Final Exam “Financial Data Analysis”
(6 Credit points/IMP Students)

March 2, 2007

Note the following important information:
1. The total disposal time is 60 minutes.
2. You have to answer all 4 questions.
3. Allocate your limited time; keep in mind how the points are distributed among the questions.
4. Read the questions and instructions carefully.

Good luck!

Question 1 (10 points): ARIMA modelling

Consider the random variable $Y_t$, which is defined by equation $Y_t = 0.8Y_{t-1} + u_t$ with $t = 1,\ldots,T$ and a given initial condition $Y_0 = 2$. For simplicity it is assumed that $\sigma_u^2 = 1$.

a) Calculate the expected values $E[Y_1]$ and $E[Y_2]$.
b) Determine the variance of $Y_1$ and the autocovariance of $Y_1$ and $Y_2$.
c) Determine in short and verbally the approximated mean and variance of $Y_{100}$. Thereby, keep in mind that it is about a covariance stationary process.

Question 2 (5 points): Invertibility and Stationarity

Explain the Box and Jenkins concept of invertibility to determine a MA(q) process uniquely from the autocorrelation function.
**Question 3 (30 points): Johansen Cointegration Test**

a) Many researchers favor the Johansen methodology over the Engle-Granger approach. Discuss the disadvantages of the latter technique. What is the main advantage of the Johansen approach?

b) Consider the following Eviews estimation outputs (page 3-4) where the index of the National Association of Real Estate Investment Trusts (NAREIT) for public real estate and the property index of the National Council of Real Estate Investment Fiduciaries (NCREIF) are tested on cointegration (where L denotes log values and d first differences). First, consider the estimation output of the Phillips-Perron unit root test. What do the results tell you about the stationarity property of the two time series and why is the property of stationarity an important condition for cointegration testing? *Hint: The Phillips-Perron test has the same null hypothesis as the ADF test!*

c) What lag length would you enter in the lag interval box of the Johansen Cointegration Test screen (lower left graph on page 4)? Justify your lag length criterion!

d) During the estimation process you are prompted to enter the intercept and trend assumption by choosing one of the 5 options (lower left graph on page 4). Which of the 5 offered option do you value as worth trying? Explain.

e) If any, how many cointegration vectors between the two series lnareit and lncreif exist according to the trace and maximum eigenvalue statistics? Explain the two cointegration tests and why might it happen that these two formal tests can conflict (Thereby, use the terms characteristic roots, eigenvalues, and trace)? Which are the estimated values of the two characteristic roots obtained from the estimated $\pi$ matrix?

f) Please explain *in short*, why we imposing restrictions after finding one or more cointegrating vectors.
Null Hypothesis: LNAREIT has a unit root  
Exogenous: Constant  
Bandwidth: 1 (Newey-West using Bartlett kernel)

<table>
<thead>
<tr>
<th>Adj. t-Stat</th>
<th>Prob.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1.088576</td>
<td>0.7183</td>
</tr>
</tbody>
</table>

Phillips-Perron test statistic  
Test critical values:  
1% level -3.492523  
5% level -2.888669  
10% level -2.581313


Null Hypothesis: LNCREIF has a unit root  
Exogenous: Constant  
Bandwidth: 8 (Newey-West using Bartlett kernel)

<table>
<thead>
<tr>
<th>Adj. t-Stat</th>
<th>Prob.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1.534859</td>
<td>0.5123</td>
</tr>
</tbody>
</table>

Phillips-Perron test statistic  
Test critical values:  
1% level -3.492523  
5% level -2.888669  
10% level -2.581313


Null Hypothesis: DLNAREIT has a unit root  
Exogenous: Constant  
Bandwidth: 1 (Newey-West using Bartlett kernel)

<table>
<thead>
<tr>
<th>Adj. t-Stat</th>
<th>Prob.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>-9.847978</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

Phillips-Perron test statistic  
Test critical values:  
1% level -3.493129  
5% level -2.888932  
10% level -2.581453


Null Hypothesis: DLNCREIF has a unit root  
Exogenous: Constant  
Bandwidth: 9 (Newey-West using Bartlett kernel)

<table>
<thead>
<tr>
<th>Adj. t-Stat</th>
<th>Prob.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>-4.760140</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

Phillips-Perron test statistic  
Test critical values:  
1% level -3.493129  
5% level -2.888932  
10% level -2.581453

VAR Lag Order Selection Criteria

Endogenous variables: LNAREIT LNCREIF
Exogenous variables: C
Date: 03/01/07   Time: 16:21
Included observations: 100

<table>
<thead>
<tr>
<th>Lag</th>
<th>LogL</th>
<th>LR</th>
<th>FPE</th>
<th>AIC</th>
<th>SC</th>
<th>HQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-63.84565</td>
<td>NA</td>
<td>0.012793</td>
<td>1.316913</td>
<td>1.369016</td>
<td>1.338000</td>
</tr>
<tr>
<td>1</td>
<td>404.3672</td>
<td>908.3329</td>
<td>1.19E-06</td>
<td>7.967343</td>
<td>-7.811033</td>
<td>-7.904082</td>
</tr>
<tr>
<td>2</td>
<td>434.3141</td>
<td>56.89917</td>
<td>7.07E-07</td>
<td>-8.486282</td>
<td>-8.225765</td>
<td>-8.380846</td>
</tr>
<tr>
<td>5</td>
<td>469.7681</td>
<td>33.07604*</td>
<td>4.43E-07*</td>
<td>-8.955362*</td>
<td>-8.382224*</td>
<td>-8.723403*</td>
</tr>
</tbody>
</table>

Sample(adjusted): 1979:2 2004:4
Included observations: 103 after adjusting endpoints
Trend assumption: Linear deterministic trend
Series: LNAREIT LNCREIF
Lags interval (in first differences): ?

Unrestricted Cointegration Rank Test

<table>
<thead>
<tr>
<th>Hypothesized</th>
<th>Trace Statistic</th>
<th>5 Percent Critical Value</th>
<th>1 Percent Critical Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>None **</td>
<td>0.177188</td>
<td>20.49825</td>
<td>15.41</td>
</tr>
<tr>
<td>At most 1</td>
<td>0.003977</td>
<td>0.410452</td>
<td>3.76</td>
</tr>
</tbody>
</table>

**(**) denotes rejection of the hypothesis at the 5%(1%) level

Johansen Cointegration Test

Deterministic Test Specification:
- Assume no deterministic trend in data
- Do not include C or Trend
- Critical values may not be valid with exogenous variables

Exog variables:
- VAR

Lag intervals:
- Summarize all 5 sets of assumptions

Unrestricted Cointegration Rank Test

Hypothesized | Max-Eigen Statistic | 5 Percent Critical Value | 1 Percent Critical Value |
<table>
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<th></th>
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</thead>
<tbody>
<tr>
<td>None **</td>
<td>0.177188</td>
<td>20.08780</td>
<td>14.07</td>
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<td>At most 1</td>
<td>0.003977</td>
<td>0.410452</td>
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**(**) denotes rejection of the hypothesis at the 5%(1%) level
Question 4 (15 points): ARCH/GARCH modelling

The following two tables present the results of volatility estimations for GSCI Livestock (Excess Return) Commodity Index. The log returns are calculated from daily index series taken from Datastream.

a) Describe the several steps of estimation and forecasting GARCH\((p,q)\) models!

b) Please explain which of the two models you would prefer for estimating the conditional volatility of the endogenous variable “dllive” (dlog of Livestock Commodity Index). In this context, please explain the “leverage effect” and also refer to parameter restrictions.

c) What happens to the conditional volatility of the GARCH(1,1) model after a positive shock? In this context, calculate the unconditional volatility.
### Exponential GARCH(1,1)

**Dependent Variable:** DLLIVE  
**Method:** ML - ARCH (BHHH)  
**Date:** 03/01/07  
**Time:** 15:04  
**Sample (adjusted):** 1/01/1991 11/29/2006  
**Included observations:** 4152 after adjusting endpoints  
**Convergence achieved after 60 iterations**  
**Bollerslev-Wooldrige robust standard errors & covariance**  
**Variance backcast:** ON

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Std. Error</th>
<th>z-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>-0.016046</td>
<td>0.011679</td>
<td>-1.373907</td>
</tr>
</tbody>
</table>

**Variance Equation**

<table>
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<th>Prob.</th>
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<tr>
<td>C</td>
<td>0.008418</td>
<td>0.002771</td>
<td>3.038202</td>
</tr>
<tr>
<td>ARCH(1)</td>
<td>0.034618</td>
<td>0.007005</td>
<td>4.941993</td>
</tr>
<tr>
<td>GARCH(1)</td>
<td>0.952666</td>
<td>0.009413</td>
<td>101.2069</td>
</tr>
</tbody>
</table>

**R-squared** -0.000005  
**Mean dependent var** -0.009438

### GARCH(1,1)

**Dependent Variable:** DLLIVE  
**Method:** ML - ARCH (BHHH)  
**Date:** 03/01/07  
**Time:** 15:08  
**Sample (adjusted):** 1/01/1991 11/29/2006  
**Included observations:** 4152 after adjusting endpoints  
**Convergence achieved after 9 iterations**  
**Bollerslev-Wooldrige robust standard errors & covariance**  
**Variance backcast:** ON

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Std. Error</th>
<th>z-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>-0.007618</td>
<td>0.011467</td>
<td>-0.664333</td>
</tr>
</tbody>
</table>

**Variance Equation**

<table>
<thead>
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</tr>
</tbody>
</table>

**R-squared** -0.000005  
**Mean dependent var** -0.009438

**Adjusted R-squared** -0.000728  
**S.D. dependent var** 0.820685

**S.E. of regression** 0.820983  
**Akaike info criterion** 2.369632

**Sum squared resid** 2795.808  
**Schwarz criterion** 2.375732

**Log likelihood** -4915.357  
**Durbin-Watson stat** 1.971100