Dynamic Additive and Multiplicative Effects (DAME) Network Model with Application to the United Nations Voting Behaviors

Bomin Kim[1] Xiaoyue Niu[1]
David Hunter [1] Xun Cao[2]

[1] Department of Statistics

[2] Department of Political Science

The Pennsylvania State University

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Dynamic Additive and Multiplicative Effects Model

- Network regression model for symmetric discrete-time networks
- Integration of two existing works:
  1. Model formulation: AMEN for latent factor models (Minhas, Hoff, and Ward, 2016)
  2. GP Priors: Bayesian dynamic networks with time-varying predictors (Durante and Dunson, 2014)

Model Formulation

- For $N \times N$ symmetric matrices $\mathcal{Y} = \{Y(t), t \in \mathcal{T}\}$, define $(i,j)^{th}$ entry

$$y_{ij}(t) = X_{ij}^T(t)\beta(t) + \theta_i(t) + \theta_j(t) + u_i(t)^T D(t) u_j(t) + \epsilon_{ij}(t),$$

where

1. $\beta(t)$: $P-$dimensional edge covariate effects
2. $\theta_i(t)$ and $\theta_j(t)$: additive nodal random effects of i and j
3. $u_i(t)^T D(t) u_j(t)$: multiplicative random effect
4. $\epsilon_{ij}(t)$: random noise

- Each parameter has Gaussian process (GP) priors

$$\beta_p(\cdot) \sim \text{GP}(0, \tau_p^\beta c_\beta) \text{ for } p = 1, ..., P$$
$$\tau_p^\beta \sim \text{IG}(a_\beta, b_\beta) \text{ and } c_\beta(t, t') = f(\kappa_{\beta_p}, |t - t'|),$$

where $f()$ is Exponential or squared Exponential covariance functions.

United Nations Voting Networks

- Roll-call votes in the UN General Assembly 1983-2014 (Voeten et al., 2016)
- 23 most active countries in international relations (Hoff, 2015)
- Annual agreement network from 'Yes', 'No', and 'Abstain'
- Six relevent dyadic predictors:
  1. Intercept
  2. log(distance)$_{ij}$
  3. Alliance$_{ijt}$
  4. Polity score difference$_{ijt}$
  5. Lower trade-to-GDP ratio$_{ijt}$ (Gartzke, 2000)
  6. Common language$_{ij}$

Results: Main Effects and Random Effects