Spatial Pattern and Determinants of Age at Marriage in Nigeria Using Geoadditive Survival Model

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Abstract

In developing countries, timing of first marriage is not only of socio-economic and demographic variables, but varies across regions and districts. We use geoadditive hazard model that allows for measuring spatial effects while incorporating non-parametric terms for the baseline and non-linear effects of continuous covariates to examine spatial patterns in timing of first marriage in Nigeria. The non-linear and baseline effects are modeled by Bayesian penalized splines; spatial components are treated as correlated random effects following a Markov random field while we assumed diffuse priors for fixed effects. Inference is Bayesian and based on the efficient MCMC technique. Application is based on data from 1999, 2003, and 2008 Nigeria Demographic and Health Surveys. Findings show that marriage is early and universal in Nigeria, and the timing is positively associated with education and urbanization and depends on religion. It presents a clear North-South divide.

Keywords: Nigeria, marriage, fertility, spatial analyses, survival analysis, prior and posterior distribution, Bayesian analysis

1. Introduction

Before the advent of the national policy on population for sustainable development in 2005, Nigeria's total fertility rate (TFR) was estimated at 5.9 from the 1991 population census and 5.7 in 2003 from the Nigeria demographic and health survey . The 2008 Nigeria demographic and health survey (NDHS) also reveals that the country's TFR still stands at 5.7 (NPC and ICF Macro, 2009). Low usage of contraceptives among sexually active men and women contributes to the high level of fertility in the country and in other sub-Saharan African countries. Level of education, religion, culture, timing of marriage, and childbearing have also been identified as proximate determinants of fertility (Bongaarts, 1978; Caldwell et al., 1992; Gupta and Mahy, 2003).

Proportional hazard regression is used to model event history data among which is data on age at marriage (Santow and Bracher, 1994; Baschieri and Hinde, 2007). Event histories are obtained in demographic surveys from retrospective interview of women. This has been analyzed by grouping the data for discrete-time analysis (Manda and Meyer, 2005; Kandala and Gebrenegus, 2006). This approach causes loss of information (Kneib, 2006). Alternatively, generalized linear models for nonnegative continuous responses (like lognormal or gamma regression) ignore censoring and truncation. To overcome this problem, Cox model of survival analysis with geoadditive predictors accounts for different covariates such as space which cannot be treated in proportional hazard models (Hennerfeind et al., 2006; Kneib, 2006; Kneib and Fahrmeir, 2007).

In demographic and health surveys, sample data often come from a multi-stage sampling scheme. Nested observations are more likely to be correlated because of some unobserved factors such as traditional norms which can influence the decision to marry at a particular age but may vary between sub-populations. Failure to take into account clustering in analyzing data from a hierarchical population leads to underestimated standard errors (Goldstein, 2003).

2. Timing of first marriage in Nigeria

In most sub-Saharan African countries, marriage occurs early and is universal. In Nigeria, 76 percent of sexually active women aged 15-19 are married (Erulkar and Bello, 2007), a pattern associated with the agrarian economy, the family organization, socialization and women's schooling. Marriage varies among the various sociocultural groups (George, 1992; Isiugo-Abanihe et al., 1993; Isiugo-Abanihe, 1994). In northern Nigeria, women marry early (age 15 years for the Hausas) which is not the case with the Yorubas and Igbos in the southern part of the country where the median age at marriage is over 24 years (Population Council, 2004; Erulkar and Bello, 2007).

The prevailing harsh economic situation in Nigeria has favoured the withdrawal of daughters from school in order to arrange marriage and earn the bride price with often much older grooms, with an average age difference of 12 years. One third of adolescent marriages are with polygamous men, who, in this case, are 18 years older on the average (Erulkar and Bello, 2007). Despite the Child Right Act passed in 2003 that imposed the minimum age of marriage to 18 years for girls, early marriage has persisted in the northern part of the country (data from the NDHS 2008). Governments of the country's 36 states have shown little commitment in enforcing this legislation. However, age at marriage can change rapidly with modernization, entailing prolonged schooling and a more balanced power between spouses (Garenne, 2004).

3. Data

We use data from the Nigeria demographic and health survey conducted in 1999, 2003, and 2008 by Measure DHS and ORC/ICF Macro in partnership with the Nigeria national population commission. We focus on timing of first marriage in Nigeria between 1999 and 2008. Comparing age at marriage across different years of the DHS is not a substitute for panel data. The sample of women born in 1980 recorded in the 1999 survey is not, for instance, the same as the respondents in the 2003 and 2008 surveys born in the same period. The samples are randomly drawn from the same population subject to the attrition of mortality so that the merged data set can be used to estimate the parameters of interest (Gyimah, 2003).

The sampling frames used for the surveys were based on the population and housing census of the Federal Republic of Nigeria conducted in 1991 and 2006. The primary sampling units (PSU), referred to as cluster for the surveys, were defined on the basis of enumeration areas (EAs) from the population census frames. The NDHS sample was selected using a two-stage stratified design. At the first stage, clusters were selected from the list of enumeration areas, while households to participate in the surveys were selected at the second stage. One eligibility criterion is that women respondents must be in the age group 15-49 years. The data were collected through oral interview including questions on marital and reproductive histories. A total of 7,225 representative households were selected in 1999; 7,647 in 2003, and 34,070 in 2008. The response rate for the eligible women in the households was 92% in 1999, 95% in 2003, and 97% in 2008.

Age at first marriage is defined as the age when the woman started living with her spouse. The median age at first marriage for women aged 25-49 is 17.9 years in 1999; 16.6 in 2003, and 18.3 in 2008. The standard deviations is 4.70 in 1999, 4.71 in 2003 and 4.69 in 2008. From the 2008 survey, the median age at marriage was as low as 15.2 in the North East and 15.6 in the North West regions, 21.8 in the South West and 22.8 in the South East. Figure 1 shows the empirical hazard function for the combined data computed from the life table function of SPSS 15.0. Age at first marriage rose after 9 years of age to reach a narrow peak at age 14 followed by a rapid decline up to age 30 from where the hazard levels off.

We consider woman's year of birth, highest educational attainment, religion, and ethnicity as individual explanatory variables; geographical region and urban or rural place of residence as collective ones. The 36 districts and the Federal Capital Territory were geo-referenced. Wealth index is absent from the 1999 survey.

4.0 Geoadditive hazard model

The Cox model of survival analysis is extended to

$$\lambda_i(t) = exp(\eta_i(t)), \qquad i = 1,2,...,n \tag{1}$$

for the observation *i*, and $\eta_i(t)$ is the geoadditive predictor:

$$\eta_i(t) = v_i'\gamma + g_0(t) + \sum_{j=1}^{J} f_j(x_{ij}) + f_{\text{spat}}(s) + b_{gi} \tag{2}$$

In Eq. (2), $f_j(x_j)$ is the non-linear effect of continuous covariates x_j, $f_{\text{spat}}(s)$ is the spatial effect, γ is the vector of linear effects and b_g, $g \in \{1,...,G\}$, are uncorrelated individual- or group-specific frailties.

Kneib (2006) proposed a geoadditive Cox model dealing with arbitrary combinations of left, right, and interval censoring and where all covariates are piecewise constant time-varying.

T_i is the survival time and C_i the censoring time for each individual $i = 1, 2, \ldots, n$. The censoring indicator is δ_i:

$$\delta_i = \begin{cases} 1 & T_l < C_i \\ 0 & \text{otherwise} \end{cases}$$

Under non-informative censoring, the censoring time is not determined by parameters of interest, and the likelihood contribution of individual *i* is

$$L_i = \lambda_i(t_i)^{\delta_i} S_i(t_i) = \lambda_i(t_i)^{\delta_i} \exp\left(-\int_0^{t_i} \lambda(u)\, du \right) \tag{3}$$

4.1 Bayesian prior

For fixed effect parameters, we assume diffuse priors, and use Bayesian P-spline (Lang and Brezger, 2004; Brezger and Lang, 2006) for the baseline $g_0(t)$ and nonlinear $f_j(x_{ij})$ effects. f is a linear combination of B-splines:

$$p(z) = \sum_{t=1}^{m} \alpha_t B_t(z) \tag{4}$$

where $B_t(z)$ are B-splines and the coefficients α_t follow smoothness priors of a first or second order Gaussian random walk:

$$\alpha_1 = \alpha_{t-1} + \varepsilon_1 \qquad \alpha_2 = 2\alpha_{j-1} - \beta_{j-2} + \varepsilon_1 \tag{5}$$

with i.i.d. errors $\varepsilon_t \sim N(0,\tau^2)$. The variance τ^2 controls the smoothness of *f*. Assigning a weakly informative inverse Gamma prior with $\tau^2 \sim \mathrm{IG}(\varepsilon,\varepsilon)$ small, the variance is estimated jointly with the coefficients of the basis function.

Random effects b_{gi} result from exchangeable normal priors, $b_{ij} \sim \mathrm{N}(0,\tau_b^2)$, where τ_b^2 is a variance component including over-dispersion and heterogeneity. The spatial effects $f_{\text{spat}}(s)$, follow a Gaussian Markov random field prior (Besag et al., 1991). It is given as

$$\{f_{str}(s) \mid f_{str}(t); t \neq s, \tau^2\} \sim \mathrm{N}\left(\sum_{t \in \partial_s} \frac{f_{str}(t)}{N_s}, \frac{\tau^2}{N_s}\right) \tag{6}$$

where N_s is the total number of adjacent sites and ∂_s is the set of neighbor sites of site *s*. The conditional mean of $f_{\text{spat}}(s)$ is taken over function evaluations $f_{\text{spat}}(s)$ of neighboring sites *t*. Again, τ^2 controls spatial smoothness.

We assign highly dispersed but proper hyperpriors to all the unknown smooth functions, to estimate the smoothing parameters τ^2, σ^2, and ϕ^2 simultaneously. For all variance components, we take an inverse gamma distribution with hyperparameters *a* and *b*: $\tau^2 \sim \mathrm{IG}(a,b)$. Common choice are a=1 and b=0.005 or a=b=0.001.

Fully Bayesian inference is based on the unknown posterior distribution of the parameters. We use MCMC sampling from full conditionals for nonlinear, spatial, and fixed effects and smoothing parameters for posterior analysis. For the sake of comparison, we adopt the deviance information criterion (Spiegelhalter et al., 2002) given by $\mathrm{DIC} = \bar{D}(\theta) + pD$ where $\bar{D}$ is the posterior mean of the deviance, measuring how well a model fits the data. pD is the effective total number of parameters, measuring complexity of the model. Small values of $\bar{D}(\theta)$ indicate a good fit while small values of pD indicate a parsimonious model. The lowest DIC indicates the best model.

5. Data Analysis and Results

5.1 Data Analysis

The full equation we fit is given as follows:

$$\eta_{ijk} = g_0(t) + time_1 + time_2 + f_{\mathrm{spat}}(s_i) + w'\gamma + u'\gamma + f(yr\_birth) + b_{1i} + b_{2i}$$

$g_0(t)$ is the baseline function; $time_1$ is a dummy for the second survey and $time_2$ is the dummy for the third, w is the vector of collective variables, u is the vector of individual variables, $f(yr\_birth)$ is a smooth function of year of birth; b_{1i} is the household and b_{2i} community random effects.

To determine what can be gained when the variables in the full equation are varied, we consider seven equations. In Eq. (7), we include time and spatial effect with the aim of determining possible trend and crude geographical variation in timing of marriage. Eq. (8) includes time, unobserved random effects at household and community levels as well as spatial effect. In addition to time and spatial effect, Eq. (9) includes collective and Eq. (10) includes individual factors. We exclude collective variables in Eq. (11) and consider the full equation in Eq. (12). In Eq. (13), we include interaction terms between time and spatial effect with the aim of determining if the spatial heterogeneity has changed over the years.

The equations were implemented in BayesX 2.1 (Belitz et al., 2012). 15,000 iterations were carried out with the first 2,000 considered as burn-in sample and the remaining 13,000 used for parameter estimation by sampling every 10th observation. The mixing and convergence were monitored through plotting and estimation of sampling paths and autocorrelations.

We investigate sensitivity to the choice of hyperparameters by varying the parameters of the inverse gamma distribution. The results were less sensitive to the choice of hyperparameters. Hence, the results for the default choice in BayesX as done in Adebayo and Fahrmeir (2005) and Kazembe (2009) are presented.

5.2 Results

Table 1 presents model diagnostic statistics for all equations examined. Overall, Eq. (12), the full model, has the best fit. Comparing Eq. (7) and Eq. (8) shows that inclusion of random effects gives a better fit though the random effects model is more complex. The same can be said of Eq. (10) and Eq. (11). The criterion also show that the equation with individual factors out-performed the one with collective factors.

The discussions of the fixed, baseline and non-linear effects shall be restricted to findings from Eq. (12). Spatial effects of Eq. (6), (12) and (13) are presented for discussion. Table 2 reveals that comparing with 1999, risk of marrying decreased significantly in 2003 but increased in 2008. Comparing with women residing in North Central zone, the risks are lower for those in the North West and South East zones but higher for those in the other three zones though none is significant. Women who live in urban areas have substantially lower risk of marrying than those in rural areas. The risks are lower for women who attain secondary and higher educational levels when compared with those without education. Our results associate women possessing primary education with higher risk than those having no education. Religion shows significant effect on timing of first marriage. With reference to women who practice none/traditional religion, those who practice Christianity (Catholic/Protestants) have significantly lower risks of marrying while, it is significantly higher for Muslim women. Women belonging to Hausa ethic group have significantly higher risk compared with those in other ethnic groups. The risks are lower for those in Igbo and Yoruba groups, though not significant for the Igbo women.

Figure 2 (a & b) shows the posterior means with 95% credible intervals for the baseline effect (time of first marriage) and women's year of birth. The baseline effect has a similar pattern for all equations examined. Timing of marriage rises to peak around 13 years of age and remain at the same level throughout the rest of the years. This is in contrast to the peak hazard at 14 years in Figure 1. The hazard function in Figure 1 is global which depends on sample and may be rather unstable. The decline after the peak in Figure 1 has disappeared. This is because some observed factors and unobserved heterogeneities have been controlled for. The effect of year of birth is nonlinear, and an assumption of a linear effect would have led to a spurious results and interpretation. It reveals an approximately inverse "V" shape in risk for women born between 1949 and 1960 and 1961 and 1970 while it rises steadily for those born after 1970.

Figure 3 shows kernel density estimates for the posterior means of family (a) and community (b) random effects. Included are the normal densities. Comparing the two plots shows that the kernel of the community random effect has a shape that resemble the normal curve than that of the family random effect. This indicates that variation in timing of first marriage can be more explained by family random factors than those of community.

Results of the spatial effects for Eq. (6), (12) and (13) are presented in Figures 4(a-d) and 5(a-d). The left panels present maps of posterior means while the right panels show the corresponding maps of 95% credible intervals used in assessing the significance of the spatial effects. States with white color are associated with significantly higher risks of marrying; those with black color with lower risks while the risks for those with grey color are not significant. Timing of first marriage shows a North-South divide with neighboring states displaying similar patterns. The same was observed in other equations whose results are not shown. Women in the northern part of Nigeria have higher risks of marrying than those in the south. Figure 4 (a & b) show that the risks of marrying are significantly lower in all the states in southern part of Nigeria as well as Kwara, Kogi, Plateau and the Federal Capital Territory, Abuja. The risks are high in all others except Nasarawa, whose risk is not significant.

The residual spatial variation (Figure 4 (c & d)) shows non-significant risks in the following states: Abia, Adamawa, Anambra, Bayelsa, Ebonyi, Enugu, FCT, Gombe, Nasarawa, Niger, Plateau and Taraba. States with significantly lower risks are: Akwa Ibom, Cross River, Delta, Edo, Kogi, Kwara, Rivers and all the six in South West zone. The risks remain significantly higher in Benue and all other states in the North East and North West zones. The geographical varying effect of time as shown in Figure 5 (a-d) reveals that between 1999 and 2003, the risks of marrying remain higher in the following states: Bauchi, Borno, Jigawa, Kano, Katsina, Yobe and Zamfara while the risks are lower in Akwa Ibom, Cross River, Edo and River. All other states have non-significant risks. However, between 1999 and 2008, the risks are non-significant in all the states of the federation.

6. Conclusion

A positive relationship was established between education and timing of first marriage. The ultimate goal of women with little or no education in Africa as soon as they are mature is marriage (Ngalinda, 1998). This may explain the high risk for women with only primary education. Education operates through other socioeconomic factors that are associated with it to determine time to enter marriage. It brings a new outlook on life as well as skills for taking advantage of new opportunities. Thus, educated women are an urbanized and modernized subgroup with better socioeconomic status and known for spending years building careers thereby delaying marriage (Maitra, 2004). Encouraging Nigerian women to spend more years in school will enhance delayed entry into marriage and, consequently, reduce duration of exposure to the risks of pregnancy. Kirk and Pillet (1998) have associated low level of education with women in rural areas in sub-Saharan Africa and that conditions that encourage high fertility are still prevalent in many of the rural societies, hence the lower risk for women who dwell in urban areas. Nigerian government has realized this and has adopted a policy that aimed at bridging existing gap between boys and girls in school enrolment at all levels by 2015 as well as achieving a balance and integrated urban and rural development. Strong and sustained commitment would be required for the targets to yield required results; a task that has been made difficult due to slow economic growth in African countries to burst the required resources (Caldwell and Caldwell, 2002).

Religion and ethnicity are also significant determinants of age at marriage. Lucas (1980) has argued that resulting from early and universal marriage, Moslems have higher fertility than non-Moslems, and Catholics frequently a higher fertility than other Christians. Consistent with this, we found that Moslems are more prone to early marriage than non-Moslems. We also found that Hausa women are at relatively higher risks of marrying than those in other ethnic groups. Policymakers need to make more efforts in formulating and implementing policies that can encourage Moslem and Hausa women in particular, to delay entry into marriage. Such policies should also be able to simulate women from other religious and ethnic groups to sustain the current timing of marriage. Even though we have found that risks of marrying have increased between 1999 and 2008, Mensch et al. (2005) have, however, opined that in most developing countries including Nigeria, there have been substantial decline in the proportion of young men and women who are married. It is more likely that our findings are due to inaccuracies in the surveys resulting from sampling error or age misreporting.

Nonlinear effect of year of birth reveals that demographic processes are not always linear. The baseline has shown that marriage is still early and universal in Nigeria. This agrees with the submissions of Gayawan et al. (2010). Our results show that risks of marrying are on the increase for women born after 1970. These were either teenagers or young women at the periods of the surveys. In Nigeria, despite the high rate of sexual activities among young women, discussions about sexual health and services are still considered inappropriate among young or unmarried persons; a situation that places them at risk for pregnancy (Otoide et al., 2001; Abiodun and Balogun, 2009), and single women who become pregnant are often forced by their parents to marry any man responsible for it.

The unmeasured family and community factors that are captured as random effects also account for variation in timing of marriage in Nigeria. Targeting both families and communities in any intervention programs geared towards delaying first marriage would be fruitful. However, more focus should be on individual families since the kernel densities have established that family factors influence variations in timing of marriage than community factors.

The spatial effects have shown that a north-south divide exists in timing of first marriage in Nigeria. The residual spatial effect show that no state in the southern part of the country has significantly higher risk. Though it might not be new that a north-south divide exists in timing of first marriage in Nigeria, this study has shown that the age is not necessarily significantly higher in all the southern states when other variables are taken into account. Likewise, Adamawa, Gombe, Niger and Taraba among the core northern states have a timing of first marriage that is not significantly lower. Findings of this nature can provide insight on the need for state specific policy on any intervention program to be put in place.

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Table 1: Summary of model diagnostic statistics for Eq. (7) to Eq. (13)

Model	Deviance ($\bar{D}$)	*pD*	DIC
Eq. (7)	220533.2	52.2	220637.6
Eq. (8)	215365.4	1028.0	217421.4
Eq. (9)	219886.8	55.8	219998.5
Eq. (10)	215077.5	60.5	215198.5
Eq. (11)	209203.8	926.2	211056.2
Eq. (12)	209120.9	933.1	210987.0
Eq. (13)	211121.8	954.8	213031.3

Table 2: Posterior estimates of the fixed effects parameters of Eq. (12)

Parameter	Mean	Std. Error	95% Credible Interval
Trend			
1999(Ref)	0		
2003	-0.065	0.014	-0.093, -0.036
2008	0.089	0.011	0.067, 0.112
Region			
North Central (ref)	0		
North East	0.120	0.111	-0.060, 0.370
North West	-0.006	0.071	-0.142, 0.127
South East	-0.202	0.128	-0.440, 0.049
South West	0.087	0.056	-0.031, 0.191
South South	0.050	0.058	-0.071, 0.160
Residence			
Rural (ref)	0		
Urban	-0.079	0.010	-0.098, -0.060
Woman's education			
No education (ref)	0		
Primary	0.295	0.011	0.273, 0.317
Secondary	-0.188	0.012	-0.209, -0.165
Higher	-0.607	0.019	-0.645, -0.568
Religion			
None/Traditional (ref)	0		
Catholic	-0.151	0.019	-0.189, -0.114
Other Christians	-0.116	0.015	-0.144, -0.085
Muslims	0.198	0.017	0.165, 0.232
Ethnicity			
Other ethnic (ref)	0		
Hausa	0.100	0.020	0.060, 0.138
Igbo	-0.011	0.028	-0.070, 0.042
Yoruba	-0.129	0.024	-0.175, -0.079

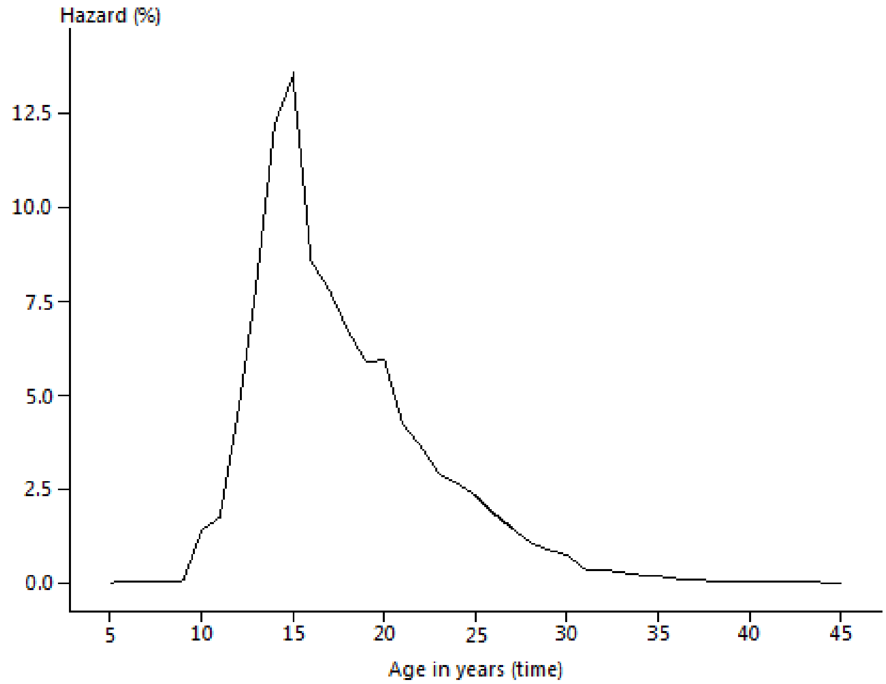
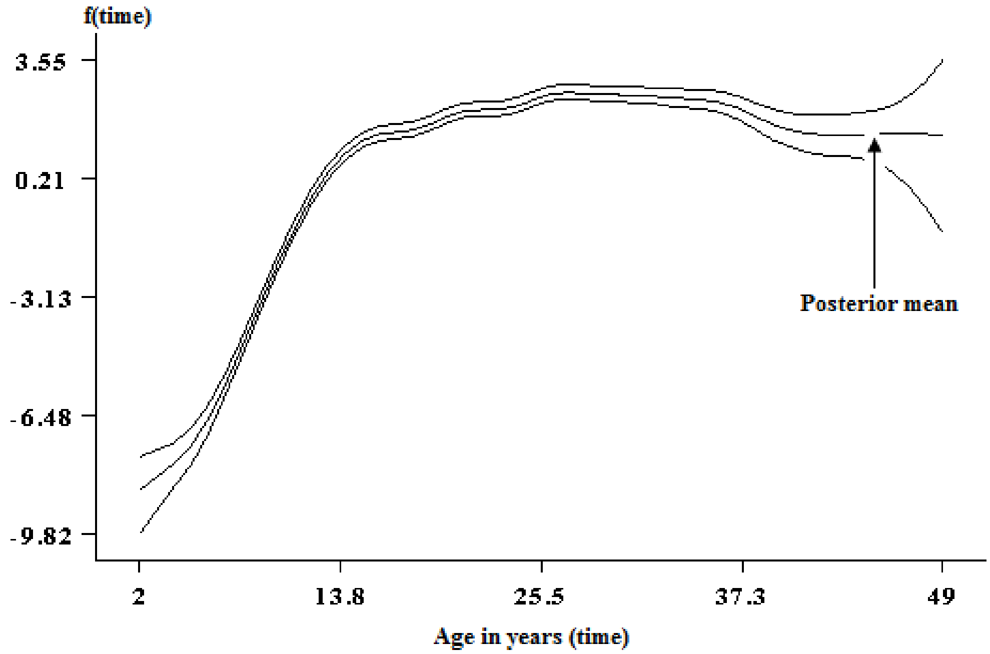


Figure 1: Empirical hazard function of age at marriage in Nigeria (1999-2008)

(a)



(b)

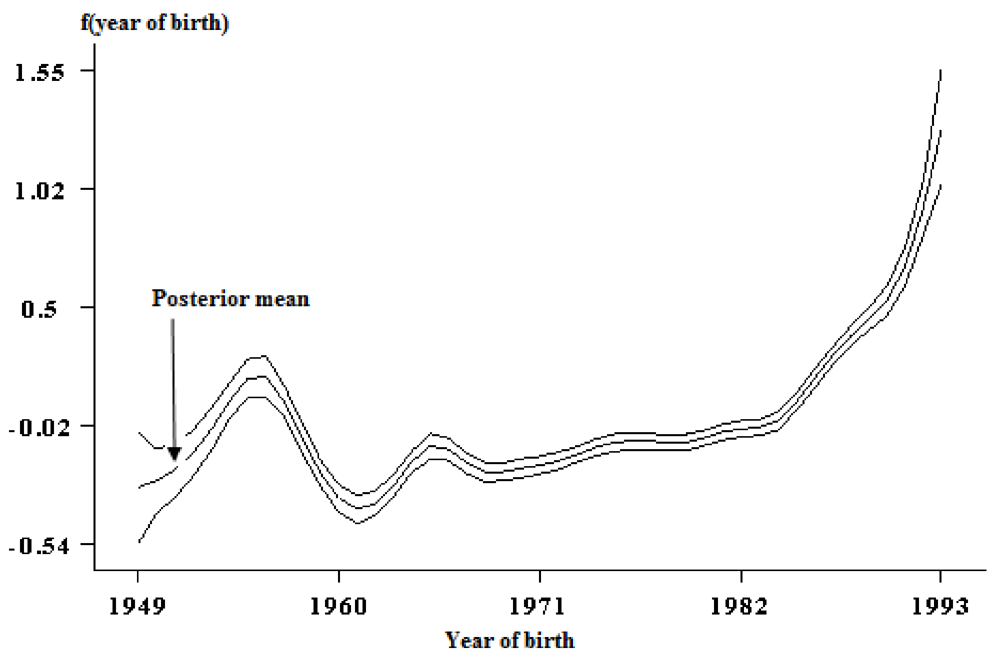


Fig. 2: Nonlinear effects of (a) age at first marriage (baseline effect) and (b) year of birth.

(a)

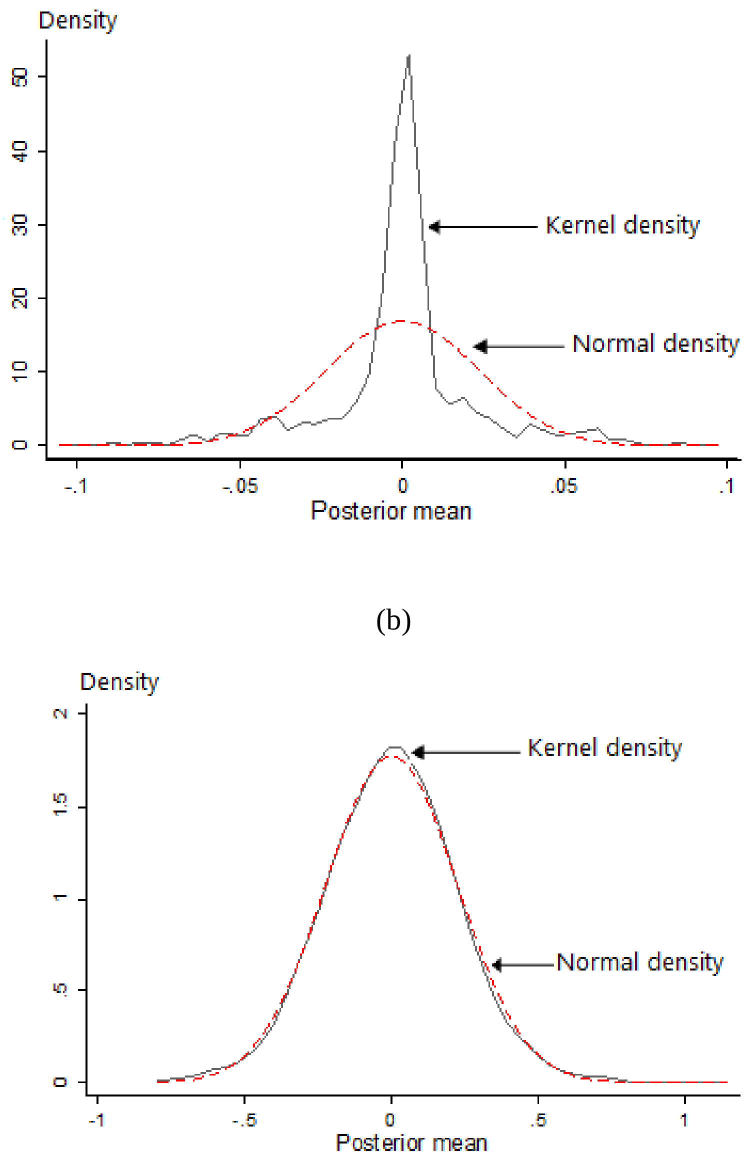


Fig 3: Kernel density estimates of the posterior mean of family random effect (a) with community random effect (b) for Eq. (12)

(a) (b)

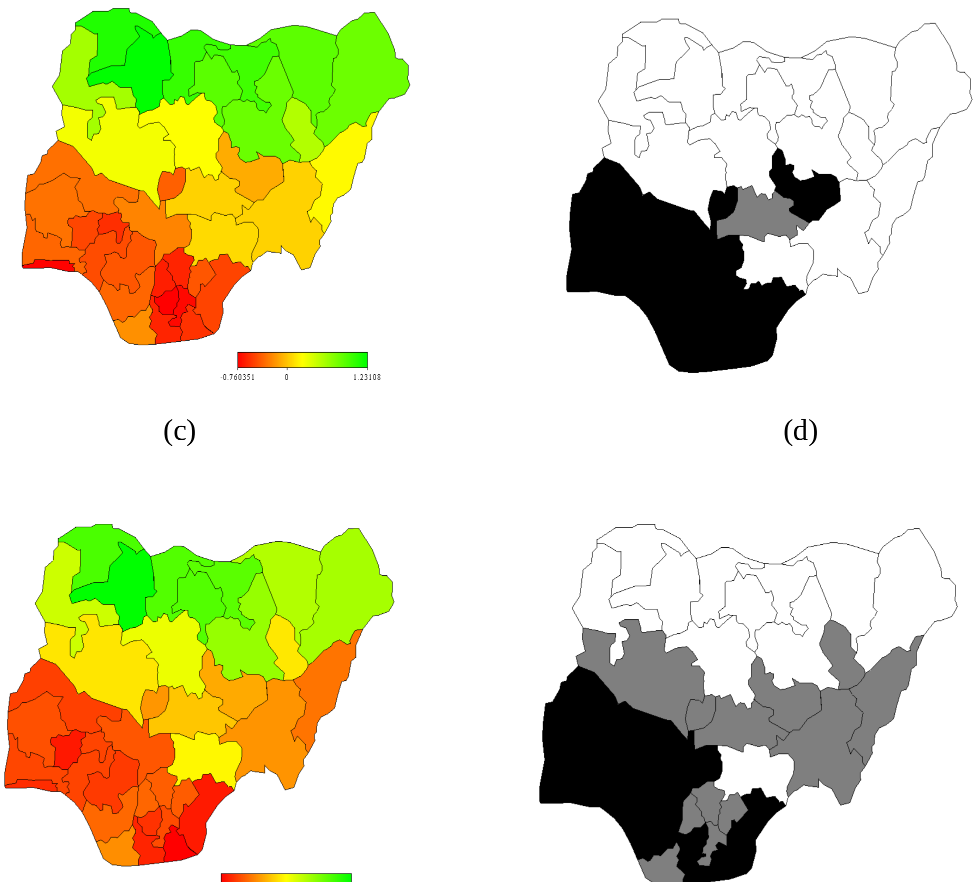


Fig. 4: Spatial effects (a) for Eq. ([illegible]) and (b) its corresponding map of 95% credible interval; (c) for Eq. (12) and (d) its corresponding map of 95% credible interval

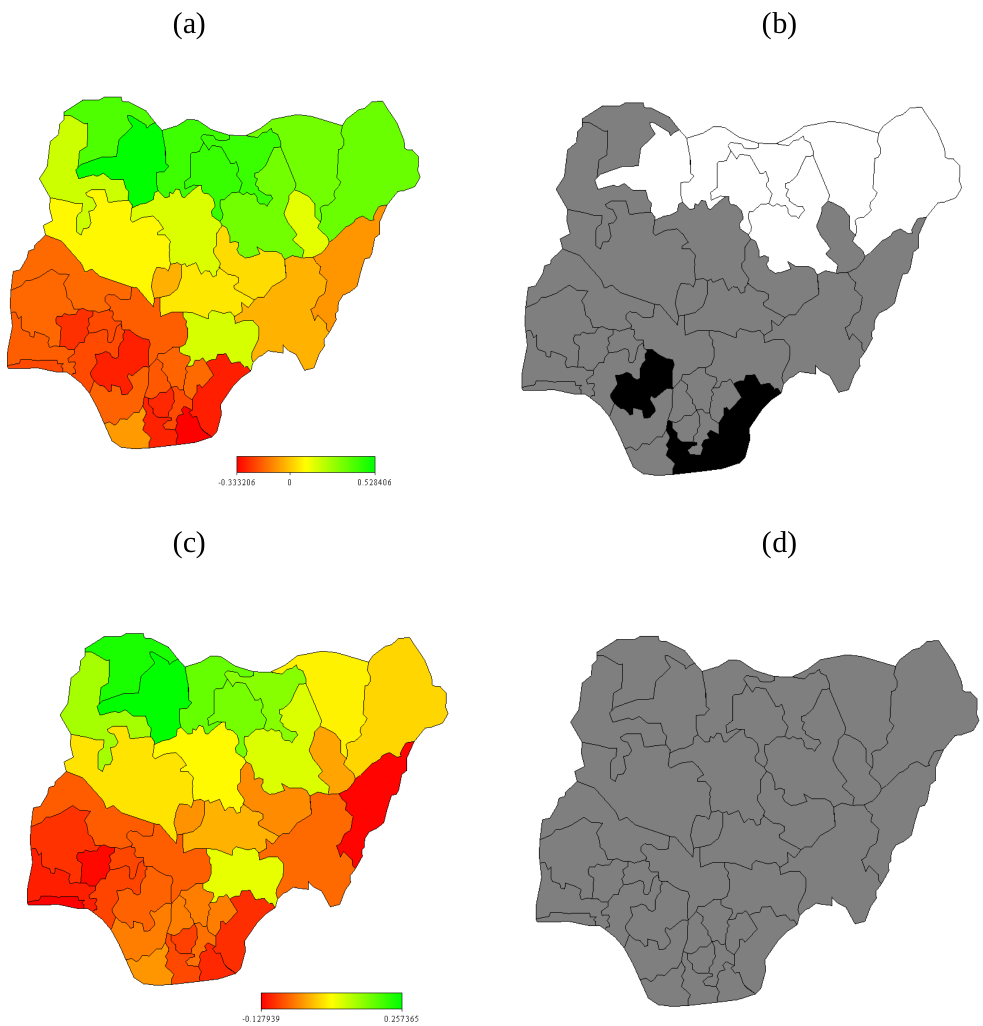


Fig. 4: Spatial effects for Eq. (13) showing geographical varying effects of (a) $time_1$ (1999-2003); (b) its corresponding map of 95% credible interval; (c) $time_2$ (1999-2008) and (d) its corresponding map of 95% credible interval