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Geophysical time series vs. financial time series of agricultural products: similarities and differences

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1. Abstract

It is known that agricultural systems depend on hydrometeorological factors such as rainfall and temperature. The purpose of this research is to analyse financial time series of agricultural products (e.g. wheat, coffee, corn, etc.), i.e., historical prices and futures prices, in comparison to time series of rainfall and temperature. The first target of the study is to spot possible similarities and differences in the stochastic characteristics between them, while the second is to explore whether these two types of time series are correlated in particular production areas.

2. Methodology and Datasets

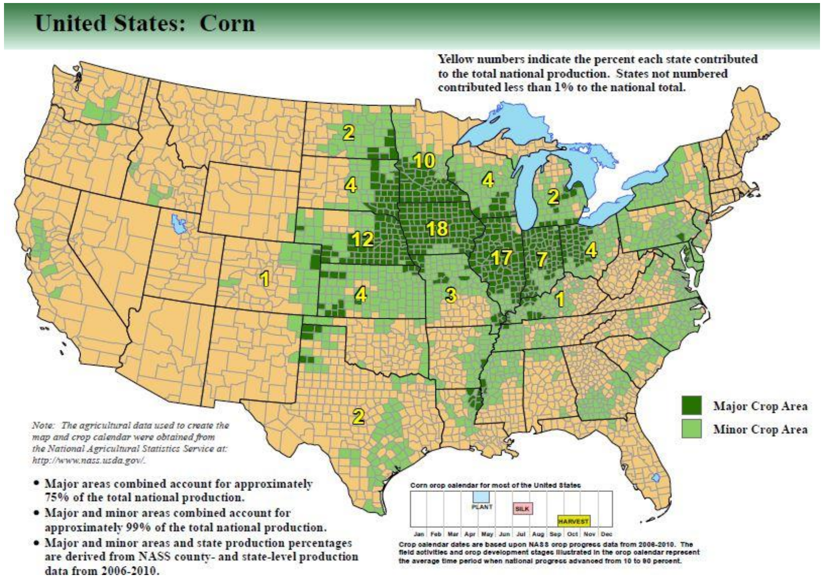
Commodity prices are affected by unstable conditions of demand and supply, which primarily depends on weather. For example, in 2005, during the Midwest crop season, there was a drought that lasted up until the beginning of August driving up the price of many agricultural products, including soybeans.(Cinquegani, 2006).

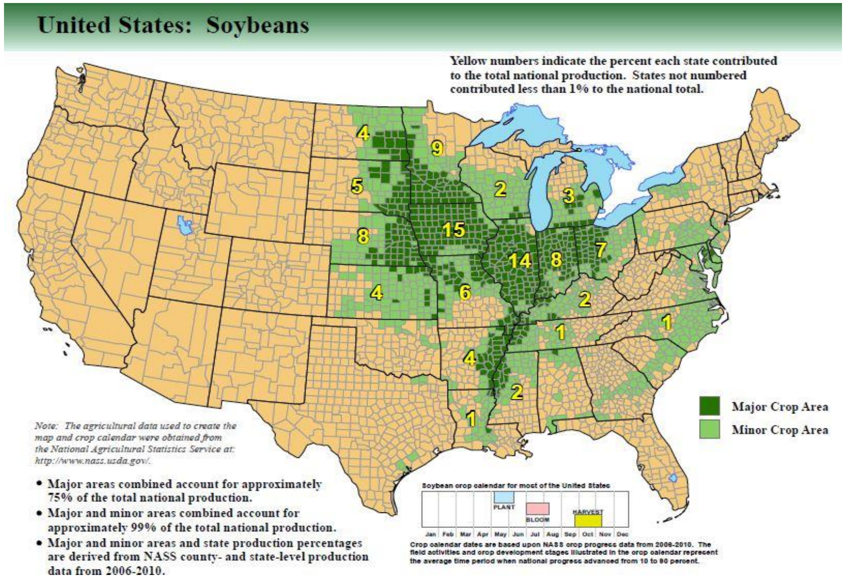
In this study, the products that are chosen for further analysis are corn and soybeans due to the fact that USA is the largest producer (about 30% of the World production) therefore their production areas can be dominated by a regional weather phenomenon.

Specifically economic datasets include:

- average nominal monthly prices received by farmers in the USA (Source: USDA, National Agricultural Statistics Service, Agricultural Prices). The initial nominal prices were deflated using CPI and both used after removing trend (with linear transformation),
- and monthly Settle Future contracts from CBOT (period *1947-2012*) .

Hydrometeorological datasets include time series of daily rain and temperature observed in the production area (period *1897-2012*).





SOURCE: *USDA, Agricultural weather Assessments*
World Agricultural Outlook Board

3.Methology

- Production area was divided into cells of dimensions of longitude and latitude differences of 5^{o} and 2.5^{o} respectively. Then for each cell 5 representative stations were selected.

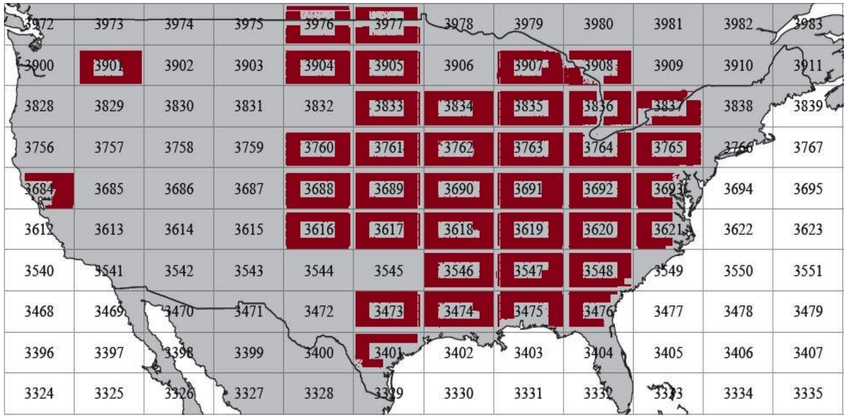


Figure 1. Corn production area in which 200 rainfall and 180 temperature stations were studied.

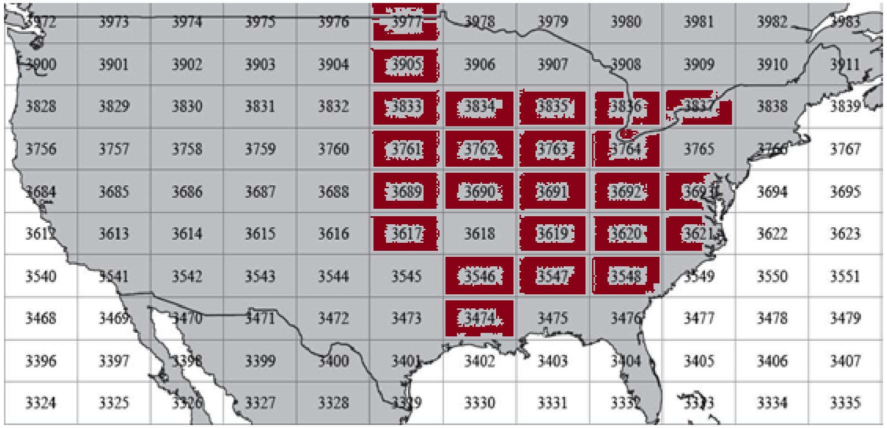
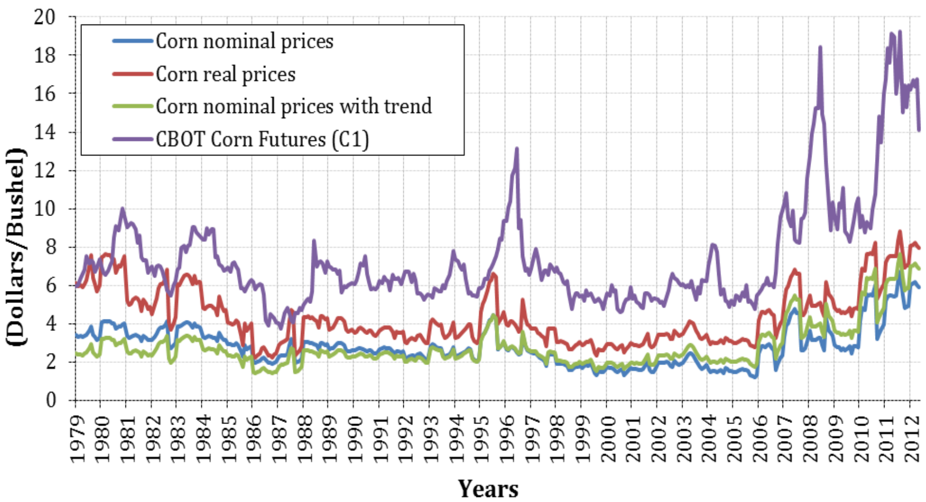


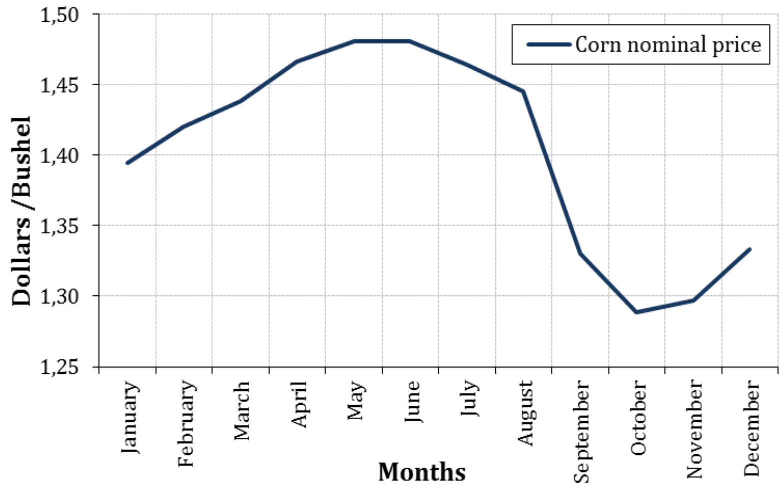
Figure 2. Soybeans production area in which 120 rainfall and 100 temperature stations were studied.

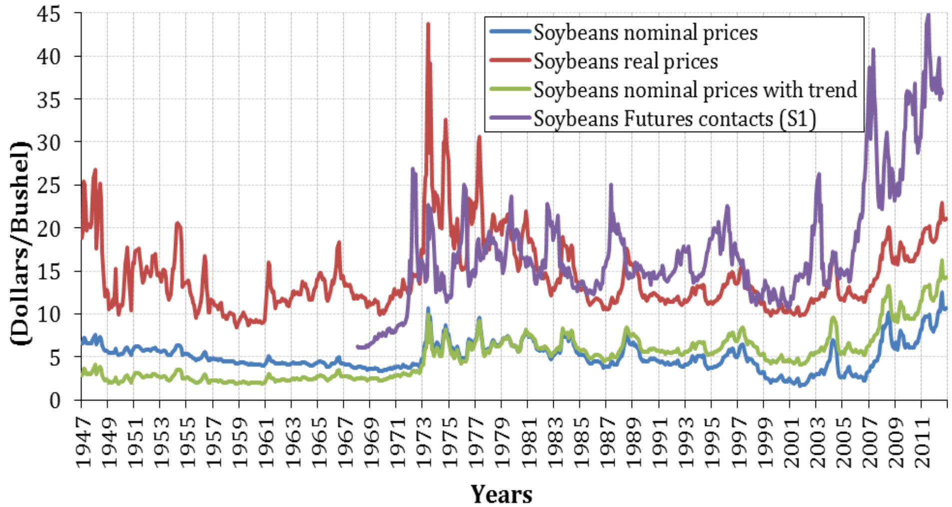
- From the daily rainfall time series the monthly rainfall was calculated.
- From the daily maximum temperature time series the monthly average was calculated.
- If a month had more than 7 days missing it was not taken into consideration.

In order to infer about the appropriate theoretical distribution of the above samples L-moment ratio diagrams were used. L-moments are widely used especially in Hydrology for statistical analysis.(Vogel and Fennessey, 1993; Lee and Maeng, 2003).

4. Monthly Timeseries of commodity prices







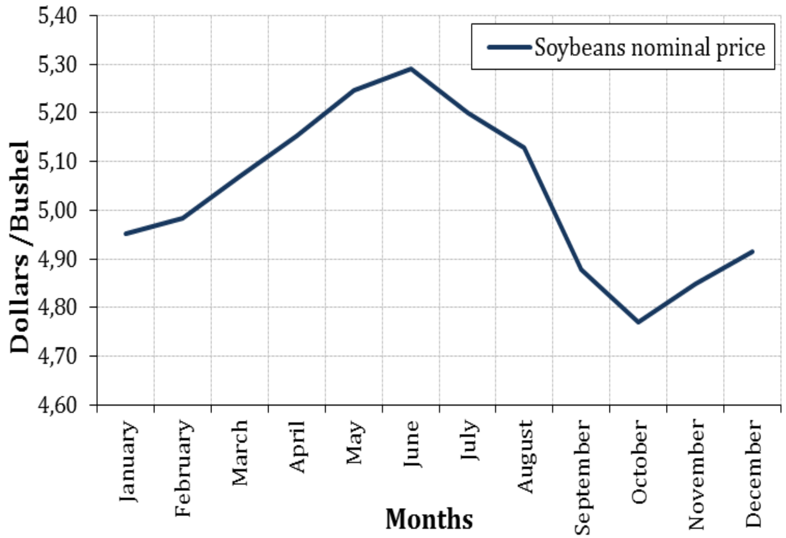


Figure 3. Monthly nominal and real prices received by farmers US . Historical Futures Prices: Corn and Soybeans Futures, Continuous Contract #1. Non-adjusted price based on spot-month continuous contract calculations. Raw futures data from Chicago Board of Trade (CBOT).

Figure 4. Nominal prices for corn and soybeans. In both graphs there is an obvious seasonality. The real prices had the same behavior.

5. L-ratios plots of commodity prices

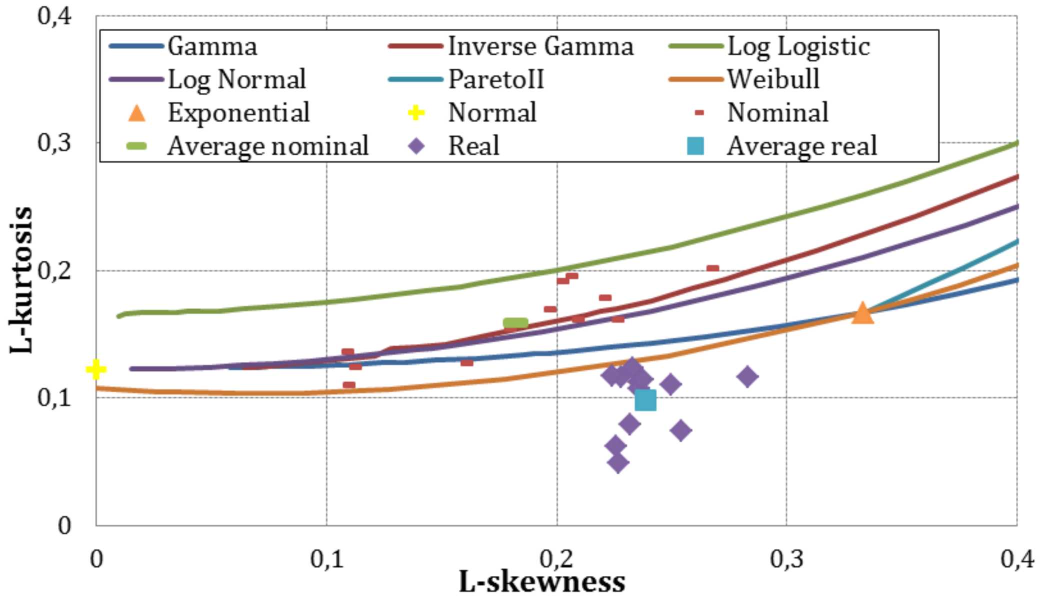
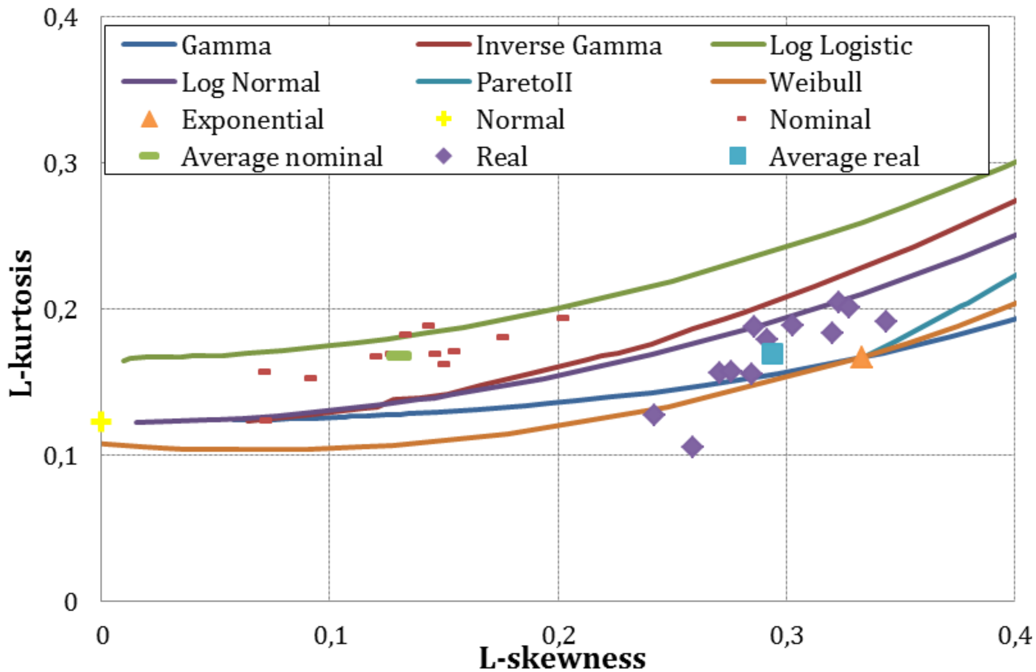


Figure 5. Tis graph shows L-moments for Corn nominal and real price. The distribution that seems to approach average nominal price is Inverse Gamma and real price average is below Weibull.

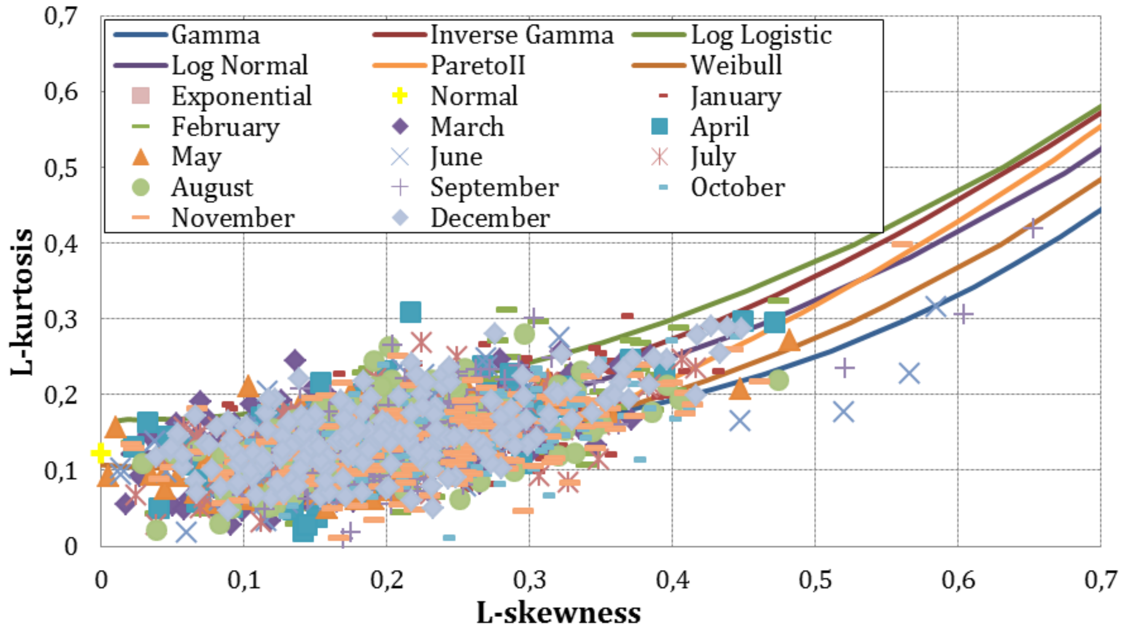
Figure 6. Soybeans average nominal price seems to be approached by Log Logistic and real prices distribution is between Log Normal and Paretto. Larger skewness of real price indicates heavier tales.

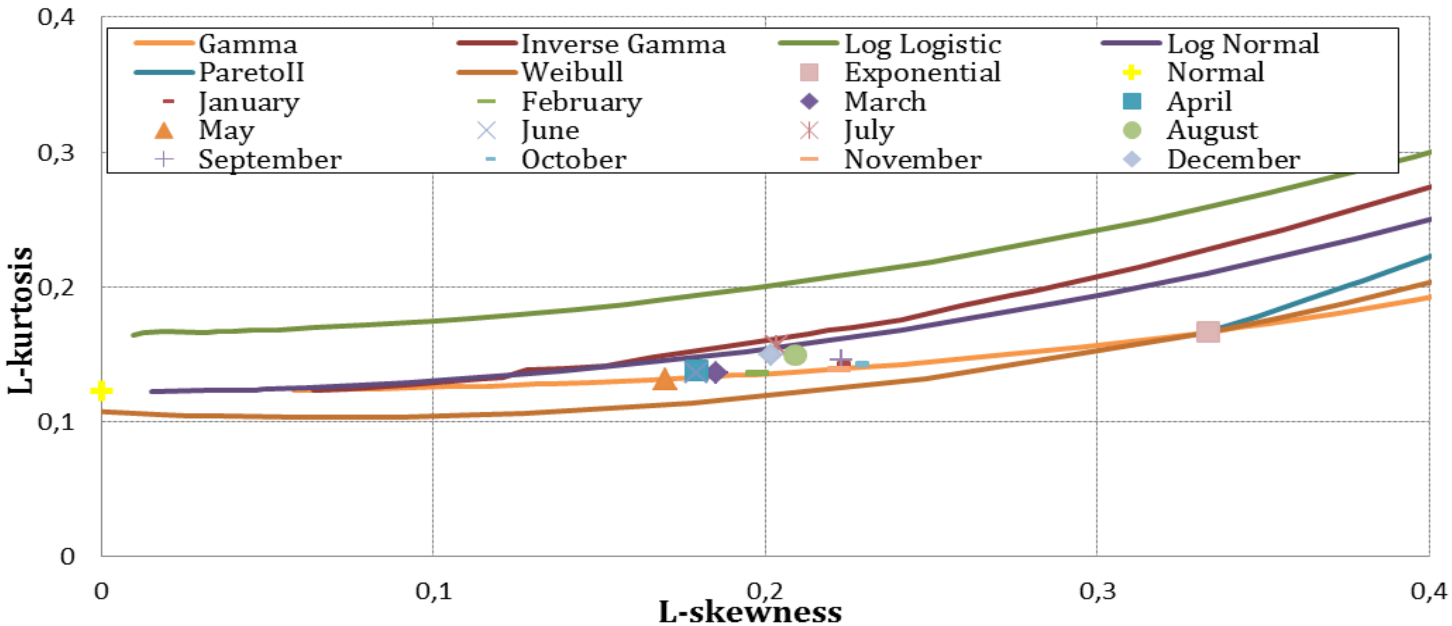


6. L-ratios plots of rainfall

Figure 7. (Right) This cloud of points consist of all months L-Moments from the stations chosen in the production areas of Corn and Soybeans.

Figure 8. (Below) Averages of L-Moments for each month. Although a large dispersion of individual spots is observed, the averages lay on a narrow area. Rain distribution for most of the months can be approached by Gamma.
July, August and December averages are close to Log Normal.

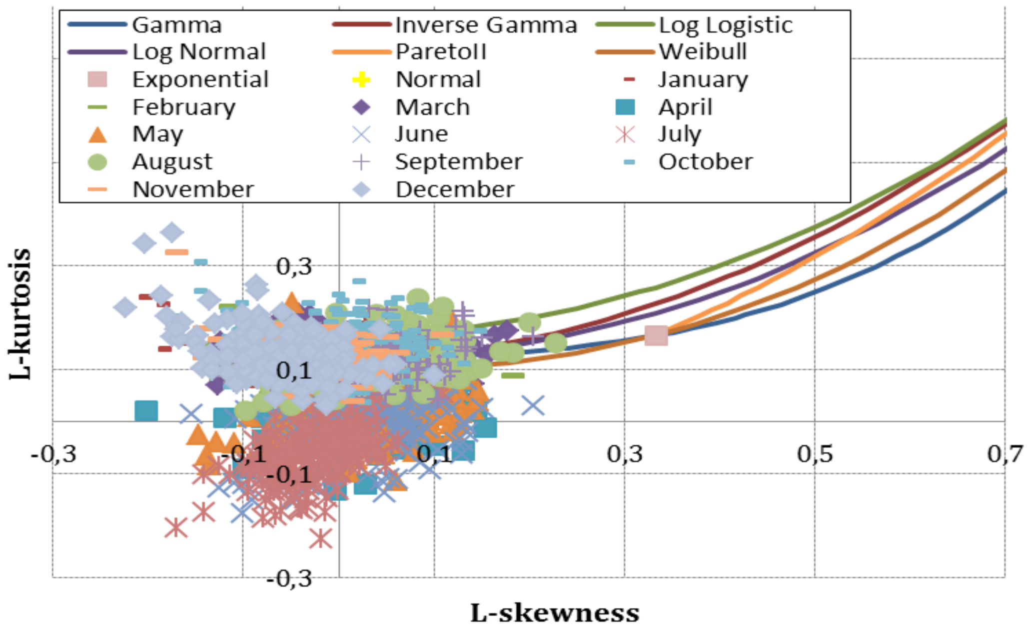


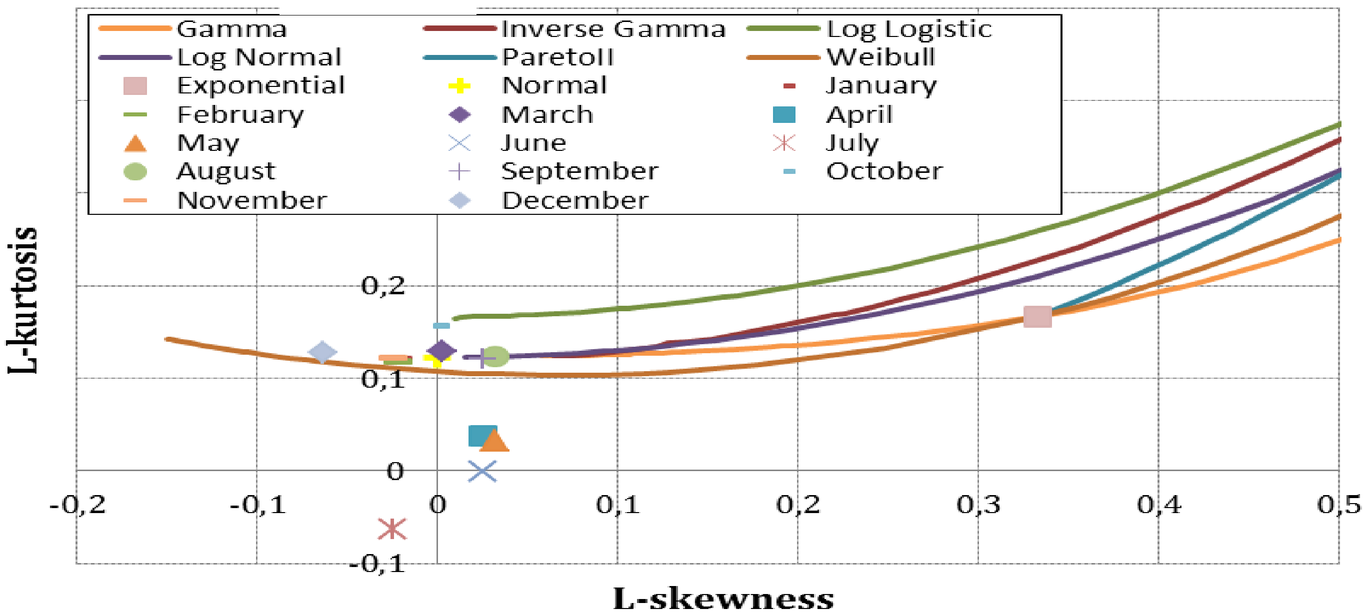


7. L-ratios plots of temperature

Figure 8. (Right) This cloud of points consist of the monthly average of maximum daily temperature from the stations chosen in the production areas of Corn and Soybeans.

Figure 9. (Below) Essentially, the points expand around the normal distribution and do not exceed skewness and kurtosis.

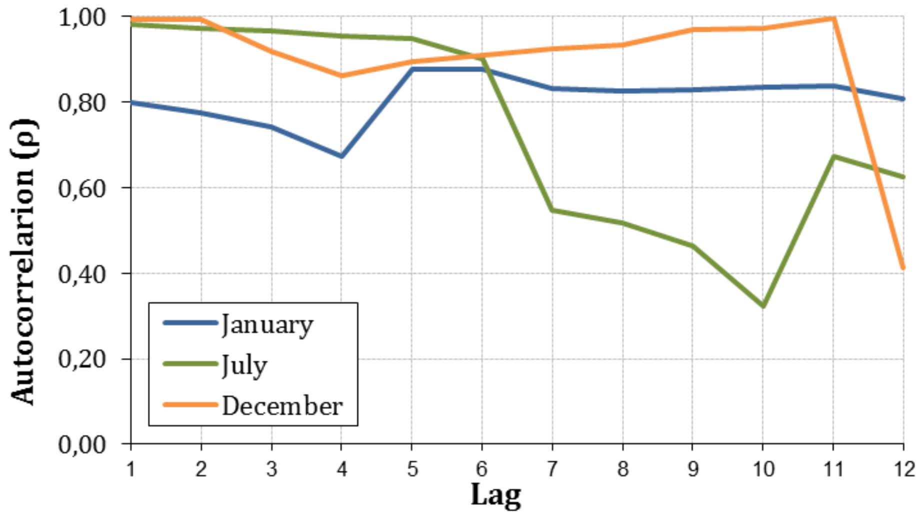




8. Autocorrelation structure of prices

Figure 10 . Corn prices. This graph indicates strong autocorrelation even for lag equal to 10 or 11 months .
Three typical months are shown.

i. December has the same behaviour as September, October and November.
ii. January behaves the same with February, March, April May and June
iii. July is similar to August



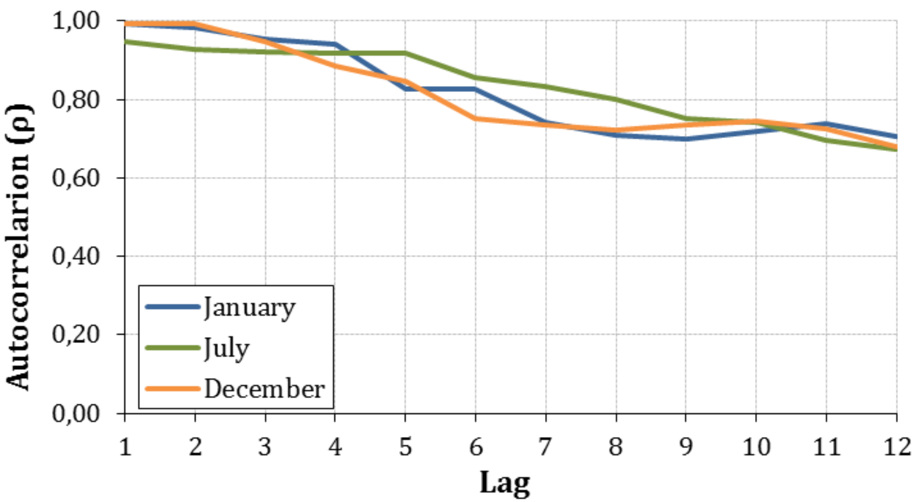


Figure 11. Soybeans prices are also strongly correlated with a smooth decrease along with the lag for all the months.

9. Autocorrelation structure of rainfall and temperature

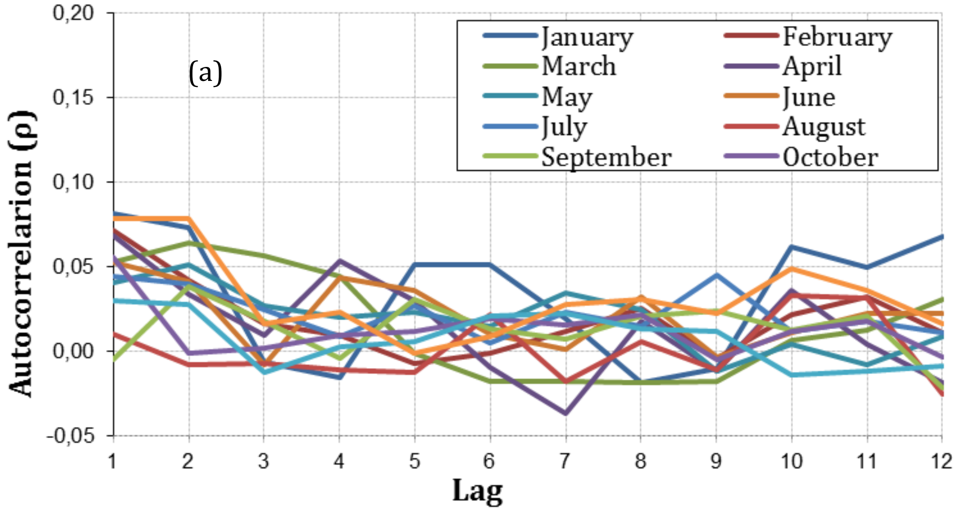
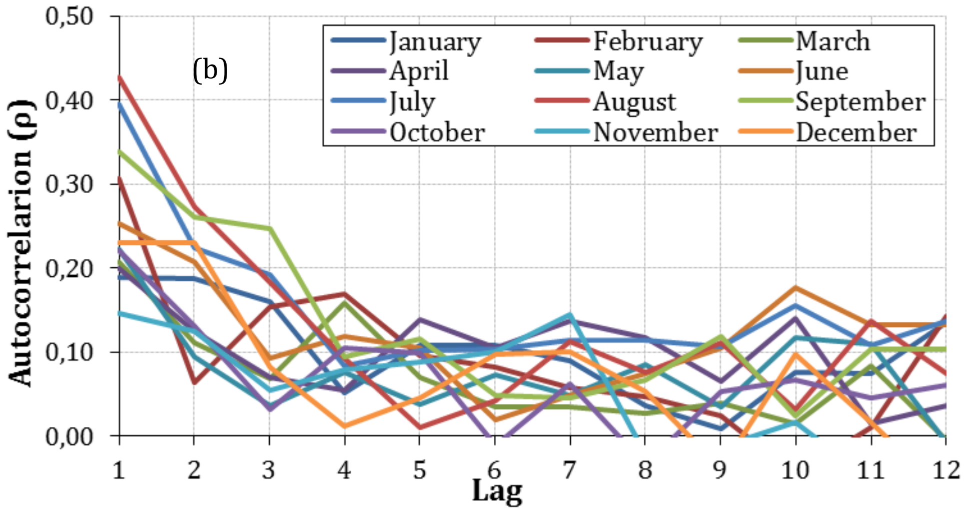


Figure 11 (a) and (b). These graphs indicate the empirical function of autocorrelation of monthly rainfall (a) and monthly average of daily maximum temperature (b) . The ρ coefficient has a maximum of 0.1 and 0.41 respectively.



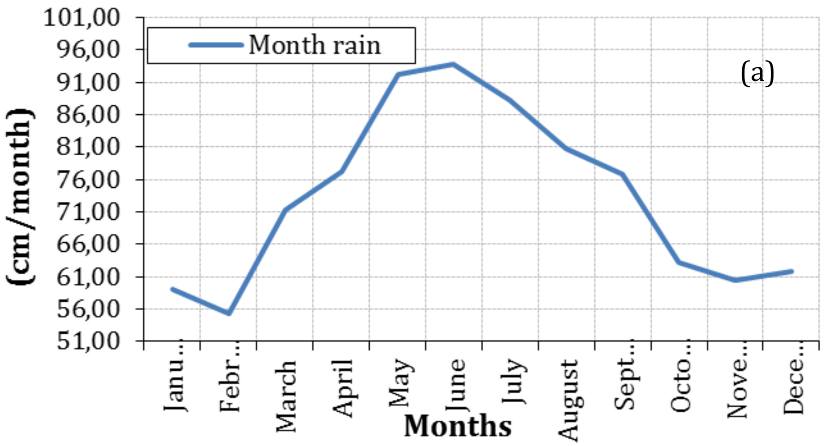
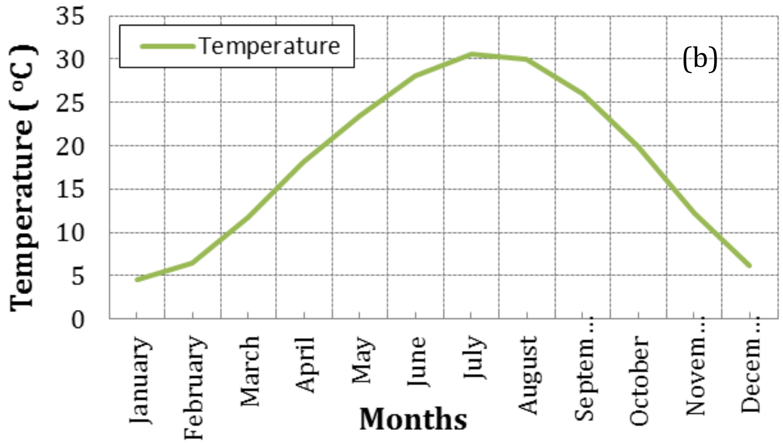
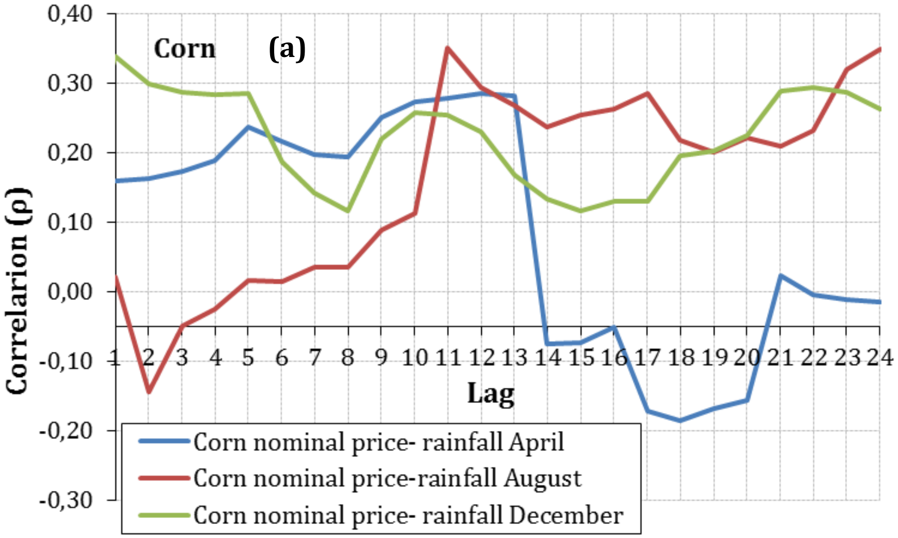


Figure 12 (a). Average monthly rainfall in the production area. As in the case of commodity prices there is an obvious seasonality.

Figure 12 (b). Seasonality of the monthly average in the production area of daily maximum temperature.



10.Crosscorelation Commodities Price-rainfall and Temperature



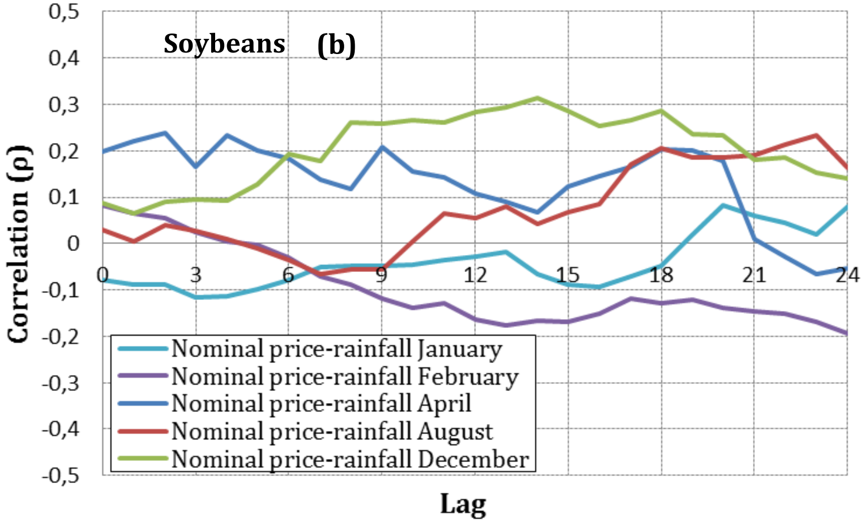
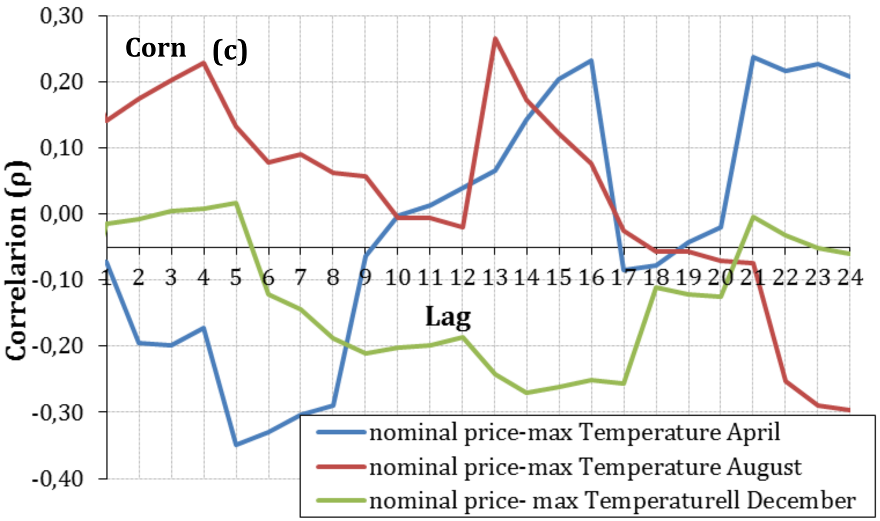
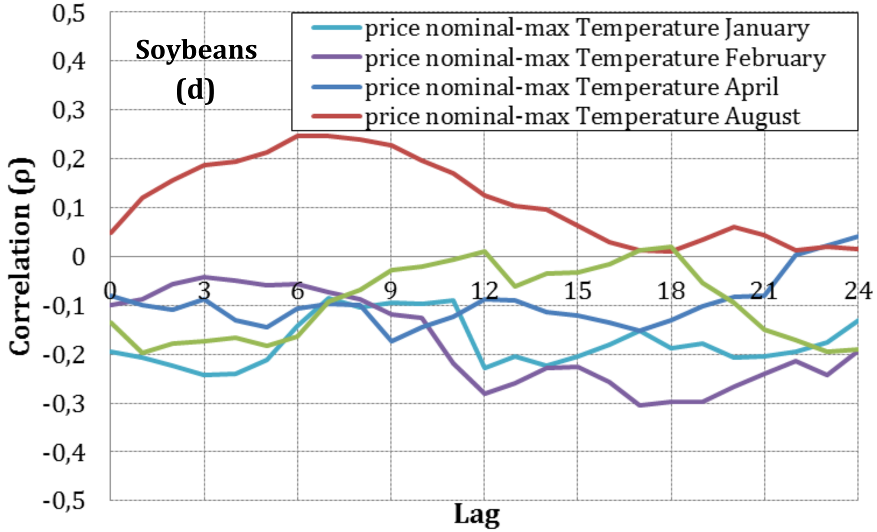


Figure 13 (a), (b), (c), (d). In these graphs monthly commodity prices were correlated with average monthly rainfall (a),(b) and monthly average of daily maximum temperature (c),(d) that correspond to each commodity's production area. The most representative months were chosen with those missing having a similar behavior. For both corn and soybean the ρ coefficient is between -0.3 and 0,4 and that indicates weak correlation between the 2 variables.





11.Crosscorelation Prices-Futures Contracts

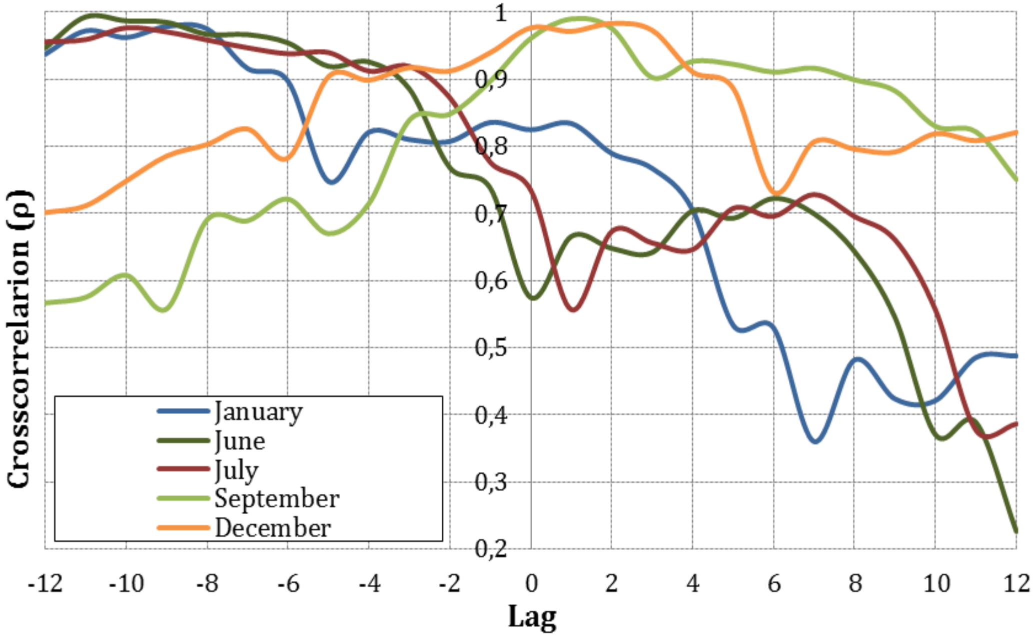


Figure 14. Monthly corn prices received by farmers were correlated with monthly future contracts traded at CBOT. For each month there is a different behavior but a significant correlation is noted for lag=0 and for some months for any lag.

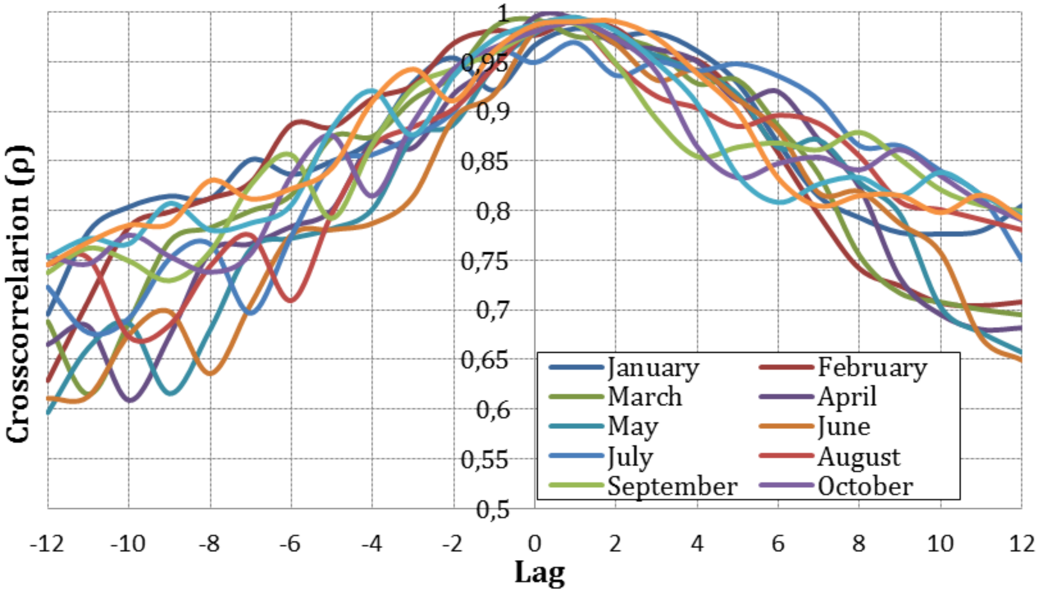


Figure 15. Monthly soybeans prices received by farmers were correlated with monthly future contracts traded at CBOT. There is a similar behavior regardless the month and a strong correlation even for lag=12.

12. Conclusions

- We tried to find similarities and differences between financial time series (corn and soybeans prices) and geophysical time series (rainfall and temperature)
- Generally financial time series are behaving differently from geophysical. Specifically L-ratios diagrams indicate different statistical properties of the marginal distribution while the autocorrelation structure is very strong.
- We used 4 types of price time series for each commodity (nominal and real, with and without trend). Autocorrelation and cross-correlation was the same regardless the type of time series.
- Cross-correlation between financial and geophysical time series did not show any significant results. This can be explained by the fact that we used average rainfall and average monthly maximum temperature rather than extreme.
- We will further extend this research by using extreme events or indexes such as SPI (standardized precipitation index for drought and flood).

References

- Cinquegani, P. 2006. Drought's Affect on Soybean Prices. The Park Place Economist: Vol. 14.
- Vogel, R.M. and Fennessey, N.M. 1993. L moment diagrams should replace product moment diagrams. Water Resources Research 29: doi: 10.1029/93WR00341. issn: 0043-1397.
- Lee, S. H. and Maeng, S. J. 2003. Frequency analysis of extreme rainfall using L-moment. Irrig. and Drain., 52: 219–230. doi: 10.1002/ird.90.