Estimation and projection of sex ratio at birth for Vietnam regions, using a Bayesian hierarchical time series model

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Introduction

Sex Ratio at Birth (SRB)

- SRB (ratio of male to female births) is an important indicator:
  - For population estimation and projection;
  - To assess the prenatal gender equality.

SRB imbalance

- The natural SRB fluctuates between 103 to 107 male births per 100 female births;
- Since 1970, observed SRB in some Asian and Eastern European countries are much higher than the natural level.
- The imbalanced SRB is due to the coexistence of 3 main factors:
  1. Strong son preference at population level;
  2. Sex determine and abortion technology is accessible and affordable;
  3. Family size is getting smaller over time.
- On national level, my previous study (Chao, F. et al 2019) reports SRB inflation in 12 countries/areas, including **Vietnam**.

SRB imbalance in Vietnam

- On national level, SRB imbalance occured in early 2000s.
- However, the levels and trends in SRB for the entire country conceal the variations within the country.
- A country of demographic and cultural heterogeneity: stronger son preference in the north than in the south.
- Important to produce SRB projection by subnational regions in Vietnam.

Objective

- Develop a Bayesian model for subnational SRB estimation and projection in Vietnam.
- Model SRB among six regional in Vietnam during 1990–2050:
  - Northern Midlands and Mountain Areas, Red River Delta, Northern Central and Central Coastal Areas, Central Highlands, South East, and Mekong River Delta.

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- Preprint available (Chao, F. et al 2021) on **SocArXiv, doi:10.31235/osf.io/9xrbk**

Results

SRB estimates by Vietnam regions in 1980, 2000, and 2018

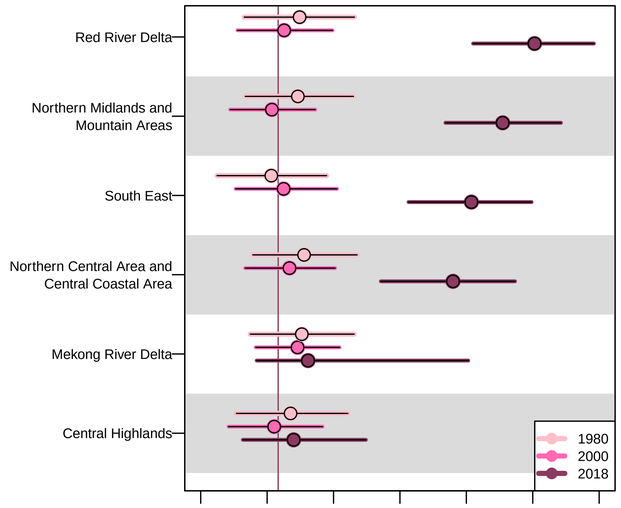
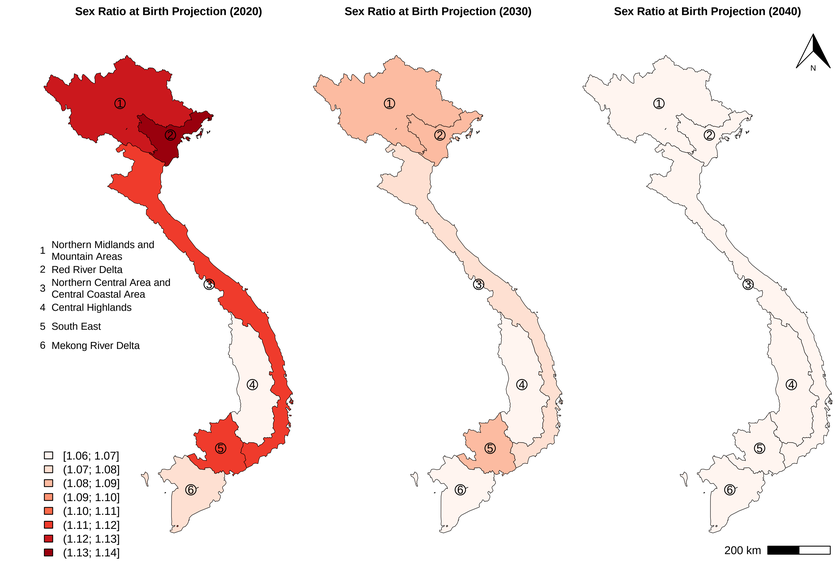


Figure 1: Median estimates are in dots. 95% credible intervals are in horizontal bars. The SRB national baseline for Vietnam as a whole is indicated by the vertical line at 1.063 (Chao, F. et al 2019). The country's regions are shown in descending order of the 2018 median estimates.

SRB median projections in Vietnam by region in 2020, 2030, and 2040



Method

Model for regional SRB

Built upon and is based on the global SRB model (Chao, F. et al 2021).

$\Theta_{r,t}$, the SRB in Vietnamese region r in year t is modeled as:

$$\Theta_{r,t} = b\Phi_{r,t} + \delta_r \alpha_{r,t}$$

$b = 1.063$: national SRB baseline level for Vietnam (Chao, F. 2019).

$\Phi_{r,t}$ follows an AR(1) times series model on the log scale to capture the natural fluctuations of SRB within region over time.

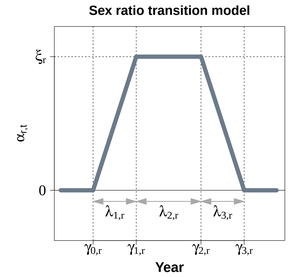
$$\begin{aligned} \log(\Phi_{r,t}) &\sim \mathcal{N}(0, (1-\rho^2)/\sigma_\epsilon^2), \text{if } t = 1990, \\ \log(\Phi_{r,t}) &= \rho \log(\Phi_{r,t-1}) + \epsilon_{r,t}, \text{if } t \in \{1991, \cdots, 2050\}, \\ \epsilon_{r,t} &\overset{\text{i.i.d.}}{\sim} \mathcal{N}(0, \sigma_\epsilon^2). \end{aligned}$$

ρ and σ_ϵ are fixed based on previous study (Chao, F. 2019).

δ_r is the binary identifier of the sex ratio transition:

$$\begin{aligned} \delta_r|\pi_r &\sim \mathcal{B}(\pi_r), \text{ for } r \in \{1, \cdots, 6\}, \\ \text{logit}(\pi_r)|\mu_\pi, \sigma_\pi &\sim \mathcal{N}(\mu_\pi, \sigma_\pi^2), \text{ for } r \in \{1, \cdots, 6\}. \end{aligned}$$

SRB imbalance process $\alpha_{r,t}$ is modeled with a trapezoid function with hierarchical structure.



- $\gamma_{0,r}$: starting year of inflation period.
- $\lambda_{1,r}, \lambda_{2,r}, \lambda_{3,r}$: period lengths of increase, stagnation and decrease of inflation.
- ξ_r: the maximum value that the adjustment factor could reach.

Data Model For the i-th observation y_i:

$$\log(y_i)|\Theta_{r[i],t[i]}, \omega \sim \mathcal{N}(\log(\Theta_{r[i],t[i]}), \sigma_i^2 + \omega^2),$$

σ_i: known sampling error for $\log(r_i)$. ω: non-sampling error parameter.

References

- Chao, F., Gerland, P., Cook, A. R., Alkema, L. (2019). Systematic assessment of the sex ratio at birth for all countries and estimation of national imbalances and regional reference levels. *PNAS, 116*(19), 9303-9311.
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