A.1.2. *Von Mises*. For the von Mises distribution, we have $f(x,\mu) = K \times \exp\{\kappa\cos(x-\mu)\}, 0 < x, \mu < 2\pi$. The mode is $\hat{x} = \mu$; thus, $(\ell'')_{\hat{x}=\mu} = -\kappa$, and the approximation is $X \simeq N(\mu, \frac{1}{\kappa})$, which is a well-known normal approximation to the von Mises distribution [Mardia and Jupp (2000), page 38].

A.1.3. *Halfnormal-gamma*. For the halfnormal-gamma distribution, we have

$$\begin{aligned}\ell &= \log f(x; r, \nu, \delta)\\ &= \log K + (r-1)\log x - \frac{1}{2}\nu x^2 + \delta x,\\ \ell' &= \frac{(r-1)}{x} - \nu x + \delta\end{aligned}$$

and

$$\ell'' = -\frac{(r-1)}{x^2} - \nu,$$

leading to an approximate variance given by $\{\nu + \frac{(n-1)}{\hat{x}^2}\}^{-1}$. Recall that the mode is $\hat{x} = \{\delta + \sqrt{\delta^2 + 4(r-1)\nu}\}/2\nu$. We therefore have the approximation $X \simeq N(\hat{x}, \mathrm{Var}(X))$. We find the approximation to be better for larger r and δ; even for small r, the approximation is good for positive values of δ, but less good for relatively large negative values of δ. Further details are given in the supplementary material.

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SUPPLEMENTARY MATERIAL

Simulation methods and a normal approximation for the halfnormal-gamma distribution (DOI: 10.1214/12-AOAS615SUPP; .pdf). We describe an acceptance-rejection method for simulating from the halfnormal-gamma distribution and investigate its efficiency over a range of parameter settings. We also investigate further the normal approximation to the halfnormal-gamma distribution, which we use to obtain efficient proposals in our Metropolis updates. We show that the approximation is best for parameter values where the acceptance-rejection method is less efficient, and hence that the two simulation methods complement each other well. aoas615_supp.pdf