Dependence in Spikes of Energy and Agricultural Prices

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Dependence in Spikes of Energy and Agricultural Prices

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Contribution

Using elements of extreme value theory, I develop a Bayesian modeling approach that is capable of capturing the extremal dependence structures characterizing energy and agricultural prices. This approach is based on asymptotic arguments that hold for many underlying distributions of prices. Positive and negative movements of prices are considered separately which allows for asymmetry. Because the model is applied only to returns designated as extreme, inference does not depend on observations in the main body of the distribution. This is appealing because there is no reason to suspect a priori that the processes generating non–extreme and extreme observations are similar.

Model and Estimation

A Poisson process is assumed to be valid in the limit over the entire region A containing extreme observations. Margins are standard Fréchet. The threshold is chosen so the point process likelihood reduces to $L(\alpha, w) \propto \prod_{i=1}^{N_A} h(w_i)$. The logistic dependence function h is

$$h(w) = \frac{1}{2}(\alpha^{-1}-1)[w(1-w)]^{-1-1/\alpha}[w^{-1/\alpha}+(1-w)^{-1/\alpha}]^{\alpha-2} \quad (1)$$

where $0 < \alpha < 1$. The larger is α, the weaker the dependence. Angular measure $w = \frac{x}{x+y}$ is constructed by transforming the data to pseudo-polar coordinates.

The dependence parameter α has a beta prior. Estimation is possible using a Metropolis–Hastings algorithm with a normal jumping distribution centered on a transformation of α.

General Procedure:

1. Transform margins to unit Fréchet using the empirical CDF or estimated parameters
2. Plot χ and $\bar{\chi}$ to inform choice of dependence function
3. Select threshold of the form $u = x + y$ (L1 norm) and retain exceedances in region A
4. Transform to pseudo–polar coordinates
5. Use MH algorithm to estimate α

Dependence Characterizations

Asymptotic dependence holds when

$$P(s) = Pr(F(X) > s|F(Y) > s) \quad (2)$$

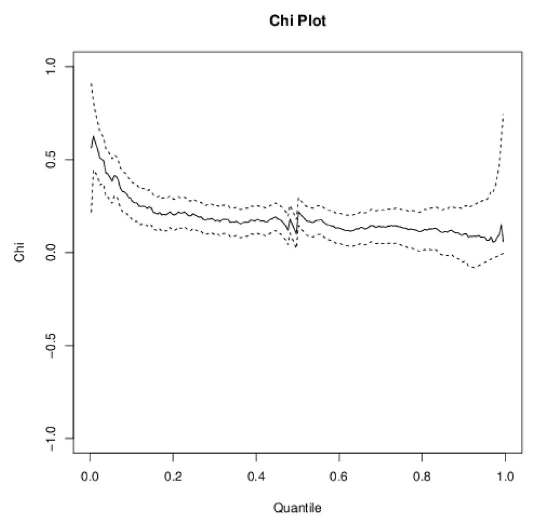
is nonzero as s approaches the endpoint of F. Otherwise, the two variables are asymptotically independent.

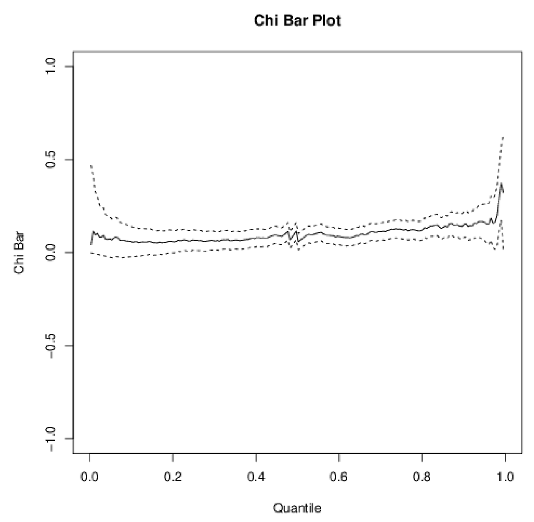
The following nonparametric measures can be used to examine the asymptotic dependence of two series.

$$\chi = \lim_{s\to\infty} \frac{Pr(X > s, Y > s)}{Pr(Y > s)} \quad (3)$$

$$\bar{\chi} = \lim_{s\to\infty} \frac{2\log Pr(Y > s)}{\log Pr(Y > s, X > s)} - 1 \quad (4)$$

These summaries are constrained such that $0 \leq \chi \leq 1$ and $-1 \leq \bar{\chi} \leq 1$. The two variables X and Y are asymptotically independent when $\chi = 0$ and the degree of dependence is given by $\bar{\chi}$. When $\bar{\chi} = 1$, the variables are asymptotically dependent with the degree of dependence given by χ.





Stationarity and Clustering

Stationarity is induced by examining log differenced prices (returns) instead of raw prices.

Clustering presents a serious impediment to the use of extreme value methods. Clustering of extremes is measured using the extremal index of Smith and Weissman which can be interpreted roughly as the inverse of the mean cluster size.

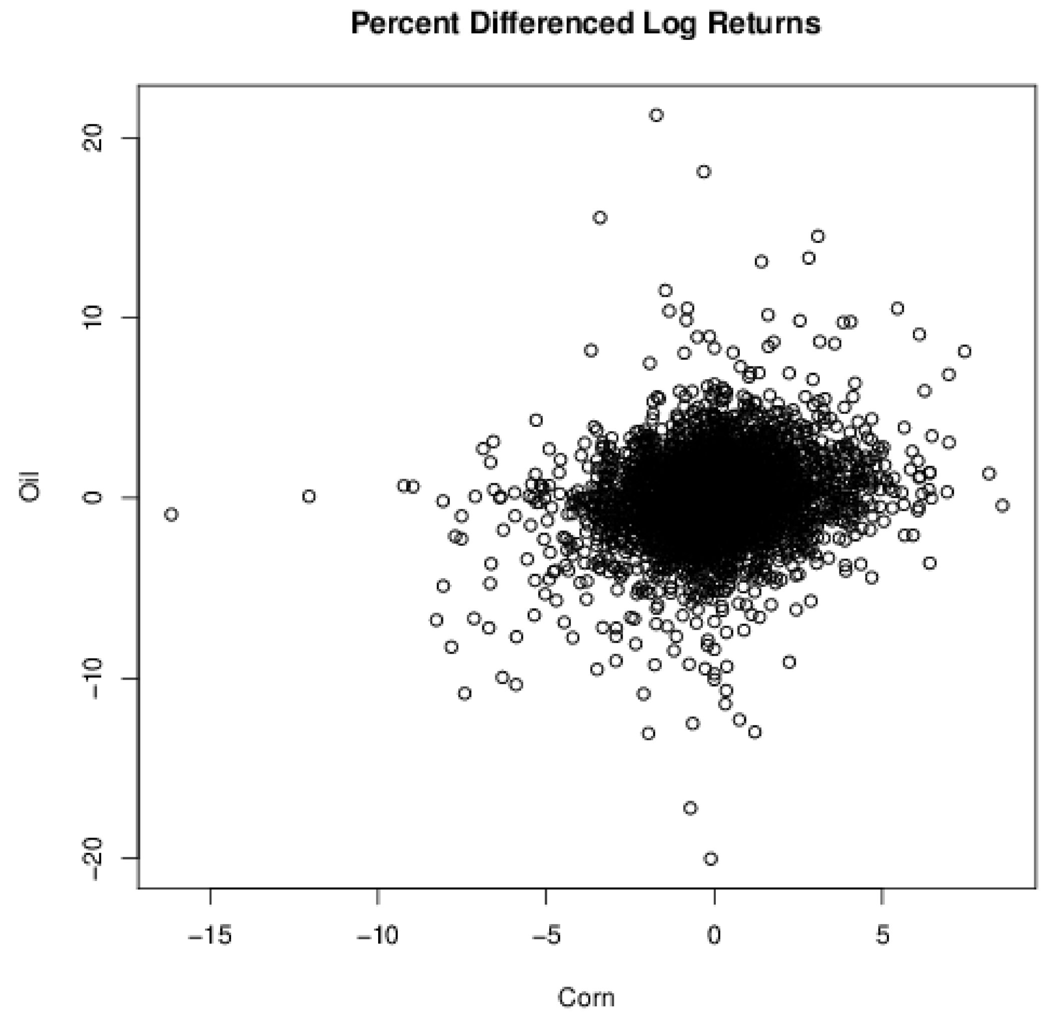
Series	Extremal Index
Corn	0.932
Oil	0.938

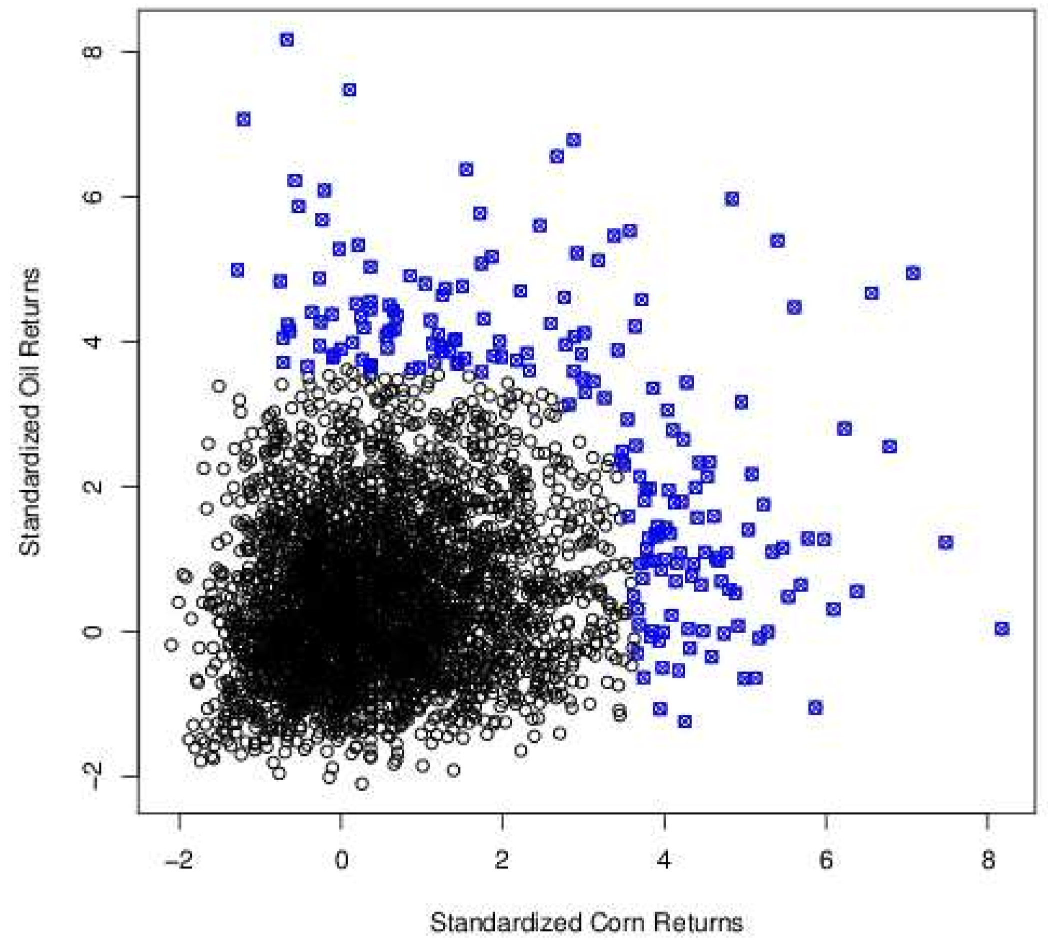
There is little evidence of clustering at thresholds selected at the 95th quantiles.

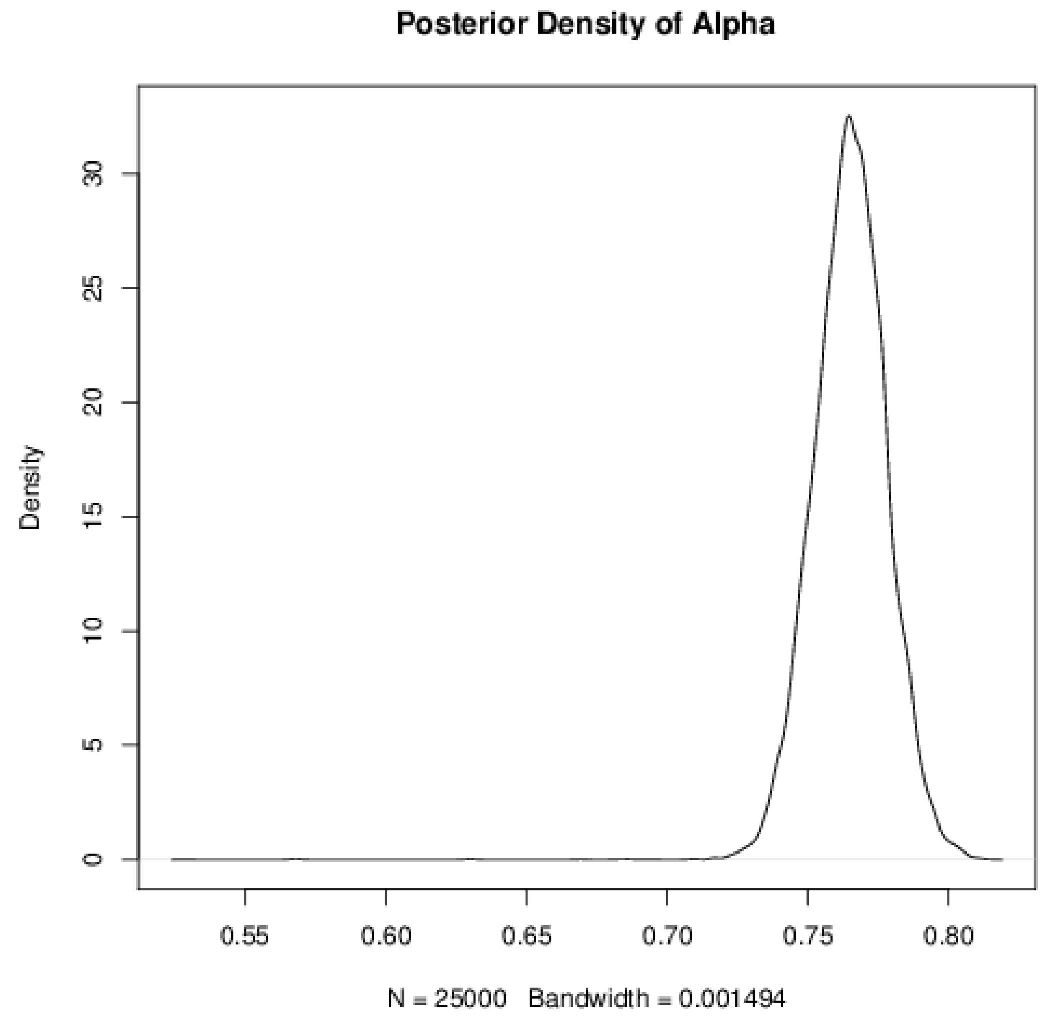
Results

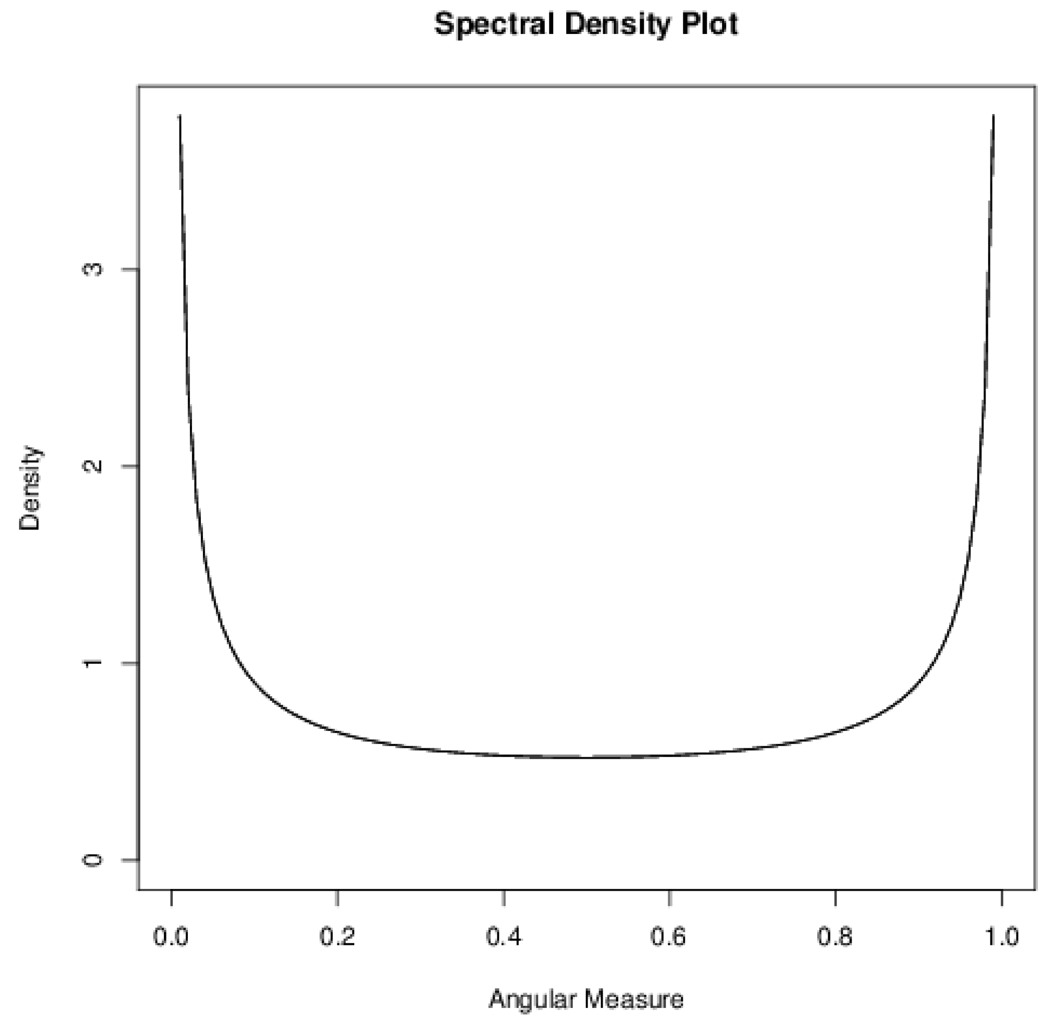
The data consists of daily cash prices for corn as reported by the CME and crude oil as reported by the NYME from January 5, 2000 to February 28, 2014. Daily returns were constructed by taking the difference of logarithmic prices and multiplying by 100.

The following results are for extreme positive returns. The threshold is $u = x_{95} + y_{95}$ where $(\cdot)_{95}$ is the 95th quantile function. Only blue points were retained. The prior is $\beta(2, 2)$. The posterior mean of α is 0.765, indicating relatively weak dependence.









Extensions

- Joint estimation of marginal distributions and dependence function
- Non–degenerate dependence functions
- Time–varying dependence parameters

References

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