Europe, Eastern Europe, and East Asia, including Japan (Goldstein, Sobotka and Jasilioniene 2009).

The magnitude of the increase in TFR for these low-fertility countries is quite small relative to long-term historical changes and current cross-national differences. However, interpretation of this small change is of critical importance for understanding the nature of lowest-low fertility. On one hand, evidence that the small rise in TFR is explained by demographic mechanisms or response to emerging socioeconomic incentives and institutional changes would suggest that lowest-low fertility may be a transitional phenomenon. On the other hand, evidence that this change is simply a temporal fluctuation, would suggest that further fertility decline and extended periods of lowest-low fertility cannot be ruled out. This information is of obvious importance for the formulation of policies to address the social and economic implications of low fertility and population aging.

Recent studies propose various explanations for the retreat from lowest-low fertility (Castiglioni and Dalla Zuanna 2009, Billari 2008, Goldstein, Sobotka and Jasilioniene 2009, Caltabiano, Castiglioni and Rosina 2009). These include slowing or reversal of the trend of postponed childbearing, increasing acceptance of new patterns of family formation, more favorable economic conditions, implementation of public policy measures to support families with children, and increasing numbers of immigrant women with relatively high fertility.

This work has focused primarily on the fertility upturn in Europe and it is not clear whether these explanations are relevant for understanding the reversal of fertility decline in other regions. A second limitation of past work is the tendency to discuss and examine the influence of various factors independently without evaluating the relative importance of each factor. In this paper, we focus on the recent fertility upturn in Japan and examine the generalizability of explanations for the European fertility upturn using a more comprehensive modeling approach than that employed in previous studies.

Specifically, we estimate ecological regression models using spatial analytical techniques to investigate how prefecture (state)-level TFR change in Japan since 2005 is associated with the factors examined in previous studies of European countries. Spatial analytic techniques not only allow for more reliable inferences than conventional modeling based on geographically aggregated data, but also allow us to consider the possibility that fertility dynamics in a given area may influence, and be influenced by, neighboring areas. We then use decomposition techniques to evaluate the relative impact of each factor on TFR increase at the national level.

2. Background

2.1 Explanations for lowest-low fertility

Previous research on lowest-low fertility has emphasized the features common to lowest-low fertility countries such as postponement of childbearing, the absence of high-fertility sub-populations, low rates of economic growth, increasing opportunity costs of childbearing, and familistic welfare regimes.

The influence of delayed childbearing on period fertility measures like TFR is typically referred to as tempo effects or tempo distortion (Ryder 1964, Bongaarts and Feeney 1998, 2005). If lowest-low fertility is due entirely to tempo effects, it should be a short-lived phenomenon, with recuperation in TFR expected as women who were postponing childbearing begin to have children at older ages. However, in most lowest-low fertility countries, delayed childbirth is linked with lower completed fertility, a

phenomenon referred to as postponement-quantum interaction (Kohler, Billari, and Ortega 2002). Techniques for eliminating tempo effects (Bongaarts and Feeney 1998) show that Japan's tempo-adjusted TFR has always been above the lowest-low threshold of 1.3 (Kaneko 2009). Tempo effects are thus likely to explain all of the emergence of lowest-low fertility in Japan.

Countries with relatively high levels of sub-replacement fertility often have relatively large high-fertility sub-populations such as immigrants from high-fertility countries (Sobotka 2008, Coleman 2006) or religious groups (Frejka and Westoff 2008). The small numbers of immigrants and religious groups with relatively high fertility is likely part of the explanation for lowest-low fertility in countries like Japan (Kojima 2008).[2]

Low economic growth in Western societies and the collapse of secured job systems in former communist countries are also thought to be part of the explanation for the emergence of lowest-low fertility (Blossfeld et al. 2005, Perelli-Harris 2005). Japan experienced three recessions over the past twenty years (1991 to 1993, 1997 to 1999, and 2001 to 2002), resulting in relatively high unemployment rates at young ages and significant growth in unstable, non-standard employment (Ministry of Health, Labour and Welfare 2006). These unfavorable economic circumstances have likely pushed young people away from family formation.

Among working women, remaining childless may be a rational response to increases in the opportunity costs of having children. The opportunity costs of motherhood are thought to be particularly high in Japan where only a small proportion of women continue working after childbirth. Although several policy efforts to improve conditions for working mothers have been implemented since the 1990s, only 20 percent of new mothers remained in the labor force in 2005, a level that has remained unchanged since the 1980s (NIPSSR 2007b, Kaneko et al. 2008).

Broad agreement exists among scholars that familistic welfare systems based on "strong family ties" also contribute to lower fertility (Dalla Zuanna and Micheli 2004, McDonald 2006, Billari 2008). In such contexts, public welfare systems are weak and families are expected to support their own members. Like Southern European countries, Japan is characterized by familistic culture and limited public support for families (Atoh 2005, Suzuki 2006) which places a heavy burden on women and is thought to be an important reason for the trends toward later and less marriage and very low fertility.

2.2 TFR reversal in lowest-low fertility countries

Despite the unfavorable conditions for family formation, most of the lowest-low fertility countries (TFR below 1.3) have experienced steady increases in fertility over the past 10-15 years. Efforts to understand this fertility upturn have focused mainly on southern European countries. For example, Castiglioni and Dalla Zuanna's (2009) analysis of the TFR reversal in Italy in the latter half of the 1990s showed that the decline in cohort fertility has come to a halt and birth rates among the older age groups have increased. They also emphasized that the fertility upturn is observed primarily in northern Italy where economic circumstances are more favorable and where new family formation behaviors associated with the Second Demographic Transition (e.g., divorce and nonmarital childbearing) are more prominent. A significant fertility upturn was not observed in southern Italy where close intergenerational

[2] In Japan, the percentage of foreign nationals is extremely low, at only 1.4 percent of the total population, and their fertility rates are actually lower than those of Japanese women (NIPSSR 2007a).

relationships and familistic culture, which contributed to high fertility rates in the past, are strong (Castiglioni and Dalla Zuanna 2009). Billari (2008) demonstrated that rapid increase in immigrant populations also contributed to the recent upturn in fertility rates in Italy and Spain.

Goldstein and his colleague (2009) showed that recovery from lowest-low fertility was observed not only in Southern European countries, but also in Central Europe, Eastern Europe, and East Asia. Their analyses suggested that a decline in the tempo effect—driven by a slowdown in the postponement of childbearing, and dramatic increases in immigrant women with fertility rates higher than those of native-born women explain part of the TFR increase in some countries (e.g. Italy and Spain). Based on panel regressions of data from 27 OECD countries, they also suggested that economic recovery may have contributed to the fertility recovery for some countries (e.g. Poland, Slovakia, and Spain).

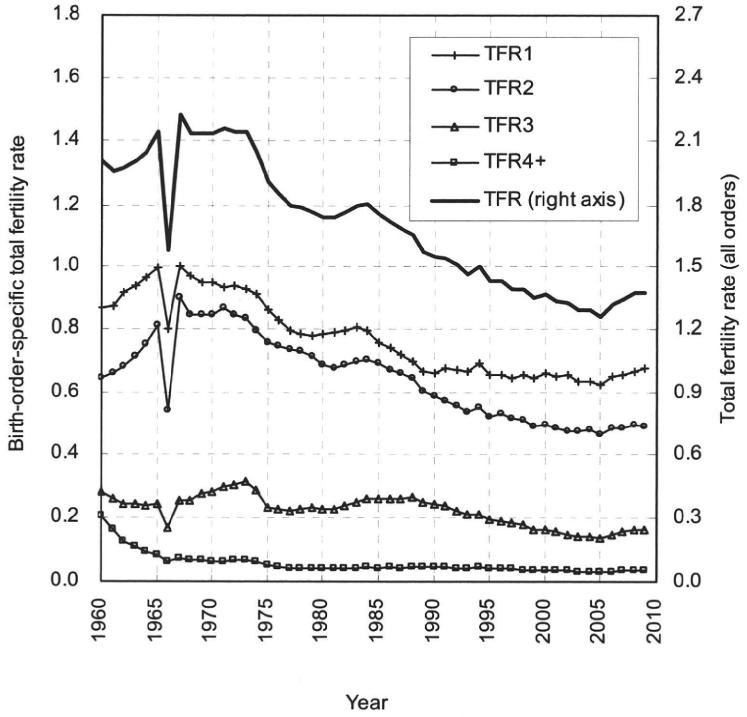
In summary, factors emphasized in this work on the retreat from lowest-low fertility include; (1) diminished tempo effects, (2) increase in immigrant sub-populations, (3) economic improvement, and (4) improvement in work-family balance. We also examined the relationship between fertility recovery and familistic culture. In the following sections, we examine the extent to which each factor explains fertility upturn in Japan.

3. TFR reversal in Japan

Japan's TFR has been below the replacement rate since the early 1970s and was below 1.3 from 2003 to 2005. In recent years, the Japanese TFR has risen above the lowest-low level, reaching 1.37 in 2009 (MHLW 2010) (Figure 1).

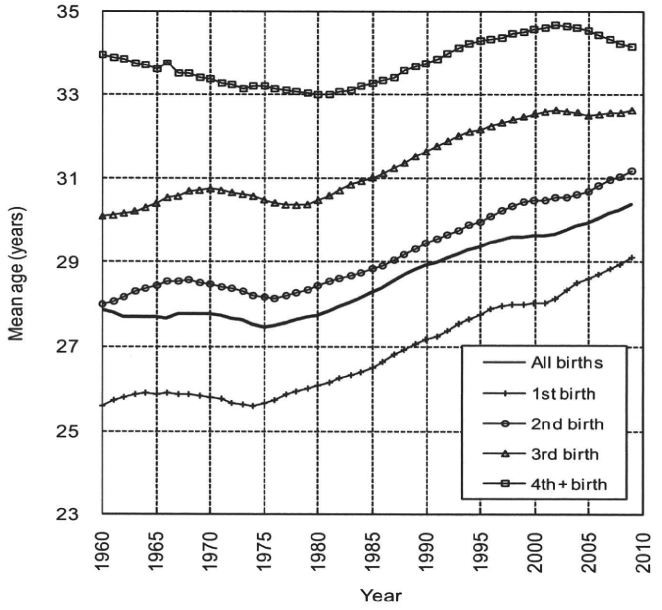
Mean age at childbearing continues to rise for first and second births, but the pace of increase in age at first birth seems to have slowed between 2005 and 2008. Furthermore, the mean age for higher-order births decreased slightly (Figure 2). These trends suggest that the impact of tempo-distortion may have diminished in recent years.

Figure 1: Overall and order-specific total fertility rates: 1960 ~ 2009



Source: Vital Statistics, various years (Statistics and Information Department, Minister's Secretariat, Ministry of Health, Labour and Welfare).

Figure 2: Mean age of the age-specific fertility schedule by birth order: 1960 ~ 2009



Source: Vital Statistics, various years (Statistics and Information Department, Minister's Secretariat, Ministry of Health, Labour and Welfare).

Trends in the number of foreign women would not seem to be relevant for understanding trends in the Japanese TFR given that the official measure provided by the Ministry of Health, Labour and Welfare is calculated only for newborn children with Japanese nationality. This means that the official TFR does not include children born to foreign couples living in Japan. Importantly, however, it does include children born to foreign mothers married to Japanese men despite the fact that the denominator used to calculate TFR is limited to Japanese women.[3,4] The TFR may thus increase as a result of growth in the number of Japanese children born to foreign mothers, even if the actual fertility of Japanese women remains unchanged. This is important given that the percentage of marriages involving Japanese men and foreign women increased from 2.8 percent in 1990 to 4.6 percent in 2005. Recent upturn in the Japanese TFR may thus be partly due to increase in the number of foreign wives who gave birth to Japanese children since 2005.

Economic improvement may also be relevant for understanding the recent upturn in the Japanese TFR. According to Labour Force Surveys, the national unemployment rate fell from 5.4 in 2002 to 3.9 in 2007. The unemployment rate for young people aged 20-24 is still relatively high but it also declined from 9.3 to 7.5 over the same period.

Since 2000, the Japanese government has been promoting a range of work and family reconciliation efforts seeking to promote family formation (Ogawa 2003, Moriizumi 2008).[5] These efforts include improvements in child-care leave benefits and implementation of the After-school Childcare plan which secures places of activity for children after school in all elementary school districts. In 2007, the "Action Agenda for Promoting Work-Life Balance" was resolved as a priority task of the "Strategies for Japan to Support Children and Families." These results of these efforts by government may be encouraging young people, particularly young working women, to start families.

4. Data and methods

To examine the impact of the factors discussed above, we estimate weighted least squares models (WLS) and weighted spatial error models (WSE) using data from the 47 Japanese prefectures. In Japan, population size varies significantly across prefectures, ranging from 12 million in Tokyo to 600,000 in

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[3] In Japan, nationality is difficult to receive even for foreign mothers married to Japanese men.

[4] The definition of the TFR in the Vital Statistics is as follows:

$$TFR = \sum_{x=15}^{49}\left(\frac{B_x}{N_x^j}\right) = \sum_{x=15}^{49}\left(\frac{B_x^j + B_x^f}{N_x^j}\right),$$

where N_x^j represents the number of Japanese females age x, B_x is the number of births with Japanese nationality born to mothers of age x, B_x^j is the number of births born to Japanese mothers, and B_x^f is the number of births born to foreign mothers and Japanese fathers.

[5] In addition to the "New Angel Plan" in 2000-2004 (reinforcement of child-rearing services, improvement of employment environment for reconciliation of work and family life, improvement of the corporate climate where gender division of labor and priority in the workplace is taken for granted), the Zero Children on Waiting List Strategy was started in 2001 with the goal of building up sufficient child-care centers. The 2003 Law for Measures to Support the Development of the Next Generation requires every municipality and business owner in Japan must develop their own action plan to support families with children.

Tottori. To deal with heteroscedasticity, we estimate the weighted regression models using the square root of the reproductive age (15-49) female population as weights.

When analyzing geographically aggregated data, it is important not only to deal with heteroscedasticity but also to pay attention to that fact that such data are often characterized by spatial autocorrelation. Spatial autocorrelation refers to systematic relationships between variables of interest and geographic location. Because ordinary least-squares regression models assume that error terms are independently, identically, and normally distributed, spatial autocorrelation may result in underestimation or overestimation of standard errors for regression coefficients (Chi and Zhu 2008). We therefore estimate weighted spatial error models which explicitly account for spatial autocorrelation in the error terms. The general form of spatial error models is as follows (Anselin 1988, Ward and Gleditsch 2008):

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

where y is a (n x 1) vector representing the dependent variables, $\mathbf{X}$ is a (n x k) matrix comprised of a constant term and k-1 independent variables, β is a (k x 1) vector of regression parameters to be estimated, and u is a (n x 1) vector of error terms presumed to have the covariance structure described in the second equation. λ is a spatial autoregressive coefficient to be estimated, $\mathbf{W}$ is a (n x n) weight matrix defining the potential relationship between neighboring locations (e.g., a binary indicator of neighbor or not), and ε is a (n x 1) vector of independently distributed (spatially uncorrelated) errors. We used a first-order queen convention to define neighbors for the weight matrix.[6] Three prefectures have only one neighbor and one prefecture has eight neighbors. Eighteen prefectures have four neighbors – the modal number.

We select a preferred model by comparing fit statistics for the WLS and WSE models and considering the significance of the spatial autoregressive coefficients. We then use this preferred model to evaluate the contribution of each factor to the increase in Japan's TFR after 2005. Model estimation is conducted using the "spdep" package in R.

5. Measurement and variables

The dependent variable is change in birth-order-specific TFR between 2005 and 2008, taken from the Japanese Vital Statistics. Our four independent variables reflect the posited explanatory mechanisms: diminished tempo effects, increase in foreign mothers, economic improvement, and implementation of policies facilitating work-family balance. We also include the measure for familistic culture as a fixed prefectural characteristic.

[6] In this convention, the neighbors for any given prefecture are other prefectures that share a common boundary in any direction. Although Hokkaidō and Okinawa don't share borders with any other prefecture, we defined Aomori as Hokkaidō's neighbor and Kagoshima as Okinawa's neighbor. Because Hokkaidō and Aomori are connected by an undersea tunnel and Okinawa and Kagoshima have a long history of frequent interchanges, it is reasonable to assume neighbor relationships between them.

Diminished tempo effect

Tempo effects that lead to "distorted" observed period measurements of TFR compared to its "true" tempo-free level are caused by the postponement or acceleration of childbearing. We measured the tempo effect using the index proposed by Bongaarts and Feeney (1998, 2005). They demonstrate that the relationship between the observed TFR in any given year and the TFR that would have been observed in the absence of tempo effects can be expressed as:

$$TFR_i = (1 - m_i)TFR_i'$$

TFR_i is the observed TFR for birth-order i in a given year, TFR_i' is the tempo-adjusted TFR for birth-order i, and m_i is the absolute change in the mean age at childbearing for birth-order i during the year the in which TFR is observed. Multiplying the tempo-free TFR_i' by the period distortion index ($1-m_i$) yields the observed TFR_i. We calculate this distortion index over three-year periods for each prefecture and measure change as the difference between the values for 2002-05 and 2005-08.[7] We expect that increase in this period distortion index (i.e., a reduction in the impact of postponement) will be positively associated with fertility increase.

Increase in foreign mothers

We measure the influence of foreign mothers as change between 2005 and 2008 in the proportion of births (with Japanese nationality) to foreign mothers. We expect that increase in births to foreign mothers will be positively associated with increase in TFR. Because tabulations of births by mother's nationality are not available by birth order in the Vital Statistics, we used values calculated based on all births for the birth-order-specific models. We are thus assuming that the contribution of births to foreign mothers does not depend on parity.

Economic improvement

To measure economic improvement, we use change in the unemployment rate. Annual Labour Force Survey reports provide estimated unemployment rates for each prefecture based on data from sample surveys. Because these measures may be influenced by short-term fluctuations, we calculated three-year-moving averages and measured change from 2002 (2001-2003) to 2007 (2006-2008) assuming that economic improvement does not exert an immediate influence on fertility. In the model we estimate, we use the employment rate (1.0 minus the unemployment rate), and we expect that increase in that index will be positively associated with change in fertility.

Policies to promote work-family balance

Although there are no established methods of measuring the effectiveness of policies, utilizing variation in policies across space is an effective way to assess the effect of policies on fertility (Neyer and Anderson 2008). In our study, we measure shifts in policies related to work-family balance indirectly

[7] For example, if the mean age at first childbearing is 28.6 years in 2005 and 28.9 in 2008, the period distortion index ($1-m_i$) for 2005-2008 is calculated as (1-(28.9-28.6)/3) =0.9.

by using change in the labor force participation rate of mothers of preschool children (under six years of age).[8] Because public and corporate efforts to improve work-family balance are expected to have the strongest impact on women who cannot easily receive childcare support from their parents(-in-law), we limited our measure to mothers of preschool children living in a nuclear family household. Using data obtained from the Employment Status Surveys in 2002 and 2007, we calculated change in these women's labor force participation rate for each prefecture. To the extent that increase in maternal labor force participation reflects improvements in work-family balance, we expect that this measure will be positively associated with fertility increase.

Familistic culture

In addition to posited mechanisms of change just described, we include a measure of familistic culture. Because familistic culture does not change in a short period of time, we treat it as a fixed prefecture effect that might be related to both the prefecture-specific level of fertility change and the other explanatory variables. Japanese scholars have documented strong relationships between familistic culture and patterns of living arrangements (Katō 2008). Living arrangements in eastern Japan, where familistic culture is particularly strong, have historically been characterized by coresidence of an older couple (parents) and a younger couple (son and daughter-in-law). In contrast, older couples in western Japan are more likely to live in an independent household, often on the same lot as their children's home.

We therefore measured the extent of familistic culture by the prevalence of extended family households. Using 2005 Japanese census data for each prefecture, we calculated the proportion of extended family households among households that included children under six years of age. We expect the proportion of extended family households to be negatively associated with fertility change to the extent that women's heavy domestic responsibilities in strong familistic cultures act as a disincentive to family formation at young ages.

Model

The model used to examine the contributions of diminished tempo effects, increase in foreign mothers, economic improvement, improvement in work-family balance, and the role of familistic culture can be expressed as follows.

$$\begin{aligned}\Delta TFR_i\ (2005\text{-}2008) = {} & \text{Constant} \\ & + \beta_1\,[\Delta \text{ Period distortion index for birth-order } i \text{ (2004-2007)}] \\ & + \beta_2\,[\ \Delta \text{ Proportion of birth to foreign mothers (2005-2008)}\ ] \\ & + \beta_3\,[\ \Delta \text{ Employment rate (2002-2007)}\ ] \\ & + \beta_4\,[\Delta \text{ Labor force participation rate among mothers of preschool children living in a nuclear family household (2002-2007)}] \\ & + \beta_5\,[\text{Proportion of extended family households among households including}\end{aligned}$$

[8] Because the Law for Measures to Support the Development of the Next Generation (implemented in 2005) obligates each municipality and business owner in Japan to take measures to support families with children, we assume that development in policies and programs varies across regions.

preschool children (2005)]

$+\lambda \mathbf{W}u$ (Spatially autocorrelated error term)

5. Results

5.1. Descriptive statistics

Table 1 shows descriptive statistics for all variables used in the analysis. The values of Moran's *I* suggest that all of the dependent variables are spatially autocorrelated.[9] Among the explanatory variables, significant spatial autocorrelation is observed in: change in the period distortion index for second-order TFR, change in the proportion of births to foreign mothers, change in employment rate, and the proportion of extended family households.

Figure 3 shows geographical patterns of birth-order-specific TFR change. Increase in first-order TFR is consistently higher in the Pacific coastal areas of Kantō and Chūbu and the coastal areas of Chūgoku and Kyūshū; and it is lower in Hokkaidō and the Tōhoku region except for Miyagi prefecture (See the appendix for a map with names of prefectures and regions). Increase in the second-order TFR is higher in Saitama, Chiba, Aichi, Hyōgo, Shimane, Hiroshima, and northern Kyūshū. Increase in third and higher-order TFR is largest in the Kyūshū region.

Figure 4 displays geographical patterns of change in the period distortion index for birth-order-specific TFR and Figure 5 shows geographical patterns of the other independent variables. From Figure 5, we can see that increase in the proportion of births to foreign mothers is most prominent in coastal Chūbu (Aichi and Shizuoka) and Chūgoku areas (e.g., Tottori and Okayama). This pattern likely reflects an influx of descendants of Japanese immigrants to South American countries who came to work in auto industry jobs concentrated in Aichi and Shizuoka. Tottori and Okayama have recently received increasing numbers of foreign technical intern trainees, especially in the seafood processing industry. Increase in the employment rate was most pronounced in the Kinki region, northern Kyūshū, and the Tokyo metropolitan area. Increase in the employment rate of mothers of preschool children living in nuclear family households was highest in Toyama, Nagasaki, Fukui, and Gunma, and lowest in Hiroshima, Ehime, and Fukushima. As expected, the proportion of extended family households was higher in the Tōhoku Region (e.g. Yamagata, Akita, and Niigata) and lower in large metropolitan areas (e.g. Tokyo, Osaka, and Kanagawa) and the western part of Japan.

[9] Moran's *I* statistic measures the degree of linear association between an attribute (y) at a given location and the weighted average of the attribute in its neighboring locations ($\mathbf{W}y$), and can be interpreted as the slope of the regression of $\mathbf{W}y$ on y (Cliff and Ord 1973, Moran 1950). As noted above, we specify neighborhood structure using a queen's case contiguity weight matrix of order one.

Table 1: Descriptive statistics for variables used in the analyses

	Variable		Period of change	Source	National-level value	Min	Max	Moran's *I*	
Dependent variables	Change in TFR	Overall		Vital Statistics [5]	0.1069	0.0089	0.1628	0.343	***
		1st order		Vital Statistics [5]	0.0472	-0.0275	0.0818	0.304	**
		2nd order	2005-08	Vital Statistics [5]	0.0291	-0.0186	0.0470	0.252	**
		3rd order		Vital Statistics [5]	0.0242	-0.0116	0.0429	0.136	#
		4th and higher-order		Vital Statistics [5]	0.0064	0.0003	0.0182	0.494	***
Explanatory variables	Change in period distortion index [1]	Overall		Vital Statistics [5]	-0.0135	-0.1193	0.0507	-0.105	
		1st order		Vital Statistics [5]	0.0529	-0.0740	0.1373	-0.031	
		2nd order	2004-07	Vital Statistics [5]	-0.0668	-0.1717	0.0617	0.123	#
		3rd order		Vital Statistics [5]	-0.0663	-0.2114	0.1921	-0.075	
		4th and higher-order		Vital Statistics [5]	0.0511	-0.3631	0.7932	0.078	
	Change in the proportion of births to foreign mothers		2005-08	Vital Statistics [5]	0.0005	-0.0033	0.0041	0.381	***
	Change in employment rate [2]		2002-07	Labour Force Surveys [6]	0.0113	-0.0010	0.0223	0.299	**
	Change in labor force participation rate among mothers of preschool children [3]		2002-07	Employment Status Surveys [6]	0.0554	-0.0066	0.1636	-0.051	
	Proportion of extended family households [4]		2005	Census [6]	0.1878	0.0789	0.5011	0.379	***

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

1) Period distortion index is defined as $(1-m_i)$. m_i is the absolute value of change in the mean age at childbearing for birth-order i during the year the in which TFR is observed. We calculate this distortion index for three years and measure change as the difference between the values for 2002-05 and 2005-08.
2) We use difference in the average employment rates from 2001-2003 to 2006-2008.
3) For mothers who live in nuclear family households.
4) For households including preschool children.
5) Statistics and Information Department, Minister's Secretariat, Ministry of Health, Labour and Welfare.
6) Statistics Bureau, Ministry of Internal Affairs and Communications.

Figure 3: Geographic patterns of change in the total fertility rate from 2005 to 2008, by birth order

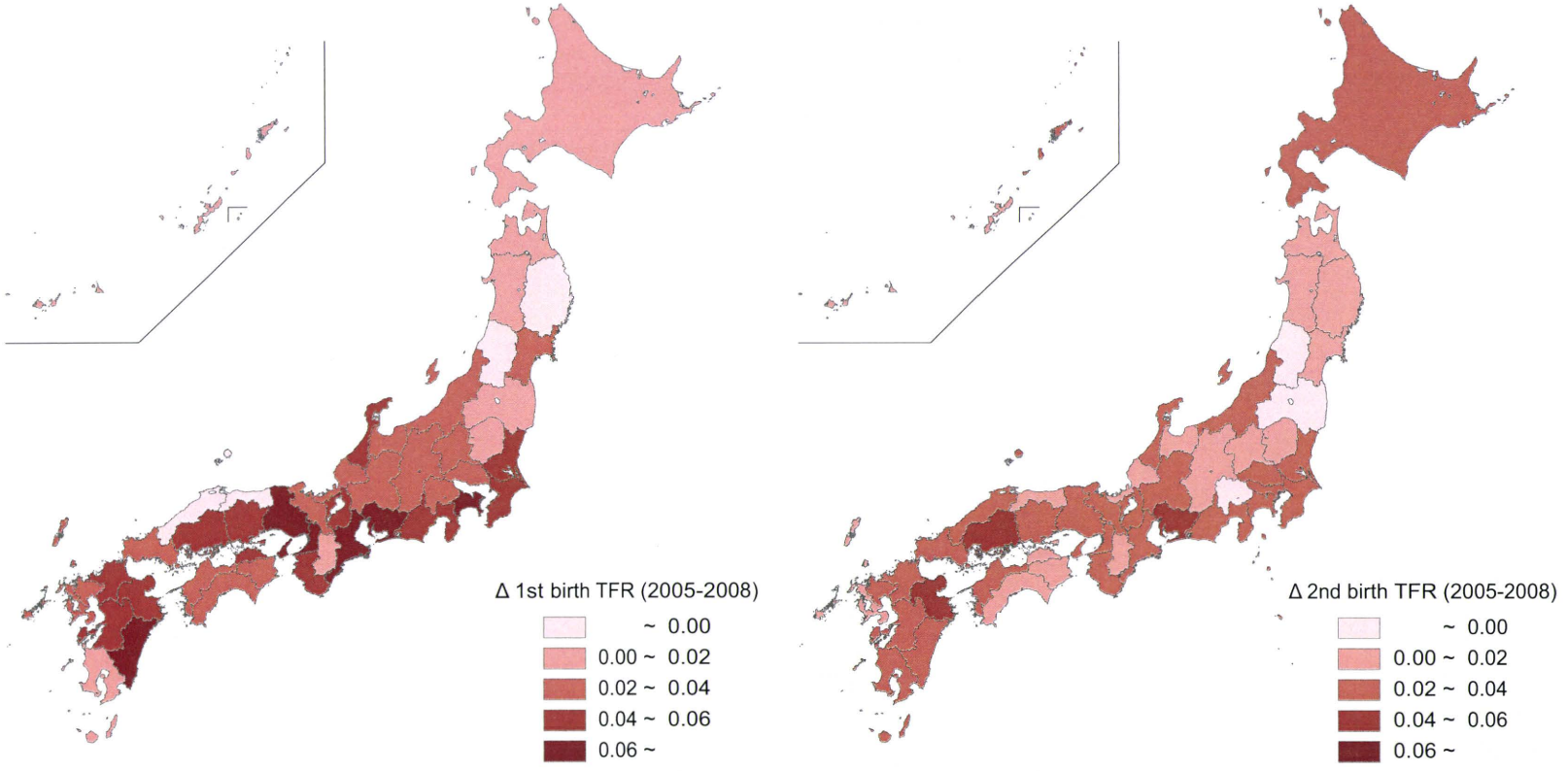
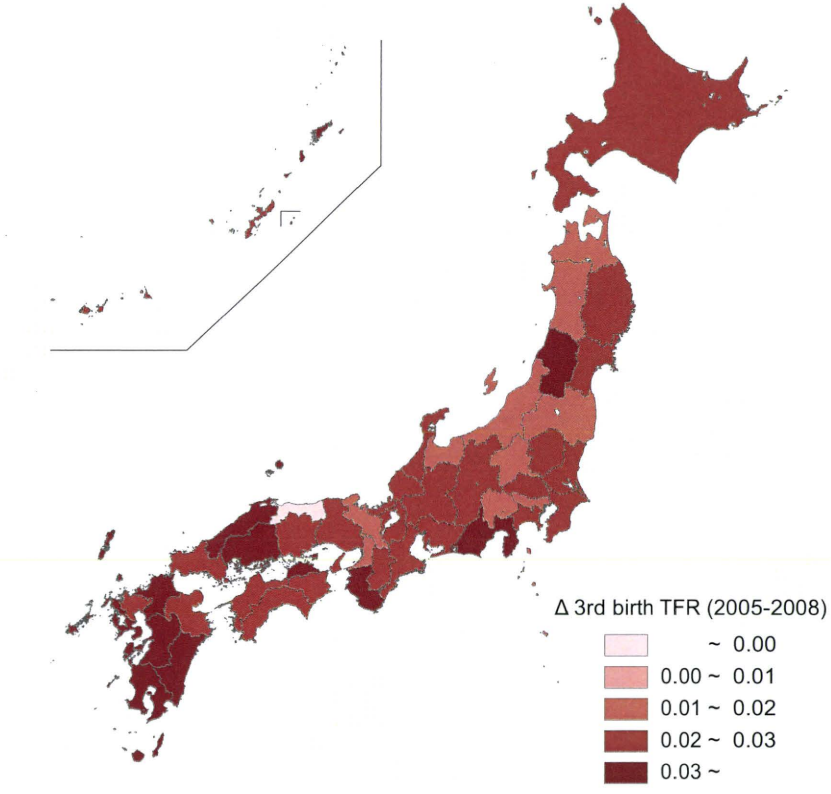


Figure 3: Geographic patterns of change in the total fertility rate from 2005 to 2008, by birth order (continued)



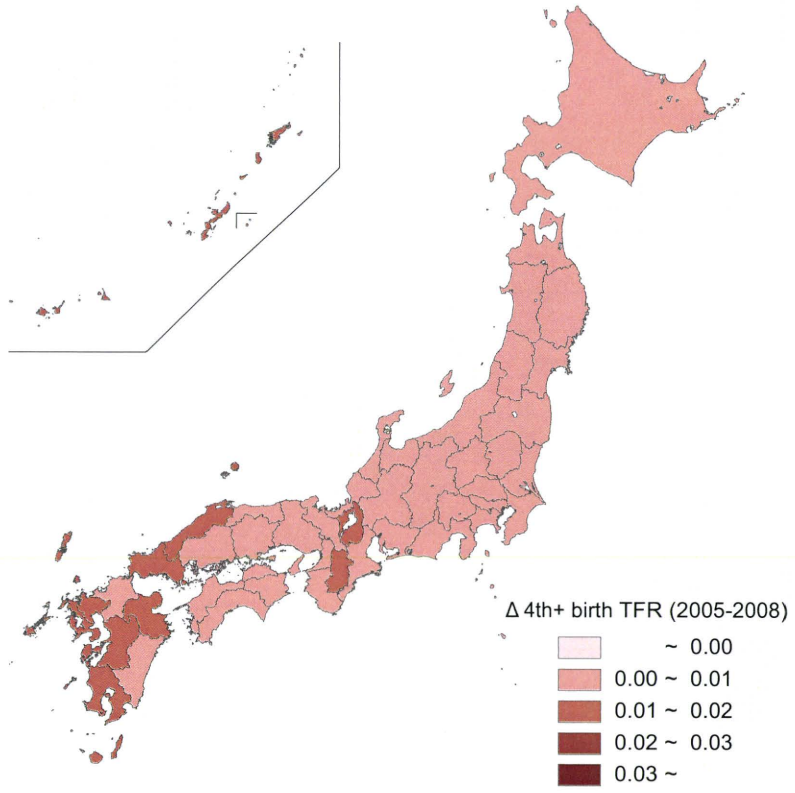


Figure 4: Geographic patterns of explanatory variables (1): Change in the period distortion index, by birth order

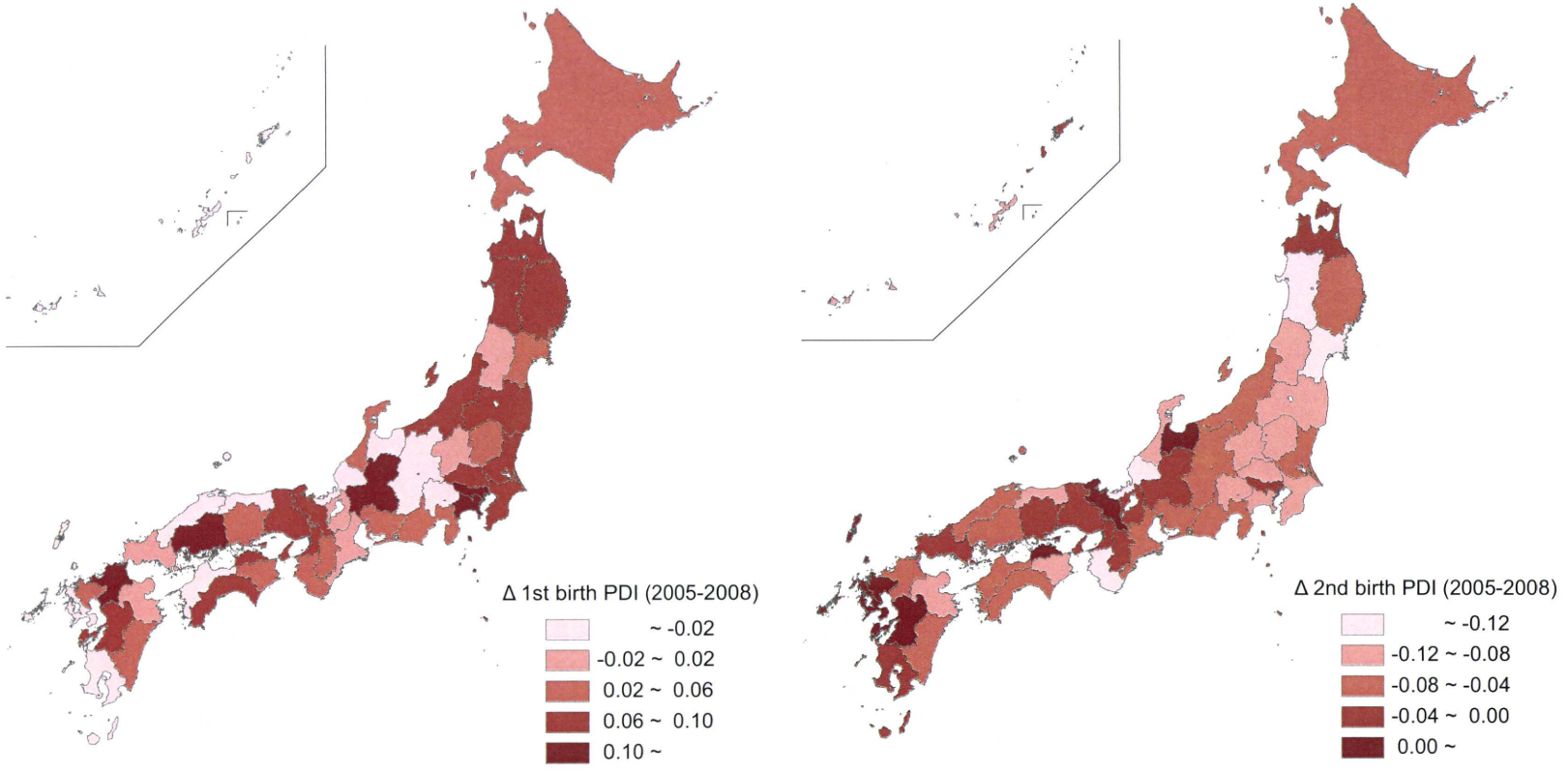


Figure 4: Geographic patterns of explanatory variables (1): Change in the period distortion index, by birth order (continued)

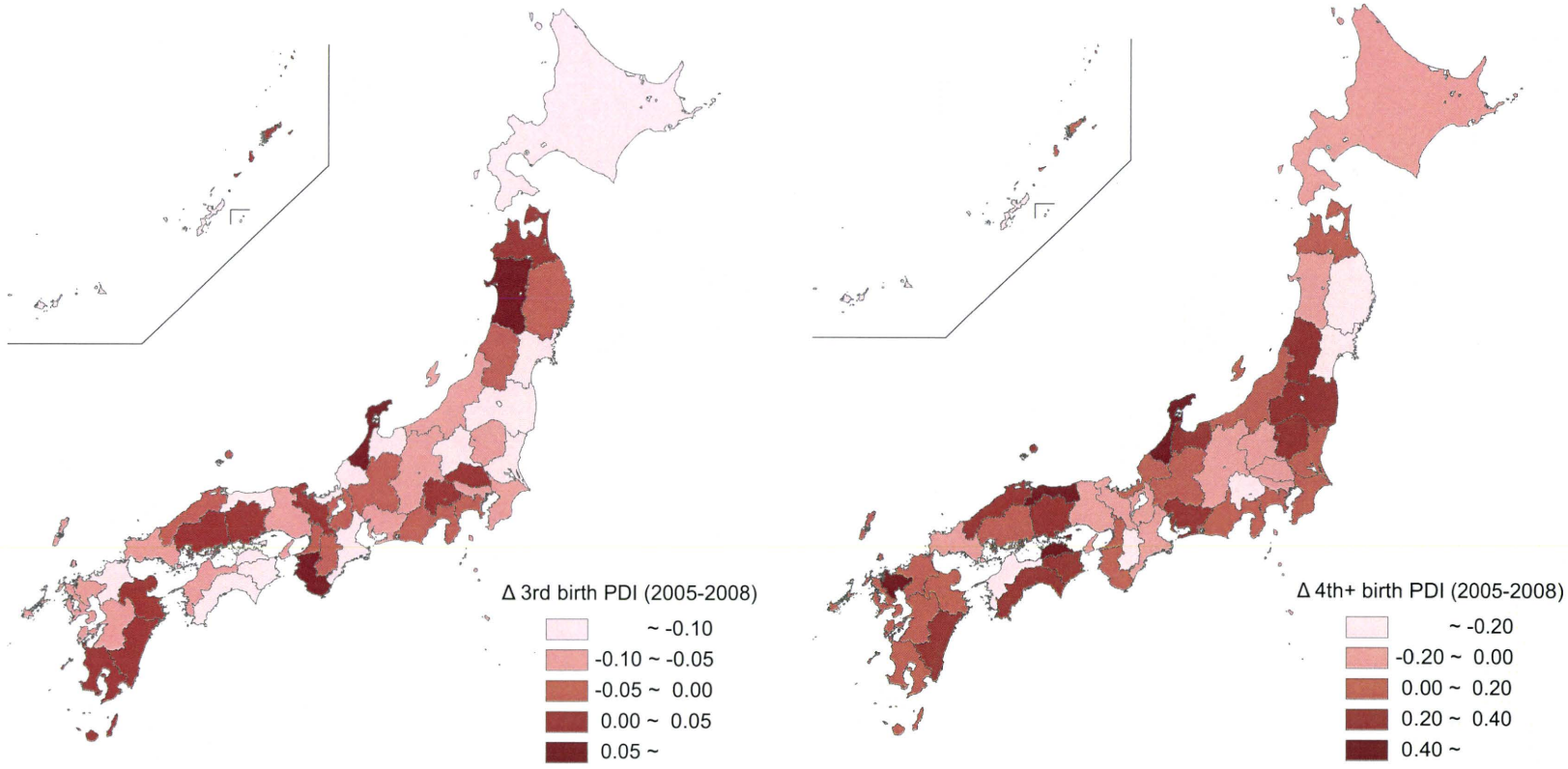


Figure 5: Geographic patterns of explanatory variables (2)

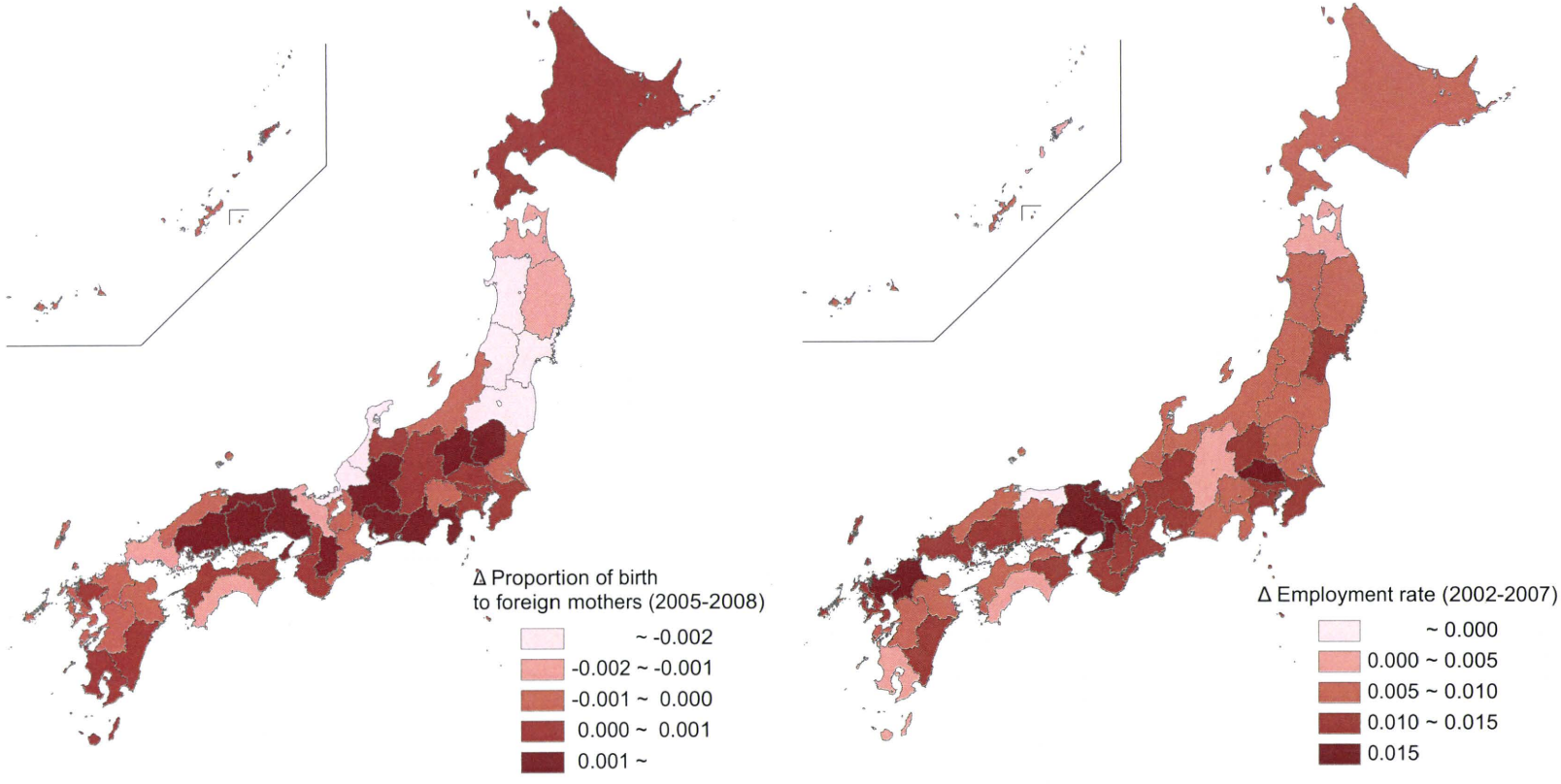
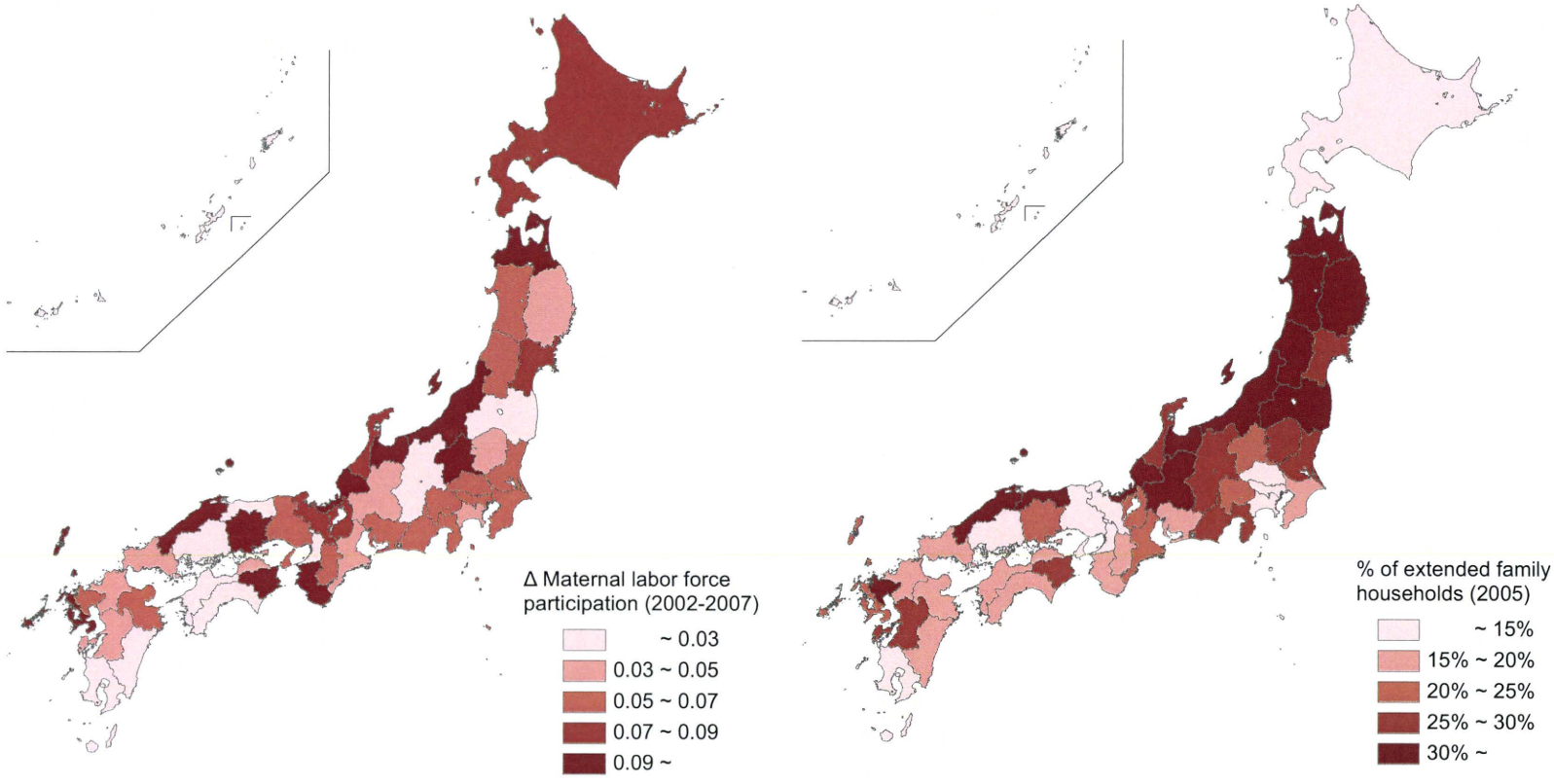


Figure 5: Geographic patterns of explanatory variables (2) (continued)



5.2. Model estimation

We estimated weighted least squares models (WLS) and weighted spatial error models (WSE) for change in birth-order-specific TFR (first, second, third, and fourth and higher-order births) and present estimated coefficients and spatial autocorrelation diagnostics in Table 2.

For change in the first-order TFR, the following three variables were significant in both the WLS and WSE models: changes in the period distortion index (+), change in the proportion of births to foreign mothers (+), and the proportion of extended family households (-). The direction of these coefficients is consistent with expectations.

For change in the second-order TFR, change in the proportion of births to foreign mothers (+), change in the employment rate (+), and the proportion of extended families (-) were statistically significant in both the WLS and WSE models. Again, the direction of these coefficients is consistent with expectations.

For change in the third-order TFR, none of the explanatory variables were significantly different from zero in either the WLS or WSE models. As for the fourth and higher-order birth model, change in the maternal labour force participation rate (-) and the proportion of extended family households (+) were statistically significant but the direction of both coefficients was opposite of expectations, suggesting that increase in higher-order TFR took place in areas with less increase in working mothers and in areas where familistic culture is stronger. Since the contribution of the fourth and higher-order births to the overall TFR is less than 3%, the influence of these unexpected results on overall change in TFR change is very limited.

The spatial autoregressive coefficient, λ, was significant in the second, third and fourth-order TFR models and comparison of AIC values indicate that the WSE model fit better than the WLS model for all birth-orders (Table 2). Values of Moran's I show that the assumption of independent error terms is violated in the WLS models, a problem that is remedied in the WSE model.

Based on the regression coefficients and the correlation coefficients between the explanatory variables and the dependent variables, we can calculate the variance explained by each independent variable. For the first-order TFR model, change in the period distortion index explained approximately 16 percent of the total variance in fertility change, another 16 percent was accounted for by change in the proportion of births to foreign mothers, 5 percent by change in the employment rate, and 22 percent by the proportion of extended family households. Together, the explanatory variables explained 57 percent of the total variance. The remaining 43 percent is thus due to other factors not included in our model. In the second-order TFR model, change in the proportion of births to foreign mothers explained 27 percent of the total variance, change in employment rate explained 9 percent, and the proportion of extended family households explained 21 percent. Again, our explanatory variables explain 57 percent of the total variance. However, in third and higher order TFR models, the five independent variables explained only 3 percent and 14 percent of total variance, respectively.

Table 2: Regression results for TFR change in the 47 Japanese prefectures

Variable	Change in 1st order TFR		Change in 2nd order TFR	
	Weighted least squares model(WLS)	Weighted spatial error model(WSE)	WLS	WSE
	β	β	β	β
Constant	0.03 **	0.03 **	0.02 **	0.02 ***
Change in period distortion index	0.14 *	0.16 **	-0.02	-0.02
Change in the proportion of births to foreign mothers	5.92 **	4.97 **	3.63 ***	3.93 ***
Change in employment rate	0.62	0.53	0.57 #	0.57 #
Change in labor force participation rate among mothers of preschool children	0.00	0.03	0.02	0.02
Proportion of extended family households 1)	-0.08 *	-0.08 *	-0.04 *	-0.05 **
Lambda (spatial autoregressive coefficient)		*0.31*		*0.30* *
R-squared	0.57		0.58	
Adjusted R-squared	0.52		0.53	
AIC	-222.9	-223.5	-292.8	-295.9
N	47	47	47	47
Diagnostics for spatial autocorrelation				
Moran's *I* (residuals)	0.11 #	0.03	0.26 **	-0.01

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

1) Centered values are used.

Table 2: Regression results for TFR change in the 47 Japanese prefectures (continued)

Variable	Change in 3rd order TFR		Change in 4th order TFR	
	Weighted least squares model(WLS)	Weighted spatial error model(WSE)	WLS	WSE
	β	β	β	β
Constant	0.03 ***	0.02 ***	0.01 ***	0.01 ***
Change in period distortion index	0.00	0.00	0.00	0.00
Change in the proportion of births to foreign mothers	0.78	0.90	0.34	0.47
Change in employment rate	-0.02	0.08	0.08	-0.02
Change in labor force participation rate among mothers of preschool children	-0.03	0.01	-0.04 *	-0.02 #
Proportion of extended family households 1)	0.02	0.01	0.02 **	0.01 **
Lambda (spatial autoregressive coefficient)		*0.39* *		*0.52* ***
R-squared	0.06		0.20	
Adjusted R-squared	-0.05		0.11	
AIC	-294.2	-296.8	-385.4	-400.7
N	47	47	47	47
Diagnostics for spatial autocorrelation				
Moran's *I* (residuals)	0.20 *	-0.14	0.52 ***	-0.16

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

1) Centered values are used.

5.3. Contribution of each factor to national-level increase in TFR

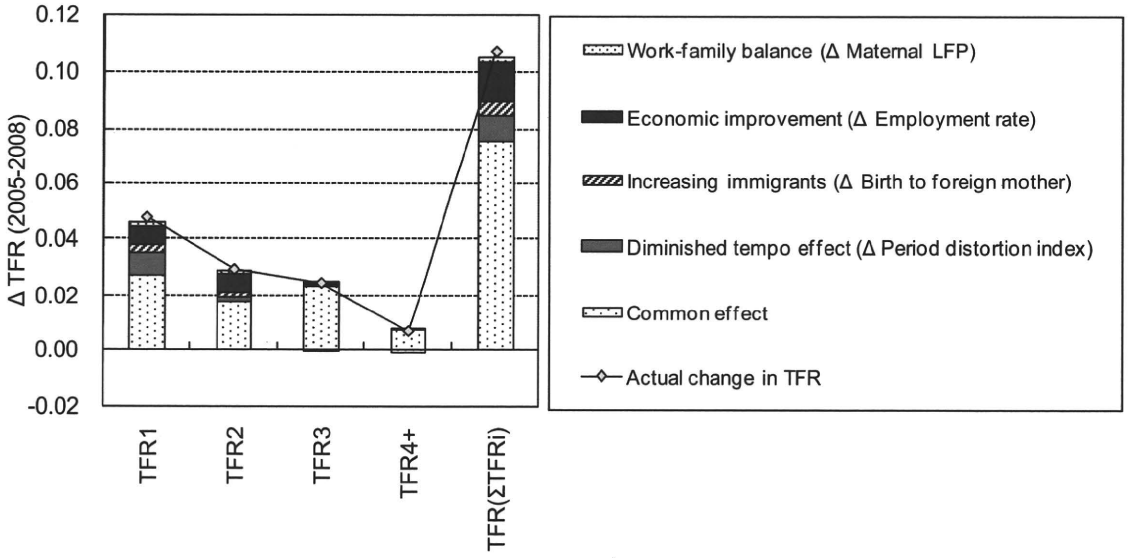
Using the regression coefficients from the best fitting models, we calculate the contribution of each factor to the increase in Japan's overall TFR from 1.26 to 1.37. The predicted values of increase in birth order-specific TFR at the national level are presented in Table 3. By summing values across birth orders, we can decompose change in the overall TFR. The results for overall TFR indicate that change in the period distortion index accounted for 9.1 percent of the total increase, change in the proportion of births to foreign mothers accounted for 5.1 percent, and change in the employment rate accounted for 12.6 percent of the total increase. Increase in the maternal employment rate explained 1.7 percent, but this is based on a statistically insignificant relationship in the regression analyses. Importantly, the common effect represented by the constant term accounted for as much as 71.5 percent of the overall change in TFR, indicating that there are other relevant factors not included in our models.

If we assume that the estimated relationships remain stable over time, we can use information on recent change in socioeconomic conditions to speculate about future trends in TFR. For example, the absolute number and the proportion of international marriages, which increased dramatically around 2000, has been declining since 2005. This trend may weaken the recent impact of births to foreign mothers observed in our models. Also, due to the slowdown of the global economy since 2008, the unemployment rate rose by 1.2 percentage points from 3.9 in 2007 to 5.1 in 2009. Our model predicts that this change in unemployment would reduce TFR, but the magnitude of change is extremely small (0.014).

Table 3: Decomposition of national-level TFR change from 2005 to 2008

Factors	Variables	1st order TFR (1)	2nd order TFR (2)	3rd order TFR (3)	4th and higher order TFR (4)	Overall TFR (1)+(2)+(3)+(4)
TFR in 2005		0.624	0.464	0.139	0.032	1.260
TFR in 2008		0.671	0.493	0.164	0.039	1.367
Change from 2005 to 2008		0.047	0.029	0.024	0.006	0.107
Decomposition						
Common effect		0.0280	0.0178	0.0229	0.0077	0.0764
Diminished tempo effect	(Δ Period distortion index)	0.0086	0.0016	-0.0003	-0.0001	0.0098
Increasing immigrants	(Δ Birth to foreign mother)	0.0027	0.0021	0.0005	0.0003	0.0054
Economic improvement	(Δ Employment rate)	0.0063	0.0066	0.0009	-0.0002	0.0135
Work-family balance	(Δ Maternal LFP)	0.0017	0.0010	0.0003	-0.0012	0.0018
Contribution (%)						
Common effect		59.4	61.3	94.6	119.6	71.5
Diminished tempo effect	(Δ Period distortion index)	18.2	5.4	-1.3	-1.0	9.1
Increasing immigrants	(Δ Birth to foreign mother)	5.7	7.1	1.9	4.0	5.1
Economic improvement	(Δ Employment rate)	13.3	22.6	3.7	-3.7	12.6
Work-family balance	(Δ Maternal LFP)	3.5	3.6	1.1	-18.9	1.7
Model used for predictions		WSE model	WSE model	WSE model	WSE model	-

Figure 6: Decomposition of national-level TFR change from 2005 to 2008 based on estimated models



Note: Decomposition for all order TFR is obtained by summing up the results for birth-order-specific TFR. All of the results are based on weighted spatial error models.

6. Discussion

To examine explanations for the TFR upturn since 2005 in Japan, we focused on the following four factors emphasized in previous studies of lowest-low fertility in Europe: (1) diminished tempo effect, (2) increasing numbers of foreign mothers, (3) economic improvement, (4) improvement in work-family balance. We examined the association between these factors and Japanese fertility upturn by taking advantage of prefecture-level variation in (1) change in a period distortion index that reflects change in age at childbirth, (2) change in the proportion of births born to foreign mothers, (3) change in the employment rate, (4) change in the employment rate of mothers of preschool children living in nuclear family households. We also examined the relationship between fertility recovery and familistic culture as measured by the proportion of extended family households.

Consistent with expectations based on European studies, portions of the upturn in Japan's TFR since 2005 were accounted for by the diminished tempo effect (for first-order births), the increase in foreign mothers (for first and second-order births), and economic improvement between 2003 and 2007 (for second-order births).

We expected that recent policy efforts to support work-family balance would encourage working women without immediate access to familial support to have another child. However, we did not find any evidence that the recent TFR upturn is related to the rise in maternal labor force participation. This suggests that it remains difficult for women to have children while working. In fact, in large