Examination paper for FIN3006
Applied Time Series Econometrics

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Examination date: 10.12.2018
Examination time (from-to): 6 hours (09.00 - 15.00)
Censorship date: 10.01.2019
Permitted examination support material: C
Formelsamling:
Calculator:
Casio fx-82ES PLUS, Casio fx-82EX Citizen SR-270x, SR-270X College or HP 30S.

Language: English
Number of pages (front page excluded): 14

Informasjon om trykking av eksamensoppgave
Originalen er:
1-sidig □  2-sidig □
sort/hvit □  farger □
skal ha flervalgskjema □

Checked by:

Date  Signature
Instructions

The exam consists of Question 1 and Question 2, each one presenting a number of subquestions. On page 6 and page 7 you will find the Stata commands (do-file) and output (log-file) relative to Question 1. On page 10 and page 11 you will find the Stata commands (do-file) and output (log-file) relative to Question 2. Read carefully the text. Answer all questions. Good luck!

Question 1


"The analysis of Bitcoin has recently received much attention. This can be attributed to its innovative features, simplicity, transparency and its increasing popularity (Urquhart, 2016), while since its introduction it has posed great challenges and opportunities for policy makers, economists, entrepreneurs, and consumers (Dyhrberg, 2016b). Bitcoin is probably the most successful - and probably most controversial - virtual currency scheme to date (ECB, 2012 p. 21), representing about 41% of the total estimated cryptocurrency capitalisation at present¹. However, recent fluctuations in Bitcoin prices (see Figure 1) have resulted in periods of high volatility. In fact, as Bitcoin is mainly used as an asset rather than a currency (Glaser et al., 2014; Baek and Elbeck, 2015; Dyhrberg, 2016a), the Bitcoin market is currently highly speculative, and more volatile and susceptible to speculative bubbles than other currencies (Grinberg, 2011; Cheah and Fry, 2015). Bitcoin has therefore a place in the financial markets and in portfolio management (Dyhrberg, 2016a), and examining its volatility is crucial. Moreover, the presence of long memory and persistent volatility (Bariviera et al., 2017) justifies the application of GARCH-type models. [...]"

Most of the previous studies of the Bitcoin price volatility have used a single conditional heteroskedasticity model, a question that remains unanswered is which conditional heteroskedasticity model can better explain the Bitcoin data. [...]"

The data used are the daily closing prices for the Bitcoin CoinDesk Index from 18th July 2010 (as the earliest date available) to 1st October 2016, which corresponds to a total of 2267 observations.

The returns are calculated by taking the natural logarithm of the ratio of two consecutive prices. Figure illustrates both the Bitcoin prices and price returns." (Katsiampa, 2017, p.3)

The returns are called return in the do-file and log-file. On page 6 and page 7 you will find the Stata commands (do-file) and output (log-file) relative to this question.

¹coinmarketcap.com accessed on Jun 12th 2017
Figure 1: Daily closing prices and price returns of the Coindesk Bitcoin Index (US Dollars)

(a) Before starting with her analysis, the author writes on p. 4 of the paper: "The value of the test for conditional heteroskedasticity confirms that there exist ARCH effects in the returns of the Bitcoin price index, suggesting that the Autoregressive model for the conditional mean needs to be expanded to include an Autoregressive Conditional Heteroskedasticity model for the conditional variance." Explain this sentence. In particular: 1) Define the two models that the author is comparing and 2) Present one test that the author has possibly performed to distinguish between the two models.

(b) Consider now the estimation of Model 1 presented on line 22-27 in the do-file and line 15-20 in the log-file. Define the Q-statistic and its purpose in this analysis.

(c) Consider now the two different GARCH models estimated. Present them and explain the results.

(d) Which model would you choose between the two estimated? Which implications do the models have for investors? Explain, justifying your choices.

(e) Suppose you wanted to compare the two models based on their forecasting performance of the conditional variance, and subsequently choose the best performing model. Explain a test based on which you could make this decision.
Focus now solely on the bitcoin price, shown in Figure 1(a). An article published in Forbes on 10 December 2013\textsuperscript{2} states:

After a summer lull of relatively stability, the crypto-currency started making headlines again as the latest investment vehicle. BabinTremblay said the coin’s latest parabolic rise started in early October as a result of Chinese demand. The demand in November was so high that some prices quoted on Chinese exchanges were almost double compared to exchanges outside the country, he said. “The rest of the world has been buying bitcoins to try and sell them to Chinese consumers because there is so much demand there,” he said. He added that the country’s growing middle class are attracted to the crypto-currency because of the lack of other alternatives. “Essentially you have the perfect storm in China,” he said. “It’s very difficult for Chinese people to invest overseas. They have a real estate bubble, they have a stock market bubble and they have one of the highest saving rates in the world.”

Chinese demand for bitcoins cooled significantly since hitting its November high, after the Chinese government announced that it was cracking down on the currency. On Dec. 5 China’s central bank barred banks from handling bitcoin transactions.”

(f) A financial analyst suspects that international events such as the one presented above have a significant permanent impact on data-generating process of the bitcoin price. Looking at Figure 1(a), present an adequate model that would account for this feature.

\textsuperscript{2}Excerpt from https://www.forbes.com/sites/kitconews/2013/12/10/2013-year-of-the-bitcoin, last retrieved on 30 November 2018
Question 2

Arms races have long been a central area of interest in the field of international relations. Beginning with the seminal work of the political scientist Lewis Richardson, scholars have been interested in the dynamics of whether, when, and to what extent states match their rivals' spending on military weapons. The question was particularly important during the Cold War, when numerous scholars examined the dynamics of the U.S.-Soviet arms race. Although the arms race literature has faded in importance in the field of international relations with the end of the Cold War, there are still important rivalries around the world that maintain the competitive dynamics that could lead states to spend heavily on weapons to match their competitors.

One intense non-superpower rivalry that has garnered some attention in the arms race literature is that between India and Pakistan. Figure 2 shows both countries' defense spending over the 1949-2001 period, when the rivalry was at its most intense. (Box-Steffensmeier, Janet M., et al. Time series analysis for the social sciences. Cambridge University Press, 2014, p.166-167)

![Figure 2: India and Pakistan Defense Spending, 1948-2001](image)

Note that the analysis in point (a) to (d) is performed for the years 1948 to 1990. In the do-file and log-file, pakds indicates Pakistani Defense Spending, while indds indicates Indian defense spending, both in millions of U.S. dollars. On page 11 you will find the Stata commands (do-file) and output (log-file) relative to this question.

(a) Present the test for nonstationarity performed on lines 22-23 in the do-file and lines 15-16 of the log file, and discuss the findings.
(b) “Because we have confirmed nonstationarity in both series, the next step is to investigate the possibility of cointegration.” Explain whether you agree with this statement.

(c) Discuss the analysis presented on lines 31-34 of the do-file and lines 28-31 of the log-file. In particular, discuss whether: 1) you find evidence of cointegration and 2) whether you agree with the use of the Dickey-Fuller test as produced by Stata.

(d) Discuss the results from the estimation of the model on line 36 of the do-file and lines 33 of the log-file. What can you conclude about the relationship between Indian and Pakistani defense spending?

(e) A young econometrician knows that the methodology discussed up to now presents a number of limitations. Hence, she decides to follow a different testing strategy to check for cointegration. In addition, she decides to extend the estimation period to 2001. The analysis is shown on line 43 of the do-file and line 40 of the log-file. Discuss the test performed and its findings, emphasizing what they imply for the relationship between Indian and Pakistani defense spending.

(f) What could explain the different results in point (c) and (e)?
***************
* Question 1  
***************

log using FIN3006exam_h18_question1_log.smcl, replace nomsg

** Log-file - QUESTION 1

clear all
use bitcoin_final.dta
tset time

** Estimation - Model 1

arch return, ar(1) arch(1) garch(1) nolog
estat ic
predict h_garch, variance
predict res_garch, res
gen std_res_garch=res_garch/sqrt(h_garch)
wttestq std_res_garch, lag(10)

** Estimation - Model 2

arch return, ar(1) arch(1) garch(1) tarch(1) nolog
estat ic
predict h_tgarch, variance
predict res_tgarch, res
gen std_res_tgarch=res_tgarch/sqrt(h_tgarch)
wttestq std_res_tgarch, lag(10)

log close
1. ........................................................................................................................
2. ** Log-file - QUESTION 1
3. ........................................................................................................................
4. clear all
5. use bitcoin_final.dta
6. tsset time
   time variable:  time, 1 to 2268
   delta:  1 unit
7. ........................................................................................................................
8. ........................................................................................................................
9. ** Estimation - Model 1
10. ......................................................................................................................
11. arch return, ar(1) arch(1) garch(1) nolog
ARCH family regression -- AR disturbances

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<tr>
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Akaike's information criterion and Bayesian information criterion

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<th>BIC</th>
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<td>-7620.472</td>
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</tbody>
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Note: N=Obs used in calculating BIC; see [R] BIC note.

17. predict h_garch, variance

18. predict res_garch, res
   (1 missing value generated)

19. gen std_res_garch=res_garch/sqrt(h_garch)
   (1 missing value generated)

20. wntestq std_res_garch, lag(10)

Portmanteau test for white noise

Portmanteau (Q) statistic = 35.6062
Prob > chi2(10) = 0.0001

21.
22.
23.
24. **********************************************
25.
26. ** Estimation - Model 2
27.
28. **********************************************
29. arch return, ar(1) arch(1) garch(1) tarch(1) nolog

ARCH family regression -- AR disturbances

Sample: 2 - 2268
Distribution: Gaussian
Log likelihood = 3830.912

<table>
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<tr>
<th></th>
<th>OPG</th>
<th></th>
<th></th>
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<th>[95% Conf. Interval]</th>
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<td>P&gt;</td>
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<td>0.007</td>
<td>.0005561 .0035544</td>
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8
ARMA

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ARCH

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30. *estatic*

Akaike's information criterion and Bayesian information criterion

<table>
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<th>Model</th>
<th>Obs</th>
<th>ll(null)</th>
<th>ll(model)</th>
<th>df</th>
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<th>BIC</th>
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</thead>
<tbody>
<tr>
<td>.</td>
<td>2,267</td>
<td>.</td>
<td>3830.912</td>
<td>6</td>
<td>-7649.825</td>
<td>-7615.468</td>
</tr>
</tbody>
</table>

Note: N=Obs used in calculating BIC; see [R] BIC note.

31. predict h_tgarch, variance

32. predict res_tgarch, res
   (1 missing value generated)

33. gen std_res_tgarch=res_tgarch/sqrt(h_tgarch)
   (1 missing value generated)

34. wntestq std_res_tgarch, lag(10)

Portmanteau test for white noise

<table>
<thead>
<tr>
<th>Portmanteau (Q) statistic</th>
<th>34.5271</th>
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</thead>
<tbody>
<tr>
<td>Prob &gt; chi2(10)</td>
<td>0.0002</td>
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</tbody>
</table>

35.

36. log close
** Question 2

log using FIN3006exam_h18_question2_log.smcl, replace nomsg

** Log-file - QUESTION 2

clear all
use indipaki.dta
tset year

** Identification

dfuller pakds if year<1991, drift
dfuller indds if year<1991, drift

** Estimation - Only up to 1990

reg indds pakds if year<1991
predict residuals if year<1991, res
dfuller residuals, drift
var d.indds d.pakds if year<1991, exog(l.residuals) lags(1/3)

** Alternative Estimation - Full sample

vecrank indds pakds

log close
1.
2.******************************************************************************
3.** Log-file - QUESTION 2
4.******************************************************************************
5. clear all

6. use indipaki.dta

7. tsset year
   time variable:  year, 1948 to 2001
   delta:  1 unit

8.
9.
10.******************************************************************************
11.
12.** Identification
13.
14.******************************************************************************
15. dfuller paksd if year<1991, drift

Dickey-Fuller test for unit root
Number of obs =  42

<table>
<thead>
<tr>
<th>Test Statistic</th>
<th>Z(t) has t-distribution</th>
</tr>
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<td>1% Critical Value</td>
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<td>Z(t)</td>
<td>1.786</td>
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p-value for Z(t) = 0.9592

16. dfuller indds if year<1991, drift

Dickey-Fuller test for unit root
Number of obs =  42

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<th>Test Statistic</th>
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<td>Z(t)</td>
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</table>

p-value for Z(t) = 0.9857

17.
18.
19.
20.
21.
22.
23. ******************************************************************************
24.
25. ** Estimation - Only up to 1990
26.
27. ******************************************************************************
28. reg indds paks if year<1991

<table>
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<tr>
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<th>SS</th>
<th>df</th>
<th>MS</th>
<th>Number of obs</th>
<th>F(1, 41)</th>
<th>Prob &gt; F</th>
<th>R-squared</th>
<th>Adj R-squared</th>
<th>Root MSE</th>
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<td>3.4435e+14</td>
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<td>0.9601</td>
<td>0.9591</td>
<td>5.9e+05</td>
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<td>Residual</td>
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<td>3.4947e+11</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Total</td>
<td>3.5867e+14</td>
<td>42</td>
<td>8.5398e+12</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

| indds     | Coef.   | Std. Err. | t     | P>|t| | [95% Conf. Interval] |
|-----------|---------|-----------|-------|-----|---------------------|
| paks      | 3.403981| 0.1084408 | 31.39 | 0.000 | 3.184981 - 3.622982 |
| _cons     | -62240.45 | 130591.3 | -0.48 | 0.636 | -325974.9 - 201494 |

29. predict residuals if year<1991, res
   (11 missing values generated)

30.
31. dfuller residuals, drift

Dickey-Fuller test for unit root

<table>
<thead>
<tr>
<th>Test Statistic</th>
<th>1% Critical Value</th>
<th>5% Critical Value</th>
<th>10% Critical Value</th>
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<tbody>
<tr>
<td>Z(t)</td>
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<td></td>
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<tr>
<td>-3.438</td>
<td>-2.423</td>
<td>-1.684</td>
<td>-1.303</td>
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p-value for Z(t) = 0.0007

32.
33. var d.indds d.paks if year<1991, exog(l.residuals) lags(1/3)

Vector autoregression

Sample: 1952 - 1990

| Equation |Parms| RMSE | R-sq | chi2 | P>|chi2|
|----------|-----|------|------|------|-------|
| Log likelihood = -1065.934 | AIC = 55.48379 |
| FPE = 4.33e+21 | HQIC = 55.72866 |
| Det(Sigma_ml) = 1.88e+21 | SBIC = 56.16627 |
|      |      | Coef.  | Std. Err. | z     | P>|z|  | [95% Conf. Interval] |
|------|------|--------|-----------|-------|------|----------------------|
| **D_indds** |      |        |           |       |      |                      |
|      |      |        |           |       |      |                      |
| LD.  | .4200342 | .171752 | 2.45     | 0.014 | .0834065 | .7566619             |
| L2D. | -.0363878 | .1616146 | -0.23    | 0.822 | -.3531465 | .280371              |
| L3D. | .7486132 | .1597915 | 4.68     | 0.000 | .4354276 | 1.061799             |
| **D_pakds** |      |        |           |       |      |                      |
|      |      |        |           |       |      |                      |
| LD.  | -.3540278 | .5340671 | -0.66    | 0.507 | -1.40078 | .6927246             |
| L2D. | -.2626064 | .5284725 | -0.50    | 0.619 | -1.298393 | .7731808             |
| L3D. | -.192713  | .4957406 | -3.89    | 0.000 | -2.898764 | -.9554965            |
| **residuals** |      |        |           |       |      |                      |
|      |      |        |           |       |      |                      |
| L1.  | -.4260569 | .1445496 | -2.95    | 0.003 | -.709369 | -.1427449            |
| _cons| 144885.6 | 77198.19 | 1.88     | 0.061 | -6420.085 | 296191.2            |

34.
35. ******************************************************************************
36.
37. ** Alternative Estimation - Full sample
38.
39. ******************************************************************************
40. vecrank indds pakds
Johansen tests for cointegration

Trend: constant  
Sample: 1950 - 2001  
Number of obs = 52  
Lags = 2

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<td>3.76</td>
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<td></td>
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41. log close