# Small area estimation of district-level fertility in sub-Saharan Africa

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6th April 2020

# Introduction

- District level estimates of fertility desired for:
  - Improved population projections at subnational levels
  - Estimation of children living with HIV
    - Key epidemic indicator
    - Resource allocation for prevention of mother-to-child transmission
  - Evaluation of family planning programamtic scaleup

**Objective** Estimate annual age-specific fertility rates at district level for SSA countries from household survey data

# Data sources | Malawi

- Household surveys with full birth histories
  - Demographic Health Surveys (2000, 2004, 2010, 2015)
  - Malaria Indicator Survey (2012, 2014, 2017)
  - Multiple Indicator Cluster Survey (2006, 2013)
- Full birth history data:
  - DHS, MICS: 15 years
  - MIS: 5 years
- Summary birth histories from censuses - to be included

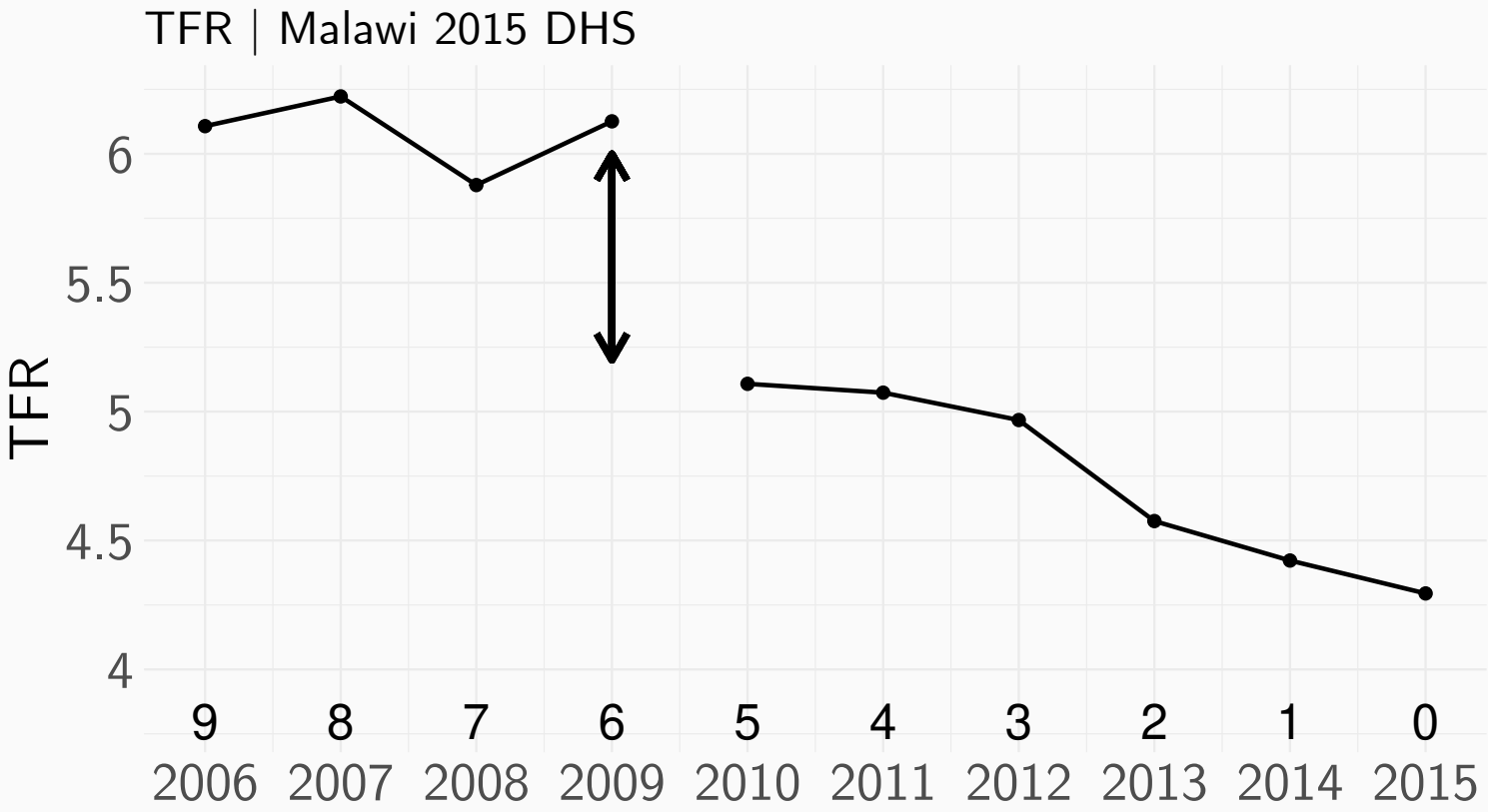
# Challenges

- Non sampling biases
  - Displacing
  - Omitting
- Data available at different spatial resolutions
  - DHS: geomasked coordinates –> district
  - MICS: coordinates unavailable –> province

# Data and workflow | Non-sampling bias in household surveys

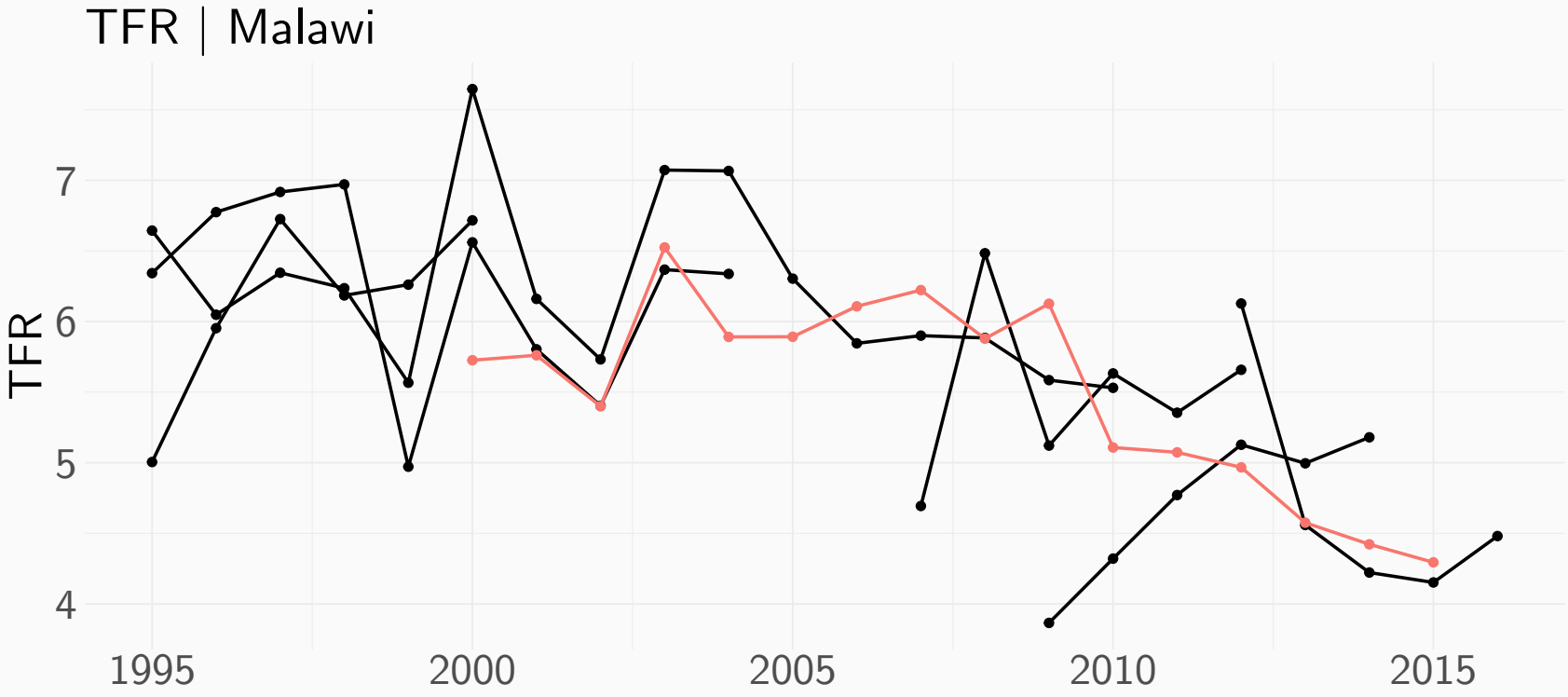
- DHS collects full birth histories for children in the 5 years preceding the survey, and an abbreviated question set thereafter
- Births are asked about "in the order in which they occured"

# Data and workflow | Non-sampling bias in household surveys



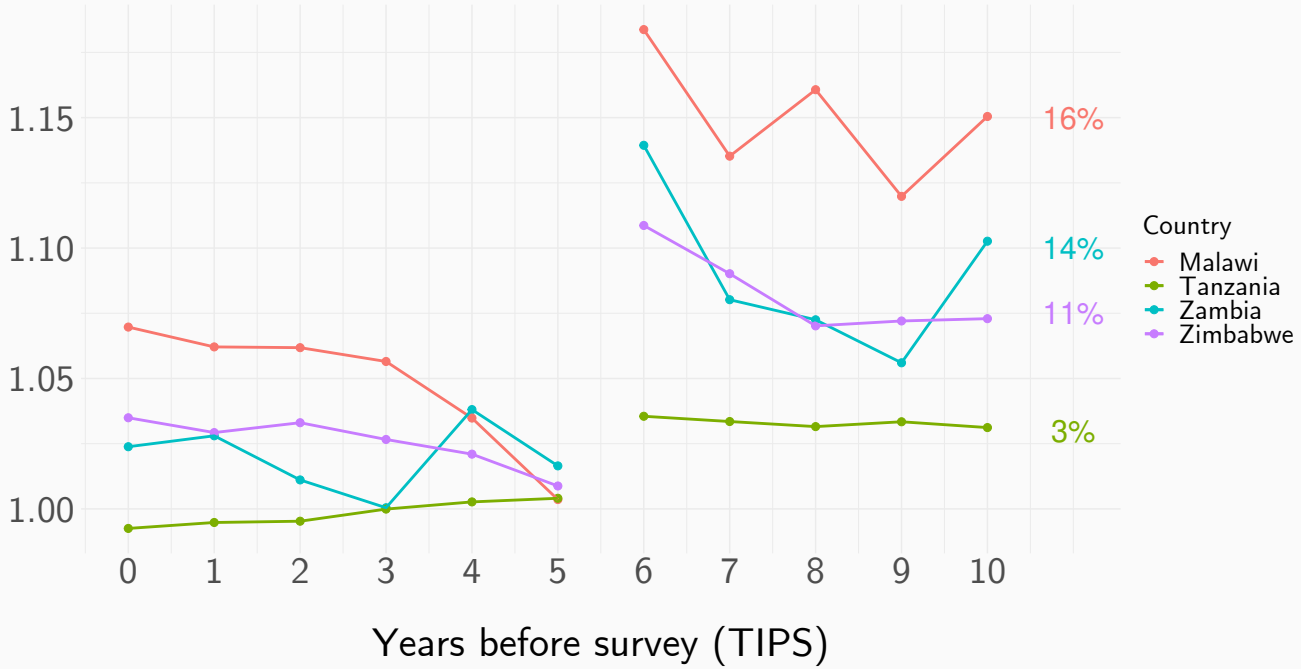
# Data and workflow | Non-sampling bias in household surveys

- Intersurvey analysis can estimate magnitude of bias due to overlap in recall periods (Masquelier, 2013; Schoumaker, 2014)



# Data and workflow | Non-sampling bias in household surveys

- Intersurvey analysis can estimate magnitude of bias due to overlap in recall periods (Masquelier, 2013; Schoumaker, 2014)
- $Y_{a,t,tips} = \mu + \alpha_a + \gamma_t + \beta_1(TIPS > 5) + \omega_{tips}$



# Model specification

$$b_{ait} \sim Po(\lambda_{ait}.E_{ait})$$

$$log(\lambda_{ait}) = \mu + \alpha_a + \gamma_t + \delta_i + \eta_{a,t} + \eta_{a,i} + \eta_{i,t}$$

Average log fertility rate: $\mu \sim N(0, 5)$

Age pattern: $\alpha_a \sim RW1(\sigma^2_\alpha)$ $\quad a \in \{15-19, 20-24 ... 45-49\}$

Time trend: $\gamma_t \sim RW2(\sigma^2_\gamma)$ $\quad t \in \{1995 : 2020\}$

Spatial correlation: $\delta_i \sim BYM2(\sigma^2_\delta)$ $\quad i \in \{1 ... n_i\}$

# Model specification

$$b_{ait} \sim Po(\lambda_{ait}.E_{ait})$$

$$log(\lambda_{ait}) = \mu + \alpha_a + \gamma_t + \delta_i + \eta_{a,t} + \eta_{a,i} + \eta_{i,t}$$

$\eta_{a,t} : AR1 \otimes AR1$

$\eta_{a,i} : AR1 \otimes ICAR$

$\eta_{i,t} : ICAR \otimes AR1$

# Model specification

$$b_{ait} \sim Po(\lambda_{ait}.E_{ait})$$

$$log(\lambda_{ait}) = \mu + \alpha_a + \gamma_t + \delta_i + \eta_{a,t} + \eta_{a,i} + \eta_{i,t}$$

Observation model

$$log(\tilde{b}_{ait}) = log(\lambda_{ait} \times E_{ait}) + \beta_1 TIPS_d + \omega_{TIPS}$$

$$TIPS_d = \begin{cases} 0, & \text{if TIPS} < 5 \\ 1, & \text{otherwise} \end{cases}$$

$\omega_{tips} \sim RW1(\sigma^2_\omega)$ $\qquad$ $tips \in \{0 : 14\}$

# Model specification

$$b_{ait} \sim Po(\lambda_{ait}.E_{ait})$$

$$log(\lambda_{ait}) = \mu + \alpha_a + \gamma_t + \delta_i + \eta_{a,t} + \eta_{a,i} + \eta_{i,t}$$

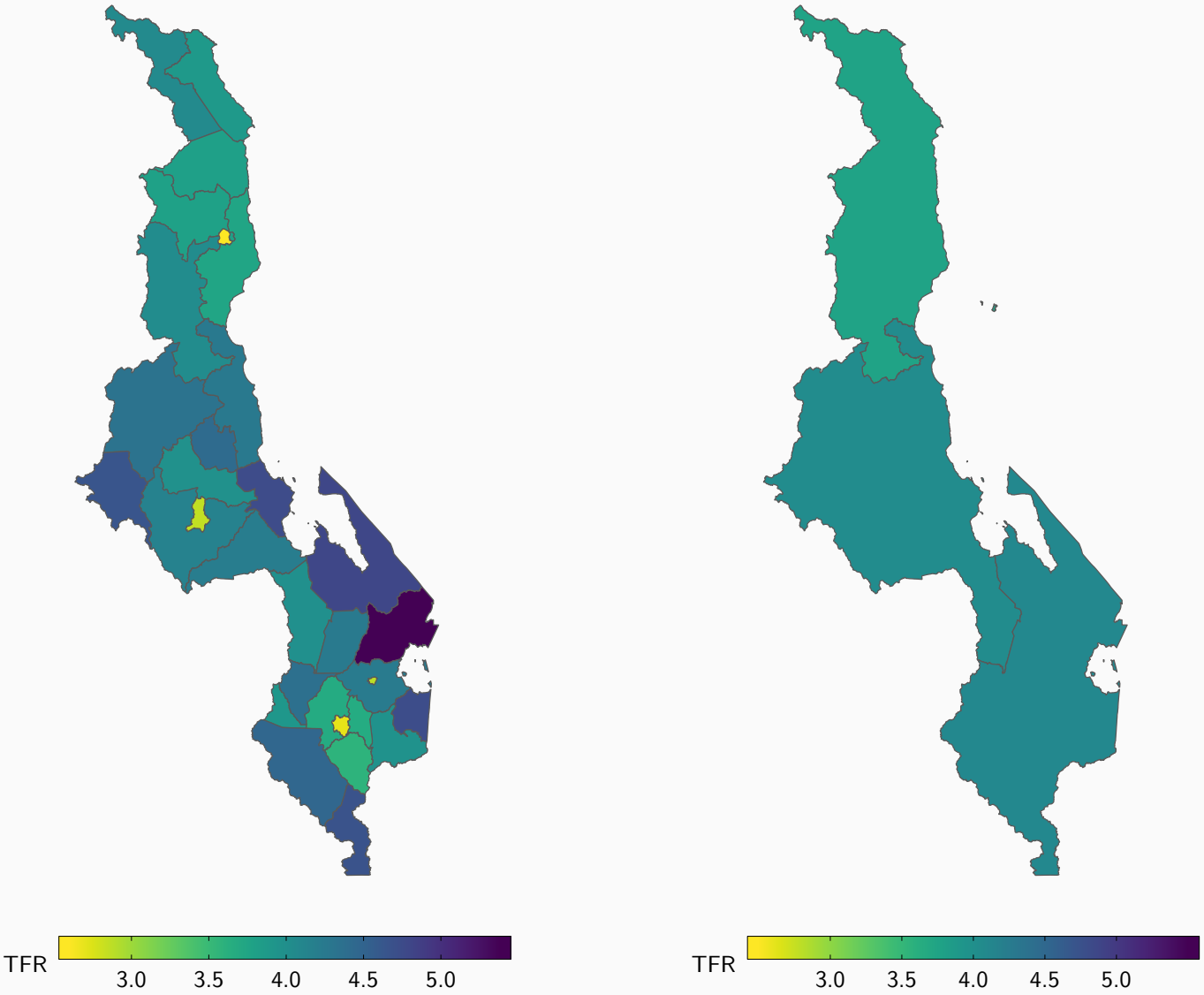
Aggregation model

$$log(\tilde{b}_{at}) = \frac{\Sigma_i log(\lambda_{ait} \times E_{ait})}{E_{at}} + \beta_1 TIPS_d + \omega_{TIPS}$$

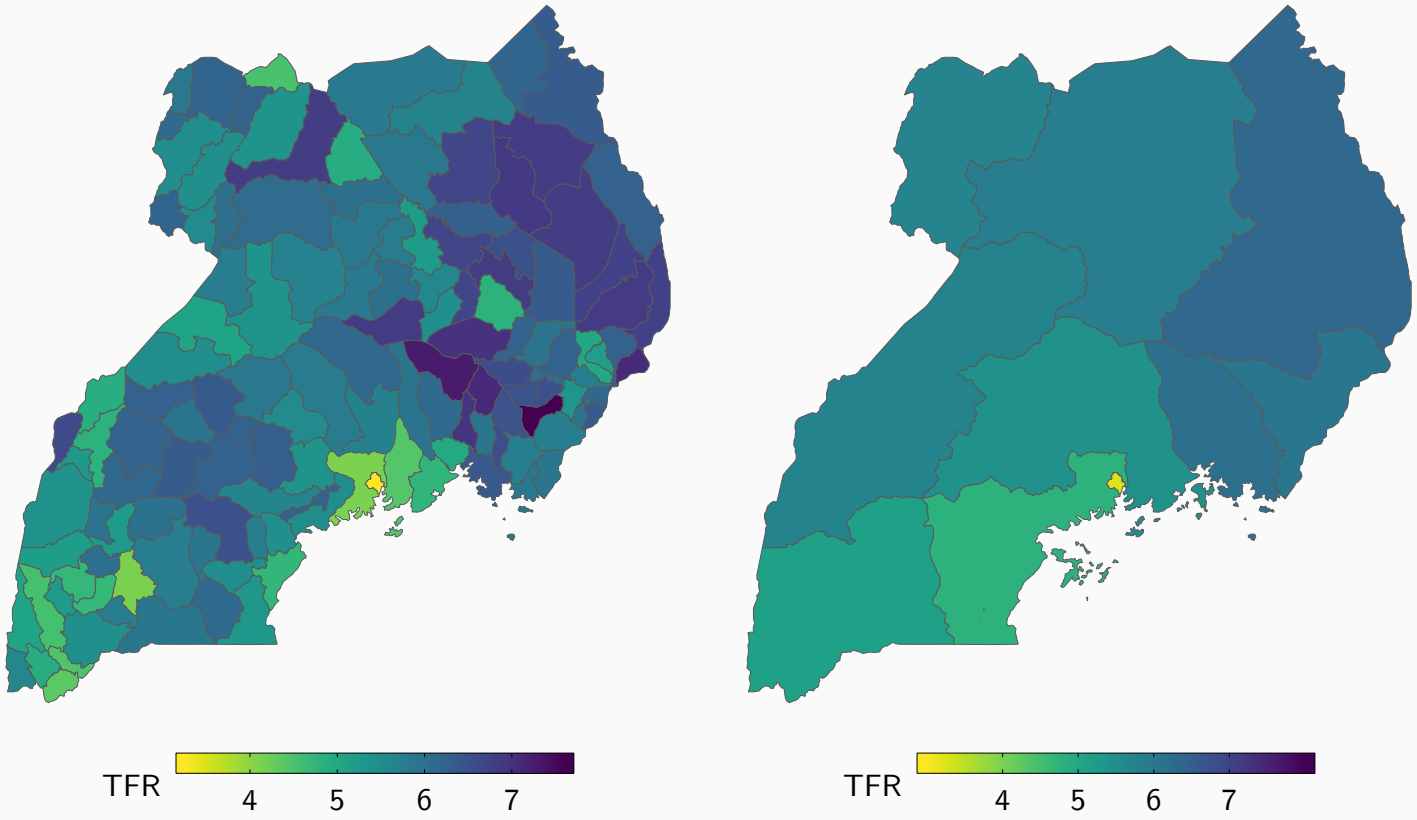
# Model specification

- Model fit in Template Model Builder (TMB)
- Countries take $< 2$ minutes to fit and sample

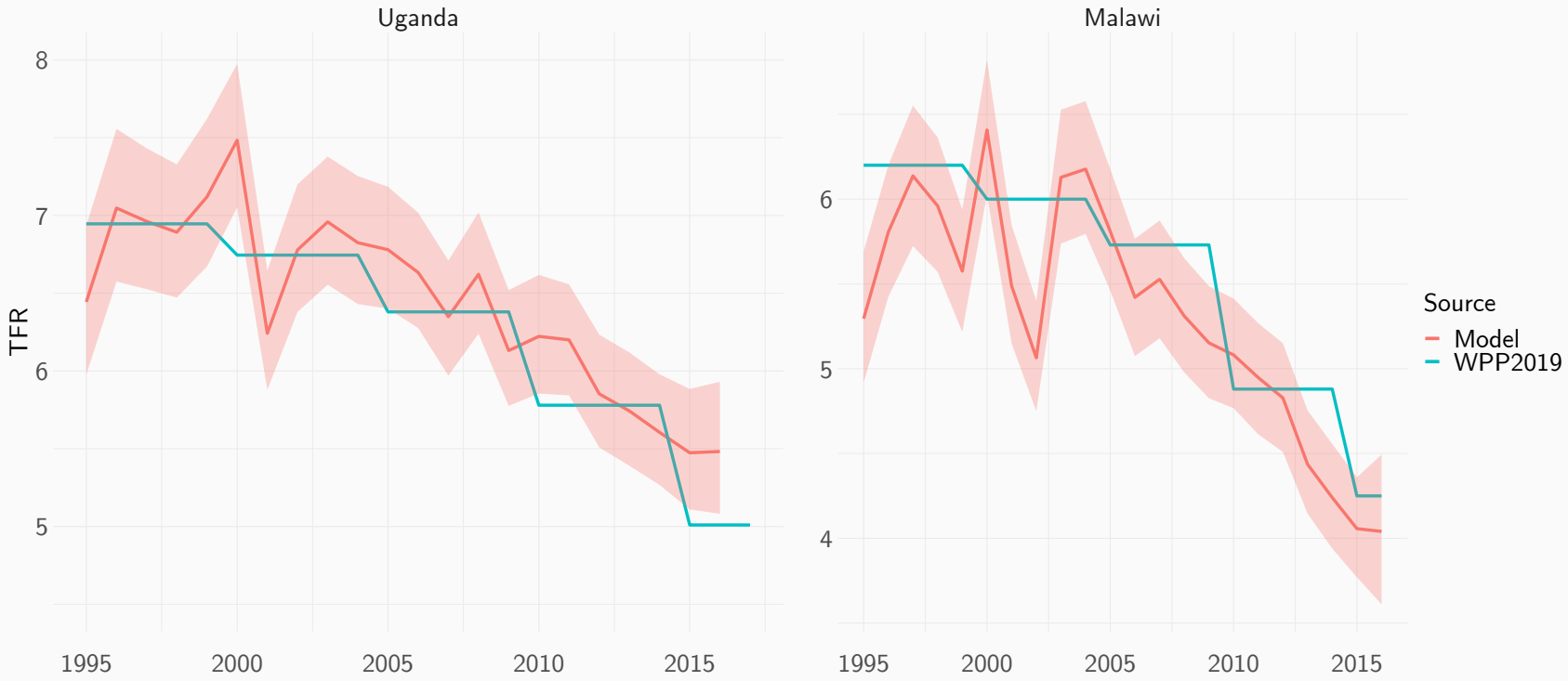
# Results



# Results



# Results


Uganda
Malawi
TFR
8
7
6
5
4
1995
2000
2005
2010
2015
Source
Model
WPP2019

# Discussion

- There exists district-level heterogeneity that is not captured by admin-1 estimates
- Non-sampling bias can lead to substantial distortion of fertility estimates in surveys
  - Role of bias adjustment depends on measure of fertility
- Can be adjusted for within automated analysis
- Consideration of further non-sampling bias
  - Displacement of first birth(s) at older ages

# Future work

- Structured model for fertility transition and projection (Alkema, 2011; Sevkicova, 2012)
- Survey random effects & multi-country fitting
- Census data, additional country-specific surveys, summary birth histories

# Many thanks

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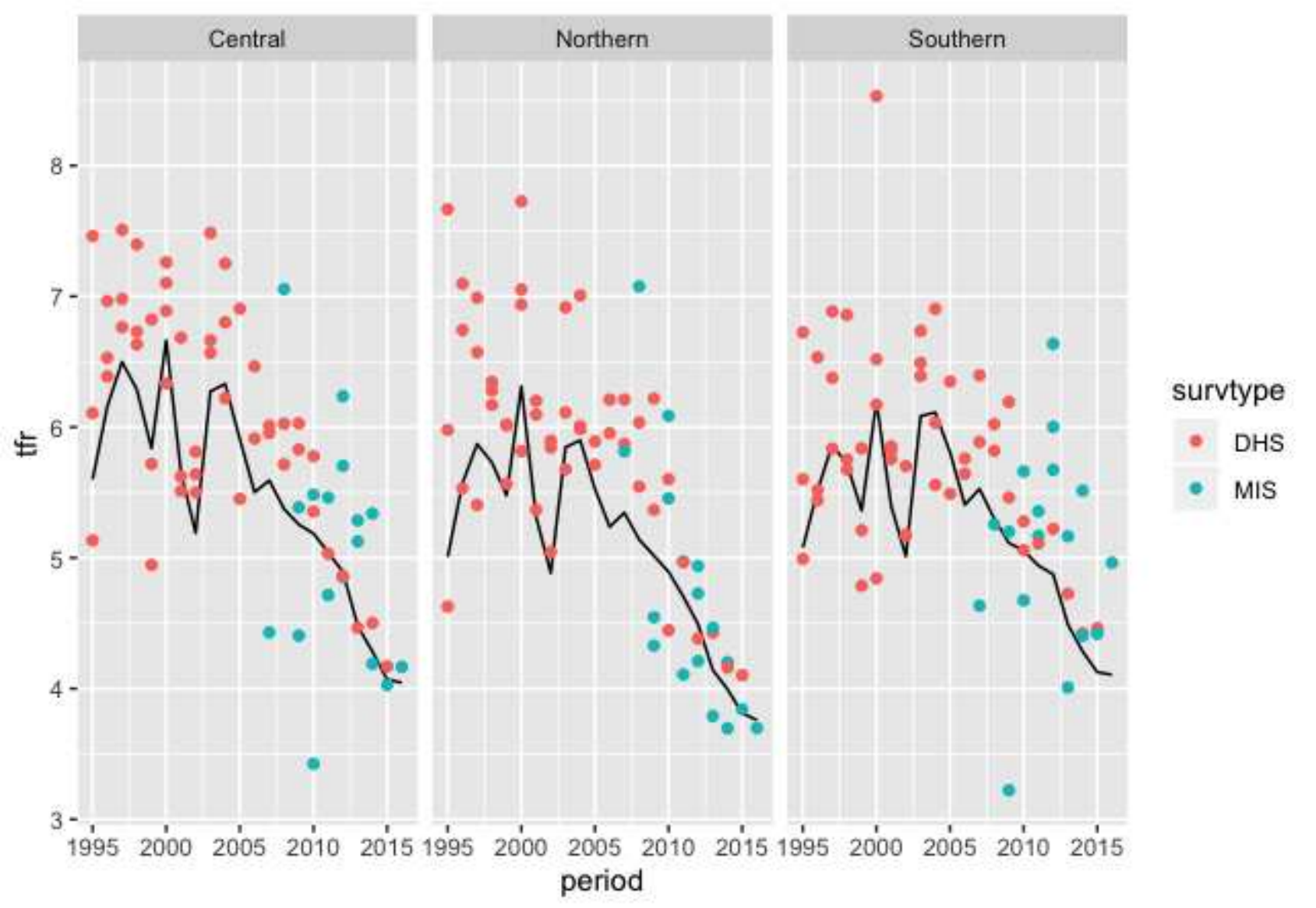
# Extras


Central
Northern
Southern
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# Extras

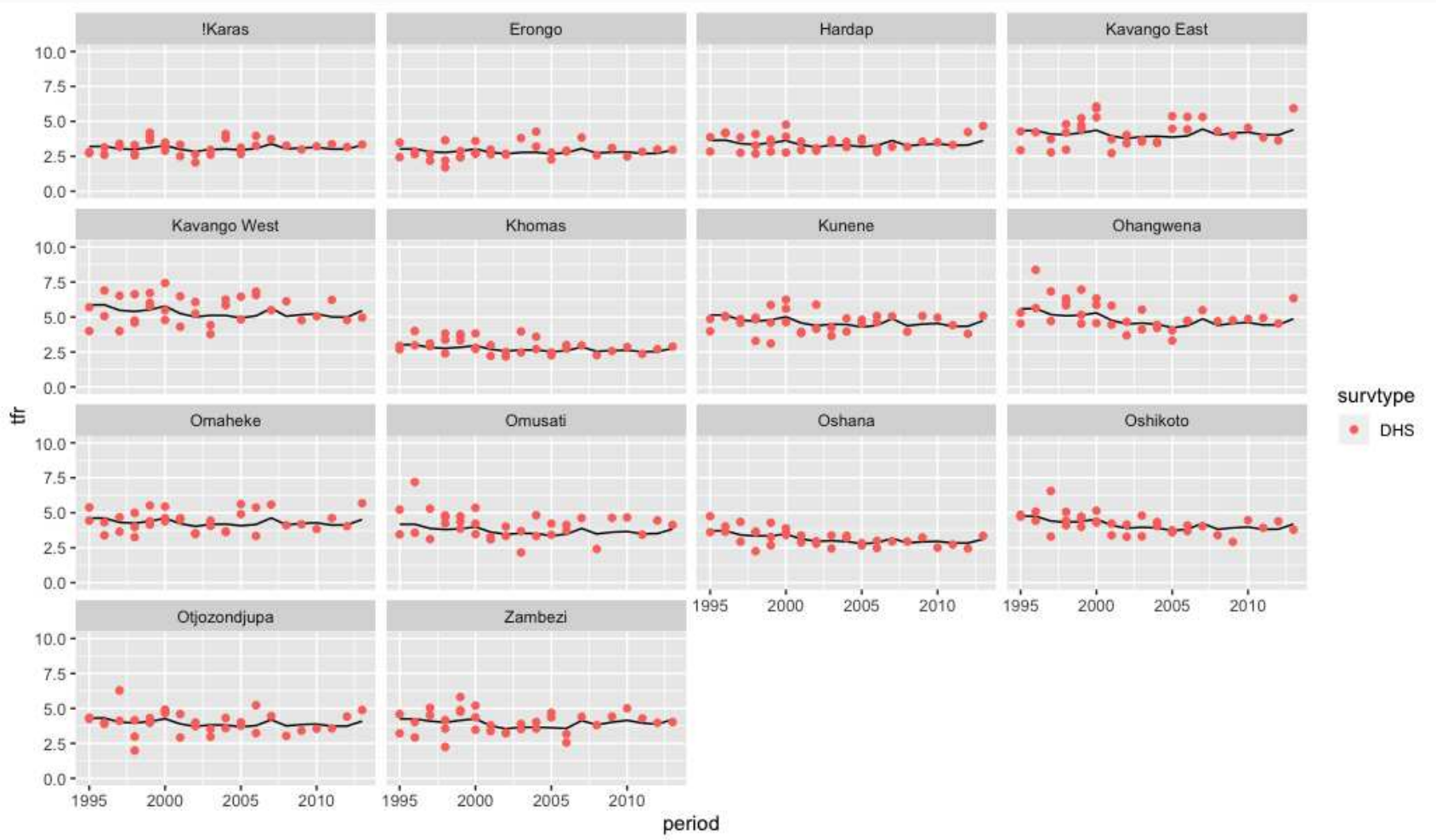



**Figure 2:** NAM admin-1

# Extras

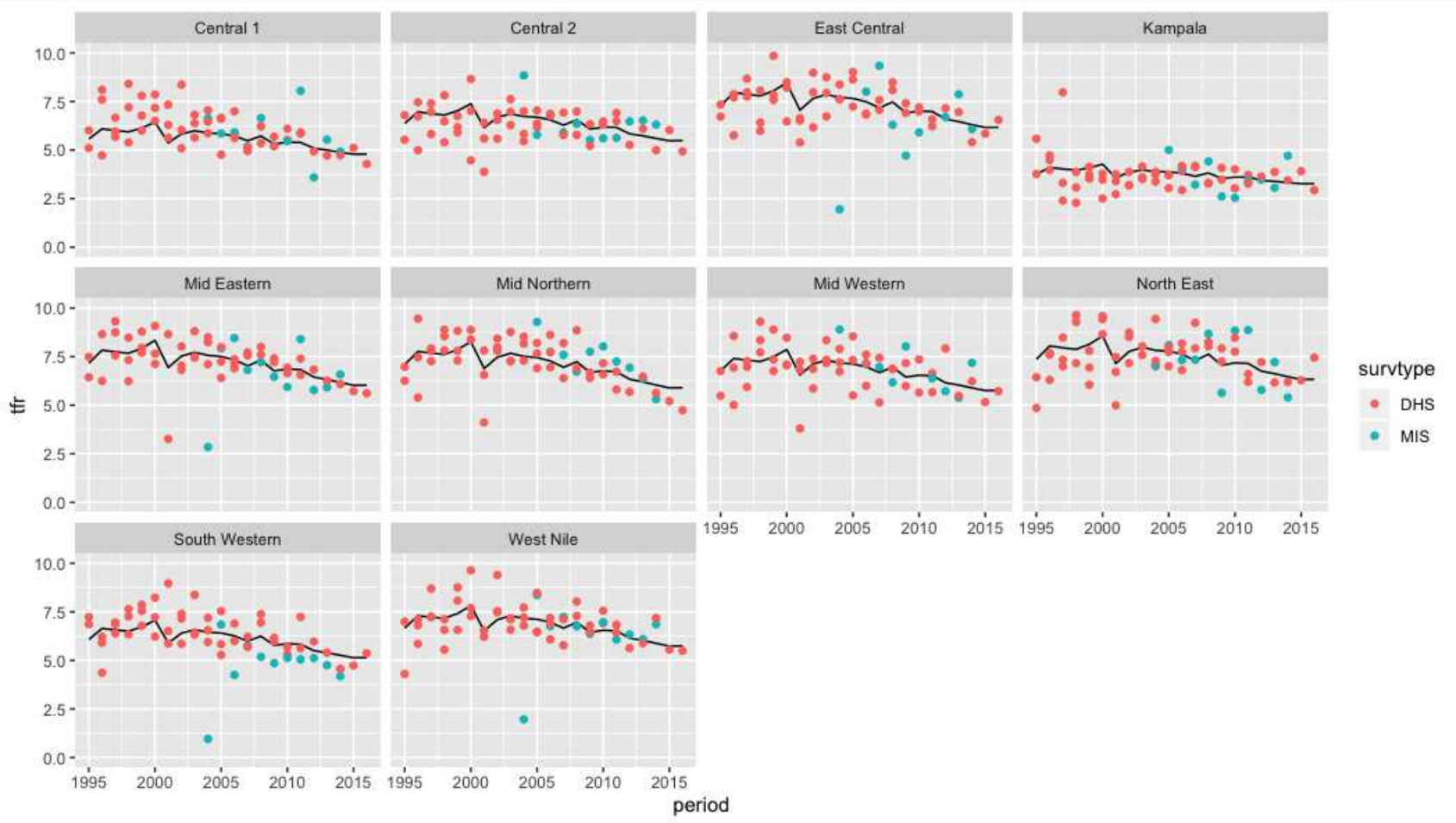



**Figure 3:** UGA admin-1

# Extras

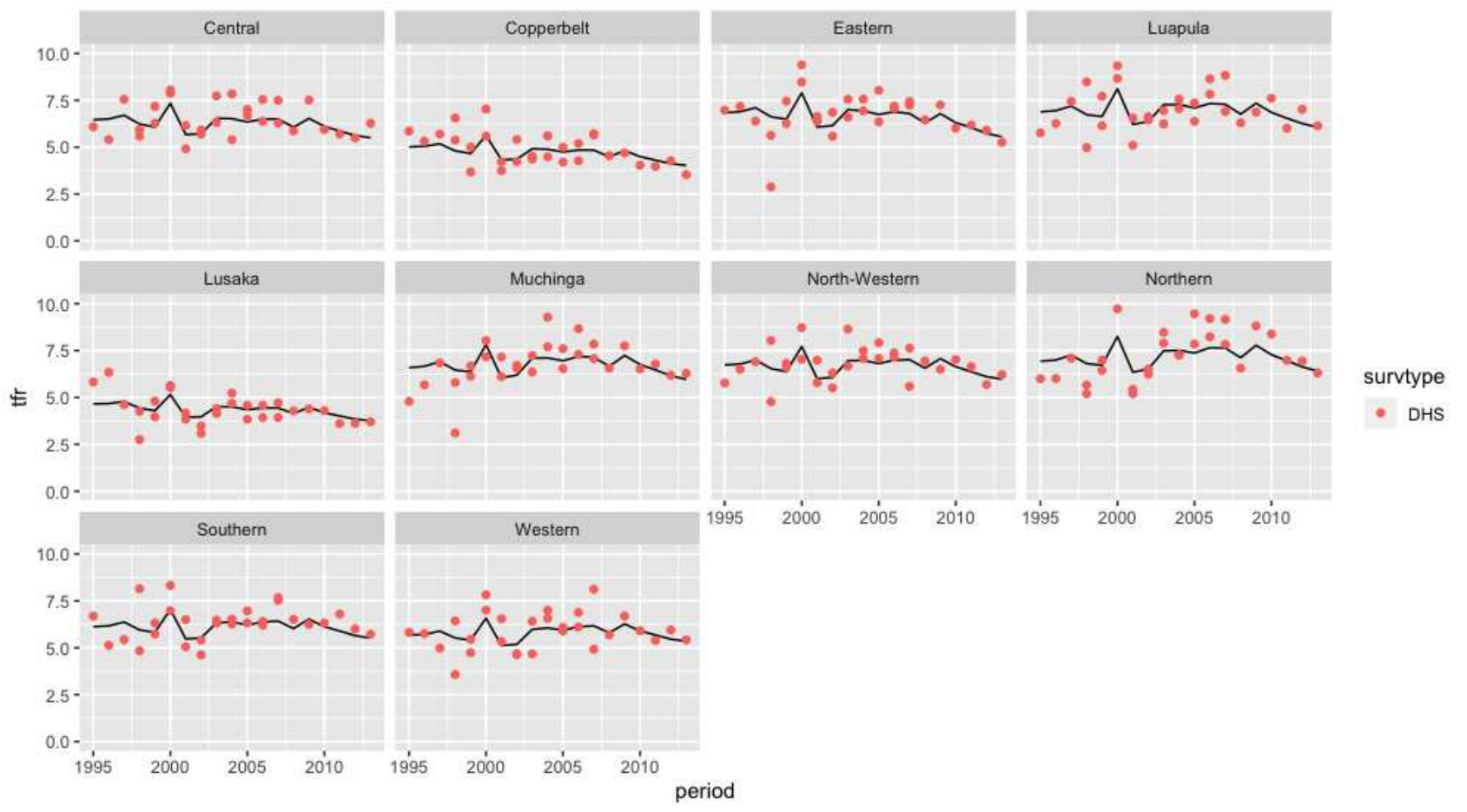
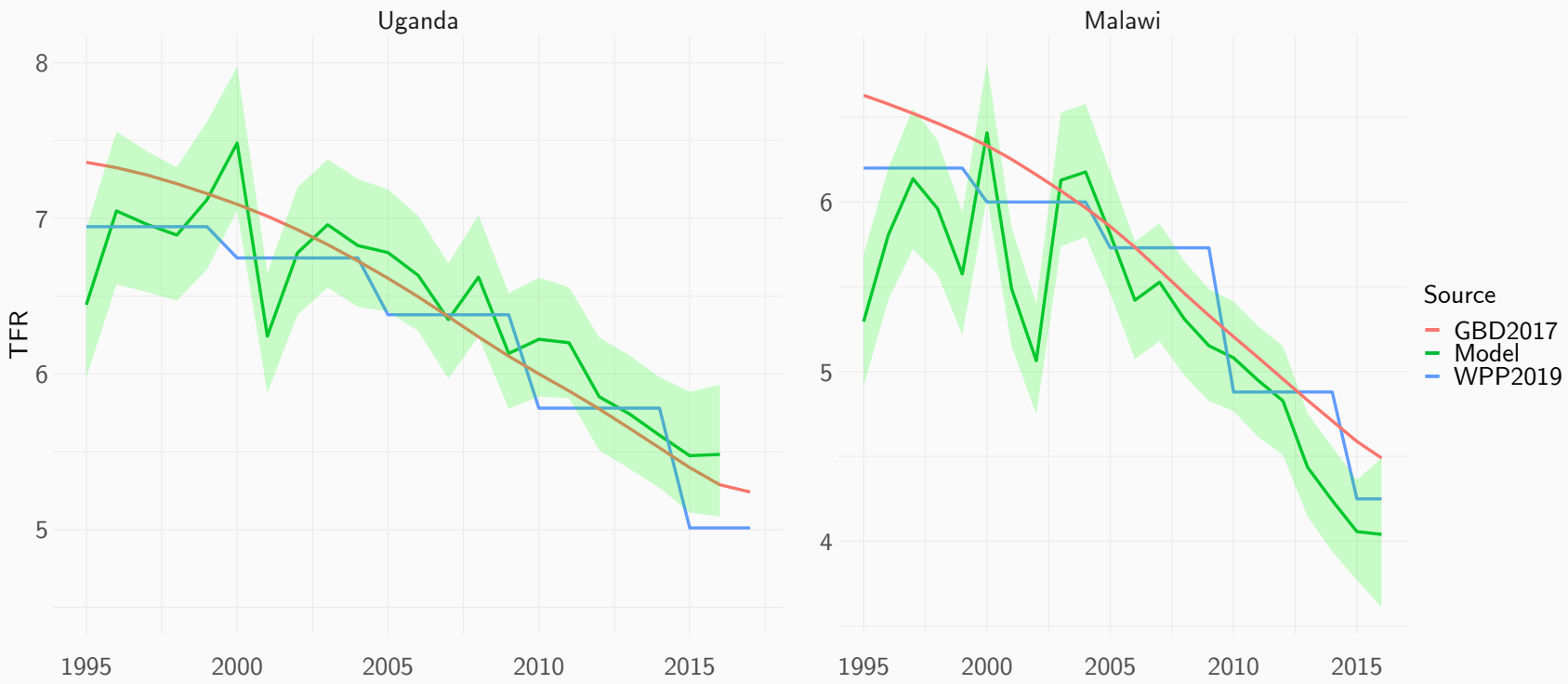



**Figure 4:** ZMB admin-1

# Extras


Uganda
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1995
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