Bayesian Weighted Regression Approach for Modelling Fertility Level in Nigeria

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Summary

Interest on determinants of fertility has continued to attract the attention of researchers/policymakers. An assumption often made in data analysis is that each data point provides equally precise information about the total variation. Whenever it is not reasonable to assume that every observation should be treated equally, weighted least squares may provide optimal efficiency of parameter estimation. Here, Bayesian weighted regression approach was used to model determinants of fertility based on the 2008 Nigeria DHS data. Appropriate priors are assumed on functions and parameters. All analyses are carried out with BayesX – a software for structured additive regression models. Space-varying effect of urbanisation was also incorporated into the predictor. Findings reveal substantial geographical variations in fertility with a clear North-South divide.

Keywords: geographically weighted regression, Millennium Development Goals, Nigeria, posterior distribution, weighted least squares

1. Introduction

Fertility levels in sub Saharan Africa are still among the highest in the world despite the current global fertility transition. This is because until recent, many African nations have been resistance to the biological and behavioural change that could result in the downward shift. As a consequence, interest on determinants of fertility in the region has continued to attract the attention of researchers and policymakers. This is partly because there has been a consensus that there are appropriate analytical frameworks for investigating these determinants. These frameworks are often based on the premise that all social and economic influences on fertility operate through a common set of biological mechanism that affect reproduction (Menken, 1987). They can therefore be useful in determining the extent that each of these determinants affects fertility level. Several scholars (Cohen, 1998, Makinde-Adebusoye, 2001, Makinde-Adebusoye and Ebigbola, 1992, Baschieri and Hinde, 2007, Kazembe, 2009) have examined the proximate determinants of fertility in the African region and majority of them concluded that changes in fertility are the direct result of changes in these proximate determinants, which thus mediate the effect of changes in social, economic and cultural factors. This idea is, however, not original to these researchers as the fact has long been established by (Bongaarts, 1978).

Bongaarts (1978) classified proximate determinants of fertility into direct (intermediate fertility variables) and indirect (socioeconomic, cultural and environmental variables). He further used a framework (Bongaarts, 1982) to emphasize that all important variation in fertility is captured by all these determinants put together. Therefore if we have quality individual-level data on contraceptive use, breastfeeding and post-partum amenorrhoea and the other proximate determinants, we should be able to capture all variations in individual-level fertility. Substantial insights can be gained if, in addition to identifying the determinant influencing fertility, the specific mechanisms through which these factors operate are identified. Given the fact that fertility often takes place within marriage, an inverse relationship between age at first marriage and fertility especially in sub-Saharan Africa has been established. This is because age at first marriage determines the length of exposure to the risk of becoming pregnant and the actual commencement of the process of child bearing (Blanc and Poukouta, 1997, Islam, 2009). Previous studies have also shown that the level of women's education and fertility are inversely related. It affects the woman's knowledge and awareness of modern contraceptive methods and usage and thus, more educated women are known to have fewer children than the less educated ones.

In Nigeria, fertility transition is slow relative to other countries in Africa. A similar slow decline has, however, been observed in countries like Burkina Faso, Burundi, Liberia, Mali, Niger and Uganda (Cohen, 1998, Kirk and Pillet, 1998). The Federal Government of Nigeria having recognized that population factors, environmental issues and social and economic developments are irrevocably interconnected and are critical to the achievement of sustainable development which in turn can lead to the country's attainment of the Millennium Development Goals (MDGs), namely, eradicating extreme poverty (MGD 1); achieve universal education, (MDG 4); reduce child mortality (MGD 4); improving maternal health (MDG 5) and combat HIV/AIDS and other disease (MDG 6), came up with a National Policy on Population for Sustainable Development in 2005. The policy was a review of an early one set in 1998. One of the set targets as a consequence of the 2005 policy is the reduction of the country's total fertility rate (TFR) by at least 0.6 children every five years by encouraging child spacing through the use of family planning. Six years have now passed since the 2005 target was set and TFR still remains stagnate at 5.7; a level it was before the policy (NPC [Nigeria] & ORC Macro, 2004; 2009).

Like other African countries, several factors have been investigated to have influenced fertility in Nigeria. The inhibiting effect of marriage has been put at 25 percent. That of contraceptive is expected to increase as the level of usage of modern method increases while fertility reduction is positively associated with education (Feyisetan and Bankole, 2002). Using Bongaarts framework, for instance, Makinde-Adebusoye and Feyisetan (1994) found that marriage is an important factor among those responsible for differences in fertility among sub-population groups in the country. Apart from socioeconomic factors that mediate fertility in Nigeria, the vast variety of cultural values and belief among the geopolitical zones also contribute to the slow decline of fertility. For instance, fertility decline has been rapid in the Southwest than the Northern part of Nigeria. Most of the studies that have examined determinates of fertility in Nigeria have neglected the possibility of spatial effect in Nigeria. For instance, see Feyisetan and Bankole (2002), Makinde-Adebusoye and Feyisetan (1994), Makinde-Adebusoye (2001), among many others. Considering the large scale socio-cultural differences, it is required to examine possible geographical effects in fertility levels in Nigeria.

Until 2008 when Nigeria Demographic and Health Survey (NDHS) was designed to provide reliable and representative estimates at state level, data that permit robust analysis at state level have not been available. In the report of 2008 NDHS, state level estimates (average) of fertility was provided for Nigeria. To further explore possible determinants of fertility at state level in the presence of geographical variations, this paper uses a novel approach that simultaneously estimates the spatial distribution that accommodates neighbourhood effect, nonlinear effect of metrical covariates, fixed effect of categorical covariates, and smoothing parameters at a step through a Bayesian approach. The procedure utilizes information on the total number of respondents over which the mean estimate per state is obtained.

Section 2 describes the data while the Bayesian weighted regression is described in Section 3. Data analysis and discussion of results are presented in Sections 4 and 5 respectively. The paper is concluded in Section 6.

2. Data

The 2008 NDHS on which is study is based was the fourth in the series of Demographic and Health Survey (DHS) conducted by Measure DHS (www.measuredhs.com) in Nigeria. Although previous surveys collected data at the national and zonal levels, the 2008 NDHS is the first NDHS survey to collect data on basic demographic and health indicators at the state level. The survey was implemented by the National Population Commission of Nigeria from June to October 2008 on a nationally representative sample of more than 36,000 households. The primary objectives of the survey as is being conducted in many other developing countries, were to provide up-to-date information on fertility levels; nuptiality; sexual activity; fertility preferences; awareness and use of family planning methods; breastfeeding practices; nutritional status of mothers and young children; early childhood mortality and maternal mortality; maternal and child health; and awareness and behaviour regarding HIV/AIDS and other sexually transmitted infections.

The sampling frame used for the 2008 NDHS was the 2006 Population and Housing Census of the Federal Republic of Nigeria conducted in 2006. The primary sampling unit, referred to as cluster in the 2008 NDHS was defined on the basis of enumeration areas from the 2006 census frame. The survey employed a two-stage sampling design. At the first stage, a systematic stratified sample of 888 clusters consisting of 286 in the urban and 602 in the rural areas were selected. At the second stage, a representative sample of 36,800 households was selected from all the sampled clusters with an average of 41 households per cluster using equal probability systematic sampling. In all, a minimum of 950 households was selected per state. All women age 15-49 who were either permanent residents of the households or visitors present in the households on the night before the survey were eligible to be interviewed. A total of 33,385 eligible women were interviewed yielding a response rate of 97%.

Fertility is directly determined by intermediate variables. Cultural, social-economic, biological or behavioural factors determine exposure to sexual intercourse and hence, to child bearing. The relative importance of each variable may differ from one society to another. We therefore explored the influence of intermediate fertility variables on fertility levels in Nigeria. Of the independent variables considered, age at first sexual intercourse is a major determinant of fertility since child bearing cannot take place unless one engages in sexual activities that eventually lead to pregnancy. The traditionally condemned premarital sexual intercourse has nowadays become much more tolerant and the consequence is the risk of pregnancy as contraceptive prevalence rate is still low in Nigeria. Hence, age at first sex and the respondent's age were included in the analysis. Previous studies have established an inverse relationship between age at first marriage and fertility. Marriage affects fertility through frequent and regular exposure to sexual relations and the age at which it is entered determines the length of exposure to the risk of becoming pregnant (Blanc and Poukouta, 1997, Islam, 2009). Women's educational level affects their knowledge and awareness of modern contraceptive methods and usage; delays entry into marriage which reduces the exposure time to risk of child bearing and can also be linked to their working status thus, an indicator of relative socio-economic level. Other covariates suspected to be related to fertility and therefore included in this study are: marriage year, partner's highest education attainment, respondent's and partner's desire for children, use of modern contraceptive (currently using and used before last birth), marital and working status of the respondent, where children live, type of place of residence, geopolitical zones and state of residence (36 states and the Federal Capital Territory, Abuja). Type of place of residence was included to capture the effects of urbanization and modernization while region of residence was to capture the large-scale socio-economic differences that exist in Nigeria. Details of the variables included in the analysis and how they were categorized are presented in Table 1

3. Bayesian weighted regression

A common assumption often made in analyzing data is that each data point (or group of data) provides equally precise information about the total variation. As a consequence, the standard deviation of the error term is assumed to be constant over all values of the predictor or explanatory variables. However, this assumption does not hold in every application.

In situations like this, when it may not be reasonable to assume that every observation should be treated equally, weighted least squares can often be used to maximize the efficiency of parameter estimation. This is done by attempting to give each data point its proper amount of influence over the parameter estimates. A procedure that treats all of the data equally would likely give less precisely measured points more influence than they should have. .

Weighted least squares (WLS) regression is useful for estimating the values of model parameters when the response values have differing degrees of variability over the combinations of the predictor values. Consider a regression situation (y_i, x_i, s_i, v_i), i=1, …, n, where y_i is a response variable indicating an average number of children given birth to by women of reproductive age in a given state – hence we assume Gaussian distribution for y_i; a vector $x=(x_1, …, x_p)'$ of metrical covariates (say respondents' age, year of marriage, etc.), s_i=(1,…, 37) the state (district) where respondent i lived during the survey and a further vector $v=(v_1, …, v_q)'$ of categorical covariates. Usually one intends to model the dependence of y_i on metrical, spatial and categorical covariates within the context of generalized additive model (Hastie and Tibshirani, 1990). The predictor η_i for the geo-additive model is defined as

$$\eta_i = \sum_{j=1}^{p} f_j(x_{ij}) + f_{spat}(s_i) + \sum_{k=1}^{K} g_k(x_{ik}, x_{ik'}) + u * f_{spat}(s_i) + v_i^{'}\beta \qquad (1)$$

where $f_1,… ,fp$ are nonlinear (unknown) smooth functions of the metrical covariates, f_{spat} is the nonlinear effect of spatial covariates, $g_1,…,g_k$ are the interaction effects of continuous variables x_{ik} and $x_{ik'}$, $u*f_{spat}(s_i)$ is the geographically weighted effects of urban and state; and $\beta_i = (\beta_1 ,…, \beta_L)'$ is a vector of fixed effect parameters for the categorical covariates. For geoadditive and geographically weighted predictor of (1), see Fahrmeir and Tutz (2001) and Fahrmeir and Kneib (2011).

Unlike least squares, however, each term in the weighted least squares criterion includes an additional weight w_i that determines how much each observation in the data set influences the final parameter estimates. The weighted least squares criterion that is minimized to obtain the parameter estimates is

$$Q = \sum_{i=1}^{n} w_i \left[y_i - \eta_i \right]^2 , \tag{2}$$

where η_i is as shown in (1). Optimal results, which minimize the uncertainty in the parameter estimators, are obtained when the weights, w_i, used to estimate the values of the unknown parameters are inversely proportional to the variances at each combination of predictor variable values:

$$w_i \propto \frac{1}{\sigma_i^2}$$

Unfortunately, however, these optimal weights, which are based on the true variances of each data point, are never known. Estimated weights have to be used instead. When estimated weights are used, the optimality properties associated with known weights no longer strictly apply. However, if the weights can be estimated with high enough precision, their use can significantly improve the parameter estimates compared to the results that would be obtained if all of the data points were equally weighted.

If there are replicates in the data, as in this case study, the most obvious way to estimate the weights is to set the weight for each data point equal to the reciprocal of the sample variance obtained from the set of replicate measurements to which the data point belongs. Mathematically, this would be

$$w_i \propto \frac{1}{\sigma_i^2} = \frac{1}{\left[\frac{\sum_{i=1}^{n_i}(y_{ij} - \overline{y}_i)^2}{n_i - 1}\right]}$$

where

- w_{ij} are the weights indexed by their predictor variable levels and replicate measurements,
- i indexes the unique combinations of predictor variable values,
- j indexes the replicates within each combination of predictor variable values,
- $\hat{\sigma}_i$ is the sample standard deviation of the response variable at the i^{th} combination of predictor variable values,
- n_i is the number of replicate observations at the i^{th} combination of predictor variable values,
- y_{ij} are the individual data points indexed by their predictor variable levels and replicate measurements,
- $\bar{y}_i$ is the mean of the responses at the i^{th} combination of predictor variable levels.

Within a Bayesian context, all parameters and functions are assumed to be random variables, hence appropriate priors are assigned on them. For the non-linear effect, a Bayesian P-splines prior with 20 knots, 3 degrees of spline was assumed. For the structured spatial effects f_{str}(s) we chose a Gaussian Markov random field prior which is common in spatial statistics, see Besag et al. (1991). Unstructured spatial effects are *i.i.d*. random effects.

In order to be able to estimate the smoothing parameters for non-linear and spatial effects simultaneously, highly dispersed but proper hyper-priors are assigned to them. Hence for all variance components, an inverse gamma distribution with hyperparameters *a* and *b* is chosen, e.g. $\tau^2 \sim IG(a, b)$. Standard choices of hyperparameters are a=1 and b=0.005 or a=b=0.001. Sensitivity to the choice of priors was investigated in this case-study through different means. First, we compared results from MCMC with similar models using Restricted Maximum Likelihood (REML) approach. Second, hyperpriors for smoothing parameters were varied systematically. Lastly, we considered different priors such as 'Markov Random Field', 'Two dimensional P-spline with first order random walk penalty' which is known as *geospline*, for spatial effects. Model diagnostic and goodness of fit is based on Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC). Variables selection is made possible through stepwise regression approach that was recently implemented in BayesX version 2.0.1 - software for Bayesian inference using structured additive regression models (Belitz et al., 2009).

In this stepwise regression, the approach simultaneously performs model choice and estimation based on penalised likelihood estimates. This is unlike the classical stepwise regression. The algorithm for Bayesian variable selection technique determines whether a particular covariate enters the model; determines whether a continuous covariate enters the model linearly or nonlinearly; determines whether a spatial effect enters the model; determines whether a unit or cluster specific heterogeneity effects enter the model; selects complex interaction effects and determine the degree of smoothness of nonlinear covariates, spatial, spatial or cluster specific heterogeneity effects. MCMC techniques are used for deriving the interval estimates. Fully Bayesian inference is based on the posterior distribution of the model parameters, which is not of a known form. Therefore, MCMC sampling from full conditionals for nonlinear effects, spatial effects, fixed effects and smoothing parameters was used for posterior analysis. For nonlinear and spatial effects, Metropolis-Hastings algorithms based on conditional prior proposals (Knorr-Held, 1999) and iteratively weighted least squares (IWLS) proposals suggested by Brezger and Lang (2006) as an extension of Gamerman (1997) were applied. Similar results were obtained from both sampling schemes but we rely on IWLS proposal which has good mixing properties without requiring tuning. Model selection is based on *Akaike's Information Criterion*.

4. Data Analysis and Results

4.1 Data Analysis

We analysed the fertility component of the 2008 NDHS data using weighted regression model. Average state fertility was measured based on the total number of children ever given birth to per women of reproductive age 15-49 years. Suppose the total number of women from which the state mean fertility was calculated is represented as k_j, for j = 1, 2, ..., 37 (total number of states in Nigeria). Several models were explored in this case study. The total number of women varies from state – to – state.

Bayesian variable selection approach using stepwise regression procedure was called in BayesX. An additional option '*weightvar*' was specified in BayesX command line. For instance, after specifying the '*stepwisereg*' object '*s*'; the command for estimating a stepwise regression model with '*totfert*' as the dependent variable with the possible independent variables that could be associated with total fertility will be specified as

s.regress totfert = urban*sstate(spatial,map=m,lambda=0.1) + sstate(spatial,map=m,lambda=0.1) + agecont(psplinerw2) + agesex1(psplinerw2) + agemar(psplinerw2) + maryyr(psplinerw2) + Hholdno(random) + maryyr*agecont(psplineinteract) + Zones(factor) + edulev(factor,reference=0) + pedulev(factor, reference=0) + idchdr(factor) + wenchd(factor, reference=5) + married + wantsame + husbmore + husbfew + usedb4b + usingcon + wantedlc + chidhome + chidelse + chiddied + workst weight weightvar, CI=MCMCselect step=10 iterations=15000 family=gaussian predict using d

s.regress tfr = comm(random) + sstate(spatial,map=m,lambda=0.1) + urban*sstate(spatial,map=m,lambda=0.1) + age(psplinerw2) + age_sex(psplinerw2) + mar_dur(psplinerw2) + age_mar(psplinerw2) + age*mar_dur(psplineinteract) + region(factor) + edu(factor) + ethnicity(factor) + part_edu(factor) + newspaper + radio + television + wealth(factor) + usingcon + cur_method(factor) + use_intention(factor) + union + desire_more(factor) + ideal_child(factor) + work weight wegvar, CI=MCMCselect step=10 iterations=15000 family=gaussian predict using d

b.regress tfr = comm(random) + sstate(spatial, map=m) + urban*sstate(spatial, map=m) + age(psplinerw2) + age_sex(psplinerw2) + age_mar(psplinerw2) + mar_dur(psplinerw2) + age*mar_dur(pspline2dimrw1) + northe + northw + southe + souths + southw + prim + sec + high + part_prim + part_sec + part_high + hausa + igbo + yoruba + christ + islam + middle + rich + con_use + folk_method + trad_method + mord_method + intend_use + notintend_use + unionn + with_2yr + latter_2yr + unsure_time + undecided + ideal1_3 + ideal4_5 + ideal_6 + ideal_god + news + radioo + telv weight wegvar, step=10 burnin=5000 iterations=15000 family=gaussian predict using d

The best model was achieved at the 15^{th} iteration with *AIC* value of 81050.324. As a consequence, the final model is

totfert = const + wantsame + husbmore + usedb4b + usingcon + wantedlc + chidhome + chidelse + chiddied + Zones_2 + Zones_3 + Zones_4 + Zones_5 + Zones_6 + edulev_1 + edulev_2 + edulev_3 + pedulev_1 + pedulev_2 + pedulev_3 + idchdr_2 + idchdr_3 + idchdr_4 + idchdr_5 + wenchd_1 + wenchd_2 + wenchd_3 + wenchd_4 + agecont(psplinerw2,df=10.9643,(lambda=52316)) + agesex1(psplinerw2,df=13.9938,(lambda=1512.31)) + agemar(psplinerw2,df=11.9852,(lambda=11299)) + maryyr(psplinerw2,df=12.9868,(lambda=12828.2)) + urban*sstate(spatial,df=27.0332,(lambda=8808.04)) + sstate(spatial,df=26.9991,(lambda=31037.8)) +

Hholdno(random,df=54.9585,(lambda=198115)) +

maryyr_c*agecont_c(psplineinteract,df=65.9848,(lambda=1.0375e-05))

Posterior samples were generated to estimate necessary parameters such as the means, standard error, credible intervals, etc. All estimates are based on the posterior samples after convergence. The final model can be assumed to be more parsimonious than the original one. For instance, marital and working status of the respondent were found not to be significant in determining fertility level in Nigeria and thus, removed in the model.

4.2 Results

Table 2 presents the results of fixed effects. The fixed effects examined allow demographic relation to be established. Fertility levels vary substantially among the geopolitical zones in Nigeria. Comparing with women respondent who lived in the North Central region, fertility is significantly high among those in the other two Northern regions (North East and North West) while it is significantly low among women in the Southern regions. Results show that mother and partner's education are inversely related to fertility level. As the education level of the respondent and her partner increases, a significant reduction in fertility level was evident. On ideal number of children the respondent desire, those who desired at most 5 children are likely to have given birth to fewer children than those who desired 6 children and more as well as those who feel it is up to God to determine. Similarly, effect of when the respondent desired the next child on overall fertility level was examined. Results show that respondents who were unsure of time or undecided are more likely to give birth to more children. Information about husband's desire for children was elicited from the respondents during the survey. Results show that husband's desire for more children do not translate to increase in overall fertility level of the woman instead, it has a reduction effect.

Contraceptive use has been shown in some studies to be significantly related to fertility. In this study, effect of current use of a modern contraceptive and use before the last birth on fertility was explored. As shown in Table 2, contraceptive use (either currently or before the last birth) results in a significant reduction in the fertility level of the women. Respondents who were currently using contraception are more likely to have fewer number of children compared with those who used before last birth. Respondents who claimed to have wanted last child are also associated with fewer number of children.

Figures 1 (a - d) present the results of the nonlinear effects of respondents' age, age at marriage, years (duration) of marriage and age at first sex. Obviously an assumption of linear dependence of any of these variables *a priori* would have been too rigid and led to wrong conclusion. With respondents' age, a steady increase in total fertility was evident up to age 32 years, after which it stabilized. Effect of age at marriage reveals a 'V' shape implying that respondents that married earlier are significantly associated with higher fertility. This declines steadily up till age 29 years after which it rises again. On duration of marriage, fertility is peaked among respondents who have been in marriage for an average of 10 years. On age at first sex, an approximately sinusoidal shape was evident. In general, fertility is higher among respondents who had their first sexual experience before age 20 years. Figure 1e displays the interaction effect of duration of marriage and respondent's age. Evidently, the duration of marriage and age of the respondent also increase, they both have positive impact on total fertility rate per woman. Model with interaction effect of duration of marriage and respondent's age was found to be more parsimonious based on the stepwise regression procedure in BayesX.

Figures 2(a - d) present the results of the spatial effects with their corresponding map of credible intervals. Figure 2(a & c) presents the map of posterior means while the map of significance with estimates presented at 95% credible intervals are shown in Figure 2(b & d). States in white are significantly associated with high fertility level (95% CI lie in the positive side) while those in black colour (negative CI) are significantly associated with low number of children per woman. Spatial effects in other states in grey colour are not significant i.e. the 95% credible intervals include zero (0). The net effect of spatial variations on total fertility in Nigeria after controlling for possible determinates of fertility reveals a North – South divide in total fertility rate (Figures 2a & b). Respondents in the northern part of Nigeria are significantly associated with higher fertility than their counterparts in the South (South East, South South, and South West). The geographically weighted interaction of place of residence (urban) and states where respondents lived during the survey is shown in Figure 2c with its corresponding map of 95% credible intervals. This further confirms a North-South divide in the geographical variations of total fertility in Nigeria. This provides a space-varying effect of urban on fertility in Nigeria. In other words, it is an interaction term between urban and state where respondents lived during the survey. The net effect of geographical variations on total fertility in Nigeria shows that many states in the Northern part of the country are associated with high fertility after adjusting for urbanisation.

5. Discussion of Results

In this paper, a Bayesian weighted regression technique with geo-additive predictors was adopted to model fertility levels of states in Nigeria. This is an important application because fertility level in Nigeria is still among the highest in the world notwithstanding the current global fertility transition. As a consequence, the already high population has continued to increase thereby defeating the purpose of setting up a target of 0.6 reduction in fertility level every five years according to the recent population policy. It therefore becomes necessary to adopt a novel approach to examine the known determinates of fertility so as to make appropriate information available to policy makers. Rather than assuming equal precision about the total variation of the response variable, the approach assigns appropriate weight to each data point and also simultaneously estimates spatial distribution that accommodates neighbourhood effect; nonlinear effect of metrical covariates; fixed effects of categorical covariates; and smoothing parameters at a step. In order to obtain a more parsimonious model, Bayesian stepwise regression was adopted.

Several features of the model can be elaborated. Consistent with findings from other studies (Mboup and Saha, 1998, Kazembe, 2009, Kirk and Pillet, 1998, Maitra, 2004, Makinde-Adebusoye, 2001, Manda and Meyer, 2005) an inverse relationship between fertility and education is established. Respondents who acquire secondary and higher education are associated with lower fertility compared to those without any formal education. This same pattern is observed for their partner's level of education. The differentials in education operate through other elements of socioeconomic development that are associated with education. Educated women belong to the modernized subgroup with better socioeconomic status conducive towards having fewer children as they are more aware of modern contraceptive methods and usage. This issue has been realized by Nigerian government and programmes that can encourage many men and women to attain higher education as well as bridging the gap in education enrolment between men and women has been yielding results especially in the urban areas(Anugwom, 2009). Contraceptive usage is another useful determinate that leads to reduced fertility. However, attitude towards the use of modern contraceptive is still poor despite the widespread knowledge of various contraceptive methods especially among young women. This is because most family planning clinics are not young women - friendly (Abiodun and Balogun, 2009, Otoide et al., 2001). Also, these studies have highlighted fear of side effects, objection from partner and conflict with religious belief among reasons for low use of contraception in Nigeria. This attitudes need be reversed and an enabling environment suitable for sexually active women both married and unmarried to assess contraception be created as this will encourage usage and in turn, results in the desired reduction in fertility levels. Desire for more children and the timing of next birth were found to significantly increase fertility levels in Nigeria. For instance, this study reveals that women who were unsure of the timing of the next birth and those who feel it is left for God to decide contribute more to fertility. It would be unlikely for this set of women to make deliberate effort in controlling pregnancy. Partner's desire of children was however found to have a reduction effect in fertility. One important programmatic implication of this is that, policy makers should intensify on behavioural change in communications that will be targeted at men which will encourage couples' discussion on the benefits of reduced fertility. Early marriage and the onset of childbearing at young ages are strongly associated with high fertility (Foote et al., 1993). Results from this study reveal that respondents who marry early as well as older respondents who are expected to have spent many years in marriage are associated with high fertility. Early marriage exposes the woman to a longer risk period of childbirth especially in most Africa societies where the main purpose of marriage is to have children. There is therefore the need to put in place programmes and activities that can discourage early marriage in all parts of Nigeria. The age at which women initiate sexual intercourse is found to affects fertility level. Delaying age at first sexual intercourse will ultimately result in lower fertility. It is expected that women who had first intercourse at older age have reduced intervals between the onset of sexual initiation and age at menopause. It is however plausible in Nigeria to put in place policies that can enhance delaying the initiation of sexual intercourse. With the existing widespread premarital sexual activities, women will therefore continue to be exposed to early sexual intercourse which will continue to constitute a treat to fertility decline unless the use of contraceptive to delay first birth is strongly encouraged.

Turning attention to the spatial effect, a clear North – South divide in total fertility was evident. Figure 2a displays the map of Nigeria with the spatial effect of total fertility with Figure 2b showing the map of significance based on 95% credible intervals (CI). States in white are significantly associated with high total fertility (95% CI lie on the positive side) while states in black colour (negative CI) are significantly associated with low total fertility. Spatial effects in other states in grey colour are not significant i.e. the 95% credible intervals include zero (0). While most states in the South are significantly associated with low total fertility, all states in the North are significantly associated with high total fertility rates apart from some states in the North Central. By implication, this shows substantial level of disproportionate level of fertility between North and South.

Having identified states that are significantly associated with high and low fertility rates, policymakers can be properly guided based on the findings from this paper. Through this, policymakers can be properly guided in prioritizing the use of the scarce resources and focus on state's specific interventions that can address needs of various states.

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Table 1: Description of all variables included in the analysis

Variables	Description of variables
Totfert	Fertility level of each of the states
Zones	Geopolitical zones: North Central (ref), North East, North West, South East, South South

	and South West
Educ	Educational attainment: no formal education (ref), Primary, Secondary and Higher
p_educ	Partner's educational attainment: no formal education (ref), Primary, Secondary and Higher
Urban	Place of residence (rural – ref category)
Idealchd	Ideal number of children grouped (None – ref category)
Whendes	Respondents desire for more children (wants no more, infecund & sterilised – ref category)
Useb4b	Whether respondent used modern FP before birth
Usingcon	Current use of modern Family Planning
Husbdes	Husband's desire for children (Others – ref category)
Workst	Respondent's working status (No (ref))
Married	Respondent's marital status (married/formerly married & never married (ref))
Wantedlc	Desire for last child
Agecont	A continuous variable of age in years
Maryyr	Duration of marriage measured in years
agesex1	Age at first sexual intercourse measured in years (continuous)
Agemar	Age at marriage (continuous)
State	Respondent's State of resident divided into 36 states and a Federal Capital Territory

Table 2: Posterior estimates of the geographically weighted regression. Shown are the posterior means and standard errors

Variable	Post mean	Std. Err	95% Credible Interval	
			Lower	Upper
Constant	5.3349	0.007	5.328	5.342
Geopolitical zones				
North Central (ref)	0.0			
North East	1.1742	0.00077	1.1732	1.1751
North West	0.4997	0.00084	0.4989	0.5005
South East	-0.1525	0.00073	-0.1535	-0.1514
South West	-0.2026	0.00081	-0.2036	-0.2016
South South	-0.0265	0.00082	-0.0275	-0.0255
Respondent's education				
None (ref)	0.0			
Primary	-0.0316	0.0001	-0.0318	-0.0314
Secondary	-0.0253	0.0001	-0.0255	-0.0250
Higher	-0.0225	0.0003	-0.0230	-0.0220
Partner's education				
None (ref)	0.0			
Primary	-0.012	0.0001	-0.0120	-0.012
Secondary	-0.009	0.0001	-0.0100	-0.009
Higher	-0.003	0.0002	-0.003	-0.002
Ideal number of children				
None	0.0			
1-3	0.129	0.0004	0.129	0.130
4-5	0.106	0.0003	0.106	0.107
6+	0.133	0.0003	0.132	0.133
Up to God	0.157	0.0003	0156	0.158
Desire for more children				
Wanted no more/sterilised /infecund	0.0			
Within 2 years	0.013	0.0001	0.013	0.013
Latter than 2 years	0.034	0.0001	0.034	0.035
Unsure of time	0.038	0.0002	0.038	0.038
Undecided	0.040	0.0002	0.040	0.041
Contraceptive usage				

Used before last birth	-0.0355	0.0001	-0.0358	-0.035
Currently using FP method	-0.0487	0.0001	-0.0490	-0.048
Husband's desire for more children				
Others (ref)	0.0			
Want the same	-0.0228	0.0001	-0.0230	-0.0226
Husband wants more	-0.0081	0.0001	-0.0082	-0.0070
Wanted last child	-0.0144	0.0001	-0.0146	-0.0141
Child lives at home	0.0012	0.00003	0.0011	0.0012
Child lives elsewhere	0.0004	0.00004	0.0003	0.0004
Child had died	0.0059	0.00003	0.0058	0.0059

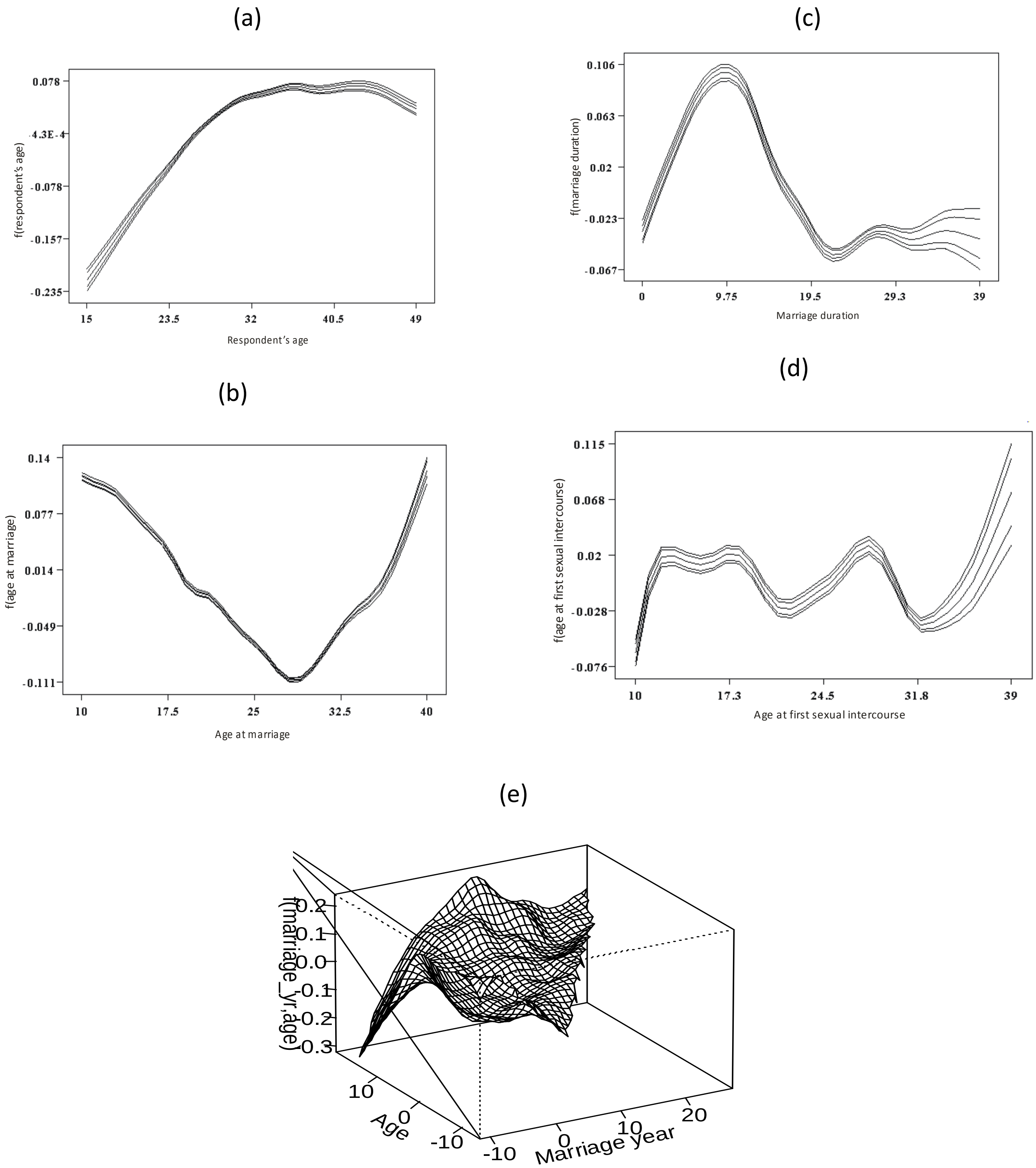

Figure 1: Nonlinear effects of (a) respondents' age, (b) age at marriage, (c) duration of marriage, (d) age at first sexual intercourse, and (e) interaction effect of duration of marriage and respondents' age. Shown are the posterior means and 95% and 80% credible intervals.

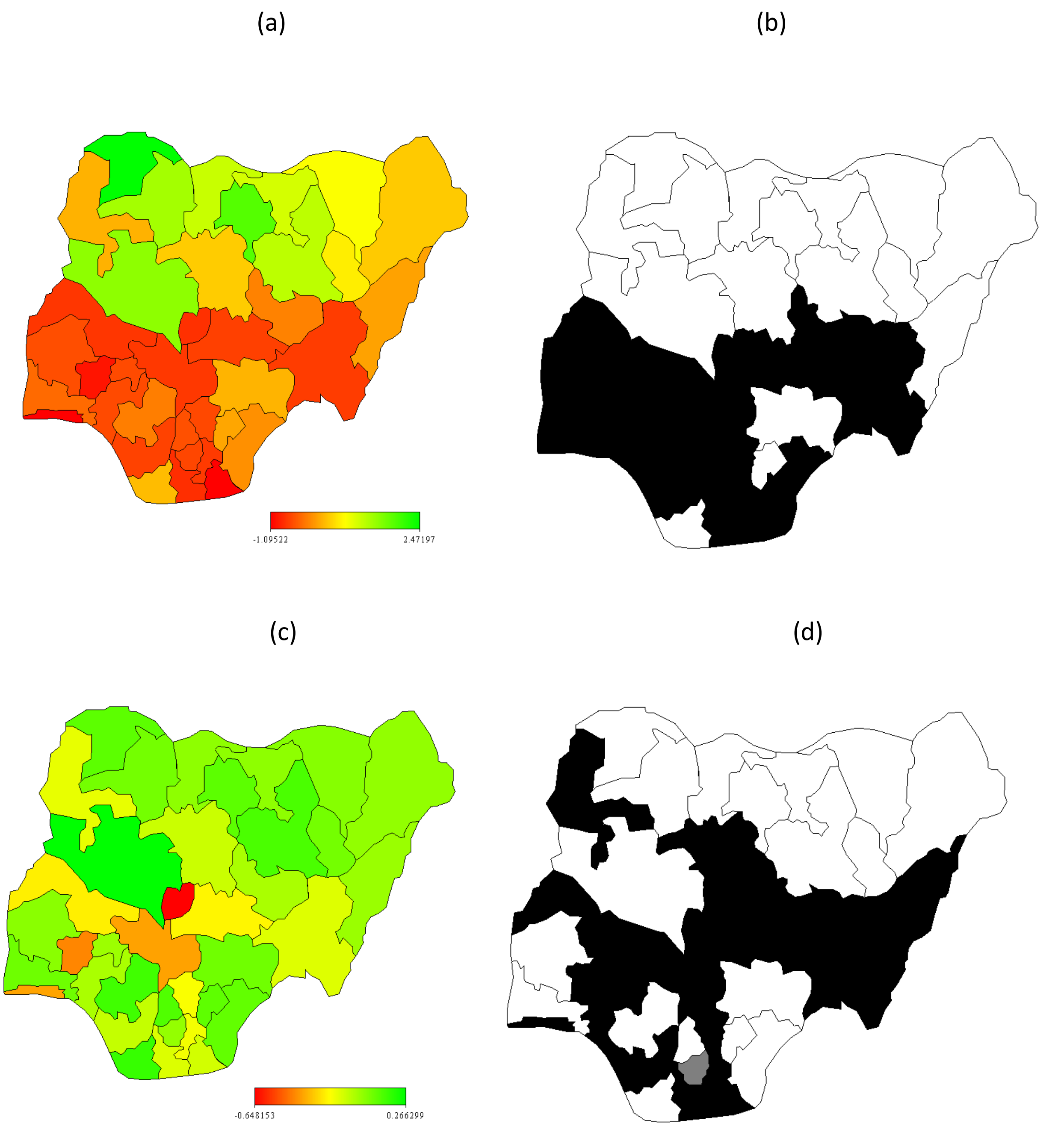

Figure 2: Spatial effects of (a) total spatial effect, (b) map of 95% credible intervals for the total spatial effect, (c) spatial effect for geographically weighted component (d) map of 95% credible interval for the geographically weighted component.