Spatial Variations in Fertility :
Geographically Weighted Regression Analyses for Town-and-Village-level TFR in Japan

Kenji Kamata[1]
Miho Iwasawa[1]
Kimiko Tanaka[2]

Paper to be presented at the annual meeting of Population Association of America
April 15 – 17, 2010, Dallas, Texas

Abstract

To re-examine previous research on fertility variations in Japan and to assess heterogeneity of the relationships between regional fertility rates and their covariates, we estimated geographically weighted regression models that allow us to consider spatial heterogeneity. Our analytical samples are 2,311 towns and villages based on administrative boundaries in 2005. Our explanatory variables are taken from a database based on the census and include economic conditions, female labor participation, and household structure as well as other social conditions. Our result showed that most coefficients of covariates on total fertility rates (e.g., male unemployment rate, employment rate of reproductive age women, proportion of nuclear families) had statistically significant geographical variations, and in some regions, the sign of one coefficient (unemployment rate) shifted in the opposite direction from what it is argued in some regions. Our findings suggest that how fertility rates respond to external forces vary across regions because of their historical and geographical settings.

[1] National Institute of Population and Social Security Research, Tokyo
[2] University of Wisconsin at Madison

Introduction

This study considers the importance of spatial effects on fertility behaviors in Japan. Specifically, based on spatial (geographical) analysis techniques, we aim to identify demographic, economical, political, and cultural factors causing regional variations of fertility behaviors.

Compared with previous studies based on ordinary least square regressions, spatial analysis techniques have strengths in overcoming limitations and possible biases in previous studies by taking geographical information into account.

Usually, social phenomena are not spatially homogeneous, but tend to be influenced by so-called geographical spatial effects. For example, regional data often exhibit phenomena such as spatial autocorrelation, where observation values from neighboring locations tend to be highly correlated, or nonstationarity, where relationships between variables may differ depending on the location. Nonetheless, in regression analyses of regional variations in the past, such spatial correlation and nonstationarity could not be handled efficiently, which often led to unreliable inferences. However, the recent development of spatial statistic analysis has allowed such methodological problems in the past to be overcome and enabled quantitative detection of spatial effects. In this study as well, we use these advantages of spatial statistic analysis methods in an attempt to investigate factors defining fertility behaviors.

Apart from the methodological strengths, our paper will provide important insights to understand regional fluctuations of fertility in Japanese society. It appears that during the fertility decline nationwide from the 1970, the regional differences narrowed down in 1990 (Takahashi 1997). However, lately growing gap among regions was observed again (Shimizu 2004). Our study aims to investigate causes behind these geographical fluctuations. In the past research, these variations have been examined using prefecture (state)-level variation of explanatory variables. Since it is well known that when the same data are aggregated at different scales of areal unit, results of statistical analysis are disparate over scales (Chi and Zhu 2008), we re-examine the previous results by using township areal data.

In this study, we first argue about the importance of focusing on spatial process in fertility research, and then review previous research on regional fertility variation and influential factors in Japan examined mainly by prefecture level analyses. Following the brief interpretation about the geographically weighted regression method (GWR), we estimate ordinary least square (OLS) model and GRW model using township data for Japan. Finally we discuss how our understanding of factors on fertility may change from the one based on previous analyses using prefecture data or the inference from the OLS model estimation, when we take into account spatial heterogeneity.

1. Spatial Analysis in Fertility Research

Our behaviors are influenced by cultures and institutions specific to regions (spatial regime) and spatial processes (diffusion, network effects, feedback effects etc.). However, individual data set has limitation in taking spatial information into account including spatial coordinates (possibility that regions exhibiting similar effects are actually adjacent), Spatial analysis, on the other hand, is able to fully consider and model such spatial effects.

Spatial autocorrelation is a phenomena where observation values from neighboring locations tend to be highly correlated, or nonstationarity, where relationships between variables may differ depending on the location. Ordinary least squares (OLS) regression model assumes that error terms are independent and identically distributed, and previous studies based on OLS regression could not handle proximity of regions efficiently, which often resulted in unreliable inferences.

One of the most basic concepts of geography is the first law of geography (Tobler, W. R.), which states "everything is related to everything else, but near things are more related than distant things" (Tobler 1970, p. 236). Phrased differently, the closer prefectures are geographically located, the higher the tendency that they have similar characteristics. Moreover, it is highly likely that the response to a certain variable varies by region due to historical/geographical reasons. Such condition, where coefficients vary according to region, is called spatial nonstationarity. When handling samples with different populations and areas, such as prefectures, towns, and villages, it is more realistic to assume that the effect of certain variables influencing fertility behaviors vary by region. Thus, it is necessary to use a local model that detects local estimates, rather than a global model that is based on the analysis that does not consider complex geographical effects. A local model estimates a set of coefficients for each region according to the assumptions that the coefficients differ for each region, while a global model assumes that each estimated coefficient is the same for all regions. In other words, global model has great limitation in identifying issues specific to certain regions and implement political measures appropriate for each region.

This study uses Geographically Weighted Regression (GWR) as the analysis model, since it permits treatment of nonstationary data and allows us to examine geographical variations of factors influencing fertility behaviors.

2. Previous Research on Regional Fertility

Before the mid-1950s, regional differences in birth rate showed a tendency of "high east and low west." After the 1960s, however, this tendency was shifted to "low in metropolitan areas and high in non-metropolitan areas" (Kawabe 1979; Nakagawa 2003) and was influenced by modernization, industrialization, and urbanization. After the middle of the 1970s, the total fertility rate showed a downward trend throughout the nation, yet regional differences were maintained. Although fertility rates in large cities tended to be higher than agrarian prefectures as of 1970, the fertility dropped most significantly in metropolitan areas in the 1970s and onward (Uehara and Ohyama 1995). Although the regional differences narrowed down in 1990 (Takahashi 1997), lately growing gap among regions was observed again (Shimizu 2004).

In Japan, migration within the nation is much larger than international migration. People often move to different region, and the timing of moving is sometimes closely tied to the timing of childbirth. For this reason, if many people move into another region while pregnant (before giving a birth), the statistics will show very low fertility rates of the region of origin, while the region they moved to will exhibit very high fertility rates. However, period total fertility rates do not adjust biases caused by such migration trend. Recent trend in domestic migration is described as large population influx into Tokyo metropolitan area (Yamauchi *et al.* 2005). Since the average number of children per couple is smaller for people who migrated from non-metropolitan areas to metropolitan areas than their counterparts (Koike 2006), the migration is expected to influence positively on fertility in urban areas. In addition, it is also noted that married women between 20 and 39 years old are more likely to migrate to metropolitan areas than other women. Thus, fertility rates are expected to be higher in urban areas (Sasai 2007). Concerning the relationship between socio-economic indicators and fertility rates by towns and villages, Sasai (2005) discussed that there are tendencies that the higher the population density, educational level, and the percentage of nuclear families, the lower the fertility rates. By contrast the higher the percentages of elderly people and population working in primary industries, the higher the fertility rates (Sasai 2005). Kojima (2005) used micro data that linked to area data and found that the percentage of male population working in primary industries is positively correlated with the total fertility rates, where as it was negatively correlated for women. Kojima (2005) also reported that unemployment rate had a negative association with the total fertility rate for men, and the net migration rate had a negative correlation with the total fertility rates for both men and women, suggesting the effect of unemployment on fertility rates, which is consistent with the previous studies pointing out that economic uncertainly is a significant factor determining future fertility rates in Japan.

Policy relevant indicators such as the availability of day-care centers also influence fertility rates as well. Previous studies based on standard regression analyses showed that there is a positive correlation between the rate of people using day-care centers and female employment rate, suggesting a correlation between the availability of daycare centers and female labor force participation. In fact, other studies pointed out clear positive correlation between usage of day-care centers and female labor force participation rate (Oishi 2003; 2005), which is another indicator determining fertility rates (Abe 2005; Shigeno 2006).

Living arrangement is another factor that influences both fertility and usage of child-care facilities, and is influenced by geography. Yamashige (2002) conducted regression analyses using prefectural data and showed that both the proportion of three-generation households and usage rate of day-care center have positive correlations to fertility (R^2=0.876) in contrast with the proportion of double-income households (R^2=0.227). Previous studies showed that household structures vary by region in Japanese society. (Shimizu 1997, Kato 2005). Japanese household structures are basically divided into two regions: northeast region characterized by single households, and southeast regions characterized by multiple households. Tendency to live in three generational households in East as opposed to the tendency of proximate residence with grandparents in West is especially prominent in Japanese society.

Although previous studies discussed the impact of various indicators (geography, living arrangements, availability of day care centers, and education level) on fertility rates, scholars use the total fertility rates as an index of reproductive behaviors. As far as period total fertility rates aggregated by year are used, it is not possible to adjust biases caused by such migration. In our study, we use a local model that detects local estimates, rather than a global model that has limitation in capturing regional diversity. .

3. Method

We used the Geographically Weighted Regression (GWR) method (Brunsdon *et al.* 1996; Fotheringham 2000; Fotheringham *et al.* 2002), which is part of nonparametric spatial regression models; more specifically, it is considered spatial extension of the conditional Kernel Regression (Nakaya 2004).

GWR method takes geographical information (spatial coordinates) to a normal regression model and applies a spatial weighting on the estimation of each coefficient of the regression model to express the spatial variability of the coefficients.

The following equations show a general regression formula of an ordinary least squares (OLS) model and a model based on GWR method. OLS model considered a global model that estimates a single set of coefficients for all locations based on the assumption that the coefficients remain constant in all locations. In contrast, GWR method is considered a local model where non-constant coefficients are estimated for each location *i*. That is, the model assumes spatial nonstationary, where the coefficients vary for each location *i*.

Ordinary least squares model (OLS):

$$y_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \cdots + \beta_n x_{ni} + \varepsilon_i$$

Geographically Weighted Regression model (GWR):

$$y_i = \beta_0 + \beta_1(i) x_{1i} + \beta_2(i) x_{2i} + \cdots + \beta_n(i) x_{ni} + \varepsilon_i$$

The following two equations show how the coefficient estimation equations are estimated in matrix form. The equation based on GWR method incorporates a function *W* (*i*) representing a spatial weighting with position *i* at the center, into the standard expression of coefficient estimates of a normal regression model. It is a distance attenuation function, where the longer the distance, the smaller the spatial weight applied on the coefficient. In such way, each set of coefficients will be estimated by a function of least squares weighted by distance attenuation.

Coefficient estimate of ordinary regression model:

$$\beta' = (X^T X)^{-1} X^T Y$$

Coefficient estimate of geographically weighted regression model:

$$\beta'(i) = (X^T W(i) X)^{-1} X^T W(i) Y$$

Here, each column of β’ for symbol *i* and *W* (*i*) are $n \times n$ spatial weight matrices. In the spatial weight matrix, the diagonal components consist of the spatial weight of regression point *i*, while all non-diagonal components are 0.

The GWR method is characterized by the use of kernel functions to express the distribution of spatial weights. Since a kernel function is a distance attenuation function where the spatial weight becomes large if the distance is small, the spatial weight applied at position *i* varies depending on the distance from the regression point to a sample point. The kernel functions used most commonly in GWR include Gaussian and bi-square functions (Note 1). The bandwidth of the kernel function can be specified by either fixed method or adapted method, and the way of specification varies depends on each method. The fixed method sets a constant bandwidth from regression point for all locations, while the adapted method determines an individual bandwidth for each location such that each bandwidth includes an equal number of sample locations (Figure 1). In fixed method, whereas the kernel function remains constant regardless of whether the sample locations are dense or dispersed whereas the adapted method changes the bandwidth according to the number of sample locations included. Thus, the weight varies depend on the clustering of sample locations. If the bandwidth is large, the number of sample locations used for estimation is greater and the bias thus becomes larger since the distribution of estimated values becomes smaller. If the bandwidth is small, however, the number of sample locations becomes smaller and the distribution of estimated values become larger, but the bias becomes smaller (Fotheringham *et al.* 2002).

In order to handle such trade-off issues and be able to select the optimum bandwidth, we employed Corrected AIC (AICc: Corrected Akaike's Information Criteria), which is a statistical model for comparisons, and CV (Cross Validation). The bandwidth where these statistics exhibit the smallest values is judged to be optimal.

[Figure 1]

As discussed above, GWR method is better than the OLS regression models in two ways. Normal OLS regression models had two problems: (1) if spatial autocorrelation exists in the error terms, the assumption of i.i.d. is violated and (2) the assumption that the estimated coefficients are constant throughout the nation is questionable. To solve the first problem spatial error models that explicitly models influence of spatial autocorrelation in error terms can be used. However, it does not solve the second problem. To solve both problems, our study estimates a geographically weighted regression model, that is, a set of local models, which allows for geographical heterogeneity of coefficients of explanatory variables. Specifically, first, we evaluate coefficients in a conventional regression model (OLS), then we estimate geographically weighted regression model (GWR) to obtain a set of local models. Then using spatial statistical method, we examine how using GWR method improved compared with OLS regressions. Lastly, we interpret the influence of the variables used in the model.

4. Data and Variables

Data

We used the “Socio-demographic Statistical System: Towns and Villages Basic Data File (1980-2005),” which is a database provided by the Statistical Information Institute for Consulting and Analysis. We also used the “japan_ver52.shp,” which is a GIS file (shape file) provided by ESRI (depicting administrative boundaries, October 1, 2005). We combined both information, and created a basic data set of 2,364 towns and villages. We excluded isolated islands, towns, and villages without adjacent regions (53 towns and villages) in order to take connectivity with adjacent towns and villages into consideration. Therefore, a dataset that contains 2,311 towns and villages was used (Note 2). Table 1 summarized the variables used in this analysis.

[Table 1]

Dependent Variable

The total fertility rate by towns and villages is used for the dependent variable. Specifically, we used the Bayesian estimates of the total fertility rate provided by two data source; (1) "Overview on Vital Statistics by Public Health Center and Municipality in 2003 – 2007", and (2) the Ministry of Health, Labour and Welfare (1896 towns and villages). Note that the total fertility rates for towns and villages that were not included in the Bayesian estimates were calculated using Vital Statistics in 2005 (415 towns and villages).

Independent Variables

Based on previous studies, we used nine independent variables discussed to cause variations in fertility rates by region (Note 2).

(1) The proportion of those who work in primary industries as an index that indicates contrasting regional differences in recent fertility rates between metropolitan areas and rural areas (non-metropolitan areas).

(2) Male unemployment rate. We used the unemployment rate for men published in the Population Census, which is slightly higher than the value in the Labor Force Survey. Since aggravation of economic conditions has a negative influence on marriage and childbearing (Kohler *et al.* 2002; Kojima 2005), the expected direction is negative.

(3) The rate of in-migration from other towns and villages obtained from the Population Census. The in-migration rate is higher and fertility tends to be low in metropolitan areas (Koike 2006); the expected direction is thus negative.

(4) The proportion of nuclear families previous studies used the proportion of three generational household. However, the measure was not available and we used the proportion of nuclear families instead (Note 4).

(5) The proportion of university graduates (among women aged 15 to 49 years old) aggregated in the Population Census. In many societies, high educational background, among women in particular, has a negative effect on fertility (Billari and Philipov 2004); the expected direction was thus chosen to be negative.

(6) Employment rate of women aged 15 to 49 years old. Some point out that an environment favorable to child-rearing influences such results because the rate of women working as civil servants, for who support for raising children can be easily obtained, is high in non-metropolitan areas (Yui 2007).

(7) The population of unmarried population (among women aged 30 to 39 years old). In Japan, where marriage and childbirth are strongly associated, the ratio of unmarried population in their 30s is considered to have a negative influence on the fertility rate, so we expect a negative direction

(8) Marriage rates the number of marriages in 2005 by the unmarried population aged 15 to 49 years old). Since an increase in the number of marriages undoubtedly leads to an increase in the number of live births, the expected direction is positive.

(9) The number of day-care centers (per population of 100,000 aged 0 to 5 years old). The sign condition was chosen to be positive.

Table 2 summarizes the relationship among these independent variables using Pearson product-moment correlation coefficients.

[Table 2]

5. Result

Regional Distributions and Spatial Autocorrelations

Figure 2 shows the distributions of selected variables used in the analysis by towns and villages. Distribution of each variable is represented by threshold values classified by 20, 40, 60, and 80 percentiles. As an index to measure spatial autocorrelation, we looked at Moran's I statistic that calculates geographical continuity / non-continuity (i.e., the covariance relations among neighboring regions as spatial autocorrelation). Moran's I can be considered a type of product-moment correlation coefficients involving spatial weights, and it summarizes the regularity in overall spatial fluctuations (Nakaya 2003). Moran's I approaches 0 if there is no relationship between the value of a certain region and the average value of neighboring regions. Positive values indicate high average value of the neighboring regions if a value of a certain region is high. In contrast, negative values mean a low average value of the neighboring regions if a value of a certain region is high. The values in brackets [ ] in Figure 2 indicate the test results at 99% significance level of the null hypothesis "no spatial autocorrelation" in Moran's I and randomization hypothesis.

[Figure 2]

Looking at the geographical distribution of total fertility rates, as indicated by the previous research, fertility rates tend to be low in the metropolitan areas (the central part of Hokkaido, the northern part of Aomori prefecture, Tokyo metropolitan district, Osaka metropolitan district, and the northern part of Fukuoka prefecture). The spatial autocorrelation is 0.52, indicating slightly high tendency of clustering same level municipalities.

Regions with high ratio of population engaged in the primary industries are distributed widely throughout the northeastern Japan; various regions in the Shikoku region and the central to southern part of the Kyushu region also indicate high ratios. The spatial autocorrelation is 0.56, which is slightly high The national distribution of rates of unemployment (for men) indicates high rates in the urban area of Hokkaido, the northern part of the Tohoku region, and the Kanto region, as well as from the Kinki region through the Shikoku region, the north and south parts of the Kyushu region, with low rates from the Chubu to Hokuriku regions as well as the Chugoku region along the Sea of Japan. The spatial autocorrelation shows a high value of 0.61.

The national distribution of the rate of in-migration shows high rates in the entire Hokkaido, the Kanto region, Aichi prefecture, areas near Osaka, from Hiroshima prefecture through Yamaguchi prefecture, and the entire Kyushu region. Areas along the Sea of Japan from the Tohoku to Chugoku regions as well as the Shikoku region tend to have low rates. The spatial autocorrelation is relatively high at 0.59.

Looking at the national distribution of proportion of nuclear families, the areas with high proportion of nuclear families tends to spread along the Pacific Ocean side of Japan, in the regions from Hokkaido over Kanto through Kyushu and Okinawa prefecture. The proportion tends to be low on the Sea of Japan side from the Tohoku region to the northern part of the Chubu region. The spatial autocorrelation is relatively high at 0.60.

In addition, we observed a trend where the ratio of population graduated from universities is low in regions from Hokkaido over to Tohoku to the Hokuriku region and high from the Kanto region to the northern part of the Kyushu region. The spatial autocorrelation also indicates the highest value of 0.73.

The nationwide distribution of employment rates (among women aged 15 to 49) shows a trend that the rate is low in the metropolitan areas and high in rural areas. The spatial autocorrelation is relatively high at 0.69.

The national distribution of ratio of unmarried population (among women aged 30 to 39) represents conditions where the ratio is high in the metropolitan areas and low in rural areas. The spatial autocorrelation is 0.45. The nationwide distribution of the rate of marriages among unmarried population shows a pattern somewhat varied throughout Japan, indicated by low value (0.15) of the spatial autocorrelation also suggests.

Finally, the national distribution of numbers of day-care centers indicates that the figure is low in the metropolitan areas and high in rural areas. The spatial autocorrelation is 0.36 and not very high.

Results from Global Models (OLS regressions)

A model is estimated using the nine independent variables above. We used the "spdep" and "spgwr" packages of the statistic analysis system R for the analysis. Table 3 shows the results obtained by the global model (OLS). All of the nine independent variables in the model are significant. Two variables had unexpected signs from previous studies: (1) male unemployment rate and (2) the rate of inward migration. For both variables, the coefficient was positive. Previous studies examined the effects of both variables by prefecture. Possible reasons are labor markets tend to be formed across multiple towns and villages. Migration and migration between towns and villages within the same prefecture may have different meanings.

The signs of other independent variables (name them) are in the direction we expected from the previous research and are statistically significant as well. However, the result based on calculating Moran's I of error term residuals in the OLS model showed that a value of I was 0.30 (statistically significant at 0.01% level), and spatial autocorrelation was detected in the residuals. Therefore, there is a possibility that the distribution of coefficients in the OLS model to be underestimated, and one must be cautious when interpreting the results. The results suggest that we should compare results from the local model based on GWR methods that adjusts the influence of the geo-spatial distribution.

Local Models (GWR)

Figure 4 shows the results based on GWR method. Although there are several options for the estimation methods of bandwidth, the adapted and bi-square type kernel function was employed because it fits the best to this model. In addition, AIC was used for estimation of the optimum bandwidth. The value of AIC declined from -1776.826 in OLS to -2868.826 in GWR method, showing dramatic improvement in the local models based on GWR method. The value of R^2 improved as well. The value increased from 0.4056 in OLS to 0.554 (average value of local R^2) in GWR method. Therefore, it is clear that the model is improved by using local models instead of OLS regressions.

The adaptive quantile, an indicator showing the bandwidth of the kernel function, is expressed as the ratio of the bandwidth with respect to the total number of samples and the bandwidth obtained by multiplying the adaptive quantile by the number of samples. In this model, the number of samples included in each kernel was approximately 165 locations (Note 5). With the determination of this bandwidth, the number of effective parameters became approximately 405. The descriptive statistics of the estimates shows the distribution of coefficients from the minimum value to 25%, over the median, 75%, to the maximum value, and the values of global coefficients match with the results of ordinary multiple linear regression analysis using all samples.

Table 5 shows the results of Leung's F-test, which examines the factor of improvement from OLS (Leung *et al.* 2000). Based on three different methods (F(1), F(2), and F(3)), Leung's F-test is calculated (Note 6).

According to this test, regional differences are statistically significant for all variables except for the number of day-care centers (per population of 100,000 aged 0 to 5 years old). In other words, regional differences could not be observed and the obtained coefficient is interpreted as being equal to the estimates in the global model. However, this result does not mean that there are no regional differences in the number of day-care centers. It simply means that there are no regional differences in the size of coefficient that indicates the relationship with the total fertility rate.

[Table 3, 4, 5]

Figure 3 shows distributions of coefficients and R^2 values by towns and villages, estimated by GWR method. Under normal circumstances, the distribution of coefficients is continuous, but in this figure, statistically insignificant coefficients (alpha less than .05) are indicated by shading. Note that since it is difficult to provide reasonable explanations for the level of coefficients in all the regions, the interpretation here focuses on the contrast between metropolitan and non-metropolitan areas, where relatively clear differences are observed.

The ratio of population engaged in primary industries shows widespread positive values in the Chubu, Hokuriku, and Koshinetsu regions (Figure 3). In other words, the fertility tends to be prominently higher in these regions for agricultural areas than other areas? The ratio of population engaged in the primary industries is associated with fertility only in these specific areas, and such a factor is not very important in many areas.

Male unemployment rate showed positive effect on fertility in many areas based the OLS regression analysis. However, the model based on GWR method showed negative effects in many areas. Areas showing positive relations include Ishikawa prefecture, the southern area of Hyogo prefecture, prefectures in the Shikoku region, Yamaguchi prefecture, the northern area of Kyushu region, and the southwestern area of Kagoshima prefecture. In the northern area of Kumamoto prefecture, the rate of unemployment was high and the negative effect of male unemployment rate on fertility was strong. The fertility rate in this area is indeed relatively low, even though it is situated in Kyushu where the fertility rate of this region is relatively high, which may indicate the strong influence of economic conditions.

The coefficient of the rate of in-migration shows positive distribution in the central area of Hokkaido, Aomori prefecture, the northern Kanto region to Hokuriku / Koshinetsu region, the entire Chubu region, the southern Kinki region, Okayama, and Ohita prefectures. Although the rate of in-migration is a variable that reflects the contrast between metropolitan and non-metropolitan areas, the level distribution is not related to the coefficient, which requires further consideration.

The coefficient of the proportion of nuclear families shows positive distribution in part of the southern area of Hokkaido, around Sendai city, in the central area of Fukushima prefecture, in the southern area of Kinki region, and in parts of Shikoku region, among other areas. Overall, many areas show negative coefficients. Nuclear families are usually considered disadvantageous for childbearing because it poses difficulty in receiving support from parents. Some areas show positive coefficients however, which may indicate the possibility of other factors compensating for such disadvantages of nuclear families.

Looking at the distribution of the coefficient of the ratio of university graduates (among women aged 15 to 49), the values are not statistically significant in most parts of the Tohoku region to the northern part of the Kanto region, in the Koshinetsu region, as well as from the area around Hyogo, Tottori, and Okayama prefectures to the eastern part of the Shikoku region. It is pointed out that the recent popularization of higher education among women generally has negative effects on the fertility rate. However, such negative relationship is limited to some areas when looking on the nationwide scale.

The coefficient of the employment rate (among women aged 15 to 49) showed positive association in the central and eastern parts of Hokkaido, Fukushima prefecture and the entire region of Tohoku, the suburbs of Tokyo, Nagano, Shizuoka, and Wakayama prefectures, in the vicinity of Osaka, as well as from Hyogo to Okayama prefectures, Shimane prefecture, and the northern Kyushu region. Areas where the coefficient was positive and negative were scattered locally.

The coefficient of the proportion of unmarried population (among women aged 30 to 39) showed statistically significant negative effects in all the regions nationally.

The marriage rate among unmarried population shows a positive association nationwide, except in Niigata prefecture. Since marriage is strongly associated with the subsequent first birth, the coefficient of marriage rate is considered to be close to the effect of the first childbirth on the total fertility rate.

Lastly, it was indicated that the coefficient of the number of day-care centers (per population of 100,000 aged 0 to 5 years old) was not different from the global model in the F(3) test. In other words, regional differences of this coefficient are not very strong as a whole.

[Figure 3]

7. Discussion

This study focused on the importance of the spatial effect on people's fertility behaviors, focusing on not only the regional variation of fertility but also the regional variation of the relationship between influential factors and fertility.

First, according to the estimation by the OLS (global model) that utilized national samples, a strong spatial autocorrelation was observed in the error terms, which indicated the possibility of unreliable inference in model estimations. For this reason, we examined the possibility that such correlation of error terms indicates that the relationships between explanatory variables and dependent variables assumed to be uniform throughout the nation, are in reality different from region to region, and needs a new estimation by the geographically weighted regression model (local model) that allows for spatial nonstationarity of the coefficients.

We used the total fertility rate in towns and villages in 2005 as our dependent variable and employed nine independent variables: (1) the ratio of the population engaged in the primary industries, (2) unemployment rate for men, (3) the rate of inward migration, (4) proportion of nuclear families, (5) ratio of university graduates (women aged 15 to 49), (6) employment rate (women aged 15 to 49), (7) ratio of unmarried populations (women aged 30 to 39), (8) marriage rate among unmarried population, and (9) number of day-care centers (per population of 100,000 aged 0 to 5 years old).

We obtained the results that the coefficients (relationships between dependent variables and explanatory variables) are significantly different depending on the region, except for the number of day-care centers. Moreover, the distribution of the R^2 value of the local model indicated that metropolitan areas such as the Tokyo metropolitan district and Kinki region showed high values. This results suggest that many of the contributing factors that were pointed out as important in past research are, in fact, more suited to explaining fluctuations of fertility in metropolitan areas. Looking at regional characteristics from the coefficients of each independent variable, we found results which are different from those in OLS regressions. For example, the relationship between the proportion of nuclear families and the fertility rate is negative based on the OLS regression. However, our study suggests that it was positive in parts of southern Hokkaido, around Sendai city and the center of Fukushima prefecture, the southern part of Kinki region, parts of Shikoku region, etc. Similarly, our results showed that the rate of unemployment, which indicated a positive relationship with the fertility rate in the global model, showed a negative relationship in many local areas.

Our results suggest the relationship between independent factors and dependent variable could not only be affected by the scale of areal unit (whether we use aggregation scale by prefecture and township) but also vary over regions. The result of the geographically weighted regression model in this study provided evidence that there are many examples where the results of the global model using the national samples can lead wrong inferences for particular regions. In other words, we must be cautious when applying the results of global models.

Such careful consideration of location into analysis will also contribute to develop better social care policies. For instance, our results suggest the importance of considering the location respondents live when we think of social care policies since the strengths and the sign of the effects could differ by region. Our study suggests that implementing the same social policy uniformly to all regions of Japan would not be effective.

Note 1: A Gaussian kernel function is obtained as follows:

$$w_{ij} = \exp[-½(d_{ij}/h)^2]$$

A bi-square type kernel function is obtained as follows:

$$\text{If } d_{ij} < h,\ w_{ij} = [1-(d_{ij}^2/h^2)]^2$$

$$\text{If not, } w_{ij} = 0$$

where, w_{ij} indicates spatial weight applied on a sample point, d_{ij} is a distance between regression point and sample point, and h is the bandwidth of the kernel. Bandwidth refers to the distance between a regression point and a sample point where the spatial weight vanishes.

Note 2: The main data used in this analysis is the basic data of Population Census, but data for some variables is not aggregated for some towns and villages; the number of towns/villages where values are missing is five on average and approximately 40 towns/villages for some variables. These values are interpolated using the average values of towns and villages with neighboring regional codes. This technique was chosen since the full data set without missing values is required by the methodology used for this analysis.

Note 3: Many previous studies present analysis results by prefectures and there are thus cases where the sign conditions are different from the present analysis of towns and villages. Moreover, since some of the results of individual slips data analysis are used by reference, it is necessary to take careful note of a potential fallacy of composition where the results are different between the micro and macro levels, and the ecological fallacy that may occur when attempting to explain individuals based on the macro level results.

Note 4: When aggregating the number of households, the Population Census classified the "private households" into three types, "private households with only related members," "non-relatives households," and "one-person households." "Private households with only related members" are further classified into "nuclear families" and "other relatives households." Three-generation households correspond to "other relatives households" of "private households with only related members." The proportion of nuclear families used in this analysis is obtained by dividing the "number of nuclear families" by the "number of private households" in accordance with the Social Indicators measured by the Statistics Bureau, Ministry of Internal Affairs and Communications; thus, strictly speaking, it is somewhat ambiguous as a substitute variable of the proportion of three-generation households.

Note 5: The area covered by 165 locations varies depending on the areas of towns and villages included. For example, if the center of Hokkaido is set as the regression point, the area covered by 165 locations is almost the entire area of Hokkaido. Similarly, if the center of Kyushu region is set as the regression point, the entire Kyushu region is covered. In case of the Tohoku region, where there are many towns and villages with large areas, the whole Tohoku region, i.e., Aomori, Akita, Iwate, Yamagata, and Fukushima prefectures, is covered if Miyagi prefecture is set as the center. On the other hand, in case of Tokyo metropolitan district, etc. where the towns and villages are of small size and overcrowded, if Tokyo is set as the center, the covered area is smaller than the areas above, although Saitama, Kanagawa, and Chiba prefectures would be included.

Note 6: The first test, F(1), evaluates the ratio between the residual sum of squares of OLS and the residual sum of squares of GWR for various degrees of freedom. A significantly small F(1) value indicates that the model fit of GWR is better than OLS. The F statistic value (0.6667) of the sum of square of OLS residuals (62.1271) and the sum of square of GWR residuals (33.9545) at one degree of freedom (203.73) and two degrees of freedom (2301) is statistically significant at a 0.001 significance level, indicating that the model fit of GWR is improved compared to OLS. The second test, F(2), evaluates the ratio between the residual sum of squares of OLS and the factors of improvement when a model is changed from OLS to GWR (DSS=RSSOLS-RSSGWR), by adjusting the degree of freedom. A significantly small F(2) value indicates that there is no statistically significant difference between the OLS and GWR models. The F statistic value (2.515) of the sum of square of OLS residuals (62.1271) and the factor of improvement (28.1727) at one degree of freedom (565.831) and two degrees of freedom (2301) is statistically significant at a 0.001 significance level, indicating that there are differences between the models. Finally, in the F(3) test, a distribution analysis is conducted for each coefficient. If the F(3) value is large, the regional differences for the coefficient in question are statistically significant.

References

Abe, Masahiro, 2005. "Impact on child education Gender Equality aid to give birth rate", Research on labor policy for the new phase of declining fertility and family, annual report, pp. 241-246. (in Japanese)

Anselin, L., 1995, "Local Indicators of Spatial Association - LISA", *Geographical Analysis*, 27-2, pp. 93-115.

Anselin, L., 2005, *Exploring Spatial Data with GeoDa^{TM} : A Workbook*, Center for Spatially Integrated Social Science.

Billari, F.C. and Philipov, D., 2004, "Education and the Transition to Motherhood: A Comparative Analysis of Western Europe", *European Demographic Research Papers*, 2004-3, Vienna, Vienna Institute of Demography.

Blossfeld, H.P. ed., 1995, *The New Role of Women: Family Formation in Modern Societies*, Boulder, Westview Press.

Brunsdon, C., Fotheringham, A.S., and Charlton, M., 1996, "Geographically Weighted Regression: A Method for Exploring Spatial Nonstationarity", *Geographical Analysis*, No.28, pp.281-298.

Brunsdon, C., Fotheringham, A.S., and Charlton, M., 1999, "Some Notes on Parametric Significance Tests for Geographically Weighted Regression", *Journal of Regional Science*, 39, pp. 497-524.

Chi, G.and J. Zhu. 2008. "Spatial regression models for demographic analysis." *Population Research and Policy Review* Vol.27, No.1, pp.17-42.

Cliff, A. D. and Ord, J. K., 1973, *Spatial Autocorrelation*, London, Pion.

Engelhardt, H., Kőgel, T., and Prskawetz, A., 2004, "Fertility and Women's Employment Reconsidered: A Macro-Level Time-Series Analysis for Developed Countries, 1900-2000", *Population Studies,* 58, pp.109-120.

Fotheringham, A. S., Brunsdon, C., and Charlton, M., 2000, *Quantitative Geography: Perspective on Spatial Data Analysis*, London, Sage Publications.

Fotheringham, A. S., Brunsdon, C., and Charlton, M., 2002, *Geographically Weighted Regression: The Analysis of Spatially Varying Relationships*, New York, John Wiley & Sons.

Fukuda, Motoo, 2002, "Hoiku service no kyokyu –hiyou men karano kentou wo tyushin ni-", National Institute Population and Social Security Research (eds.), *Shoshi syakai no kosodate sien*, pp. 265-289. (in Japanese)

Hayashi, Yoshitsugu, 1998, "Jidou hukushi to zaisei seisaku", *The Quarterly of Social Security Research* (Kikan Shakai Hosho Kenkyu), Vol. 34 No.1, pp. 26-34. (in Japanese)

Ishikawa, Akira, 1992, "An Analysis of Recent Regional Fertility Changes: Effect of Changes in Marital Structure", *The Journal of Population Problems* (Jinko Mondai Kenkyu), Vol. 48, No.3, pp. 46-57. (in Japanese)

Kato, Akihiko, 2008, "Regionality of Family Structure and Demographic Events", Population Association of Japan, Annual Meeting Program 2008.6.7.. (in Japanese)

Kato, Hisakazu, 2000, "Econometric Analysis of Birth, Marriage, and Labor Market", *The Journal of Population Problems* (Jinko Mondai Kenkyu), Vol. 56, No.1, pp. 38-60. (in Japanese)

Kawabe, Hiroshi, 1979, "On the Regional Differences of the Fertility in Japan", *The Journal of Population Problems* (Jinko Mondai Kenkyu), No.150, pp. 1-14. (in Japanese)

Kőgel, T., 2004, "Did the Association between Fertility and Female Employment within OECD Countries really Change in Sign?", *Journal of Population Economics*, 17, pp.45-65.

Kojima, Hiroshi, 2005, "Chihojichitai niokeru Shoshika taisaku to goukei syusshoritu/mikonsya wariai", shoshika no shin kyokumen to kazoku/roudou seisaku ni kansuru kenkyu, Annual Report. (in Japanese)

Kohler, H. P., Billari, F. C., and Ortega, J. A., 2002, "The Emergence of Lowest-low Fertility in Europe during the 1990s", *Population and Development Review*, 28-4, pp. 641-680.

Koike, Shiro, 2006, "On the Impact of Migration on Fertility —Can Migration Reduce Fertility—", *The Journal of Population Problems* (Jinko Mondai Kenkyu), Vol. 62, No. 4, pp.3-19. (in Japanese)

Komamura, Kohei, 2006, "Hoiku juyo no keizai bunseki", *The Quarterly of Social Security Research* (Kikan Shakai Hosho Kenkyu), Vol. 32, No. 2, pp. 255-260. (in Japanese)

Leung, Y., Mei, C.-L., and Zhang, W.-X., 2000, "Statistical Tests for Spatial Nonstationarity based on the Geographically Weighted Regression Model", *Environment and Planning A*, 32, pp.9-32.

Messner, S. F., Anselin, L., Baller, R. D., Hawkins D. F., Deane G., and Tolnay S. E., 1999, "The Spatial Patterning of County Homicide Rates: An Application of Exploratory Spatial Data Analysis", *Journal of Quantitative Criminology*, 15-4, pp.423-450.

Ministry of Health, Labour and Welfare, 2009, "Heisei 15 nen – Heisei 19 nen Jinko Dotai Hokenjo - Shikuchoson no gaikyo (Vital Statistics specific reports) ". (in Japanese)

Moran, P. A. P., 1950, "Notes on Continuous Stochastic Phenomena", *Biometrika*, 37, pp. 17–33.

Morita, Youko, 2002, "Hoiku seisaku to josei no syugyo", National Institute Population and Social Security Research (eds.) , *Shoshi syakai no kosodate sien*, pp. 215-240. (in Japanese)

Nakagawa, S., 2003, "The Long-term Regional Fertility in Japan", *Acta Facultatis Rerum Naturalium, Universitatis Universitatis Comenianae Geographica*, Nr. 43, pp. 11-35.

Nakaya, Tomoki, 2003, "Spatial correlation analysis", in Sugiura, Y. ed. *Geographical Spatial Analysis*, Tokyo: Asakura-Shoten, 23-48. (in Japanese)

Nakaya, Tomoki, 2004, "Spatial Epidemiological Analysis", in Nakaya, T., Tanimura, S., Nihei, N. and Horikoshi, Y. eds. (2004): *Health GIS*, Tokyo: Kokon Shoin, 74-121. (in Japanese)

National Institute of Population and Social Security Research, 2008, "Population Migration Survey 6th". (in Japanese)

Oishi, S. Akiko, 2003, "The Effect of Childcare Costs on Mother's Labor Force Participation", *The Quarterly of Social Security Research* (Kikan Shakai Hosho Kenkyu), Vol. 39, No.1, pp. 55-69. (in Japanese)

Oishi, S. Akiko, 2005, "Hoiku service no saihaibun kouka to hahaoya no shugyo", National Institute of Population and Social Security Research (eds.), *Kosodate Setai No Shakai Hosho*, pp. 165-184. (in Japanese)

Okui, Masatoshi, 2008, "Local Model Estimation of Car Ownership Rates by Japan's Municipalities", *Utsunomiya University Faculty of Education bulletin*, 58, pp. 55-69. (in Japanese)

Statistical Information Institute for Consulting and Analysis, 2007, "Socio-demographic Statistical System: Towns and Villages Basic Data File (1980-2005)". (in Japanese)

Sasai, Tsukasa, 2005, "The fertility trends and their determinants of differentials for Japan's munincipalities", *The Journal of Population Problems* (Jinko Mondai Kenkyu), Vol. 61, No. 3, pp. 39-49. (in Japanese)

Sasai, Tsukasa, 2007, "A Study of Regional Differentials in Marital Fertility", *The Journal of Population Problems* (Jinko Mondai Kenkyu), Vol.63, No. 3, pp. 3-23. (in Japanese)

Shigeno, Yukiko and Yasushi Okusa, 1999, "Hoiku seisaku ga syussan no ishikettei to syugyo ni ataeru eikyo", *The Quarterly of Social Security Research* (Kikan Shakai Hosho Kenkyu), Vol. 35 No.2, pp.

192-207. (in Japanese)

Shigeno, Yukiko, 2006, "Syurou to syussan/ikuji no ryoritsu kigyou no ikuji shien to hoikujo no syussyouritu kaihuku heno kouka", *Syoshika to Nihon no Keizai Shakai 2 tsu no sinwa to 1 tsu no Shinjitsu*, pp. 81-114. (in Japanese)

Shimizu, Hiroaki, 1997, "Chiiki jinkou no syakaikouzou", *Chiiki jinkou bunseki no kiso*, pp. 143-158. (in Japanese)

Shimizu, Masato, 2004, "Syusshoryoku no todouhuken kakusa", *Toukei*, pp. 20-25. (in Japanese)

Suzuki, T., 2009, "Fertility Decline and Governmental Interventions in Eastern Asian Advanced Countries", *The Japanese Journal of Population*, 7-1, pp. 47-56.

Tasakasa, Hiroyuki, 2005, "Korekara no GIS", Chiri jouhou system, pp. 184-201. (in Japanese)

Takahashi, Shinichi, 1997, "Syusshoryoku no chiikiteki bunseki", *Chiiki jinkou bunseki no kiso*, pp. 37-59. (in Japanese)

Tobler, W. R., 1970, "A Computer Movie Simulating Urban Growth in the Detroit Region", *Economic Geography*, 46, pp. 234-240.

Uehara, Hiroto and Tatsuo Oyama, 1995, "On the Regional Characteristics of Total Fertility Rates:Approaches of Entropy Model Approahes", *The Jounal of Population Studies* (Jinkogaku Kenkyu), No. 19, pp. 39-45. (in Japanese)

Yamauchi, Masakazu, Hachiro Nishioka and Shiro Koike, 2005, "Fertility in metropolitan and non-metropolitan areas of Japan from 1980-2000", *The Journal of Population Problems* (Jinko Mondai Kenkyu), Vol.61, No. 1, pp. 1-17. (in Japanese)

Yamaguchi, Kazuo, 2005, "josei no roudouryoku sanka to syusshoritu no shin no kankei nituite: OECD syokoku no bunseki", RIETI Discussion Paper Series 05-J -036 .

Yamashige, Shinji, 2002, "Hoikujo jujitsu seisaku no kouka to hiyou: kazoku/seihu/sijou niyoru hoiku service kyokyu no bunseki", National Institute Population and Social Security Research (eds.), *Shoshi syakai no kosodate sien*, pp. 241-264. (in Japanese)

Yui, Y., 2007, "Setai no tayoka to chiikiteki sai (diversification of households and regional differences) " , Y. Ishikawa (ed.) *Jinkogensho to chiiki: Chirigakuteki approach (Population decline and regions: Geographical approach)*. Kyoto, Japan: Kyoto University Press, pp. 17-41. (in Japanese)

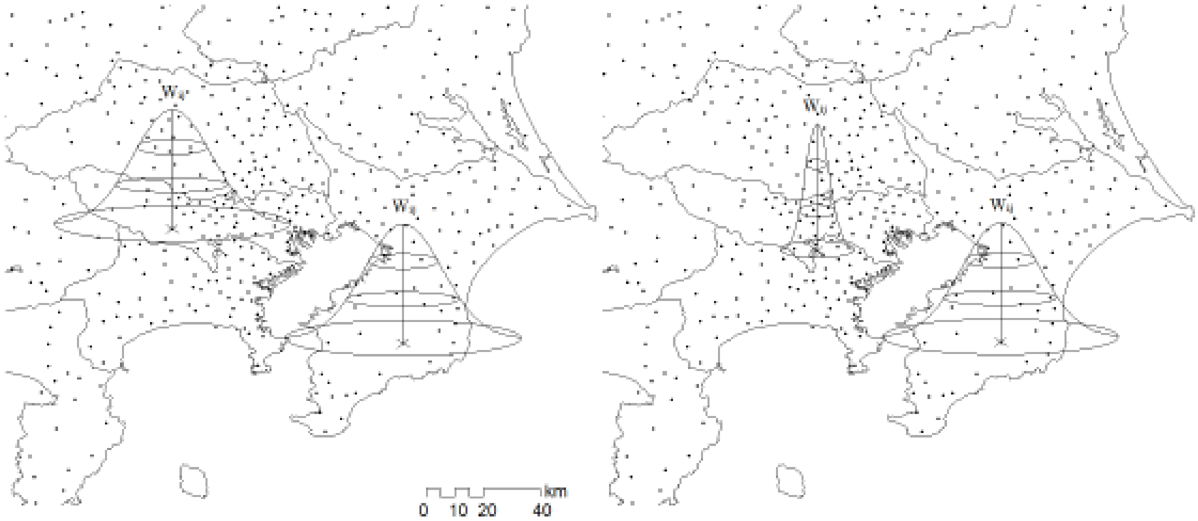

Figure 1 Fixed kernel weighting (Left) and Adaptive kernel weighting (Right)

※ W_{ij} is a matrix of weights specific to location i at j point

Table 1 Variable List and descriptive statistics

Variables		Year	Source	Direction	Min.	25%	Median	Mean	75%	Max.
Dependent Variable	Total Fertility Rate	2005	Vital statistics※		0.74	1.26	1.40	1.40	1.54	2.42
Independent Variables※2)										
①	Proportion of people working in the primary industry (%)	2005	Census	+	0.01	3.32	9.36	12.21	18.60	77.24
②	Male unemployment rate(%)	2005	Census	−	0.46	3.54	4.56	4.66	5.40	21.02
③	In-migrants rate (%)	2005	Census	+	1.16	2.58	3.29	3.66	4.37	14.37
④	Proportion of nuclear family households (%)	2005	Census	−	29.57	51.22	56.52	56.24	61.56	78.06
⑤	Proportion of those who have a college degree [female, 15-49 years old] (%)	2005	Census	−	0.84	4.43	6.40	7.21	8.90	29.86
⑥	Employment rate [female, 15-49 years old] (%)	2005	Census	+	40.59	56.29	61.27	61.05	65.76	80.00
⑦	Proportion of never-married population [30-39 years old, female]	2005	Census	−	0.00	19.65	22.71	23.06	25.82	48.37
⑧	Marriage rate among never married female(%)	2005	Census	+	0.00	21.49	25.21	25.38	29.09	83.87
⑨	The number of day-care centers per population of 100,000 aged 0 to 5 years old	2005	Social welfare facilities Survey	+	63.1	260.1	441.5	586.0	747.7	5263.2

※1) Vital statistics(Bayesian estimates) in 2005 (Ministory of Health, Labour and Welfare 2005; 2009)

※2) ①～④, ⑨: Calculations following "Social Life Index"(Ministry of Internal Affairs and Communications). ⑤～⑧: Authors calculations.

Table 2 Correlation coefficient table (Pearson product-moment correlation coefficient)

	Total Fertility Rate	Primary industry workers(%)	Male unemployment rate(%)	In-migrants rate (%)	Nuclear family households (%)	Famales with a college degree (%)	Female employment rate (%)	Never-married female in their 30s (%)	Marriage rate among never married female(%)	Day-care centers accessibility
Total Fertility Rate	1.000	0.308 ***	-0.118 ***	-0.188 ***	-0.093 ***	-0.393 ***	0.321 ***	-0.524 ***	0.283 ***	0.185 ***
Primary industry workers(%)		1.000	-0.389 ***	-0.322 ***	-0.306 ***	-0.529 ***	0.532 ***	-0.230 ***	-0.003	0.415 ***
Male unemployment rate(%)			1.000	0.166 ***	0.257 ***	0.077 ***	-0.490 ***	0.366 ***	-0.004	-0.162 ***
In-migrants rate (%)				1.000	0.209 ***	0.493 ***	-0.448 ***	0.321 ***	0.227 ***	-0.298 ***
Nuclear family households (%)					1.000	0.205 ***	-0.574 ***	0.058 ***	0.049 **	-0.273 ***
Famales with a college degree (%)						1.000	-0.499 ***	0.315 ***	0.011	-0.044 ***
Female employment rate (%)							1.000	-0.304 ***	-0.009	0.435 ***
Never-married female in their 30s (%)								1.000	-0.183 ***	-0.054 ***
Marriage rate among never married female(%)									1.000	-0.015
Day-care centers accessibility										1.000

Significance Level: *** < 0.001 ** < 0.01 * < 0.05 + < 0.10

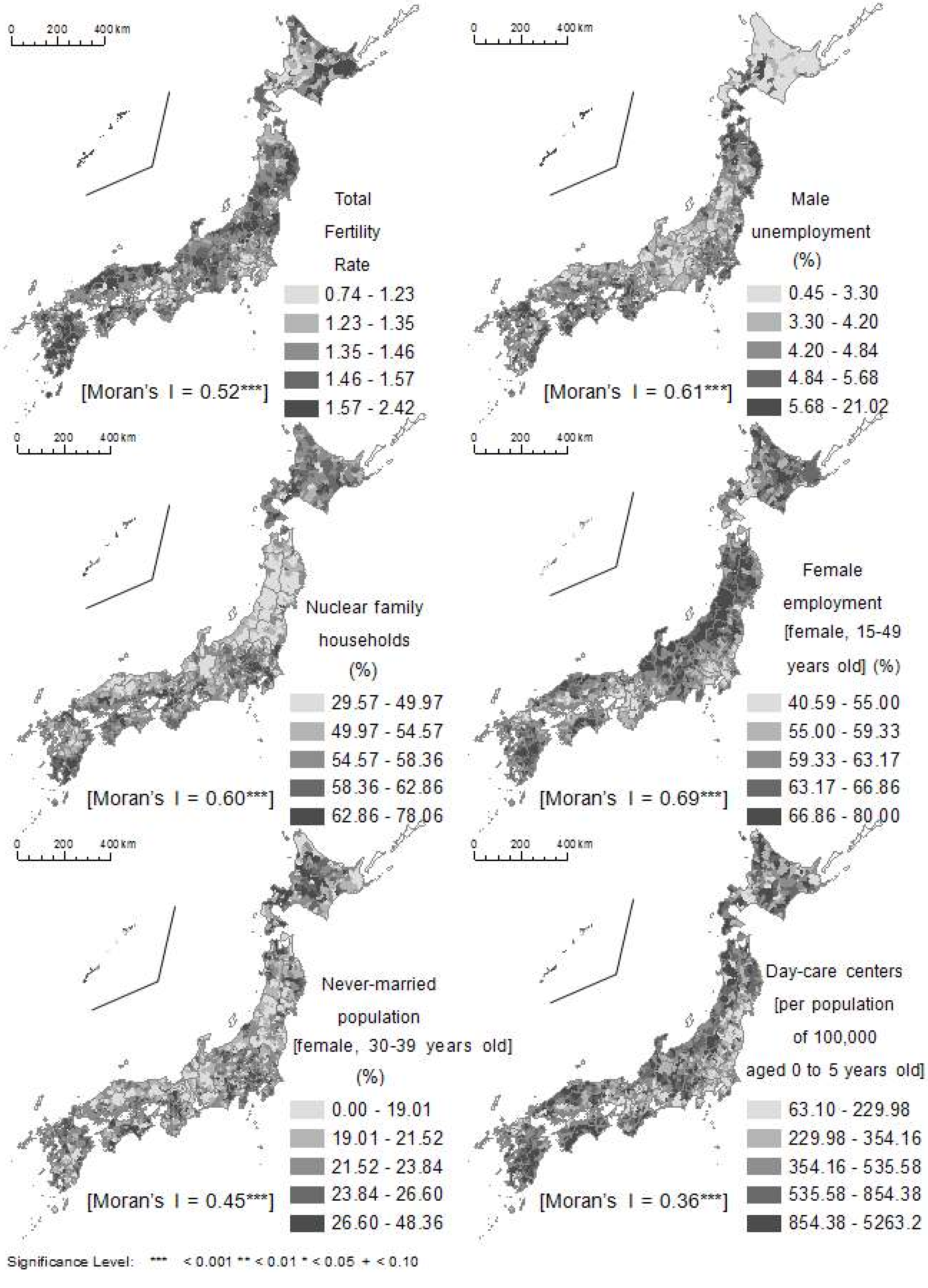

Figure 2 The distributions of selected variables ([ ]: Moran's I statistics)

Table 3 The results obtained by the global model (OLS)

Dependent Variable: Total Fertility Rate

Independent Variables	Coefficients		Std. Error	t-value
Primary industry workers(%)	0.0023	***	0.0004	5.4510
Male unemployment rate(%)	0.0201	***	0.0024	8.2420
In-migrants rate (%)	0.0115	***	0.0028	4.0350
Nuclear family households (%)	0.0011	+	0.0005	1.9570
Famales with a college degree (%)	-0.0079	***	0.0012	-6.4950
Female employment rate (%)	0.0053	**	0.0009	5.9370
Never-married female in their 30s (%)	-0.0185	***	0.0008	-23.6860
Marriage rate among never married female(%)	0.0054	***	0.0005	10.2220
Day-care centers accessibility	0.0000	***	0.0000	3.4430
Intercept	1.1840	***	0.0844	14.0200
Adjusted R^2	0.4056			
F-statistic	176.20	***		

Significance Level: *** < 0.001 ** < 0.01 * < 0.05 + < 0.10

Table 4 The descriptive statistics of the GWR results: summary

Kernel function: Bi-square
Adaptive quantile: 0.0714 (bandwidth＝165.144)
Summary of GWR coefficient estimates:

Independent Variable	Min.	25%	Median	75%	Max.	Global
Intercept	0.44310	1.32200	1.60900	2.04900	3.83400	1.18350
Primary industry workers(%)	-0.02626	-0.00324	-0.00073	0.00117	0.01892	0.00230
Male unemployment rate(%)	-0.07443	-0.01425	-0.00115	0.00871	0.04430	0.02010
In-migrants rate (%)	-0.08535	-0.01348	0.00226	0.01553	0.05622	0.01150
Nuclear family households (%)	-0.01328	-0.00357	-0.00161	0.00010	0.00574	0.00110
Famales with a college degree (%)	-0.05485	-0.01325	-0.00576	0.00433	0.03194	-0.00790
Female employment rate (%)	-0.01688	-0.00301	0.00198	0.00452	0.01546	0.00530
Never-married female in their 30s (%)	-0.02924	-0.02117	-0.01790	-0.01188	-0.00245	-0.01850
Marriage rate among never married female(%)	-0.00207	0.00389	0.00610	0.00878	0.01961	0.00540
Day-care centers accessibility	-0.00016	-0.00003	0.00000	0.00004	0.00018	0.00003

Effective number of parameters: 404.8585; Effective degrees of freedom: 1886.14
AIC : -2432.270 (OLS: -1776.826) AICc : -2868.826
Mean of R^2: 0.554; Residual sum of squares: 33.95445

Table 5 The results of Leung's F-test

Leung et al. (2000)	F-value		df1	df2	SS OLS residuals	SS GWR residuals	SS GWR improvement
F(1) test	0.6667	***	2003.73	2301	62.1271	33.9545	
F(2) test	2.515	***	565.831	2301	62.1271		28.1727

F(3) test	F-value		Numerator d.f.	Denominator d.f.
Intercept	1.6847	***	649.95	2261.7
Primary industry workers(%)	2.0408	***	224.64	2261.7
Male unemployment rate(%)	1.1683	*	495.38	2261.7
In-migrants rate (%)	1.8943	***	438.11	2261.7
Nuclear family households (%)	1.1574	***	708.48	2261.7
Famales with a college degree (%)	3.0083	***	555.13	2261.7
Female employment rate (%)	1.3136	***	605.46	2261.7
Never-married female in their 30s (%)	2.2929	***	666.49	2261.7
Marriage rate among never married female(%)	1.8973	***	531.67	2261.7
Day-care centers accessibility	0.8500		214.28	2261.7

Significance Level: *** < 0.001 ** < 0.01 * < 0.05 + < 0.10

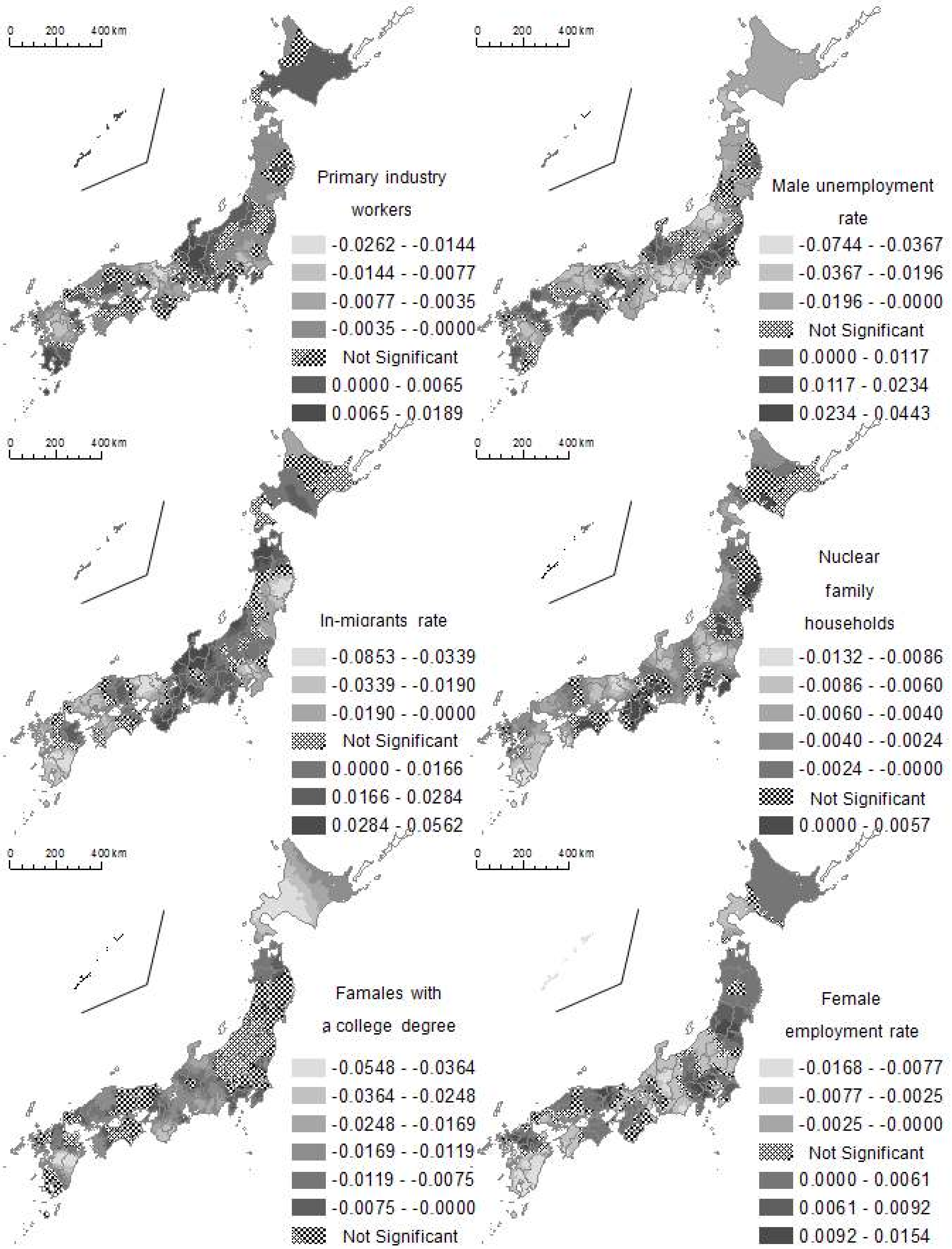

Figure 3 Distributions of Local Coefficients estimated by GWR and R^2
("Shaded" part indicate "not significant")

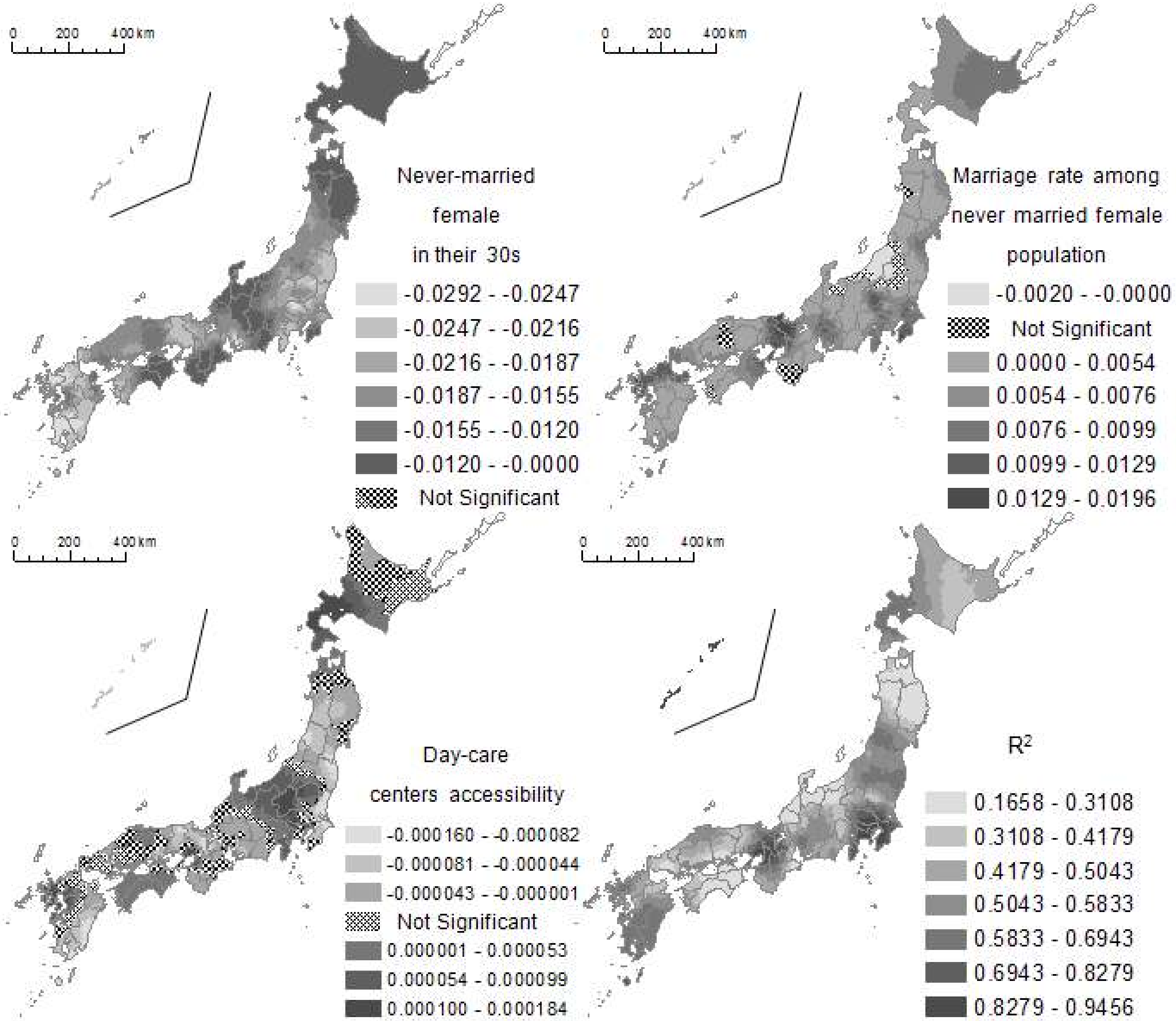

Figure 3 Distributions of Local Coefficients estimated by GWR and R^2
("Shaded" part indicate "not significant") (continue)