.8)	(37.6)	(37.7)	(37)	(42.2)	(45.7)	(41.3)	(41.4)	(50)
3-7 years	63,700	1,100	2,000	2,800	12,600	25,600	15,500	3,200	800	100
	(30.4)	(22.4)	(18.3)	(20.3)	(26.9)	(32.4)	(35.6)	(42.7)	(27.6)	(50)
8-12 years	21,800	400	1,100	1,400	5,300	8,500	4,000	700	400	0
	(10.4)	(8.2)	(10.1)	(10.1)	(11.3)	(10.8)	(9.2)	(9.3)	(13.8)	(0)
13-22 years	21,500	600	1,700	1,700	5,700	7,700	3,400	400	300	0
	(10.3)	(12.2)	(15.6)	(12.3)	(12.2)	(9.8)	(7.8)	(5.3)	(10.3)	(0)
more than 23 years	16,200	1,000	1,900	2,700	5,800	3,800	700	200	100	0
	(7.9)	(20.4)	(17.4)	(19.6)	(12.4)	(4.8)	(1.6)	(2.7)	(3.4)	(0)

Share of the period that households live in their house divided by monthly rent in parentheses

From the above discussions, we consider that many households in poverty situation before opening TX continued to live in same rental housings even after opening TX, and the number of households with lower income decreased in areas closely located to TX after opening TX. Therefore, we conclude that improvement of accessibility to the nearest urban metropolitan area would improve living level of people in poverty situation located in surrounding areas, and our result suggesting the decreases in poverty rates by TX (described in Table 5) is not just a result of increases in people not in poverty caused by gentrification.

6. Conclusion

We investigate the relationship between municipalities' accessibility to the nearest urban metropolitan area and rural poverty rates by focusing on the case of Japanese municipalities. We find that whereas increasing the time distance to the nearest urban metropolitan area increases rural poverty rates, linear distance does not explain the situation of rural poverty. When focusing on the case with many

[17] The data is from The House and Land Statistics Survey by Ministry of Internal Affairs and Communications Statistics Bureau (2018).

geographical barriers, there will be difference between linear distance and time distance in explaining the spillover effects of urban agglomeration on regional economic performance.

Moreover, we focus on the impacts of the opening of the commuting train TX in 2005 on surrounding municipalities' poverty rates and conduct panel analysis to control for time invariant characteristics of municipalities. Even when we control for regional time invariant characteristics, the causal effects of access to the nearest urban metropolitan area on rural poverty rates are observed significantly in municipalities close to the new commuting train. This result suggests that slight changes of accessibility to the nearest urban metropolitan area do not affect the regional poverty situation significantly.

From our estimations, one-minute increases of time distance to the nearest urban metropolitan area increase rural poverty rates by about 0.002 percentage point. This implies that about 0.78 additional households begin to receive public assistance and cause increases of the annual expenditure for public assistance of about 1.75 million yen on average. In addition, we find that the economic effects of opening TX on the surrounding regions did not appear until 6–10 years later. This result suggests that when governments invest in transportation infrastructures to improve their economic performance, they ought to expect that the effects will not appear until a few years later.

Our results show that economic agglomeration spillovers are effective in reducing the poverty of surrounding regions, and improving accessibility to closely located urban metropolitan areas enlarges the magnitude and ranges of the effects. Transportation investments that improve accessibility to urban metropolitan areas may stimulate their own economic performance and reduce poverty.

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