The End of Lowest-low Fertility in Japan?: Spatial Analyses of the Fertility reversal after 2005

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Abstract

The major goal of this paper is to explore the explanation of the fertility upturn in Japan after 2005. We focus on possible explanations such as elimination of tempo effects of delayed childbirth, inflation by immigrant women, improvement of the economic condition, policy improvements facilitating childbearing among working women, and contextual effects through spatial processes. We employed spatial analytic techniques to explain inter-prefecture (state) variation in the relative change in total fertility rate from the lowest level. Estimates from spatial error models suggest that some TFR upturn can be explained by the end of tempo effects, and it occurred in more economically favorable areas. However, the association with migration and policy improvement is not clear from the analysis. The result also showed that, even after controlling for the effect of structural covariates, clusters of fertility increase are apparent in the southern part of Japan (Kyushu), especially for two or later childbirth rates, which leads us to argue possible interpretations of this contextual effect.

Introduction

Since the 1990s, period total fertility rates (TFR) in Eastern and Southern Europe and East Asian countries have fallen below 1.3 and the idea of "lowest-low fertility" was introduced to explain with this new phenomenon (Kohler, Billari, and Ortega 2002). To explaining the fall to an extremely low level and to predict future trends have become some of the primary challenges in population studies since then. Because a part of the lowest-low fertility can be explained by the tempo effect of fertility due to the delayed timing of childbirth, some scholars suggested that lowest-low fertility should be a transient phenomenon that will end soon (Bongaarts 2001). On the other hand, the possibility that lowest-low fertility could become long-lasting or even permanent is suggested as long as socioeconomic and cultural conditions remain disadvantageous for children (McDonald 2006) or negative feedback of fewer births leads to further hardships for the young generation (Lutz, Skirbekk, and Testa 2006).

In most of these lowest-low fertility countries, however, fertility decline has come to a halt or showed recovery since about 2000 (Goldstein et al. 2009). For example, TFR in Italy reached 1.41 in 2008 after recording the lowest level of 1.19 in 1995 (ISTAT 2008), and Spanish TFR rose from 1.16 in 1996 to 1.40 in 2007 (Eurostat) (Figure 1). In Italy, the fertility reversal has taken place primarily in the more economically advanced areas located in the Center-North areas, where novel family behaviors have been observed more than other areas (Castiglioni and Dalla Zuanna 2008). In Spain, migrant women had an important role in pushing the Italian TFR upward (Goldstein et al. 2009).

In Japan, another country with the lowest-low fertility, recording 1.26 in 2005, interestingly, TFR has increased since 2005 and reached 1.37 in 2008. How can we explain this reversal? Is the explanation for other lowest-low fertility countries such as Italy and Spain applicable? In this paper, we explored the explanation for this recent TFR upturn in Japan. More specifically, we examined how this upturn is associated with the change in tempo effect, migration, economic condition, policy improvement, and contextual effects through spatial processes. For our analysis, we focused on regional (prefectural) level variations in fertility reversal in Japan (Figure 2) and the association with their structural covariates, and applied spatial analysis techniques to explain inter-prefectural variations in fertility upturn after 2000.

Figure 1: Trends in TFR in Japan and Italy

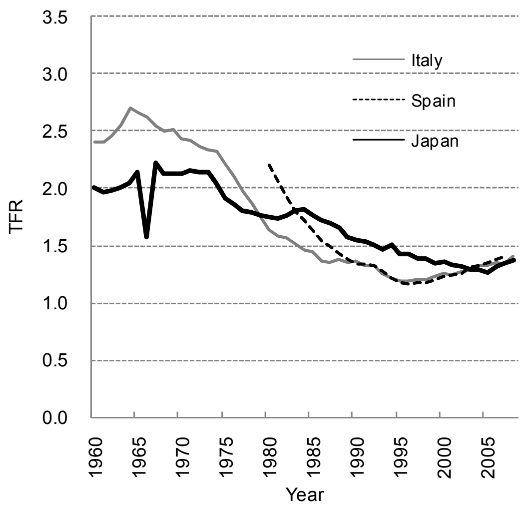
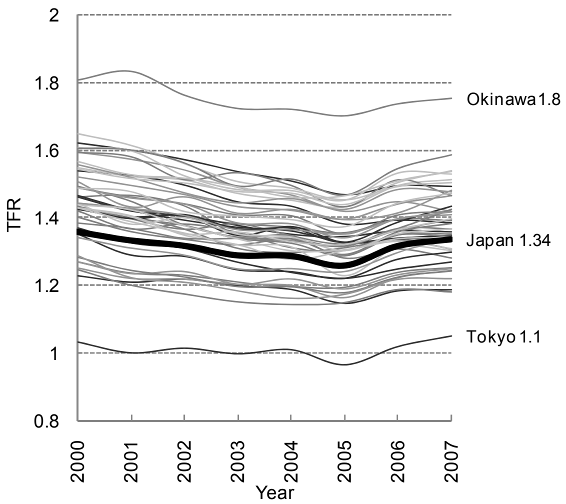


Figure 2: Trends in TFR by prefectures



Possible problems such as ecological fallacy or unreliable estimates due to the small sample size can arise in conducting ecological regression analysis with the data aggregated to geographic areas. Since our goal is to specify the causal factors, individual data from panel surveys would be preferable. However, collecting individual data usually requires substantial time, and the aggregate data are usually obtained relatively faster than collecting individual data. In addition, human behaviors such as partnership formation and reproductive behavior are often influenced not only by individual attributes but also by "social" effects through social interaction processes, including the diffusion/feedback mechanism, network effects, and social learning. These effects have long been recognized in literature on fertility (Tolnay 1995, Montgomery and Casterline 1996). However, they are also recognized for the difficulty in modeling. One of the sophisticated methods allowing for social effects beyond individuals is multi-level analysis. But in previous studies, spatial information is not fully utilized. Thus, in this study, we adopt spatial regression analysis to explore the possible existence of social effects being observed as a spatial process in fertility change.

Spatial analyses are important for both statistical and substantive reasons. Statistically, if spatial processes are not accounted for, inference will be inaccurate and estimates of the effects of covariates may be biased (Baller et al. 2001). To assess invariance in the structural covariates of fertility upturn, explicit modeling of spatial effects is crucial. In addition, spatial analyses are useful tool to detect social interaction process including diffusion, feedback, and social learning, since (1) the influence of such interaction is more likely to be stronger for those who are in frequent contact and (2) residential proximity generally increases the frequency of such interaction. This process is consistent with Tobler's first law of geography: "Everything is related to everything else, but near things are more related than distant things" (Tobler 1970). Therefore, in addition to the structural covariates effects discussed above, spatial analyses enable us to argue the possible existence of the social interaction process through assessing the existence of spatial autocorrelation.

In this study, we will call this spatial autocorrelation a contextual effect, and looking at simple ecological relationships, we investigate two possible scenarios that explain this effect: (1) diffusion of non-normative marital and reproductive behaviors often referred to as the second demographic transition process, and (2) contribution of the strong family networks that may facilitate childbearing.

Explanations for the lowest-low fertility in developed countries

More than half of the total population in Europe lived in countries with the lowest low fertility in 2001 (Sobotka 2004). Although period TFRs of these nations are below 1.3, these countries have not recorded cohort TFR below 1.3 (Sardon 2006). This suggests that the so-low fertility is caused by delays in timing of childbirth. Logically, if all women of reproductive age postpone childbirth to the next year, period TFR in the current year will record 0. Postponement of childbirth is a common mechanism among these nations, but the pattern differs widely. In Southern and Central Europe, the postponement of first birth was most notable, while in some countries in Eastern Europe, delay not in the first birth but in the second and third birth was prominent (Philipov and Jasilioniene 2008).

Generally, these countries have a traditional family system in which gender roles in the family are asymmetrical, and inter-generational relationships are strong (McDonald 2006). The public support system has been less developed and individuals, especially women, are expected to support their own family members. This makes it difficult for mothers to participate in the labor force, and more than a few women are likely to reduce the number of children to stay in labor market. Thus, many scholars argue that other factors than postponement such as particular social, cultural or economic forces also contribute to lowest-low fertility.

The trends in economy also had an impact on reproductive behavior in nations of the lowest-low fertility. Fertility decline in Eastern Europe is thought to be linked to the economic crisis and uncertainty during the economic and social transition in the 1990s (Perelli-Harris 2005).

Another factor causing differences between higher-fertility countries and lowest-low fertility countries among developed countries is caused by the difference in impact of immigration on fertility. Since immigrant women in most European countries and the United States have higher fertility rates on average than the native ones (Coleman 2006), fertility rates in countries with a large number of immigrants are pushed upward by a compositional effect.

For most social processes, individuals interact with each other and thereby influence each other. Fertility behaviors are also considered to be influenced by some social effects. Previous literature suggested the diffusion mechanism of fertility decline (Rogers 1995, Retherford and Palmore 1983, Montgomery and Casterline 1996, Kohler 2000, Casterline 2001). Recently, Lutz and his colleague suggested the negative feedback of fertility decline called "low fertility trap" (Lutz, Skirbekk and Testa 2006). They suggested that once fertility falls below a certain level, the ideal family size for the younger cohorts declines as a consequence of the lower fertility they see in the previous cohorts and the expected income becomes below their aspirations for younger cohorts due to population ageing induced by low fertility.

Explanations for the lowest-low fertility in Japan

Postponement of first birth is also observed in Japan, and this postponement is considered to be negatively associated with the quantum of fertility for two reasons. First, most of these postponements are led by postponement of union formation including cohabitation. Delayed marriage without prevalence of non-marital childbearing has caused difficulty in catching up. Even For the demand side, attractiveness of marriage has declined because of education and work aspirations of women who are more reluctant to follow the normative pathway of a married housewife with children (Raymo 1998). For the supply side, declining marriage rates are partly explained by the mismatch that an increasing number of highly educated women still seek higher educated men than themselves (hypergamy) in relatively small numbers (Raymo and Iwasawa 2005). While the chances for arranged marriages and match-making through the workplace have diminished, alternative opportunity has not developed (Iwasawa and Mita 2007). As a consequence, half of the single respondents over 25 years of age in Japanese National Fertility Survey selected "Cannot meet an acceptable partner" as a reason for staying single (Kaneko et al. 2008). The difficulty of union formation is a bottleneck of rising fertility.

Second, since later childbearing by women with higher human capital has increased, the opportunity costs of childbearing, the magnitude of so-called "postponement-quantum interactions" (Kohler, Billari, and Ortega 2002) now depends on the compatibility between female labor force participation and childrearing. Japan as well as Southern Europe provides insufficient public and private childcare support. Although a part of this deficit may be compensated by strong family networks such as grandmother's childcare support, these supports are not available for all working mothers. Considering these conditions, recuperation of reduced fertility appears difficult in Japan, and the proportion of childlessness has dramatically increased. The proportion of lifetime childlessness of women born in 1970 is estimated at over 25% (NIPSSR 2007, Kaneko et al. 2009). While the proportion of unintended births has declined, unachieved planned fertility has been extended, and the gap between planned and achieved fertility is more prominent in younger cohorts. In fact, official population projection assumes that the TFR will stay below 1.3 until 2050 in Japan (Kaneko et al. 2008). The postponement-quantum interaction remains very strong, that is, increase in fertility among women in their 30s is much weaker in Japan compared to other countries with moderately low fertility..

Increasing uncertainty in early adulthood is considered as another relevant factor leading to lowest-low fertility in Japan as well as European countries. From the beginning of the 1990s through the beginning of the 2000s, Japan experienced a long-term recession, and the number of young temporary employees increased. Many of them remained single during this period (Sakai and Higuchi 2005, Tsuya 2009). Under economic hardship, more people are likely to make human capital investments to access more stable jobs with a sufficient wage. According to the Japanese National Fertility Survey, the proportion of those who reported "to concentrate on education or work" as the reason for being single increased during the recession (Kaneko et al. 2008).

Most moderately low fertility countries have sub-groups with high fertility such as immigrants from high fertility countries, religious people, and those who experienced teenage birth, and this contributes positively to overall fertility. The number of immigrants in Japan has increased but is still limited. Furthermore, the fertility rate of non-Japanese women is lower than Japanese women (NIPSSR 2007). As for religion, Buddhism and Shintoism have long permeated Japanese life, but it does not have a direct influence on fertility behaviors. The level of teenage birth rates for Japan is the lowest among developed countries. While the teenage birth rate is 43 (per 1000 women aged 15-19) for the USA and 10 for France in 2002, Japan's corresponding figure is 3.9 (Darroch et al. 2001, Ventura et al. 2006, Vital Statistics for Japan 2002).This is partly because induced abortion is more accessible in Japan, and the age of initial sex is the highest among developed countries (Sato and Iwasawa 2008).

In sum, in addition to limited union formation combined with an aversion to non-marital childbearing and an institutional setting that increased the opportunity cost of women, the lack of high fertility sub-population and economic hardship for young adults during the 1990s makes it difficult for Japanese women to catch up in later ages led to lowest-low fertility.

Regional characteristics and spatial pattern of fertility

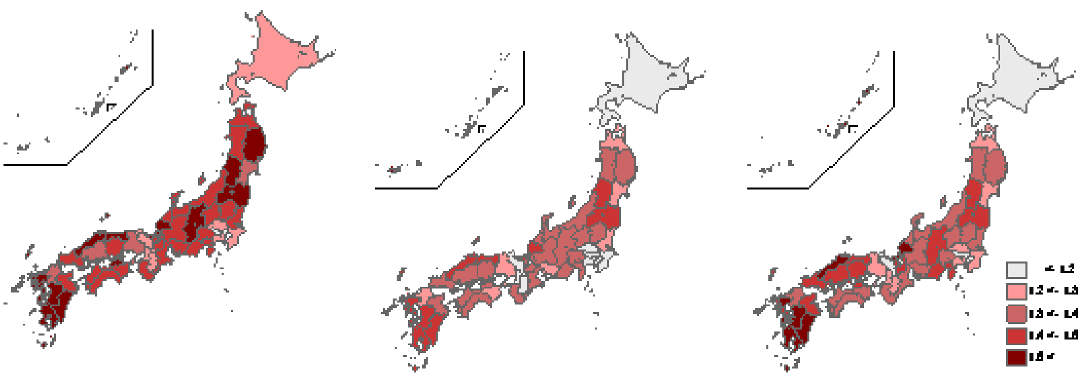
With the exception of a couple of traditional ethnic minority groups, Japan is considered to be relatively homogeneous. However, there are a variety of regional cultures built up by their long history and environment. These unique features mold people's values and affect reproductive behaviors.

47 prefectures in Japan are usually grouped into seven regions: (from north to south) Hokkaido, Tohoku, Kanto, Chubu, Kansai, Chugoku, Shikoku, and Kyushu/Okinawa, and Kanto and Kansai regions include major metropolitan areas (e.g. Tokyo, Kyoto, Osaka, Kobe). On the other hand, Tohoku, Shikoku and southern Kyushu are more agricultural regions. As for the family system relevant to reproductive behaviors, the stem family remains strong in Japan. However, according to studies done by anthropologists, the Japanese stem family system consists of two types, the "single household stem family system" which is typically observed in the Tohoku region (the northern part of the main island) and the Hokuriku region (the northern part of the middle area of the main island) and the "multiple households stem family system" which is mainly observed in the west-southern part of Japan (Kyushu region) and Tokai/Tosan (the middle part of the main island) (Shimizu 1986, Kato 2006). In the former system, at least two generations (parental couple and one of their children's, mostly the eldest son's family) live together in the same household. On the other hand, in the latter system, after parents go into retirement, the parent's couple and children's couple live separately as different households in the same site or the same district. Generally, the family system in Hokkaido has distinctive features due to her unique histories. In the Meiji era, many immigrants moved to Hokkaido from various areas of the rest of Japan, and they have developed their own system that is free from the traditional family culture.

Various researchers have studied regional differences in fertility patterns in Japan (Takahashi 1976; Ishikawa 1992; Kōno 1992). Previous studies showed geographical patterns of the (first) demographic transition, starting with what is known as the "high in the east, low in the west" trend in fertility, shifting to significant fertility decline in the west and major city areas, then diminishing geographical gaps in fertility (Takahashi 1976, Nakagawa 2003). Recent studies pointed out enlarging geographical differences in fertility followed by a period of shrinking geographical differences (Shimizu 2004). Other studies also explored geographical differences in fertility through looking at factors that trigger fertility decline such as marital behavior and fertility behaviors among couples. For instance, using data from a series of Japanese National Fertility Surveys, Sasai (2007) analyzed regional differences in marital fertility, controlling for respondents' biological and socio-economic factors. For completed number of children, the result shows a significant effect of age of wife at first marriage (+), wife's education (-), Densely Inhabited District (-), coresidence with parents at survey (+), the north-east region of Japan (+). However, for the number of children in the middle stage of their reproductive process, a positive relationship was observed in the Tokai and Kyushu regions. Mizuho Information & Research Institute (2005) indicated that the geographical variation showing the "high in the east, low in the west" trend is explained by climate, long working hours for men, and the rate of childcare facilities. Yamauchi et al. (2005) focused on fertility trends since 1980 in metropolitan areas. They claimed that the decline in marital fertility is observed regardless of population density, and pointed out that suburb areas began to experience the distinctive fertility drop observed in metropolitan areas (Yamauchi et al. 2005).

Figure 3: Spatial pattern in Total Fertility Rates

[2000] **[2005]** **[2007]**



Most of the time, fertility rates are more likely to be higher in the east and lower in the west, but after 2005, this superiority in the Tohoku regions became less clear (Figure 3). Fertility changes have never occurred homogenously across regions, that is, space can make a difference. If so, the recognition of a spatial dimension in fertility analysis may yield different, and more meaningful results than other statistical analyses (e.g. OLS regressions) that ignore spatial information.

Possible explanations for TFR upturn in Japan

Despite many demographers' expectations that lowest-low fertility is likely to be a persistent pattern lasting several decades, fertility in lowest-low fertility countries has steadily rose since 2000 in Europe and East Asia including Japan. Although the upturn in Japan is less visible compared to other European countries such as Italy and Spain, we argue the possibility of testing several hypotheses which are considered relevant to the recent fertility reversal of the lowest-low fertility countries in Europe.

Structural effects

Since the most prominent explanation of the lowest-low fertility is a trend towards a later timing of childbearing, recovery may reflect the end of fertility postponement, that is, an elimination of the tempo effect. In fact, according to the analysis for Italy, the upturn of fertility rates in the Center-North of Italy is due to the stabilization in fertility rates at younger ages for the cohorts born in the 1970s, and to the rising fertility rates at older ages for the cohorts born in the 1960s (Castiglioni and Dalla Zuanna 2008). If the same mechanism accounts for the recent TFR upturn in Japan, fertility reversal should be more prominent in the areas with an age pattern of later childbearing.

In most affluent European countries, immigration has escalated, especially since 2001. As immigrant women in most European countries have higher fertility rates on average than native ones, migrant women have an important role in pushing the TFR upwards. According to Castiglioni and Dalla Zuanna (2008), the contribution of foreigners to the increase of general fertility in Italy from 1996 to 2006 was 40%.

Official statistics of total fertility rate provided by the Japanese government are a measurement limited to the Japanese population. Japanese fertility rates are calculated using the number of Japanese women as a denominator and the number of babies having Japanese nationality as a numerator. However, since Japanese babies as a numerator include those who were born to non-Japanese women married to Japanese men, this fertility indicator is inflated by a compositional effect of the proportion of non-Japanese women who are mothers of Japanese babies. Therefore, increase in non-Japanese women in reproductive age may push the

TFR upward in Japan. We expect that the increase in these women may contribute to the change in "Japanese" fertility indicator.

An important commonality of the socioeconomic context among lowest-low fertility countries is a high level of economic uncertainty in early adulthood (Kohler, Billari, and Ortega 2002). High unemployment risks provide an incentive to delay decisions that imply long-term commitments, such as marriage and having children, and they provide an incentive to invest in education and other forms of human capital. Using micro-data linked to town-level macro data, Kojima (2005) showed that the unemployment rate for males was negatively associated with fertility by a regression analysis. Therefore, once the economic climate has improved, people may decide to marry and to have a (another) child. Unemployment rates in Japan have fallen since 2002, and we expect that upturn in TFR should be strong in more economically favorable areas.

Most policies that are likely to have contributed to the fertility increase belong to the category of family-friendly measures aimed at facilitating work and family reconciliation. In Japan, during initial phase of introducing policies, due to inconsistencies in the family support scheme, limited resources, limited cooperation in workplaces, Japan was referred to as an example of policy failure (McDonald 2006). However, from the early 1990s, numerous policies and programs were enacted in Japan (Ogawa 2003, Moriizumi 2008): Angel Plan for 1995-1999, New Angel Plan for 2000-2004, Zero Children on Waiting List Strategy in 2001, Basic Law for Measures to Cope with a Low Birth Rate Society in 2003, Children and Childcare Plan for 2005-2009, Formulation and implementation of action plans by local government and businesses from 2005, Unification of Preschool Educational System and of Preschool Curriculum from 2006 (establishment of *Nintei-kodomoen*), and action agenda for work-life balance from 2007. Through these plans and laws, the government introduced parental leave, expanding childcare services and similar measures to facilitate childbearing among working married mothers. In our study, we assess the effect of family-related policy especially for balancing work and childrearing among women that is expected to reduce opportunity cost for women.

Contextual effects

Fertility and family formation behaviors are not only influenced by individual level determinants, but also affected by social interaction processes or the value system in that society (Montgomery and Casterline 1996). For example, the traditional family system in Japan is more similar to other East Asian countries than

North European countries (Esping-Andersen 1999). The idea of the optimal timing of childbearing is influenced by childbearing and career experiences of friends through social learning (Kohlar et al. 2002). Knowing someone who has engaged in innovative behaviors is positively associated with their own tolerant attitudes toward innovative family behaviors (Rindfuss et al. 2004). These complicated processes are not easily formulated. Our study employed an idea that such interaction and sharing common values is likely to be stronger for those who are in frequent contact, and residential proximity generally increases the frequency of such interactions. If so, we should be able to observe spatial autocorrelation referred to as a situation in which values on a variable of interest (fertility upturn) are systematically related to geographic location.

In our study, we will first assess the spatial influence of unmeasured independent variables (contextual effects) on fertility upturn using spatial regression techniques. Then, we will explore the meaning of these contextual effects. Although structural predictors we examined in model analyses are relatively short-term drivers of fertility change, these contextual effects may reflect more long-term drivers reflecting cultural and value aspects. Culture and values are considered to diffuse through social interaction processes such as networks and social learning, and it seems to be compatible with spatial process. In this study, we will explore possible explanations for these contextual effects by examining two specific scenarios which are closely related to culture and the value system: (1) the second demographic transition process and (2) a cultural system of strong family system.

Second Demographic Transition process: The first scenario we will examine is related to the so-called second demographic transition (SDT). The SDT is profound social-demographic transitions that have occurred in mainly Northern and Western Europe since the 1960s (Lesthaeghe 1995). It includes the emergence of secular and anti-authoritarian sentiments of better-educated men and women who held an egalitarian worldview, placed greater emphasis on self-actualization, individualistic and expressive orientations. Furthermore, the SDT is also be characterized by postponement of marriage, prevalence of cohabitation, increase in birth to unmarried couples, and increase in divorce. In the societies going through SDT, postponement of fertility would not only lead to a temporary drop of period TFR below the replacement level, but to long-term sub-replacement cohort fertility. On the other hand, fertility decline in these societies is moderate (>1.5) and it doesn't reach lowest-low level (<1.3). Indeed, there was a strong positive correlation between new marital and reproductive behaviors and fertility level among European countries at the beginning of the 1990s (Castiglioni and Dalla Zuanna 2008), and the recent fertility reversal in Italy is prominent in the area where new marital behaviors such as cohabitation, out-of-wedlock births, and legal separations have spread more rapidly.

Strong family system: The other scenario for explaining contextual effects is that the strong family ties embedded in Japan may have a positive impact on raising more children. While lowest-low fertility countries in Southern European and East Asian countries have some of the lowest levels of state support for families with children through tax allowances or direct transfers, a strong family network, as for instance through the provision of childcare or economic resources by grandparents, plays an important role to support young couples' childrearing (Reher 1997). Since public childcare support would still be insufficient for most working mothers, a familialistic support system may work more sufficiently. We assume here that the area with high prevalence of intergenerational coresidence or proximate residence would have stronger family networks than the rest of area with lower prevalence.

Research Questions- Five plausible explanations for the recent fertility upturn in Japan

Based on previous studies, we will examine the following five plausible explanations regarding the recent fertility upturn in Japan.

1) Because of the end of fertility postponement, tempo effects depressing the period TFR have disappeared.

2) Because of increasing immigrants, childbirths born to non-Japanese women married Japanese men have inflated "Japanese" fertility rates.

3) The improvement of the economic condition has enabled young adults to get married and have a (another) child.

4) The improvement of family-related policy has facilitated working women to have more children.

5) Contextual effects through some spatial process positively have influenced fertility behaviors. These contextual effects may be associated with the SDT process and/or strong family system.

Methods

To answer the questions, we will conduct ecological regression that focuses on regional variation of the fertility reversal at the prefectural level.

We first provide descriptive statistics and visual images on variations and spatial patterns of basic variables. Spatial autocorrelation of dependent and independent variables is also assessed by means of Moran's I statistics (Cliff and Ord 1973, Moran 1950). Moran's I statistics is 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. 2006).

This exploratory phase is followed by an ordinary least squares regression of prefecture level TFR upturn on the predictors which represent the elimination of tempo effect, immigrant effect, economic improvement effect, and policy effect discussed above. The results of the OLS regressions are investigated for the existence of spatial autocorrelation. Assuming that spatial dependence is observed with controls of structural covariates, we estimate the spatial error 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):

$$\begin{aligned} y &= X\beta + u, \\ u &= \lambda W u + \varepsilon, \\ \varepsilon &\sim N\left(0, \sigma^2 I\right) \end{aligned}$$

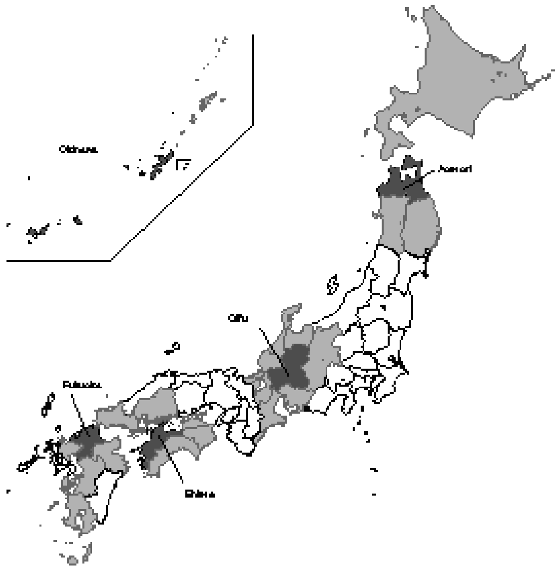
where y is a (n x 1) vector representing the dependent variables, X is a (n x k) matrix representing the k-1 independent variables, β is a (k x 1) vector of regression parameters to be estimated, u is a (n x 1) vector of error terms presumed to have a covariance structure as given in the second equation, λ is a spatial autoregressive coefficient to be estimated, W is a (n x n) weight matrix defining the "neighborhood" structure that reflects the potential interaction between neighboring locations and zeros out pairs of locations for which spatial correlation is ruled out a priori, and ε is a (n x 1) vector of independently distributed (spatially uncorrelated) errors (i.i.d.). 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 the weight matrix used in estimating spatial regression model, we used a first-order queen convention. This means that the neighbors for any given prefecture “A” are those other prefectures that share a common boundary with “A” in any direction. Although Hokkaido and Okinawa don’t share any borders with any other prefecture, we defined Hokkaido as having Aomori and Okinawa as having Kagoshima as their respective neighbors. Because Hokkaido and Aomori are connected with an undersea tunnel, Seikan tunnel, and Okinawa and Kagoshima have historically shown frequent interchanges with each other, it is natural to assume proximity between them. We also connect Hiroshima with Ehime, and Yamaguchi with Fukuoka, because these prefectures are connected via Shimanami Bridge and Kanmonkyo Bridge with their potential neighbors. We show some prefectures and their neighbors on a map in Figure 4. As a result, the mode number of neighbors is four and the prefecture that has the largest number of neighbors is Nagano having 8 and the smallest number of neighbors is one for Hokkaido, Nagasaki and Okinawa.

Contrasting the OLS regression result and spatial error model result, we will assess how the model is improved with modification that incorporates spatial process effects. The spatial error model is often referred to as a spatial disturbance model, and it is distinguished from the spatial lag model in which spatial autocorrelation is suggestive of a possible diffusion process – events in one place predict an increased likelihood of similar events in neighboring place, net of the effect of structural covariates (Baller et al. 2001). In the spatial disturbance model, spatial autocorrelation is indicative of omitted (spatially correlated) covariates that if left unattended would affect inference.

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 used GIS software, ArcGIS 9.3 of ESRI, and the spatial regression analyses were carried out using ‘spdep’ package in R.

Figure 4: Defined neighbors by first-order queen convention:
Aomori, Gifu, Ehime, Fukuoka, Okinawa (dark gray) and their neighbors (light gray)



Data

Data for prefecture-level fertility are obtained from fertility rates constructed from Japanese vital statistics and the Population Census of Japan or Population Estimates from 2000 to 2007 (based on 5-age-group population). Fertility reversal is measured as the relative change from the lowest TFR between 2000 and 2007 to 2007 TFR. First-order TFR (TFR1) and second or later birth TFR (TFR2+) are also examined as well as all birth TFR (TFR).

Independent variables for the regression models are manipulated as follows. For the termination of the tempo effects, we used the postponement index of fertility proposed by Lesthaeghe and Neidert (2006). It is the ratio of the sum of age-specific fertility rates above age 30 to the sum of these rates between ages 20 and 29, and we calculated it for first birth fertility rates. If we observe steeper increase in TFR in those areas with higher postponement index, increase in TFR should be led by the elimination of the tempo effect due to the end of fertility postponement. In this study, we calculated postponement index using first birth fertility rates in 2007.

As for the impact of non-Japanese women which may inflate official TFR index, we used the proportion of non-Japanese women to total women aged between 20 and 35. If the increase in the number of international marriage plays an important role in recent fertility upturn, we should observe a positive relationship.

Economic condition is measured by the unemployment rate for men using the 2005 Population Census. Unemployment rates in Japan increased since the beginning of the 1990s, but show a fall after 2002 (Labour Force Survey, the Statistics Bureau, the Ministry of Internal Affairs and Communications). We expect that fertility increase should be more prominent in areas with lower unemployment rates, because couples who postponed childbirth in difficult times may begin to have another child.

As for the contribution of policy, we focused on the equilibrium between childcare and paid labor. We used the proportion of children in day-care facilities to all preschool children in 2005. The number of children in day-care facilities came 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 half of the number of 6 aged children).

Contextual effects though spatial processes will not be examined directly, but if we confirm spatial autocorrelation within a neighborhood even after structural covariates effects are eliminated, we could suggest the possible existence of some space-relevant factors. Once contextual effects are estimated, we can investigate the ecological correlation between the volume of contextual effects extracted from the model analyses and some index for the SDT process and strong family system.

Although it would be arguable how the degree of the progression in the SDT should be measured, here, following the analyses by Lesthaeghe and Neidert (2006), we utilized a classic principle component analysis using a set of demographic indicators. While Lesthaeghe and Neidert (2006) focused on 12 indicators at the state-level in the USA to interpret a factor of the SDT, we selected only three demographic behavioral indicators: the proportion of those who have cohabitation experience among 20-49 age women, proportion of non-marital first birth fertility rate to all first birth TFR, and the total divorce rate among women in reproductive (15-49) age. As for the prevalence of cohabitation, the proportions of ever-cohabited women are estimated using the first National 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 by summed 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 was about

2% in 2005), but it is slightly increasing. We calculated age-specific first birth fertility rates and age-specific first non-marital fertility rates in 2005 by prefecture using the Vital Statistics, and we obtained the ratios of total first non-marital birth fertility rate to total first birth fertility rate.

As the indicator of the SDT, we used the individual score of the principle component. It is important to keep in mind that this SDT indicator we used reflects only a part of features on the SDT. Our indicator does not include the trends in childlessness, later marriage, secularization and so on usually relevant to that process. Because the pattern of the SDT varies across developed countries and the universality of it is still controversial (Coleman 2004, Raymo and Iwasawa 2008), we will argue this only in relation to the aspect of novel marital and reproductive behaviors.

As the indicator for a strong family system, we focused on the pattern of the intergenerational residence of couples with small children. Using data from Japanese National Fertility Surveys conducted in 1997, 2002, and 2005, we obtained the proportion of those who live with their parent(s)(-in law)(coresidence), those who live in the same city/town as their parent(s)(-in law)(proximate residence), and those who live apart from their parent(s)(-in law)(living far away) among married women with at least one child under 13 (we also tested with the proportion among married women with preschool children, but the inference was not different).

We will discuss the possibility of whether these factors explain contextual effect on fertility upturn by looking at the simple ecological correlation between these variables.

Results

Fertility upturns at prefecture level

Figure 5 shows the geographical pattern of the TFR upturn. All birth TFR upturn seems to be concentrated around the Pacific belt zone from Tokyo to Aichi and the west side of Kyushu. For second or later birth TFR, the upturn seems to be stronger in the southern part of Japan. We show descriptive statistics for all birth and order-specific TFR upturn in Table 1, and change in fertility, the lowest level and year, and the contribution of TFR1 to the all birth TFR increase by prefecture in Appendix table 1.

Figure 5: Relative change in TFR from the lowest level
(= TFR in 2007 / the lowest TFR between 2000 and 2007 x 100)

[All birth TFR] **[First birth TFR]** **[Second or later birth TFR]**

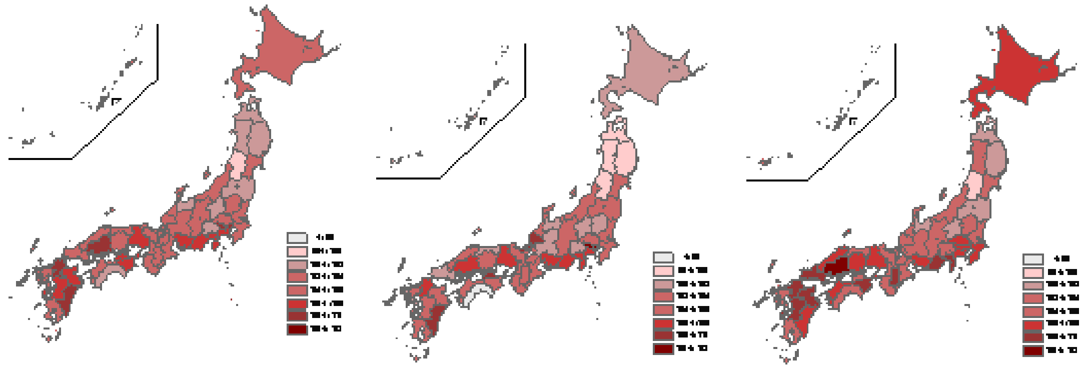


Table 1: Descriptive statistics for TFR upturn and covariates

Variable	N	Mean	Min	Max	Spatial autocorrelation Moran's I
Dependent variables					
Relative change in TFR (through 2007)	47	104.5	100.0	108.9	0.323 ***
Relative change in TFR1 (through 2007)	47	103.5	96.8	110.7	0.211 *
Relative change in TFR2+ (through 2007)	47	105.3	100.0	110.1	0.311 **
Explanatory variables					
Postponement Index for first birth (2007)	47	61.5	46.1	117.0	0.400 ***
Proportion of non-Japanese women of age 20-34 (2005)	47	2.6	0.9	6.0	0.469 ***
Unemployment rate for men (2005)	47	6.8	4.9	13.7	0.411 ***
Proportion of preschool children in day care (2005)	47	32.5	15.4	51.8	0.214 *

*** p<.001 ** p<.01 * p<.05

While mapping would provide us a visual message on variations and spatial patterns of variables, visual inspection is not sufficiently rigorous to assess significant clusters or spatial dependence. According to Moran's I statistics in Table 1, spatial autocorrelations are statistically significant for all birth TFR upturn and the second or later birth TFR upturn, but is not clear for first birth TFR upturn. Most covariates are spatially autocorrelated. We can expect that a part of spatial autocorrelation in fertility upturn should be explained by spatially correlated covariates. To ascertain whether fertility upturn is solely determined by the structural factors included in the model, that is, no remaining spatial autocorrelation should be found once the structural similarity of neighboring prefectures has been explicitly controlled for, we need to look at the results from multivariate models estimating the effects on fertility upturn of structural variables with adjustments for spatial autocorrelation.

Bivariate relationships between TFR upturns and covariates are shown in Table 2. Based on Pearson's correlation coefficients, the postponement index has positive association with fertility upturn, and the male unemployment rate and the proportion of children in day care show a negative relationship.

Table 2: Pearson's correlation matrix

Variable		(1)	(2)	(3)	(4)	(5)	(6)	(7)
TFR upturn	(1)	1.00	0.89	0.84	0.34	0.10	-0.18	-0.25
			(0.000)	(0.000)	(0.019)	(0.525)	(0.222)	(0.088)
TFR1 upturn	(2)	0.89	1.00	0.51	0.36	0.24	-0.29	-0.20
		(0.000)		(0.000)	(0.014)	(0.103)	(0.047)	(0.173)
TFR2+ upturn	(3)	0.84	0.51	1.00	0.21	-0.11	-0.02	-0.25
		(0.000)	(0.000)		(0.151)	(0.471)	(0.894)	(0.096)
Postponement Index for first birth	(4)	0.34	0.36	0.21	1.00	0.15	-0.06	-0.40
		(0.019)	(0.014)	(0.151)		(0.323)	(0.711)	(0.006)
Proportion of non-Japanese women	(5)	0.10	0.24	-0.11	0.15	1.00	-0.56	0.10
		(0.525)	(0.103)	(0.471)	(0.323)		(0.000)	(0.509)
Unemployment rate for men	(6)	-0.18	-0.29	-0.02	-0.06	-0.56	1.00	-0.07
		(0.222)	(0.047)	(0.894)	(0.711)	(0.000)		(0.660)
Proportion of children in day care	(7)	-0.25	-0.20	-0.25	-0.40	0.10	-0.07	1.00
		(0.088)	(0.173)	(0.096)	(0.006)	(0.509)	(0.660)	

Figures in the second row represent p-values for H0 (Rho=0).

OLS and Spatial regression results

Table 3 presents OLS regression results that include the structural predictors of relative change in fertility for all birth and parity specific birth. For all birth TFR upturn, only the postponement index show a weak significant positive association. TFR upturn occurred in areas with an age pattern of later first childbearing, that is, elimination of tempo effect can be a possible explanation for the recent TFR reversal in Japan. Other predictors show negative association but these are not statistically significant. However, diagnostics for spatial autocorrelation reveal a strong presence of spatial autocorrelation for residuals (Moran's I =0.42). This indicates the violation of the independence assumptions. Thus, estimates by the OLS regression are no longer "BLUE"-best linear unbiased estimator. Judging from the specification test using the Lagrange Multiplier principle, a spatial error model is a more appropriate alternative to an OLS model than a spatial lag model. This means that the residual spatial autocorrelation can be adequately accounted for in terms of unmeasured predictor variables that are spatially correlated, and it is unnecessary to posit distinctive effects of the lagged dependent variable being compatible with common notions of diffusion processes.

The second column in Table 3 shows the results of a spatial error model. Two coefficients of explanatory variables, the unemployment rate for men and the proportion of children in day care became significant, and the spatial autoregressive coefficient, Lambda, is 0.52 and statistically significant. This Lambda value indicates that if the average value on neighbors increases by one unit, the value of that area will increase by 0.52 even after controlling their covariates. The model fit was much improved and spatial autocorrelation among residuals was essentially eliminated (Moran's I =-0.07).

We estimated the same models for the relative change in first birth TFR and second and later birth TFR. Improvement in the model with specification of a spatial stochastic process for the error term is much greater for second or later birth TFR upturn than for first birth TFR upturn. This implies that an unmeasured effect on fertility upturn would be more relevant to second or later childbearing than first birth. Returning to the structural covariates estimated by spatial error models, the positive effect of the postponement index and the negative effect of the unemployment rate for men are significant for first birth TFR upturn. On the other hand, contrary to our expectation, for second or later birth TFR upturn, the proportion of children in day care alone shows a significantly negative impact. The proportion of non-Japanese women does not show any significant effect in all models.

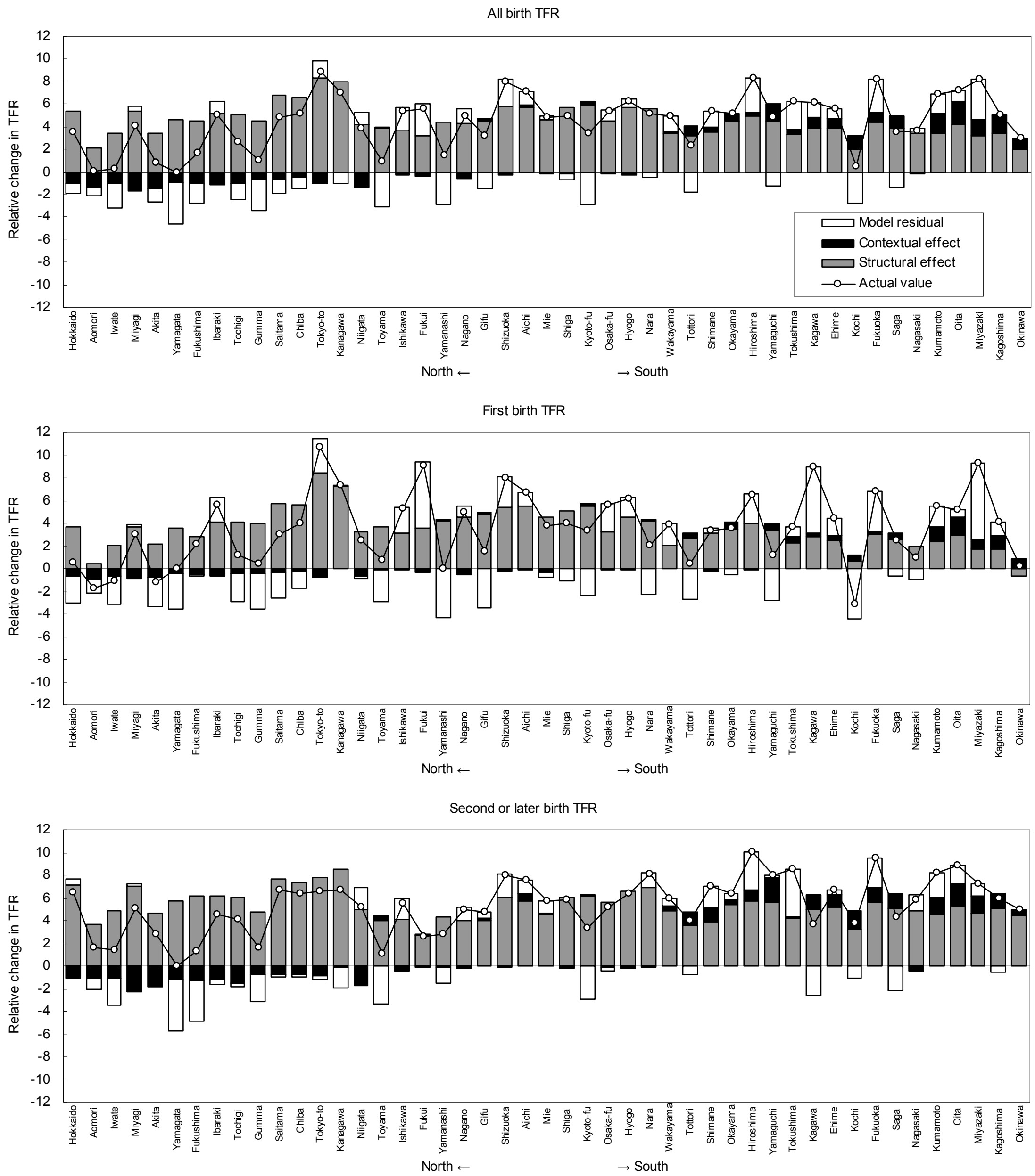
Based on the spatial error model specification, the actual value of fertility change can be decomposed into the predicted value by structural covariates (structural effect), predicted value by spatial autoregressive coefficient and the residual of the neighboring prefecture (contextual effect), and i.i.d. error term. We show these components in Figure 6 by prefecture. The volume of contextual effects is likely to be larger in the Southern part of Japan such as Kyushu, and the negative effect seems stronger in the Northern part, such as the Tohoku area. This pattern is apparent for second or later birth TFR upturn, but not so clear for first-order TFR upturn.

Table 3: Regression results, prefecture-level upturn of TFR: OLS and spatial error model

Variable	Relative change in TFR				Relative change in TFR1				Relative change in TFR2+			
	OLS model		Spatial error model		OLS model		Spatial error model		OLS model		Spatial error model	
	β	(p-value)	β	(p-value)	β	(p-value)	β	(p-value)	β	(p-value)	β	(p-value)
Constant	104.97	(0.000) ***	106.48	(0.000) ***	103.33	(0.000) ***	104.16	(0.000) ***	107.20	(0.000) ***	109.36	(0.000) ***
Postponement Index for first birth	0.05	(0.084) #	0.06	(0.027) *	0.07	(0.066) #	0.07	(0.043) *	0.03	(0.314)	0.04	(0.156)
Proportion of non-Japanese women	-0.09	(0.806)	-0.09	(0.745)	0.20	(0.661)	0.22	(0.597)	-0.37	(0.308)	-0.44	(0.124)
Unemployment rate for men	-0.30	(0.246)	-0.42	(0.053) #	-0.48	(0.151)	-0.57	(0.062) #	-0.19	(0.479)	-0.29	(0.178)
Proportion of children in day-care	-0.04	(0.339)	-0.07	(0.025) *	-0.04	(0.465)	-0.05	(0.273)	-0.04	(0.300)	-0.10	(0.003) **
Lambda (spatial autoregressive coefficient)			*0.52*	*(0.000)* ***			*0.32*	*(0.048)* *			*0.56*	*(0.000)* ***
R-squared	0.17				0.21				0.10			
Adjusted R-squared	0.09				0.14				0.01			
AIC	217.67		207.30		240.60		239.28		220.54		208.04	
Likelihood Ratio Test			12.37	(0.000) ***			3.32	(0.068) #			14.50	(0.000) ***
N	47		47		47		47		47		47	
Diagnostics for spatial autocorrelation												
Moran's I (residuals)	0.42	(0.000) ***	-0.07	(0.665)	0.21	(0.008) **	-0.01	(0.445)	0.44	(0.000) ***	-0.08	(0.717)
Lagrange multiplier diagnostics for spatial autocorrelation												
LM(error)	14.08	(0.000) ***			3.39	(0.066) #			15.46	(0.000) ***		
LM(lag)	10.96	(0.001) ***			2.69	(0.101)			11.60	(0.001) **		
Robust LM(error)	4.94	(0.026) *			0.91	(0.341)			4.39	(0.036) *		
Robust LM(lag)	1.81	(0.178)			0.21	(0.648)			3.41	(0.065) #		
LM(SARMA)	15.90	(0.000) ***			3.60	(0.165)			19.85	(0.000) ***		

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

Figure 6: Actual and Predicted values for relative change in TFR



Note: Y axis is shown as actual values minus 100.

Possible explanation for the contextual effect

The results of the spatial regression analyses reveal that fertility reversal is not accounted for solely by internal structural factors, and spatially correlated unmeasured variables seem to contribute to TFR upturn. We also found that this positive effect is more apparent in the southern part of Japan.

Table 4 shows descriptive statistics and the spatial autocorrelation indicator of each variable. As specified in the spatial error model, contextual effects are strongly spatially autocorrelated. The index for the SDT and the proportion of proximate residence are also spatially autocorrelated. Figure 7 shows the spatial pattern of these variables. Contextual effects are more prominent in Kyushu, a part of Shikoku and Chugoku, Kansai and Chubu. As for the SDT score, west-Kyushu, Kochi, east-Tohoku, and Hokkaido show relatively high levels. Unlike Italy, we cannot say that the STD emerges from metropolitan areas such as Kanto or Chubu regions. Living arrangements with parents among couples with pre-junior high school children also show distinctive spatial patterns. While coresidence with parents is more prominent in Tohoku, Hokuriku, and the northern part of Chugoku, proximate residence is more noticeable in the west-southern part of Japan. In the Kanto area, nearly half of couples are living far away from their parental homes. These spatial patterns are consistent with the spatial pattern of the stem family system typology.

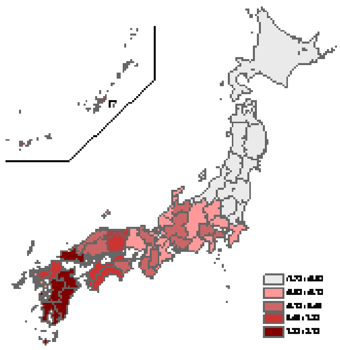
Table 4: Descriptive statistics for contextual effects, SDT score, and living arrangement with parents

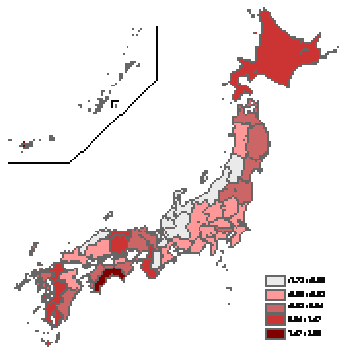
Variable	N	Mean	Min	Max	Spatial autocorrelation Moran's I	
Contextual effect						
Contextual effect in TFR (through 2007)	47	0.01	-1.73	2.12	0.819	***
Contextual effect in TFR1 (through 2007)	47	0.00	-1.02	1.53	0.748	***
Contextual effect in TFR2+ (through 2007)	47	0.04	-2.24	2.13	0.772	***
Second Demographic Transition						
Second Demographic Transition score	47	0.00	-1.72	2.99	0.384	***
Proportion cohabited among women of age 20-49 (2004)	47	14.68	0.00	44.44	-0.070	
Proportion of nonmarital fertility to all first birth TFR (2005)	47	2.60	1.64	5.70	0.333	***
Total divorce rate among women of age 15-49(2005)	47	1.04	0.74	1.28	0.340	***
Strong Family Ties						
Proportion of coresidence (1997-2005)	47	34.72	7.51	75.00	0.171	*
Proportion of proximate residence (1997-2005)	47	39.77	16.67	67.68	0.278	**
Proportion of living far away (1997-2005)	47	25.51	5.36	55.01	0.175	*

*** p<.001 ** p<.01 * p<.05

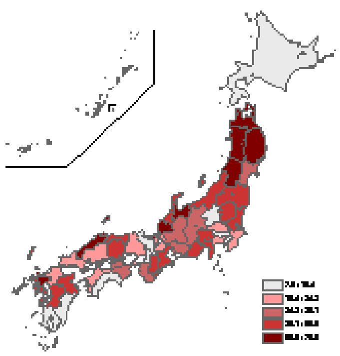
Figure 7: Contextual effects and possible factors:
Second Demographic Transition and living arrangement with parents

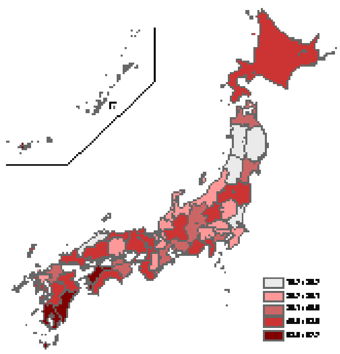
[Contextual effects] **[SDT scores]**

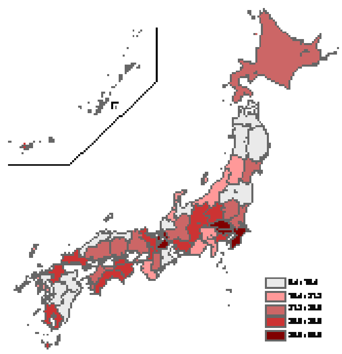




[Coresidence] **[Proximate residence]** **[Living in different town]**







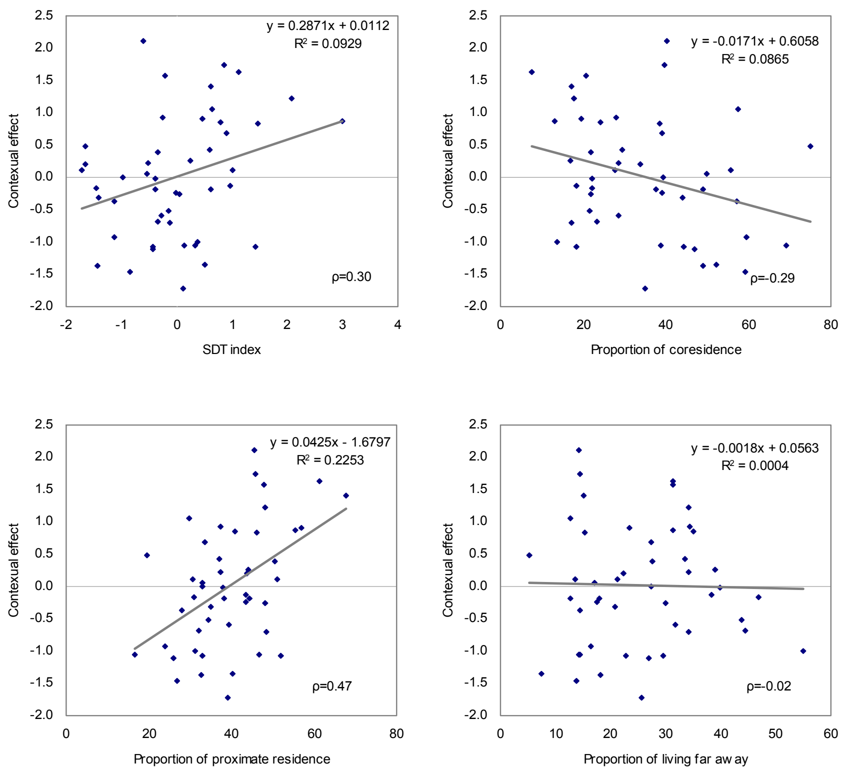
Finally, Table 5 shows a correlation matrix of variables to discuss which scenario could be more probable as the explanation of contextual effects by showing simple bivariate relationships. Pearson's coefficients indicate that the proportion of coresidence is negatively associated with contextual effects on fertility upturn. On the other hand, both the SDT score and the proportion of proximate residence are positively associated with contextual effects contributing to fertility reversal. More interestingly, comparing two factors, proximate residence is much more correlated with contextual effects. Scatter plot and slopes are also shown in Figure 8.

Table 5: Pearson's correlation matrix

Variable		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Contextual effect in TFR	(1)	1.00	0.95	0.96	0.30	-0.09	0.28	0.36	-0.29	0.47	-0.02
			(0.000)	(0.000)	(0.037)	(0.549)	(0.055)	(0.013)	(0.045)	(0.001)	(0.888)
Contextual effect in TFR1	(2)	0.95	1.00	0.83	0.33	-0.07	0.32	0.36	-0.33	0.49	0.01
		(0.000)		(0.000)	(0.025)	(0.621)	(0.028)	(0.014)	(0.024)	(0.001)	(0.921)
Contextual effect in TFR2+	(3)	0.96	0.83	1.00	0.24	-0.10	0.20	0.32	-0.24	0.41	-0.04
		(0.000)	(0.000)		(0.102)	(0.510)	(0.173)	(0.027)	(0.099)	(0.004)	(0.808)
Second Demographic Transition score	(4)	0.30	0.33	0.24	1.00	0.42	0.90	0.87	-0.50	0.57	0.18
		(0.037)	(0.025)	(0.102)		(0.003)	(0.000)	(0.000)	(0.000)	(0.000)	(0.235)
Proportion cohabited	(5)	-0.09	-0.07	-0.10	0.42	1.00	0.22	0.13	-0.23	0.16	0.18
		(0.549)	(0.621)	(0.510)	(0.003)		(0.134)	(0.393)	(0.120)	(0.286)	(0.219)
Proportion of nonmarital 1st birth ferti	(6)	0.28	0.32	0.20	0.90	0.22	1.00	0.66	-0.48	0.59	0.14
		(0.055)	(0.028)	(0.173)	(0.000)	(0.134)		(0.000)	(0.001)	(0.000)	(0.343)
Total divorce rate among women	(7)	0.36	0.36	0.32	0.87	0.13	0.66	1.00	-0.38	0.46	0.12
		(0.013)	(0.014)	(0.027)	(0.000)	(0.393)	(0.000)		(0.008)	(0.001)	(0.426)
Proportion of coresidence	(8)	-0.29	-0.33	-0.24	-0.50	-0.23	-0.48	-0.38	1.00	-0.72	-0.76
		(0.045)	(0.024)	(0.099)	(0.000)	(0.120)	(0.001)	(0.008)		(0.000)	(0.000)
Proportion of proximate residence	(9)	0.47	0.49	0.41	0.57	0.16	0.59	0.46	-0.72	1.00	0.11
		(0.001)	(0.001)	(0.004)	(0.000)	(0.286)	(0.000)	(0.001)	(0.000)		(0.472)
Proportion of living far away	(10)	-0.02	0.01	-0.04	0.18	0.18	0.14	0.12	-0.76	0.11	1.00
		(0.888)	(0.921)	(0.808)	(0.235)	(0.219)	(0.343)	(0.426)	(0.000)	(0.472)	

Figures in the second row represent p-values for H0 (Rho=0).

Figure 8: Bivariate relationship between contextual effect and possible factors in prefectures: All birth TFR upturn



The result is partially consistent with the situation observed in the Italian fertility reversal. In Italy, apparent fertility upturn has not occurred in more familialistic areas with higher fertility, and fertility reversal was particularly strong in areas where new family formation behaviors considered as the components of the SDT have spread more rapidly. In Japan, the Tohoku area, where the proportion of coresidence is highest and fertility was highest in previous years, is now the area of least fertility reversal. These results can lead to a conclusion that the strong family ties symbolized by coresidence with parents may no longer contribute to reproduction, and the catch-up of postponed fertility would be realized more easily in areas with less traditional family values. However, the fact that proximate residence has the strongest association with the contextual effects on fertility upturn encourages a reconsideration of the role of traditional family values and the network of family ties for reproduction.

According to the classic studies on the regional pattern of social organizations by Aruga (1972) and Ohbayashi (1996), the multiple households stem family system typically observed in south-western Japan is strongly linked with the organization system which places emphasis on age (*nenrei-kaiteisei)*. Based on Kato's review of the traditional family system (Kato 2008), in this system, communities (*mura*) are governed by multiple organizations composed of the same generation of people, such as young men and elders. In these areas, the unit of community was emphasized more than the individual households, and spouse selection and family formation of young people were basically led by themselves under peer regulations. On the other hand, in the single household stem family system characterized in north-eastern Japan, communities are considered as the hierarchical unification of individual households, where spouse selection and family formation are strongly regulated by the patriarchic household (*ie*) (Kato 2008). Taking these historical settings into account, a positive relationship between proximate residence and fertility reversal may suggest that family networks may still make positive contribution to young couples' childrearing, and the family value system in which households have much precedence over individuals may be less beneficial to reproduction than the system based on a more horizontal peer network. The family system and values symbolized by a high proportion of proximate residence in south-western Japan can be seen as modified strong family ties take advantage of familial support networks, while following the recent trends toward individualism and antiauthoritarianism, particularly spread among younger generations.

Conclusion

In this paper, we explored the factors that explain TFR upturn in Japan after 2005. We examined five possible explanations, elimination of the tempo effect due to the end of first birth postponement, inflation of the fertility index due to the increase in the number of non-Japanese women married to Japanese men, improvement of economic conditions (fall in unemployment rates for men), contribution of policies facilitating childbearing among working women, and contextual effects that cannot be explained by these structural effects. We focused on two scenarios relevant to this contextual effect that fertility reversal may be more apparent in the area (1) where new marital and reproductive behaviors are much more accepted (the SDT process) and/or (2) where strong family networks measured by intergenerational residential proximity among couples in reproductive age are still working (strong family system contribution). Using prefectural-level data, we examined the impact of these structural covariates and contextual effect on relative fertility change from the lowest level.

Our results suggest that the TFR upturn after 2005, especially for first birth, was associated positively with the postponement index. Thus fertility upturn could be partially explained by the elimination of the tempo effects, which also has been observed in other European lowest-low fertility countries. Second, our results suggest that a lower unemployment rate for men also pushed TFR upward, especially for first birth. It appears that economic improvement has much more impact on marriage and the following childbirth than the high order births. It also suggests the possibility that the economic crisis after 2008 and following rise in unemployment rate may lower the fertility again. The proportion of children in day care showed a negative association with fertility upturn, especially for second or later birth. In this analysis we did not use the increase in the proportion but the proportion itself. Since the improvement of childcare policy varies across regions, future studies should examine the impact of not the level itself but the change of policy. The proportion of non-Japanese women does not show any impact on fertility change. In Japan, the role of immigrants in TFR recovery seems still negligible.

Residual spatial autocorrelation was strongly apparent, especially for the second or later birth model. Hotspot clusters of contextual effects are observed in south-western Japan such as Kyushu and Shikoku. The spatially correlated errors and the existence of hotspot clusters suggest that some other unobserved feature(s), we describe as “social influence”, may affect fertility behavior. Bivariate relationships suggest that the SDT index reflecting the prevalence on new marital and reproductive behaviors is weakly but positively associated with the level of these contextual effects. Furthermore, while the proportion of coresidence with parents shows a negative association, the proportion of proximate residence shows a strong positive relationship with the contextual effects on a fertility upturn. Traditionally, the regions with a high proportion of coresidence based on the single household stem family system typically observed in north-eastern Japan have a specific cultural system in which patriarchic households (*ie*) exercise authority over household members. On the other hand, the regions with a high proportion of proximate residence based on the multiple households stem family system typically observed in south-western Japan have a specific culture in which a unit of the community is much more emphasized than individual households, and individual members are relatively allowed to act on their own initiative in the mating process (Kato 2008). We may call this modified strong family system compared to the normative strong family system typically observed in the Tohoku area. It would be reasonable to think that these historical cumulative characteristics form today's peoples' norm or lifestyle. Contact between young couples and their parents must be much more frequent in both these agricultural regions than metropolitan areas where the majority live far from their parents. However, a positive relationship between south-western family and community culture and fertility upturn and negative relationship between patriarchal stem family system in Tohoku and fertility upturn may suggest that the social relationship between individuals or the role of community may be as important as familial support availability.

As for the evaluation of the weak positive association between the SDT and contextual effects, we need further examination. The variables we used as the components (divorce, cohabitation, and out-of-wedlock childbearing) may not reflect all of the features of the SDT. The value aspect should be looked into much further. We also need more reliable data on these novel family formation behaviors at the prefecture level.

In this study, we only focused on the cultural aspect of the family system as a possible contextual effect. However, there are other possibilities to explain spatial processes through social interactions. 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 an effective countermeasure by a certain local government is followed by neighbors immediately. Although the spatial error model cannot specify the mechanisms of spatial process, considering observed spatial autocorrelation may improve our understanding of change in reproductive behavior. Further explorations by a combination of qualitative research such as a field survey and spatial data analyses would be useful to prove these hypotheses.

Since the results of these analyses are led by using data aggregated to geographic areas, we cannot directly assess the mechanism of behavioral change at the individual level. Future studies should collect individual data including fertility behaviors after 2005. However, even if we use multi-level analysis, it would still be impossible to fully model the behavioral change. Cumulative effects of the historical path or diffusion of innovative behaviors through the social network are also an important viewpoint for understanding different responses to external forces across different countries. That means modeling contextual effects is useful for not only international but also international comparative studies on fertility and family formation.

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Table.A1. Change in TFR and the contribution of parity-specific TFR to TFR increase by prefectures.

Prefecture	Lowest TFR	TFR1	TFR2+	Year	Latest TFR (2007)	TFR1	TFR2+	Absolute change			Relative change			% of contribution TFR 1 to the TFR rise
								TFR	TFR1	TFR2+	TFR	TFR1	TFR2+	
All	1.24	0.61	0.63	2005	1.31	0.64	0.66	0.07	0.03	0.04	105.4	104.8	106.0	44
Hokkaido	1.15	0.58	0.56	2005	1.19	0.59	0.60	0.04	0.00	0.04	103.5	100.6	106.5	9
Aomori	1.28	0.63	0.66	2005	1.28	0.62	0.67	0.00	-0.01	0.01	100.0	98.3	101.7	0
Iwate	1.38	0.65	0.73	2005	1.39	0.64	0.74	0.00	-0.01	0.01	100.3	99.0	101.4	0
Miyagi	1.22	0.60	0.62	2005	1.27	0.62	0.65	0.05	0.02	0.03	104.0	103.0	105.0	37
Akita	1.30	0.65	0.65	2004	1.31	0.64	0.66	0.01	-0.01	0.02	100.8	98.8	102.8	0
Yamagata	1.42	0.67	0.75	2007	1.42	0.67	0.75	0.00	0.00	0.00	100.0	100.0	100.0	0
Fukushima	1.47	0.67	0.79	2005	1.49	0.69	0.80	0.02	0.01	0.01	101.7	102.2	101.3	58
Ibaraki	1.29	0.61	0.68	2005	1.35	0.65	0.71	0.07	0.03	0.03	105.1	105.7	104.6	53
Tochigi	1.36	0.67	0.69	2005	1.39	0.68	0.72	0.04	0.01	0.03	102.7	101.1	104.1	21
Gumma	1.34	0.65	0.70	2005	1.36	0.65	0.71	0.01	0.00	0.01	101.1	100.4	101.6	19
Saitama	1.20	0.60	0.59	2005	1.26	0.62	0.63	0.06	0.02	0.04	104.9	103.1	106.7	32
Chiba	1.19	0.61	0.58	2005	1.25	0.63	0.62	0.06	0.02	0.04	105.1	104.0	106.4	39
Tokyo-to	0.97	0.53	0.44	2005	1.05	0.59	0.47	0.09	0.06	0.03	108.9	110.7	106.6	66
Kanagawa	1.17	0.61	0.55	2005	1.25	0.66	0.59	0.08	0.04	0.04	107.0	107.3	106.7	55
Niigata	1.32	0.63	0.68	2005	1.37	0.65	0.72	0.05	0.02	0.04	103.9	102.5	105.2	31
Toyama	1.33	0.65	0.68	2005	1.34	0.65	0.69	0.01	0.00	0.01	100.9	100.7	101.1	39
Ishikawa	1.32	0.63	0.69	2005	1.40	0.66	0.73	0.07	0.03	0.04	105.4	105.3	105.5	47
Fukui	1.43	0.67	0.77	2005	1.52	0.73	0.79	0.08	0.06	0.02	105.6	109.1	102.6	75
Yamanashi	1.33	0.62	0.70	2005	1.35	0.62	0.72	0.02	0.00	0.02	101.5	100.0	102.8	0
Nagano	1.40	0.66	0.73	2005	1.47	0.70	0.77	0.07	0.03	0.04	105.0	104.9	105.0	47
Gifu	1.30	0.62	0.68	2005	1.34	0.63	0.72	0.04	0.01	0.03	103.2	101.5	104.7	23
Shizuoka	1.33	0.66	0.67	2005	1.44	0.71	0.73	0.11	0.05	0.05	108.0	108.0	108.0	49
Aichi	1.29	0.64	0.65	2005	1.38	0.69	0.70	0.09	0.04	0.05	107.1	106.7	107.6	47
Mie	1.30	0.62	0.68	2005	1.37	0.65	0.72	0.06	0.02	0.04	104.8	103.8	105.7	38
Shiga	1.35	0.65	0.71	2005	1.42	0.67	0.75	0.07	0.03	0.04	105.0	104.0	105.8	39
Kyoto-fu	1.14	0.55	0.59	2004	1.18	0.57	0.61	0.04	0.02	0.02	103.4	103.4	103.3	49
Osaka-fu	1.18	0.59	0.59	2005	1.24	0.62	0.62	0.06	0.03	0.03	105.4	105.6	105.2	52
Hyogo	1.22	0.60	0.62	2005	1.30	0.63	0.66	0.08	0.04	0.04	106.2	106.1	106.4	48
Nara	1.16	0.56	0.60	2004	1.22	0.58	0.64	0.06	0.01	0.05	105.2	102.1	108.1	20
Wakayama	1.28	0.61	0.67	2004	1.34	0.63	0.71	0.06	0.02	0.04	105.0	103.9	105.9	37
Tottori	1.43	0.67	0.77	2005	1.47	0.67	0.80	0.03	0.00	0.03	102.3	100.4	104.0	8
Shimane	1.45	0.67	0.78	2005	1.53	0.69	0.84	0.08	0.02	0.06	105.4	103.4	107.1	29
Okayama	1.34	0.62	0.72	2005	1.41	0.65	0.76	0.07	0.02	0.05	105.1	103.6	106.4	33
Hiroshima	1.32	0.65	0.67	2005	1.43	0.69	0.74	0.11	0.04	0.07	108.3	106.4	110.1	38
Yamaguchi	1.35	0.63	0.72	2005	1.42	0.64	0.77	0.07	0.01	0.06	104.8	101.2	108.0	12
Tokushima	1.23	0.59	0.64	2005	1.30	0.61	0.70	0.08	0.02	0.05	106.2	103.7	108.5	28
Kagawa	1.40	0.66	0.74	2005	1.48	0.72	0.76	0.09	0.06	0.03	106.2	109.0	103.6	69
Ehime	1.32	0.64	0.68	2005	1.40	0.67	0.73	0.07	0.03	0.05	105.6	104.5	106.7	39
Kochi	1.30	0.62	0.68	2004	1.31	0.60	0.71	0.01	-0.02	0.03	100.5	96.8	103.7	0
Fukuoka	1.24	0.60	0.64	2005	1.34	0.64	0.70	0.10	0.04	0.06	108.2	106.8	109.5	40
Saga	1.46	0.63	0.82	2005	1.51	0.65	0.86	0.05	0.02	0.04	103.5	102.5	104.3	31
Nagasaki	1.43	0.64	0.78	2005	1.48	0.65	0.83	0.05	0.01	0.05	103.7	101.0	105.8	12
Kumamoto	1.44	0.66	0.78	2005	1.54	0.70	0.84	0.10	0.04	0.06	106.9	105.5	108.2	36
Oita	1.38	0.65	0.72	2005	1.47	0.69	0.79	0.10	0.03	0.06	107.2	105.2	108.9	35
Miyazaki	1.47	0.66	0.81	2005	1.59	0.72	0.87	0.12	0.06	0.06	108.2	109.2	107.3	51
Kagoshima	1.46	0.66	0.80	2004	1.54	0.69	0.85	0.07	0.03	0.05	105.1	104.1	105.9	37
Okinawa	1.70	0.70	1.00	2005	1.75	0.71	1.05	0.05	0.00	0.05	103.0	100.2	105.0	3