TRENDS AND LONG-RUN RELATIONS IN COINTEGRATED TIME SERIES OBSERVED WITH NOISE

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Overview

Many applied papers study the dynamics of multivariate time series of financial assets and/or commodities with the aim of finding some long-run relationship governing the behavior of the observed variables. In this stream of research integration and cointegration testing are very useful and common tools. In this paper we stress that tests for integration and cointegration of time series may fail when data show some characteristics that are typical in financial, commodity and, in particular, electricity prices, such as leptokurtosis, high additive noise and close-to-unity moving average components. We show that results of the standard Augmented DickeyFuller (ADF) and Johansen's tests are biased towards "more stationarity". In these cases, the ADF tends to reject the null of integration too often and Johansen's test tend to find false common long-run trends. In this paper we show how simple filtering-before-testing techniques should be applied to time series in order to make integration and cointegration tests reliable.

Methods

We propose three time series filters that can improve the performance of unit root and cointegration tests:

1. reducing the frequency of the time series by taking averages, for instance by working on weakly means of daily or hourly prices;

2. extracting the level component using the Kalman filter in an unobserved component model (UCM) containing trend, noise and, possibly, seasonal components.

3. extracting the level component using the smoother in an unobserved component model (UCM) containing trend, noise and, possibly, seasonal components.

We prove theoretically why these filtering techniques are expected to improve the performance of ADF and Johansen's test and, to empirically assess the effects of the frequency-reduction and UCM-based filters on the ADF and Johansen tests, we performed a set of Monte Carlo simulations. Each experiment evaluates the performances of ADF and Johansen tests both under the null and alternative hypothesis, in order to evaluate the size and power of the tests before and after filtration takes place.

Then, we use electricity prices to implement the filtering methods previously analysed with the aim of understanding their impact on the size of ADF and Johansen tests. Electricity prices are a prominent example of time series generated in a bid/ask context where market operators, as well as international movements of fossil fuel prices and other random shocks, may influence the dynamics. Properties of electricity prices then depend on the interplay among physical characteristics of the good and exchange methods adopted. Indeed, in the early studies concerning electricity prices in liberalized markets, many researches found stationarity and the "mean reversion" of electricity prices has become an acceppeted feature by many. Since electricity prices are (often heavly) dependent on hydrocarbon prices, which are well know to follow integrated processes, we attributed this contradiction to unriability of ADF and Johansen's test when applied to data with the characteristics of electricity prices.

We provide also an application to financial data. In particular, we show that filtering-before-testing reduces the number of cointegated stock log-prices when looking for paris-trading strategies.

Results

Our theoretical results show that all filtering approaches (almost) cancels the close-to-unity root of the moving average (MA) part in time series where the signal is buried into high level of white noise. This result is extremely relevant for ADF and Johansen's test since the data generating process they are based on cannot manage a persistent MA component.

The simulation experiment shows that as noise increases in integrated time series, the ADF applied to raw data rejects much more that the nomial size while the same test applied to all filtered time series keeps its size close to the nomial size. The ADF applied to the smoothed time series keeps the size at its nomial level. This robustness to noise comes with some cost in terms of power of the test, but this is common for robust procedure, however if no noise is present UCM-based filters guarantee the same power ADF on raw data.

As for cointegration, the simulations confirm that Johansen's test applied to raw noisy data selects a larger number of cointegrating relations too often. The same test on filtered data performs better with the UCM-Kalman filter providing the highest frequency of correctely identified number of cointegration relations. The test applied to mean-filtered time series tends to select a too small number of cointegration relations.

Conclusions

The results assess that all the filtering methods improve the size of the ADF and Johansen tests. The approach based on UCM and Kalman filter is the most effective for selecting the right number of cointegrating relations. This kind of filtering should become routinely when testing for integration and cointegration dealing with series affected by high-frequency noise to avoid dominating spurious results.

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