Spatial modelling of Determinants of Childhood Undernutrition in Developing Countries

Kandala Ngianga-Bakwin , Ludwigstr. 33 D-80539, University of Munich.
kandala@stat.uni-muenchen.de

August 4, 2001

Abstract

We estimate semiparametric regression models of chronic undernutrition (stunting) using the 1992 Demographic and Health Surveys (DHS) from Malawi, Tanzania and Zambia. We concentrate particularly on the influence of the child's age, the mother's body mass index, and spatial influences on chronic undernutrition. We present a Bayesian semiparametric analysis of the effects of metrical and spatial covariates on chronic undernutrition. Compared to previous work with a simple fixed effects approach for the influence of provinces, we model small scale district specific effects using flexible spatial priors. Inference is fully Bayesian and uses recent Markov chain Monte Carlo techniques.

Keywords: developing countries; semiparametric Bayesian inference; spatial models; undernutrition

Data and Results

We analyzed the Demographic Health Surveys (DHS) of Malawi, Tanzania and Zambia, conducted in 1992. We concentrate in the analysis on the unstructured and structured spatial effects of the district as well as , the flexible modelling of the effects of the child's age and the mother's BMI on chronic undernutrition (stunting), measured using the Z-score (multiplied by 100). In addition, we consider several categorical variables including the sex of the child, the education and employment situation of the mother, the size of the family, Type of toilet facility, electricity in the household, radio ownership, and locality (urban and rural). The spatial covariate district consist of 24 districts for Malawi, 103 districts for Tanzania and 54 districts for Zambia .

We estimate separate models for each countries with predictor

$$\eta = \gamma_0 + f_1(AGC) + f_2(BMI) + f_{unstr}(s_i) + f_{spat}(s_i) + \gamma' w,$$

w includes the categorical covariates in effect coding. The functions f_1 and f_2 are modelled by second order random walk priors . $f_{unstr}(s_i)$ and $f_{spat}(s_i)$ are respectively unstructured and structured effect of district specific spatial effect modelled by Marchov chain random fields.

the results of the fixed effects parameters in Tanzania are generally as expected. Children of highly educated mothers living in urban areas are better nourished than other children. Female children are also less likely to be stunted. Non availability of electricity, radio and toilet facility have a negative impact on stunting . Large households are associated with reduced level of stunting in the three countries.

The results are quite similar for Malawi and Zambia.

As hypothesized, we find the influence of BMI to be in the form of an inverse U shape (Figure 1left). While the inverse U looks nearly symmetric, the descending portion exhibits a much larger range in the credible region. This appears quite reasonable as obesity of the mother (possibly due to a poor quality diet) is likely to pose less of a risk for the nutritional status of the child as very low BMIs which suggest acute undernutrition of the mother. The Z-score is highest (and thus stunting lowest) at a BMI of around 30-35 months.

As suggested by the nutritional literature, we are able to discern the continuous worsening of the nutritional status up until about 20 months of age (Figure 2right). This deterioration set in right after birth and continues, more or less linearly, until 20 months. Such an immediate deterioration in nutritional status is not quite as expected as the literature typically suggests that the worsening is associated with weaning at around 4-6 months. After 20 months, stunting stabilizes at a low level. There is a blip around 24 months of age. This is picking up the effect of a change in the data set that makes up the reference standard.

There is a strong South-North gradient in these district spatial effects (Figure 2a) with a fairly sharp dividing line running through the center of the country. there appear to be negative influences on undernutrition in the South of Tanzania that are quite general and affect most of the districts there. Given that the Southern districts all are at significantly lower elevation than the rest of the country, it is likely that climatic and associated disease factors are responsible for this pronounced regional pattern. The structured effects in figure 2b show a sizeable difference between significantly worse undernutrition in the Central and Southern districts of the country, and significantly better nutrition in the northern districts (in particular Chipita and Karonga districts).

Figures 2c shows the structured random effects for Zambia. The structured effects show a sizeable difference between significantly worse undernutrition in the Northern parts of the country (in particular the districts in Luapula and Northern provinces), and significantly better nutrition in the Central and South-Western parts. The unstructured random effects are mostly not significant and results are not displayed.

Conclusion

In this paper, we have applied Bayesian methodology to the spatial modelling of the determinants of chronic undernutrition (stunting) in Malawi, Tanzania and Zambia. We were able to discern suitable spatial variation of undernutrition and also, the method identified subtle relationships between the mother's BMI and the child's age on undernutrition. We are able to analyze this dataset using a unified semiparametric Bayesian approach based on MCMC techniques where spatial effects as well as nonlinear effects and fixed effects are all treated within the same general framework.

Appendix

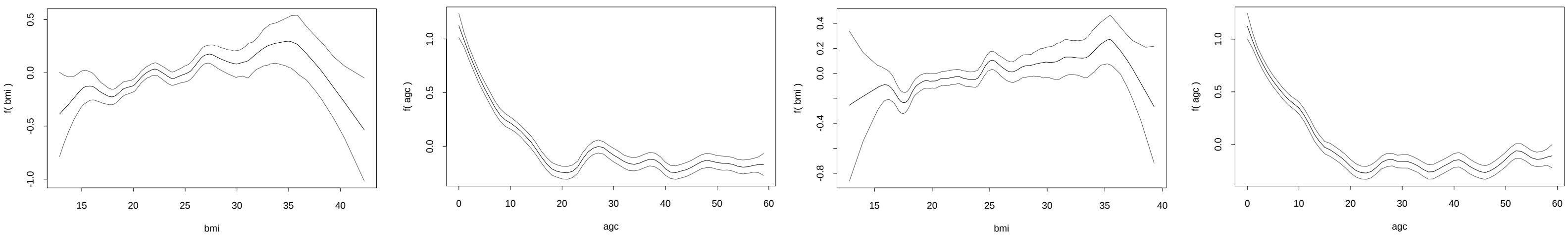

Figure 1 Nonlinear effects of mother's body mass index (left) and child's age (right) for Tanzania and Zambia.

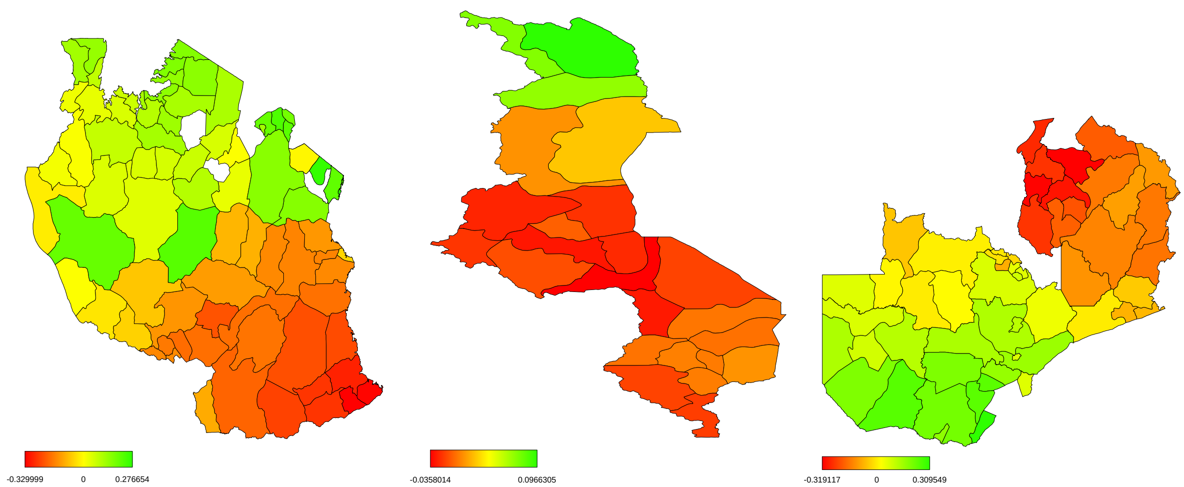

Figure 2 structured posterior mean for Tanzania(left), Malawi(middle), and Zambia(right).