AR1 models in stan

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True values

```
##                  coef betas  n
## 1           cor_y1y2   0.2 12
## 2           cor_y1y3   0.3 13
## 3           cor_y2y3   0.5 23
## 4   wealthindex:y10    0.3 10
## 5   wealthindex:y11    0.4 11
## 6             y1_sd    0.5  1
## 7   wealthindex:y20    0.3 20
## 8   wealthindex:y21    0.8 21
## 9             y2_sd    0.3  2
## 10  wealthindex:y30    0.4 30
## 11  wealthindex:y31    0.5 31
## 12            y3_sd    0.7  3
```

Continous outcome

BRMS

```
##  Family: MV(gaussian, gaussian, gaussian)
##   Links: mu = identity; sigma = identity
##          mu = identity; sigma = identity
##          mu = identity; sigma = identity
## Formula: y1 ~ wealthindex + (1 | hhid) + (1 | years)
##          y2 ~ wealthindex + (1 | hhid) + (1 | years)
##          y3 ~ wealthindex + (1 | hhid) + (1 | years)
##    Data: sim_data (Number of observations: 3000)
## Samples: 2 chains, each with iter = 2000; warmup = 1000; thin = 1;
##          total post-warmup samples = 2000
##
## Correlation Structures:
##          Estimate Est.Error l-95% CI u-95% CI Rhat Bulk_ESS Tail_ESS
## ar_y1[1]     0.82      0.02     0.79     0.85 1.00     1885     1782
## ar_y2[1]     0.80      0.01     0.77     0.82 1.00     3423     1735
## ar_y3[1]     0.80      0.01     0.78     0.83 1.00     1923     1609
##
## Group-Level Effects:
## ~hhid (Number of levels: 100)
##                 Estimate Est.Error l-95% CI u-95% CI Rhat Bulk_ESS
## sd(y1_Intercept)     0.85      0.08     0.70     1.01 1.00      664
## sd(y2_Intercept)     0.55      0.06     0.44     0.68 1.00     1107
## sd(y3_Intercept)     0.88      0.08     0.74     1.03 1.00      633
##                 Tail_ESS
## sd(y1_Intercept)     1156
## sd(y2_Intercept)     1349
```

```
## sd(y3_Intercept)        947
##
## ~years (Number of levels: 30)
##                  Estimate Est.Error l-95% CI u-95% CI Rhat Bulk_ESS
## sd(y1_Intercept)     0.53      0.08     0.40     0.70 1.01      481
## sd(y2_Intercept)     0.31      0.05     0.24     0.41 1.00      570
## sd(y3_Intercept)     0.76      0.11     0.58     1.01 1.00      428
##                  Tail_ESS
## sd(y1_Intercept)      900
## sd(y2_Intercept)      923
## sd(y3_Intercept)      802
##
## Population-Level Effects:
##                Estimate Est.Error l-95% CI u-95% CI Rhat Bulk_ESS Tail_ESS
## y1_Intercept       0.31      0.15     0.03     0.59 1.01      349      645
## y2_Intercept       0.31      0.10     0.12     0.50 1.00      662     1077
## y3_Intercept       0.37      0.17     0.02     0.71 1.00      262      490
## y1_wealthindex     0.40      0.01     0.39     0.42 1.00     4061     1262
## y2_wealthindex     0.82      0.01     0.80     0.84 1.00     5554     1474
## y3_wealthindex     0.51      0.01     0.49     0.52 1.00     4872     1178
##
## Family Specific Parameters:
##           Estimate Est.Error l-95% CI u-95% CI Rhat Bulk_ESS Tail_ESS
## sigma_y1      0.61      0.01     0.60     0.63 1.00     4423     1392
## sigma_y2      0.61      0.01     0.60     0.63 1.00     4305     1286
## sigma_y3      0.61      0.01     0.60     0.63 1.00     4356     1394
##
## Residual Correlations:
##               Estimate Est.Error l-95% CI u-95% CI Rhat Bulk_ESS Tail_ESS
## rescor(y1,y2)     0.00      0.02    -0.03     0.04 1.00     3707     1303
## rescor(y1,y3)    -0.01      0.02    -0.05     0.03 1.00     4420     1233
## rescor(y2,y3)     0.00      0.02    -0.03     0.04 1.00     5021     1260
##
## Samples were drawn using sampling(NUTS). For each parameter, Eff.Sample
## is a crude measure of effective sample size, and Rhat is the potential
## scale reduction factor on split chains (at convergence, Rhat = 1).
```

Binary response

```
## Warning: The model has not converged (some Rhats are > 1.05). Do not analyse the results!
## We recommend running more iterations and/or setting stronger priors.

## Warning: There were 69 divergent transitions after warmup. Increasing adapt_delta above 0.8 may help
## See http://mc-stan.org/misc/warnings.html#divergent-transitions-after-warmup

##  Family: MV(bernoulli, bernoulli, bernoulli)
##   Links: mu = probit
##          mu = probit
##          mu = probit
## Formula: y1bin ~ 0 + intercept + wealthindex + (1 | hhid) + (1 | years)
##          y2bin ~ 0 + intercept + wealthindex + (1 | hhid) + (1 | years)
##          y3bin ~ 0 + intercept + wealthindex + (1 | hhid) + (1 | years)
##    Data: sim_data (Number of observations: 3000)
## Samples: 2 chains, each with iter = 2000; warmup = 1000; thin = 1;
```

```
##          total post-warmup samples = 2000
##
## Correlation Structures:
##             Estimate Est.Error l-95% CI u-95% CI Rhat Bulk_ESS Tail_ESS
## ar_y1bin[1]     0.02      0.04    -0.06     0.08 1.00      545      904
## ar_y2bin[1]    -0.05      0.04    -0.12     0.03 1.00      348      800
## ar_y3bin[1]     0.03      0.04    -0.05     0.10 1.00      336      696
## sderr_y1bin     6.21      2.39     1.42    10.70 1.17        8       13
## sderr_y2bin     3.96      1.23     2.04     6.58 1.03       57       77
## sderr_y3bin     5.14      1.91     2.18     9.48 1.13       12      112
##
## Group-Level Effects:
## ~hhid (Number of levels: 100)
##                     Estimate Est.Error l-95% CI u-95% CI Rhat Bulk_ESS
## sd(y1bin_Intercept)     2.56      0.97     0.70     4.45 1.16        8
## sd(y2bin_Intercept)     1.05      0.34     0.54     1.83 1.03       72
## sd(y3bin_Intercept)     2.31      0.85     1.05     4.29 1.13       12
##                     Tail_ESS
## sd(y1bin_Intercept)       12
## sd(y2bin_Intercept)      162
## sd(y3bin_Intercept)      104
##
## ~years (Number of levels: 30)
##                     Estimate Est.Error l-95% CI u-95% CI Rhat Bulk_ESS
## sd(y1bin_Intercept)     2.06      0.82     0.57     3.82 1.15        9
## sd(y2bin_Intercept)     0.25      0.17     0.02     0.66 1.00      180
## sd(y3bin_Intercept)     2.00      0.80     0.85     3.85 1.12       12
##                     Tail_ESS
## sd(y1bin_Intercept)       12
## sd(y2bin_Intercept)      506
## sd(y3bin_Intercept)      156
##
## Population-Level Effects:
##                  Estimate Est.Error l-95% CI u-95% CI Rhat Bulk_ESS
## y1bin_intercept      0.67      0.47    -0.12     1.68 1.05       65
## y1bin_wealthindex    1.45      0.53     0.42     2.39 1.18        8
## y2bin_intercept      0.81      0.27     0.38     1.41 1.03       78
## y2bin_wealthindex    2.02      0.58     1.11     3.24 1.03       57
## y3bin_intercept      0.88      0.46     0.11     1.91 1.03      138
## y3bin_wealthindex    1.43      0.51     0.65     2.58 1.13       12
##                  Tail_ESS
## y1bin_intercept       228
## y1bin_wealthindex      12
## y2bin_intercept       173
## y2bin_wealthindex      84
## y3bin_intercept       487
## y3bin_wealthindex     116
##
## Samples were drawn using sampling(NUTS). For each parameter, Eff.Sample
## is a crude measure of effective sample size, and Rhat is the potential
## scale reduction factor on split chains (at convergence, Rhat = 1).
```

STAN

```
## Inference for Stan model: mvt_probit.
## 2 chains, each with iter=2000; warmup=1000; thin=1;
## post-warmup draws per chain=1000, total post-warmup draws=2000.
##
##            mean se_mean   sd 2.5%  25%  50%  75% 97.5% n_eff Rhat
## beta[1,1] 0.23       0 0.04 0.15 0.20 0.23 0.26  0.31  2627    1
## beta[1,2] 0.39       0 0.04 0.30 0.36 0.39 0.42  0.47  2296    1
## beta[2,1] 0.36       0 0.04 0.27 0.33 0.36 0.39  0.44  2013    1
## beta[2,2] 0.88       0 0.05 0.79 0.85 0.88 0.91  0.97  1281    1
## beta[3,1] 0.33       0 0.04 0.25 0.30 0.33 0.36  0.41  2244    1
## beta[3,2] 0.46       0 0.04 0.39 0.44 0.46 0.49  0.55  1912    1
##
## Samples were drawn using NUTS(diag_e) at Sun Jan 12 20:12:51 2020.
## For each parameter, n_eff is a crude measure of effective sample size,
## and Rhat is the potential scale reduction factor on split chains (at
## convergence, Rhat=1).
```