EFRP - Assignment 3

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Contents

1 Introduction

This short paper is about an empirical analysis about cointegration using six stock prices (downloaded from Bloomberg) from 2003 December to 2019 June. Testing cointegration between stocks is a relevant technique to pairs trading, which is a widely used strategy. However pairs trading may be based on several pairs choosing rules, many papers concluded formerly, that cointegration leads to higher profitability on real-world data[Huck and Afawubo, 2014]. In this study I do not focus on this methods efficiency, only on the frequency of cointegrated stock prices. For this purpose I commit two different cointegration-test (Engel-Granger method and Johansen test) on the full time-interval, after I also use this methods with rolling windows. All the R codes of this paper are uploaded to my public github repository (https://github.com/MarcellGranat/EFRP).

2 Engle-Granger method

Engle-Granger method is simple way to test cointegration in bivariate case. Cointegration is diagnosed if the two tested series are integrated in the same order and a linear combination of them exist, which has an integration order of the original non-stationer series minus one [Kirchgässner and Wolters, 2007]. The most common is when the tested stock prices are I(1) and their linear combination is stationer.

The used stock prices are presented in figure 1. For a first glance there is a high chance that some cointegrated pairs can be found in this set of series. To commit the tests the first step is to check the time-series integration order. For this purpose I use ADF-test with a significance level 5%. As a

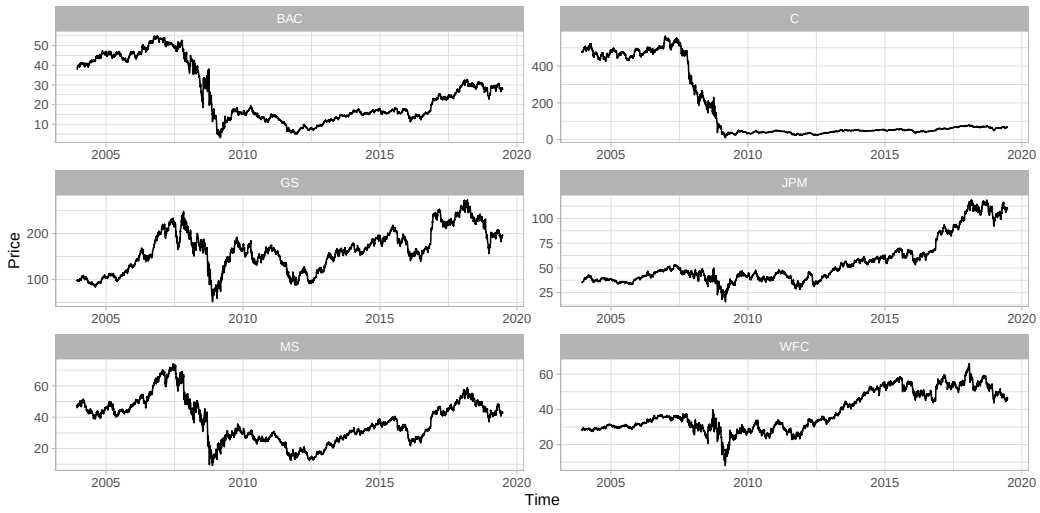

Figure 1: Time-series used in this study.

result it is concluded that all the series are I(1), if any of their bivariate linear combination is stationer, then cointegration is diagnosed. The first difference of the stock prices is shown on figure 2.

The second step is run OLS with all the possible pairs and check if there is a series of residuals stationer. Just as at the previous step the stationary test is augmented Dickey-Fuller test without constant or trend component in the auxiliary regression and $\alpha = 5\%$.

With the described parameters [1] the tests confirms only one cointegrated pair (see Figure 3), and that result holds only if the stock price of Bank of America is in regressor role, but is does not, when that is used as dependent variable[2].

3 Johansen test

Johansen test is adequate cointegration test, when there are more that two tested series at the same time. This test is performed in order to estimate the number of cointegrated vectors (r) in the system. If there is any cointegration in the model then $0 < r < k$, where k is number of tested time-series. The

[1] In my previously mentioned github repository you may find that I wrote an R function to commit the whole Engle-Granger method with specified parameters. It would be reasonable to see the results with different stationary test or with different significance level (specially if calculating its profitability is also in focus). With the written function, it is possible to modify the test parameters and see how the results change.

[2] The matrix of the results is not a symmetrical.

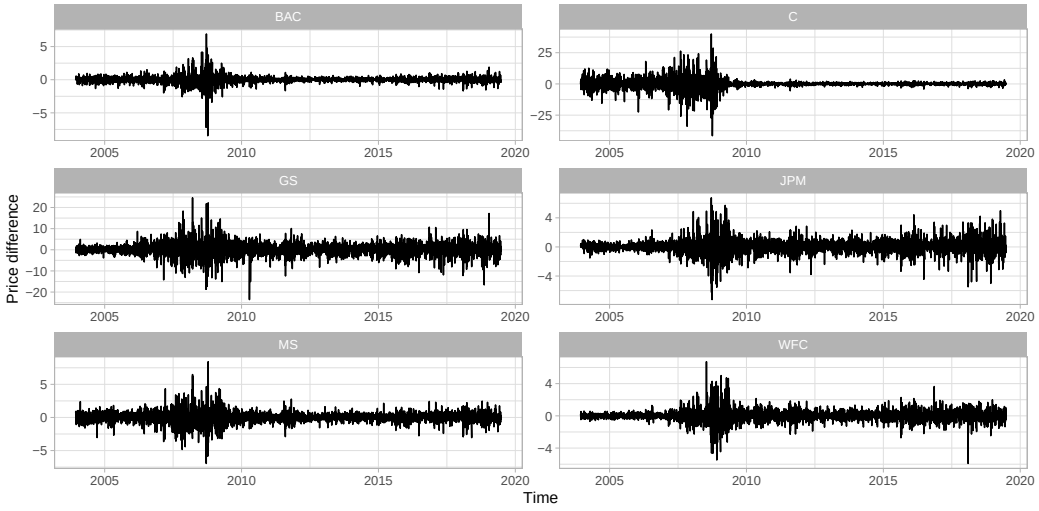

Figure 2: First difference of the time-series.

system decomposition is not unique, so we can only estimate the cointegration rank r [Kirchgässner and Wolters, 2007]. The method can be performed with several tests, in this paper I chose the Lmax test. It gives a vector of test statistic as a result and that may be compared to critical values. The null hypothesis is that $r \leq x$, where $x = 0, 1, 2, ..., k-1$. The number of cointegrated vectors is the smallest x, under which null hyphothesis is not rejected. The empirical analysis in this study shows that the r in this system is 1 on the full time-interval[3], which confirms the identical result as the one found with the Engel-Granger method.

4 Engle-Granger method with rolling window

In this section I expound the results of the previously presented Engle-Granger method performed with rolling window. The size of windows is 250 days. Important to note, it is not sure that a stock price has the same integration order in each window. It can happen that a cointegration test is not permittable, because in that period the integration orders do not match. Since this calculation is realy time-consuming, only three of the six stock will be tested in this paper. This means that the maximum number of cointegrated pairings is 6 ($3 \times 3 - 3$). The test parameters are the same as described before, results are shown on figure 4.

In figure 4 it can be seen that the number of cointegrated pairings reaches

[3]Same result is stated on 1%, 5% and 10% significance level.

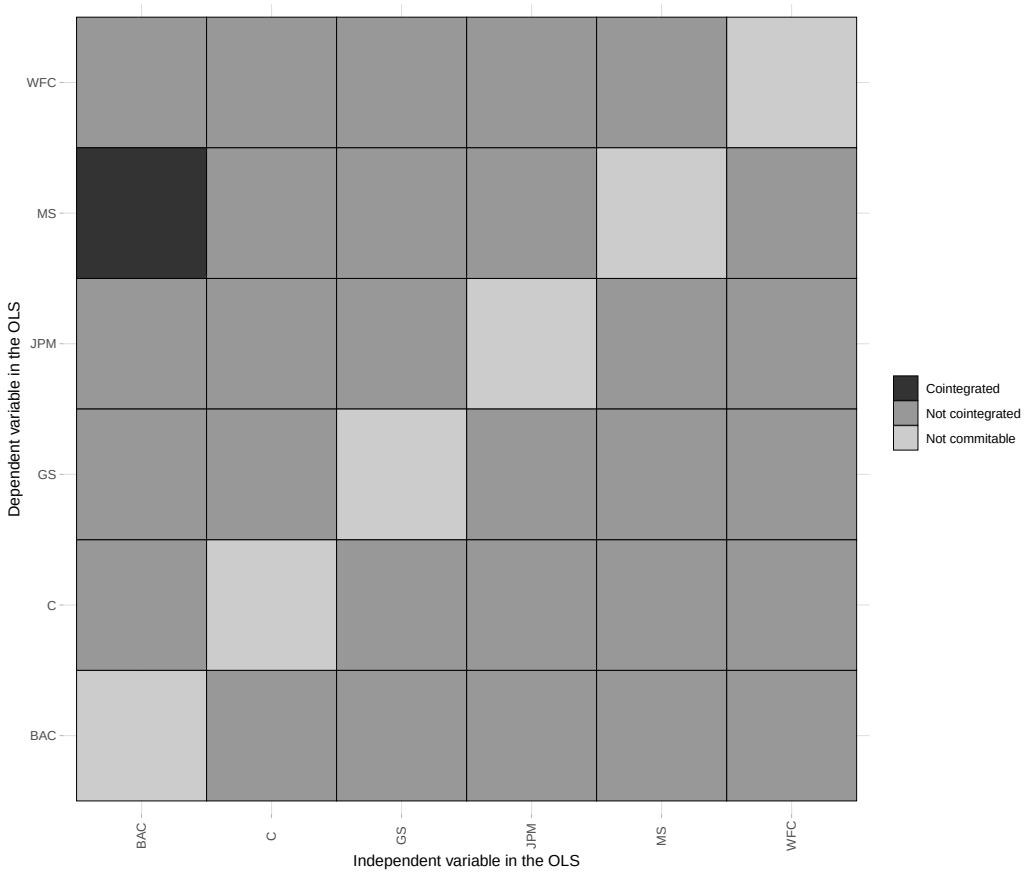

Figure 3: Results of Engle-Granger method.
Calculations are based on ADF-test (level, $\alpha = 5\%$)

the maximum number at the end of 2008, 2012 and in the middle of 2008, 2016. In 2008 there is also a long preriod, when there are 4 cointegrated pairings. This result suggests a pattern that in recession cointegration may be more frequent.

5 Johansen test with rolling window

Performing Johansen test with rolling window is a totally similar extension as the one presented in the previous chapter. The calculations were performed with the same 250 window size and r is examined at the significance level of 1%, 5% and 10%. Result can be seen in figure 5.

In figure 5 the period of recession is also visualized. It looks like the $r = 1$ result at that time is more frequent than most of the case when there is no

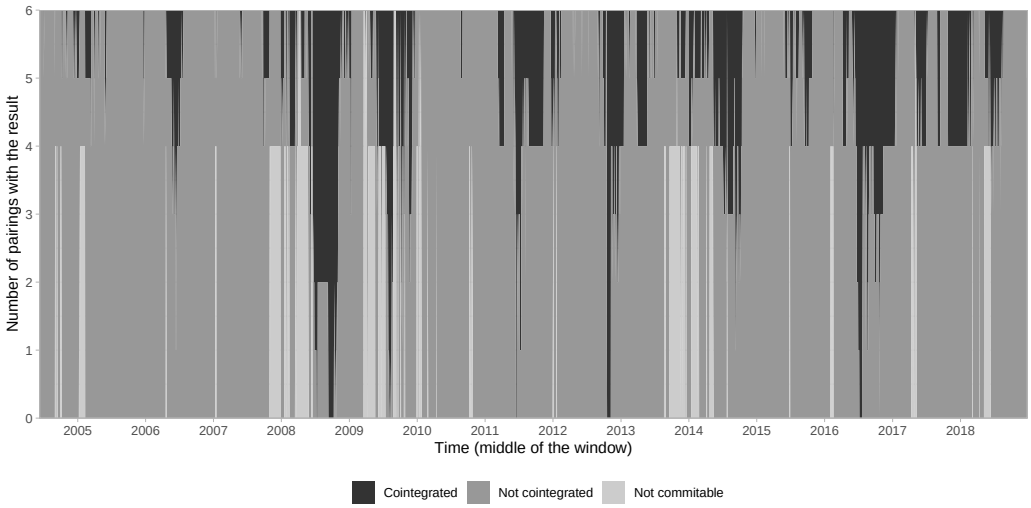

Figure 4: Results of Engle-Granger method with rolling window. Calculations are based on ADF-test (level, $\alpha = 5\%$). Number of total pairings is 6.

recession, similarly the $r = 2$ result. One deviation from this pattern is at 2018, where $r = 1$ result is extremly frequent.

Looking at the distribution of the results controlling for the period of recession also confirms this hyphothesis. During recession the proportion of $r = 2$ result (2.19%) is twice as much as the proportion when there is not recession (1.08%) with 10% significance level. Similarly $r = 1$ is the result of 15.31% of the total tests performed with $\alpha = 10\%$ in periods of recession, while 7.34% is when there is expansion. With different significance level identical results can be concluded.

6 Conclusion

This short paper is an empirical analylsis of cointegration tests performed on real-world stock prices. The results show that in many cases cointegration can be diagnosed on short periods (250 days), but not on the full time-interval. Using roling window and controling fo r the recession pattern that during recession cointegration is more frequent is suggested. This emerges further research question: Is the efficiency of pairs trading higher during recession[4]? As an additional further research idea I would say the efficiency of the pairs

[4]This one is an important connection point with the articles from Nelly [Neely et al., 2014] and Huck [Huck and Afawubo, 2014].

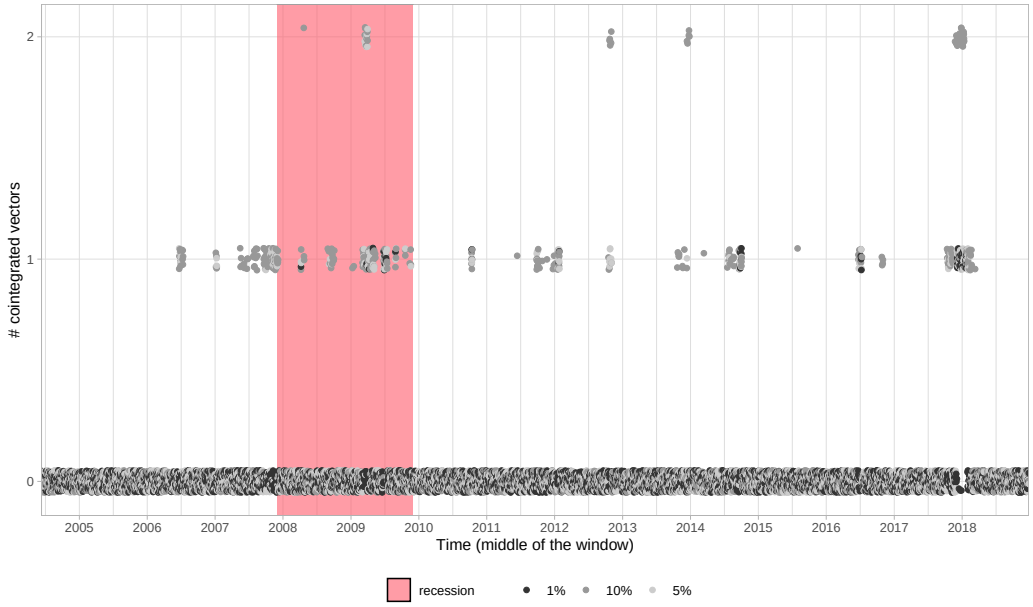

Figure 5: Results of Johansen test with rolling window across time. Size of windows is 250 days. Points are jittered around their true y value for better visualisation (the number of cointegrated vectors is interger). Date of recession is from the National Bureau of Economic Research (https://www.nber.org/cycles.html).

trading (Is there truly convergence where cointegration is ascertained?) and parameter optimalization.

List of Figures

References

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