Regional patterns and correlates in recent family formation in Japan: Spatial Analysis of Upturn in Prefecture-level Fertility after 2005

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Abstract

Although fertility level in Southern European countries and the rich nations in East Asia is recognized as very low, fertility decline in some of these countries including Italy and Japan came to a halt recently. In Italy, fertility recovery is more prominent in the Center-North areas, which are highly correlated with features of the so-called the Second Demographic Transition (SDT). The goal of this paper is to confirm whether upturn of Japanese TFR after 2005 can be explained by the same factors as the case in Italy. . We adopt spatial analysis for this purpose. First we examine the spatial clustering of prefecture (state)-level upturn in TFR. This exploratory analysis will be followed by multivariate modeling in which we estimate the effects on TFR upturn of structural variables (socio-economic structures and innovative family behaviors) with adjustments for spatial dependence. We then assess the existence of hotspot cluster of high upturn in TFR and discuss the possible meaning of spatial dependence that is observed. The result indicates that TFR upturn after 2005 in Japan can be partially explained by the covariates relevant in Italian fertility recovery. TFR has been increased in the area with more economically favorable area, but the association between TFR recovery and novel family behaviors is not so strong. Hotspot clusters are still apparent in Kyusyu region even after controlling for spatial heterogeneity.

Introduction

Total fertility rates (TFR) of Sothern European countries and the rich nations of East Asia are far below the replacement level and their family formation patterns are distinguishable from other western society (Lesthaeghe and Moors 2000, Caldwell and Schindlmayr 2003). In some of these countries, however, fertility decline has come to a halt or showed the recovery recently. For example, TFR in Italy reached at 1.34 in 2007 after recording the lowest level of 1.19 in 1995 (ISTAT 2008)(Fig.1). Furthermore, the upturn in fertility has taken place primarily in the more economically dynamic areas located in Center-North areas, where novel family behaviors have much more spread (Castiglioni and Dalla Zuanna 2008).

In Japan, another title-holder of the very low fertility, TFR has increased after 2005. Is the same explanation as one for Italy applicable for the recent upturn of fertility? To answer this question, we adopted spatial analysis. More specifically, we examined the extent to which prefecture (state)-level TFR upturn (= TFR in 2007 / the lowest TFR between 2000 and 2007 x 100) can be explained by covariates around 2005 relevant to Italian fertility recovery. We estimated spatial error models that are ecological regression models assuming that the error terms are spatially autocorrelated among neighbors.

Fig.1. Trends in TFR in Japan and Italy

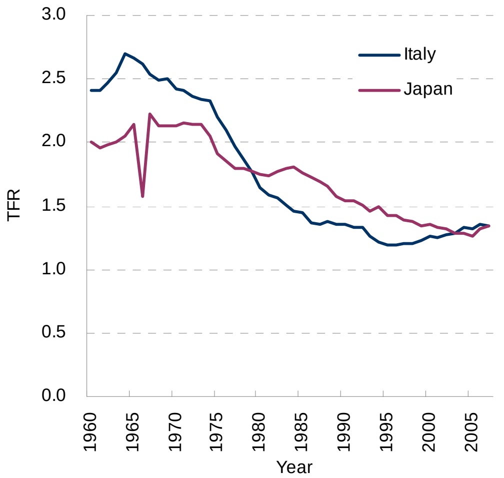
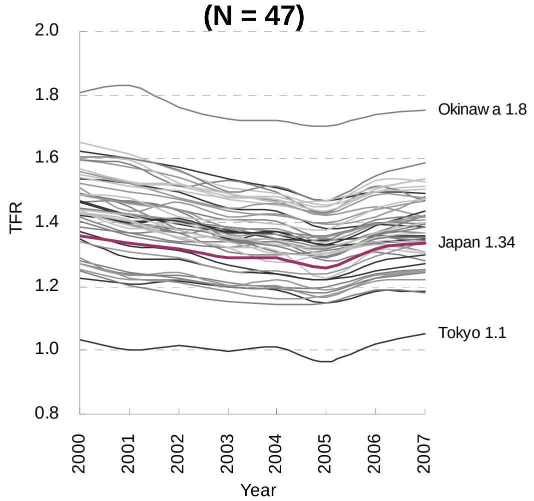


Fig.2. Trends in TFR by prefectures in Japan (N = 47)



Hypotheses

To examine whether TFR upturn in Japan is associated with the similar process approaching central and northern European countries which was observed in Italy (Caltabiano 2008, Castiglioni and Dalla Zuanna 2008), we set eight hypotheses below.

If Japan follows the similar process which was observed in Italy, TFR upturn should be more prominent in;

1) Urban areas than agricultural areas

2) More economically favorable areas
3) Areas with higher women's educational attainment
4) Areas with extremely low TFR in previous years

These factors are related to socio-economic structure of the area in question.

We also look at factors that reflect the aspect of innovative behaviors on family formation. We focus on cohabitation, divorce, out-of-wedlock childbirth, and childcare use.

TFR upturn should be also more prominent in;
5) Areas where cohabitations have been spread
6) Areas where divorces have been spread
7) Areas where out-of-wedlock childbirths have been spread
8) Areas with more favorable conditions in terms of finding equilibrium between childcare and paid labor

We don't assume direct causalities from these factors to fertility behavior. Rather, we treat these as indicators for conceptual variables. Factors related to socio-economic structure could represent indicators of globalization and economical development, and those for novel family package could represent indicators of individualization, weaker familial and social ties, and more gender symmetry social system. In other words, increasing in the population those who adopt these kinds of family behaviors could represent the level of change from conventional family formation system dominating in Japan (Rindfuss 2004).

Methods

1. Exploratory Spatial Data Analysis

While mapping would provide us visual message on variations and spatial patterns of variables, visual inspection is not sufficiently rigorous to assess significant clusters or spatial dependence. Therefore it is important to look at Moran's I (a global statistic for spatial autocorrelation) and its local counterpart, Local Moran, and its decomposition into four types of spatial association (Moran scatterplot and local indicators of spatial association (LISA) map) (Anselin 1995, Messner et al. 1999) for the prefecture-level TFR upturn.

Global autocorrelation is assessed by means of Moran's I statistics (Cliff and Ord 1973, Moran 1950) defined as follows:

$$I = \left(\frac{n}{\sum_i \sum_j w_{ij}} \right) \left(\frac{\sum_i \sum_j w_{ij} (x_i - \bar{x})(x_j - \bar{x})}{\sum_i (x_i - \bar{x})^2} \right)$$

where i and j index the areal units of which there are n, and w_{ij} is a spatial weight defining the connection between areal unit i and areal unit j. w_{ij} denotes the elements of the (n x n) row-standardized spatial weights matrix, W, defining the neighborhood structure. Positive and significant values of Moran's I suggest spatial clustering of similar values (Voss et al. 2004).

2. Spatial Regression Analysis

The exploratory phase is followed by regression analysis of prefecture-level upturn in TFR on the predictors. Because spatially autocorrelated errors observed in the OLS are problematic, we estimate a spatial error models to try to correct for it and contrast the results with OLS model.

A spatial error model explicitly assuming that the errors of a model are spatially correlated is specified as follows (matrix notation) (Anselin 1988, Ward and Gleditsch 2008):

$$y = X\beta + u,$$
$$u = \lambda W u + \varepsilon,$$
$$\varepsilon \sim N\left(0, \sigma^2 I\right)$$

where y is a (n x 1) vector representing the dependent variables, X is a (n x k) matrix representing the k-1 independent variables, β is a (k x 1) vector of regression parameters to be estimated, u is a (n x 1) vector of error terms presumed to have a covariance structure as given in the second equation, λ is a spatial lag parameter to be estimated, W is a (n x n) weight matrix defining the "neighborhood" structure, and ε is a (n x 1) vector of independently distributed (spatially uncorrelated) errors. Under this specification, spatial autocorrelation in the dependent variable results from exogenous influences. Portions of the spatial autocorrelation may be explained by the included independent variables (themselves spatially autocorrelated) and the remainder is specified to derive from spatial autocorrelation among the disturbance terms.

To define neighbors for weight matrix used in calculation of Moran's I or estimating spatial regression model, we use first-order queen convention. It means that the neighbors for any given prefecture "A" are those other prefectures that share a common boundary with "A" in any direction. Hokkaido and Okinawa don't share any borders with any other prefecture, but we defined Hokkaido has Aomori and Okinawa has Kagoshima as their neighbor. Because Hokkaido and Aomori are connected with the undersea tunnel, Seikan tunnel and Okinawa and Kagoshima have historically shown frequent interchanges with each other. As a results, the mode number of neighbors is four and the prefecture that has the largest number of neighbors is Nagano having 8 and that has smallest number of neighbors is Hokkaido, Nagasaki and Okinawa having only one.

We developed a prefecture-level shapefile, a standard geospatial vector data format for GIS software, for Japan merged with variables of characteristics. For exploratory spatial analysis, we use one of the GIS software, ArcGIS 9.3 of ESRI and GeoDa 0.9.5-i5. The spatial regression analysis was carried out using GeoDa 0.9.5-i5. GeoDa is a freeware developed by Luc Anselin, and you can downlord it at < http://geodacenter.asu.edu/>.

Data

The indexes for the upturn of TFR are obtained from the TFRs constructed from Japanese vital statistics and the Census of Japan or Population estimates from 2000 to 2007 (based on 5-age-group population). The TFRs in 2007 are divided by the lowest TFR between 2000 and 2007.

Independent variables for socio-economic structure are the proportion of agriculture industry (the 2005 Census), unemployment rate for male (the 2005 Census), college/university enrollment rate for female from the Report on School Basic Statistics in 2005 by Ministry of Education, Science and Culture, and the lowest TFR between 2000 and 2007.

The indexes of innovative family formation behaviors consist of prevalence of cohabitation, divorce, out-of-wedlock childbearing and childcare use. As for the prevalence of cohabitation, the proportions of ever-cohabited women are estimated using the 1st Survey on Population, Family and Generation (SPFG), conducted in 2004 by the Population Problems Research Council, the Mainichi Newspapers. The survey sampled 2,421 married and unmarried women age between 20 and 49. Divorce occurrences are measured to sum up age-specific divorce rates among married women of reproductive age (15-49) constructed from the Vital Statistics and Census in 2005. Out-of-wedlock childbearing in Japan is still rare (ratio to all birth is about 2 % in 2005), but it is slightly increasing. We calculate age-specific first birth fertility rates and age-specific first non-marital fertility rates in 2005 by prefecture using the Vital Statistics, and we obtain the ratios of total first non-marital birth fertility rate to total first birth fertility rate. As for the index for equilibrium between childcare and paid labor, we use the proportion of children in day-care facilities to all of preschool children in 2005. The number of children in day-care facilities is from the Case Reports of Welfare Administration, Statistics and Information Department, Minister's Secretariat, Ministry of Health, Labour and Welfare, and the number of preschool children is from the Census in 2005 (the number of 0-5 aged children plus the half of the number of 6 aged children).

Results

1. Exploratory Spatial Data Analysis

Fig.3 shows the geographical pattern of the TFR upturn. The upturn seems to be concentrated around pacific belt zone from Tokyo to Aichi and the west side of Kyusyu.

Figure 4 displays the Moran scatterplots of the TFR upturn. In the Moran scatterplot map, the data are standardized so that units on the graph are expressed in standard deviations from the mean. The horizontal axis shows the standardized value of upturn in TFR for a prefecture, and the vertical axis shows the standardized value of the average upturn in TFR for that prefecture's "neighbors" as defined by the weights matrix. The slope of the regression line through these points is called as the global Moran's I. It is 0.325 for the TFR upturn. This strongly positive and statistically significant value indicates powerful positive spatial autocorrelation.

Figure 5 demonstrates a localized version of the Moran statistics (Anselin 1995), which are valuable for gaining a "local" understanding of the extent and nature of spatial clustering in a data set. It is called as a LISA (Local indicators of Spatial Association) map. The LISA map shows the geographic distribution of the four type of the value combination for prefectures across Japan. For example, "High-high" means that prefectures with above average upturn in TFR also share boundaries with neighboring prefectures that have average values on the same variables. On the other hand, "high-low" means that prefectures with above average upturn in TFR is surrounded by prefectures with below average values. Hotspot clusters of upturn are apparent in Kyusyu region and coldspots are apparent in Hokkaido and Tohoku region. The low-high prefecture was Yamanashi. There is no high-low prefecture with statistically significance.

Fig.3. TFR upturn after 2005
(= TFR in 2007 / the lowest TFR between 2000 and 2007 x 100)

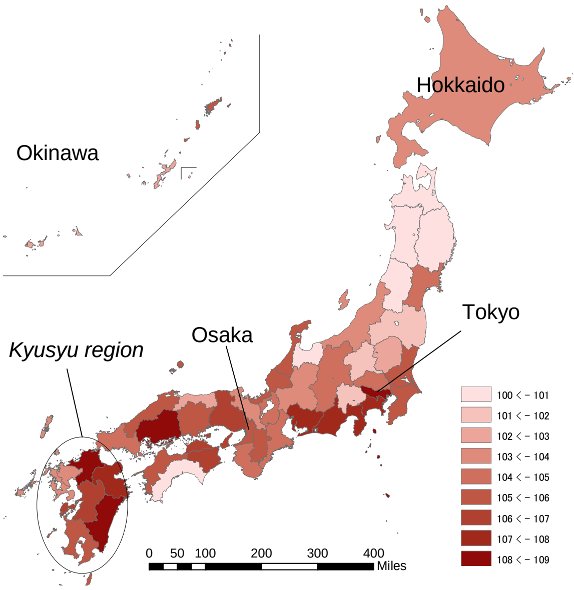


Fig. 4. Moran scatterplot of the TFR upturn

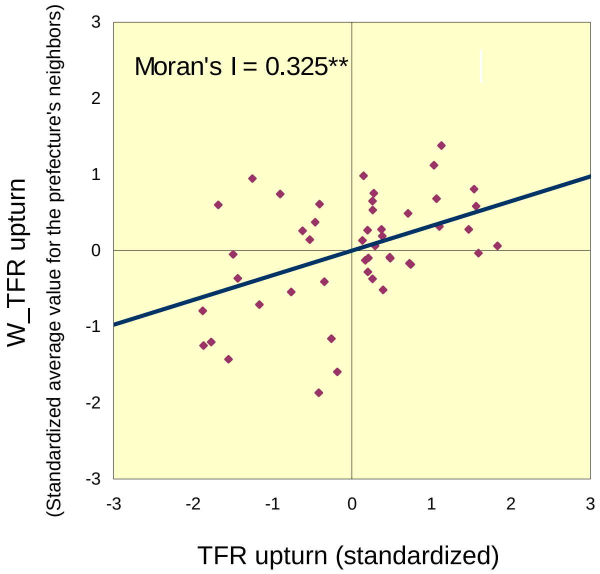
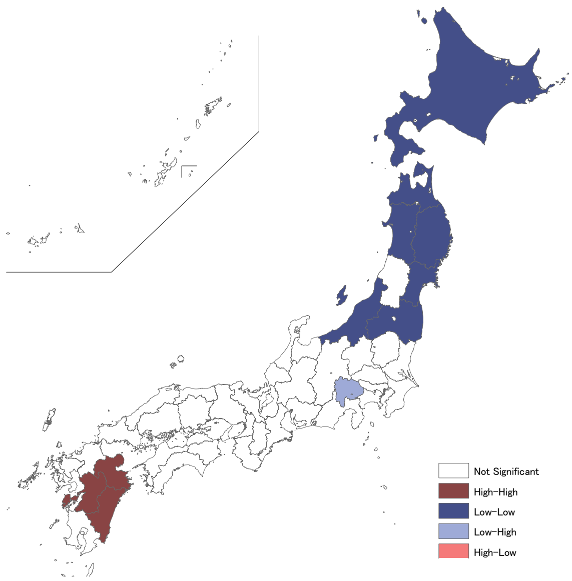


Fig5. LISA cluster map of the TFR upturn



2. Spatial Regression Analysis

Table 1 presents OLS regression and spatial error model results for the model with socio-economic structure covariates only (model 1), the model with novel family package covariates only (model 2), the full model (model 3), and the final model with powerful explanatory covariates (model 4). The change in the Moran's I of residuals indicates that spatial autocorrelation among residuals in OLS model was essentially eliminated in the spatial error model. The Lambda value in model 4 indicates that if the average value on neighbors increases by one unit, the value of that area will increase by

0.58 even after controlling their covariates.

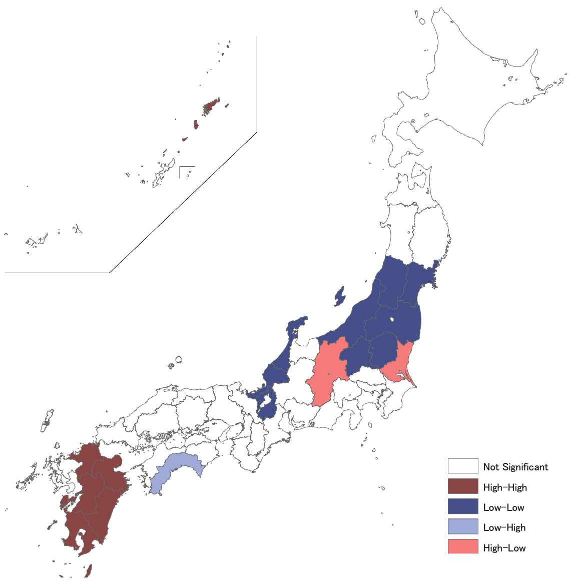
The coefficients of covariates suggest that fertility upturn took place in area with less agriculture workers, less unemployment rate for male, less divorce rates and high nonmarital fertility rates. However, significant spatially correlated errors imply that the variations in the TFR upturn cannot be fully explained by spatial heterogeneity (Xβ). The LISA map of spatially correlated errors tells us that hotspot clusters are still apparent in Kyusyu region and coldspots include Southern Tohoku and Hokuriku region (Fig. 7).

Table 1. Regression results, prefecture-level upturn of TFR: OLS and spatial error model

Variable	Model 1		Model 2		Model 3		Model 4	
	OLS	Spatial error model (ML)	OLS	Spatial error model (ML)	OLS	Spatial error model (ML)	OLS	Spatial error model (ML)
Constant	101.30 ***	114.03 ***	106.96 ***	111.58 ***	100.96 ***	114.94 ***	106.27 ***	113.23 ***
Socio-economic structure								
Proportion of agriculture industry	-0.20	-0.27 **			-0.10	-0.13	-0.28 **	-0.31 ***
Unemployment rate for male	-0.06	-0.38 #			-0.83 *	-0.80 **	-0.84 *	-0.87 **
University enrollment rate for femal	0.08	0.00			0.13	0.07		
Lowest TFR between 2000-2007	1.02	-3.83			-0.35	-4.21		
Novel family package								
Proportion of ever-cohabited women			-0.02	0.01	0.00	0.00		
Divorce rate among married women			0.04	-4.38	-0.73	-5.52 *	1.19	-4.55 #
Extramarital fertility ratio			-0.03	0.17	2.30 *	1.92 *	1.78 #	1.55 *
Proportion of children in day-care			-0.07	-0.10 **	-0.03	-0.03		
Lambda (spatial autoregressive coefficient)		*0.56* ***		*0.55* ***		*0.60* ***		*0.58* ***
R-squared	0.22		0.07		0.35		0.30	
AIC	212.44	200.82	220.83	208.19	212.05	200.50	207.65	197.31
Likelihood Ratio Test		11.63 ***		12.64 ***		11.55 ***		10.35 **
N	47	47	47	47	47	47	47	47
Diagnostics for spatial dependency								
Moran's I (residuals)	0.34 ***	-0.06	0.38 ***	-0.03	0.28 ***	-0.06	0.28 **	-0.05
Lagrange Multiplier	9.11 **		11.39 ***		6.25 *		6.07 *	

*** p<.001 ** p<.01 * p<.05 # p<.1

Fig.7. LISA cluster map for predicted spatially correlated error (model 4)



Conclusion and discussions

TFR upturn after 2005 in Japan can be partially explained by the covariates that were relevant in Italian fertility recovery. TFR has been increased in the area with more economically favorable area, but the association between TFR recovery and novel family behaviors is not so strong.

The spatially correlated errors and the existence of hot-spot clusters suggest that some other unobserved feature(s) we may call "social influence" (Montgomery and Casterline 1996) may affect fertility behavior. Historically cumulative characteristics due to geographical variations of family institution (Kato 2005, Kumagai 2008) might contribute grouping responses to external forces. Personal network among neighbors could play an important role for adopting innovative behaviors (Rogers 1995, Rindfuss et al.2004). Local TV or newspapers could be a vehicle for some ideas (Hornik and McAnany 2001). One of the social effects, social competition or social emulation (Casterline 2001) could be a possible explanation if effective countermeasure by a certain local government is followed by neighbors immediately. As stated above, thinking about this remaining spatial autocorrelation may improve our understanding of change in reproductive behavior.

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