Financial Econometrics Gauss Exercises

1st set GAUSS assignments Financial Econometrics

The following assignment is based on Hamilton(1994) pp. 409-411

1. Create a t-distributed random variable

GAUSS procedure:

Create a t_ν-distributed random variable Y (sample size N=10000) from a normally distributed r.v. X and a χ^2_ν-distributed r.v. $U = \sum_{i=1}^{\nu} Z_i^2$ where Z is normally distributed. X and Z have to be independent. For example, Y could be computed as:

$$Y = \frac{X}{\sqrt{U/\nu}}$$

2. Create an objective function to estimate the parameter ν

The density function of a t_ν- distributed r.v. is:

$$f_Y(y;\nu) = \frac{\Gamma[(\nu+1)/2]}{(\pi\nu)^{1/2}\Gamma(\nu/2)}[1+(y^2/\nu)]^{-(\nu+1)/2}$$

The unconditional second and forth moments are:

$$\begin{aligned} \mu_2 \equiv E(Y^2) &= \nu/(\nu-2) \\ \mu_4 \equiv E(Y^4) &= \frac{3v^2}{(v-2)(v-4)} \end{aligned}$$

The sample second and forth moments are:

$$\begin{aligned} \hat{\mu}_2 &= (1/N)\sum_{i=1}^{N} y_i^2 \\ \hat{\mu}_4 &= (1/N)\sum_{i=1}^{N} y_i^4 \end{aligned}$$

GAUSS procedure:

Write a procedure which returns the objective function

$$Q(\nu) \equiv g'Wg$$

where

$$g = \begin{bmatrix} \left\{\hat{\mu}_2 - \frac{\nu}{\nu-2}\right\} \\ \left\{\hat{\mu}_4 - \frac{3v^2}{(v-2)(v-4)}\right\} \end{bmatrix}$$

3. Evaluating the objective function

GAUSS procedure:

Evaluate the objective function for different values of ν in a grid search. Save the values of ν and the corresponding value of the objective function and plot them. (Hint: Use this procedure as the main procedure which will be called later. Therefore, nest the previous procedure inside.)

Now, call your data generating procedure and use the output as your data set. Use the generated data set for the grid search procedure.

2nd set GAUSS assignments Financial Econometrics

In this practical exercise we try to evaluate the GMM objective function via a two-dimensional grid search for the Consumption Based Model (for details on the CBM, see Cochrane(2001) ch.1 and ch.2).

The basic pricing equation for the return of any asset i is:

$$E_t[m_{t+1}R^i_{t+1}] = 1$$

with m_{t+1} being the stochastic discount factor. In the Consumption Based Model the stochastic discount factor is the marginal rate of substitution:

$$m_{t+1} = \beta \frac{u'(c_{t+1})}{u'(c_t)}$$

Using the power utility function this results in

$$m_{t+1} = \beta \left(\frac{c_{t+1}}{c_t} \right)^{-\gamma}$$

This result can be translated directly into moment conditions:

$$E_t[m_{t+1}R^i_{t+1} - 1] = E_t \left[\beta \left(\frac{c_{t+1}}{c_t} \right)^{-\gamma} R^i_{t+1} - 1 \right] = 0$$

1. Create an objective function to estimate the parameter β and γ

First, load the consumption growth data and the return data into a GAUSS matrix. Consumption growth data from 2nd quarter 1947 to 4th quarter 1993 are provided in the file `consgr_1947Q2_1993Q4.fmt`. Return data for ten portfolios (1st size decile to 10th size decile) from 2nd quarter 1947 to 4th quarter 1993 are provided in the file `ret_dec10_1947Q2_1993Q4.fmt`. You can load those files with the `load` command (look it up in the GAUSS Help).

GAUSS procedure:

Write a procedure which returns the objective function

$$Q(\beta, \gamma) \equiv g'Wg$$

where W is the identity matrix and

$$g = \begin{bmatrix} \sum_{t=1}^{T} \left[\beta \left(\frac{c_{t+1}}{c_t} \right)^{-\gamma} R^1_{t+1} - 1 \right] \\ \vdots \\ \sum_{t=1}^{T} \left[\beta \left(\frac{c_{t+1}}{c_t} \right)^{-\gamma} R^{10}_{t+1} - 1 \right] \end{bmatrix}$$

2. Evaluating the objective function

GAUSS procedure:

Evaluate the objective function for different values of β and γ in a grid search. Save the values of β and γ together with the corresponding value of the objective function and plot them either in a three-dimensional `XYZ` plot or a three-dimensional surface plot or both. Preparing the data for a surface plot is slightly less intuitive, therefore start with the `XYZ` plot. (Hint: Use this procedure as the main procedure which will be called later. Therefore, nest the previous procedure inside.)

3rd set GAUSS assignments Financial Econometrics

Take the examples of the 1st and 2nd assignment and optimize the objective with help of the GAUSS GMM Toolbox.

1. Create a matrix containing the moment conditions

GAUSS procedure:

a) Write a procedure (modify the procedure of assignment 1) which returns the matrix

$$u = \begin{bmatrix} y_1^2 - \frac{\nu}{\nu-2} & y_1^4 - \frac{3v^2}{(v-2)(v-4)} \\ y_2^2 - \frac{\nu}{\nu-2} & y_2^4 - \frac{3v^2}{(v-2)(v-4)} \\ \vdots & \vdots \\ y_n^2 - \frac{\nu}{\nu-2} & y_n^4 - \frac{3v^2}{(v-2)(v-4)} \end{bmatrix}$$

b) Write a procedure (modify the procedure of assignment 2) which returns the matrix

$$u = \begin{bmatrix} \beta\left(\frac{c_1}{c_0}\right)^{-\gamma} R_1^1 - 1 & \beta\left(\frac{c_1}{c_0}\right)^{-\gamma} R_1^2 - 1 & \cdots & \beta\left(\frac{c_1}{c_0}\right)^{-\gamma} R_1^{10} - 1 \\ \beta\left(\frac{c_2}{c_1}\right)^{-\gamma} R_2^1 - 1 & \beta\left(\frac{c_2}{c_1}\right)^{-\gamma} R_2^2 - 1 & \cdots & \beta\left(\frac{c_2}{c_1}\right)^{-\gamma} R_2^{10} - 1 \\ \vdots & \ddots & & \vdots \\ \beta\left(\frac{c_T}{c_{T-1}}\right)^{-\gamma} R_T^1 - 1 & \beta\left(\frac{c_T}{c_{T-1}}\right)^{-\gamma} R_T^2 - 1 & \cdots & \beta\left(\frac{c_T}{c_{T-1}}\right)^{-\gamma} R_T^{10} - 1 \end{bmatrix}$$

Generally, the GMM procedure in the GMM toolbox needs as input the raw matrix of moment conditions without taking sample means of the respective moment conditions.

2. Call the estimation procedure using the GMM toolbox

GAUSS procedure:

Write a GAUSS procedure containing all the global settings and the estimation procedure. The estimation procedure is called in the following way:

```
gmm(initial,model,matrix1,matrix2,matrix3);
```

where `initial` is a column vector of initial values for your parameters, `model` is a reference to the procedure written in step 1 (e.g. if your procedure creating the moment matrix is called `cbm_moments`, then `model` would be `&cbm_moments`). For the last three arguments `matrix1` to `matrix3` assign an empty matrix and plug it in.

3. Load data and call estimation procedure

a) Use the procedure of the 1st assignment which produces a t-distributed random variable to create a data vector.

Call estimation procedure!

b) First, load the consumption growth data and the return data into a GAUSS matrix. Consumption growth data from 2nd quarter 1947 to 4th quarter 1993 are provided in the file `consgr_1947Q2_1993Q4.fmt`. Return data for ten portfolios (1st size decile to 10th size decile) from 2nd quarter 1947 to 4th quarter 1993 are provided in the file `ret_dec10_1947Q2_1993Q4.fmt`. You can load those files with the `load` command (look it up in the GAUSS Help).

Call estimation procedure!

4th set GAUSS assignments Financial Econometrics

a) Estimate the CAPM. The stochastic discount factor m is specified as:

$$m = a + b(R^m - R^f)$$

Moment conditions result from:

$$E(mR - 1) = 0$$

b) Estimate the famous Fama/French model, i.e. using $E(mR) = 1$ with the GMM toolbox in GAUSS. The stochastic discount factor m is formulated as a linear function of three factors:

$$m = a + b_1 f_1 + b_2 f_2 + b_3 f_3$$

where

$$\begin{aligned} f_1 &= (R^m - R^f) \\ f_2 &= (R^H - R^L) \\ f_3 &= (R^S - R^B) \end{aligned}$$

R^S denotes the return of a portfolio of *small* firms (in terms of market capitalization). R^B denotes the return of a portfolio of *big* firms. R^H denotes the return of a portfolio of firms with a *high* ratio of book value to market value. R^L denotes the return of a portfolio of firms with a *low* book to market ratio. In order to construct those portfolios, distribution deciles of the respective variable (e.g. book value/market value) are created for a set of assets. Then, portfolios are constructed according to those deciles. Typically, one uses the upper decile and the lower decile for calculating the return difference. Note, that all factors in the Fama/French model are excess returns.

c) Use excess returns $R_t^{ei} = R_t^i - R_t^f$ to conduct a (pooled) time series regression for all assets on the market portfolio as a single factor:

$$R^{ei} = \alpha_i + \beta_i f_t + \epsilon_t^i$$

The moment conditions require that:

$$g_T(b) = \left[\begin{array}{c} E_T(R^e - \alpha + \beta f_t) \\ E_T[(R^e - \alpha + \beta f_t) f_t] \end{array} \right] = \left[\begin{array}{c} E_T(\varepsilon_t) \\ E_T(\varepsilon_t f_t) \end{array} \right] = 0$$

Further, compute the GRS test statistic for $H_0 : \alpha_1 = \alpha_2 = \ldots = \alpha_{10} = 0$ which is asymptotically the following:

$$T \left[1 + \left(\frac{E_T(f)}{\hat{\sigma}(f)} \right)^2 \right]^{-1} \alpha' \hat{\Sigma}^{-1} \alpha \sim \chi_N^2$$

1. Create a matrix containing the moment conditions

GAUSS procedure:

a), **b)** and **c)**: Write a procedure returning the element wise moment conditions.

2. Call the estimation procedure using the GMM toolbox

GAUSS procedure:

Write a GAUSS procedure (or take the procedure from the 3rd GAUSS assignment) containing all the global settings and the estimation procedure.

3. Load data and call estimation procedure

a), **b)** and **c)**: First, load the factor data and the return data into a GAUSS matrix. Factor data from 2nd quarter 1947 to 4th quarter 1993 are provided in the file `ff_factors.fmt`. The first column contains the market excess return over the T-bill rate. The second column contains the series `SMB` and the third column contains the series `HML`. For task c) you will need the T-bill rate data provided in `tbill.fmt`. Return data for ten portfolios (1st size decile to 10th size decile) from 2nd quarter 1947 to 4th quarter 1993 are provided in the file `ret_dec10_1947Q2_1993Q4.fmt`. You can load those files with the `load` command (look it up in the GAUSS Help).

Call estimation procedure!

5th set GAUSS assignments Financial Econometrics

For convenience, collect all previously written and new procedures belonging to the estimation of asset pricing models in a source file which you include (`#include filename.src`) before you call the procedures in a separate program.

1. Test for joint significance

Estimate the Fama/French model with help of the GMM toolbox and the procedures developed in the 4th assignment. Are the coefficients of the Fama/French factors statistically significant different from zero? Use the estimated variance covariance matrix to compute an F-statistic for joint significance of the coefficients:

$$F \equiv (\mathbf{Rb} - \mathbf{r})'[\mathbf{R}\widehat{Var(\mathbf{b}|\mathbf{X})}\mathbf{R}']^{-1}(\mathbf{Rb} - \mathbf{r})/\#\mathbf{r}$$

where $\#\mathbf{r}$ is the dimension of $\mathbf{r}$ (number of restrictions).

Example: For the construction of the matrix $\mathbf{R}$ and the vector $\mathbf{r}$, suppose you have estimated the parameter vector $\mathbf{b} = (\ b_1 \quad b_2 \quad b_3 \quad b_4\ )'$ and want to test the joint hypotheses whether the true parameter $\beta_2 = \beta_3$ and $\beta_1 = 0$. Then, you can write the null hypotheses as a system of linear equations:

$$H_0 : \mathbf{R}\boldsymbol{\beta} = \mathbf{r}$$

In this example, it follows for $\mathbf{R}$ and $\mathbf{r}$:

$$\mathbf{R} = \begin{bmatrix} 0 & 1 & -1 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix}, \qquad \mathbf{r} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

2. Plot the time series of the stochastic discount factor

Estimate an asset pricing model of your choice and save the estimated coefficients in a vector.

Write a GAUSS procedure which returns the time series of the stochastic discount factor for a specific asset pricing model (e.g. Fama/French, CAPM etc.). Then, use this procedure in a second procedure which plots the SDF series.

3. Plot the average excess return vs. predicted excess return

Estimate an asset pricing model of your choice and save the estimated coefficients in a vector.

The predicted returns R^i for each return decile can be calculated from

$$E(R^i) = \frac{1 - cov(m, R^i)}{E(m)}$$

Use the procedure which returns the SDF series together with the matrix of returns to compute the predicted mean returns for each return decile. Further, calculate the realized mean returns $\bar{R}^i$ for each return decile and collect them in a vector. Plot the realized mean returns on the x-axis versus the predicted mean returns on the y-axis. Draw an additional 45° line to provide an illustration how well the model fits the data. (*Look up the graphics syntax in the example program provided in* `gmmprocs.src`)

6th set GAUSS assignments Financial Econometrics

Add all additional procedures in your personal procedure file.

1. Conditional estimates ("Managed portfolios")

Write additional procedures to estimate the consumption based model, the Fama/French model and the CAPM with instruments. In the GAUSS file `instruments.fmt` you find the two instruments used by Cochrane(JPE 1996). In the first column you find the term spread (yield on long term government bonds less yield on 3-month Treasury bills) and in the second column you find the dividend/price ratio of the equally weighted NYSE portfolio. Instead of using the d/p ratio directly, use $1 + 100 \times [(d/p) - 0.04]$ to keep the scale of the moments comparable. The moment conditions if you use excess returns are:

$$g_T(b) = \begin{bmatrix} E[m_{t+1}R^{e,1}_{t+1}] \\ \vdots \\ E[m_{t+1}R^{e,10}_{t+1}] \\ E[(m_{t+1}R^{e,1}_{t+1})z^1_t] \\ \vdots \\ E[(m_{t+1}R^{e,10}_{t+1})z^1_t] \\ E[(m_{t+1}R^{e,1}_{t+1})z^2_t] \\ \vdots \\ E[(m_{t+1}R^{e,10}_{t+1})z^2_t] \end{bmatrix}$$

where z^1_t is the term spread and z^2_t is the dividend/price ratio.

Hint: If excess returns are used you need an additional moment restriction to identify the parameters. This moment restriction follows directly from the fact that $E(mR^F) = 1$.

2. Plot the average excess return vs. predicted excess return

Estimate and compare the different asset pricing models according to how well the predicted returns fit the realized returns.

The predicted returns R^i for each return decile can be calculated from

$$E(R^i) = \frac{1 - cov(m, R^i)}{E(m)}$$

Predicted excess returns can be computed as:

$$E(R^{e,i}) = -\frac{cov(m, R^{e,i})}{E(m)}$$

Use the procedure which returns the SDF series together with the matrix of returns to compute the predicted mean returns for each return decile. Further, calculate the realized mean returns $\bar{R}^i$ or $\bar{R}^{e,i}$, respectively, for each return decile and collect them in a vector. Plot the predicted mean returns on the x-axis versus the realized mean returns on the y-axis. Draw an additional 45° line to provide an illustration how well the model fits the data. (*Look up the graphics syntax in the example program provided in* `gmmprocs.src`)

7th set GAUSS assignments Financial Econometrics

Add all additional procedures in your personal procedure file.

1. Scaling factors

i) Write additional procedures to estimate the CAPM with scaled factors. In the GAUSS file `cay.fmt` you find the instrument used by Lettau/Ludvigson(JPE 2001). To replicate the results of Lettau/Ludvigson, use the 25 Fama/French portfolios provided in `ff_25.fmt`, the market return provided in `mkret_ll.fmt` and the T-bill rate provided in `tbill_ll.fmt`. The stochastic discount factor is specified as:

$$m_{t+1} = a_1 + a_2 cay_t + b_1 R^m + b_2(R^m_{t+1} \times cay_t)$$

The moment conditions are collected in a vector $g_T(b)$:

$$g_T(b) = \begin{bmatrix} E[m_{t+1}R^{e,1}_{t+1}] \\ \vdots \\ E[m_{t+1}R^{e,10}_{t+1}] \end{bmatrix}$$

<u>Hint</u>: If excess returns are used you need an additional moment restriction to identify the parameters. This moment restriction follows directly from the fact that $E(mR^F) = 1$.

ii) 1. Estimate the CAPM with scaled factors for the Cochrane deciles. Scale the factors with the two instruments term spread and dividend/price ratio provided in `instruments.fmt`. Provide unconditional estimates as in i). The stochastic discount factor is specified as :

$$m_{t+1} = a_1 + b_1 R^m + b_2(R^m_{t+1} \times d/p) + b_3(R^m_{t+1} \times term)$$

Note, that the constant is not scaled by the instruments (hence, the constant is not time varying), since Cochrane does not include the instruments themselves as factors. The moment conditions for unconditional estimates of the scaled factor model are again:

$$g_T(b) = \begin{bmatrix} E[m_{t+1}R^{e,1}_{t+1}] \\ \vdots \\ E[m_{t+1}R^{e,10}_{t+1}] \end{bmatrix}$$

2. To replicate the results in Cochrane(JPE 1996), you have to provide conditional estimates of the scaled model (use only return decile 1, 2, 5 and 10 together with the "managed portfolios" $R^{e,i}z^i$). The stochastic discount factor is specified as before in 1. The moment conditions for conditional estimates of the scaled factor model are now (as

in the managed portfolio case):

$$g_T(b) = \begin{bmatrix} E[m_{t+1}R^{e,1}_{t+1}] \\ \vdots \\ E[m_{t+1}R^{e,10}_{t+1}] \\ E[(m_{t+1}R^{e,1}_{t+1})z^1_t] \\ \vdots \\ E[(m_{t+1}R^{e,10}_{t+1})z^1_t] \\ E[(m_{t+1}R^{e,1}_{t+1})z^2_t] \\ \vdots \\ E[(m_{t+1}R^{e,10}_{t+1})z^2_t] \end{bmatrix}$$

where z^1_t is the term spread and z^2_t is the dividend/price ratio.

2. Plot the average excess return vs. predicted excess return

Modify your procedure which returns the series for the stochastic discount factor to account for the different specifications of the SDF in part 1 of this assignment sheet and produce the plot fitted return vs. realized return.

8th set GAUSS assignments Financial Econometrics

Create a new procedure file for today's procedures and the following procedures related to the estimation of trade indicator models (e.g. call it `timprocs.src`). Copy the `estimate_gmm` procedure (or however you named the general estimation procedure) into that procedure file. For convenience and a data description, you can also copy the `readdata` procedure provided in the procedure file on the homepage.

1. Estimating the Madhavan/Richardson/Roomans(1997) model

i) Write a procedures which returns the moment conditions implied by the MRR model. In the GAUSS files `ads_tim.fmt`, `bmw_tim.fmt` and `dcx_tim.fmt` you find trade data for the three stocks over a period from 1st February 2004 to 10th February 2004. The estimable equation which can be derived from the theoretical MRR framework reads as:

$$\Delta p_t = \theta(Q_t - \rho Q_{t-1}) + \phi \Delta Q_t + u_t$$

and implies the following moment conditions:

$$E \begin{bmatrix} Q_t Q_{t-1} - \rho \\ u_t \\ u_t Q_t \\ u_t Q_{t-1} \end{bmatrix} = 0$$

where Q_t is a trade indicator taking the value 1 if the trade is a buy and -1 if the trade is a sell. Δp_t is the price change from period $t-1$ to t.

ii) Write a procedure which returns the standard error for the implied spread $s_E = 2(\phi + \theta)$ and the asymmetric information share $r = \theta/(\theta + \phi)$. Use the delta method to compute the standard errors:

Suppose that $\{\mathbf{x}_n\}$ is a sequence of K-dimensional random vectors such that $\mathbf{x}_n \xrightarrow{p} \boldsymbol{\beta}$ and

$$\sqrt{n}(\mathbf{x}_n - \boldsymbol{\beta}) \xrightarrow{d} N(\mathbf{0}, \boldsymbol{\Sigma})$$

then

$$\sqrt{n}(\mathbf{a}(\mathbf{x}_n) - \mathbf{a}(\boldsymbol{\beta})) \xrightarrow{d} N(\mathbf{0}, \mathbf{A}(\boldsymbol{\beta})\boldsymbol{\Sigma}\mathbf{A}(\boldsymbol{\beta})')$$

where $\mathbf{A}(\boldsymbol{\beta})$ is the matrix of continuous first derivatives of $\mathbf{a}(\boldsymbol{\beta})$ evaluated at $\boldsymbol{\beta}$:

$$\mathbf{A}(\boldsymbol{\beta}) = \frac{\partial \mathbf{a}(\boldsymbol{\beta})}{\partial \boldsymbol{\beta}'}.$$

Hint: Look in the GAUSS help how the `gradp` function works.

iii) Estimate the model for all three stocks and save your results in a matrix. Note, that if you want to add information having character format you have to convert your numeric values first since mixed matrices (numeric and character) are not allowed in GAUSS.

9th set GAUSS assignments Financial Econometrics

Add the new procedures related to the estimation of trade indicator models to the procedure file related to trade indicator models (e.g. `timprocs.src`).

1. Estimating the Huang/Stoll(1997) model

i) Write a procedure which returns the moment conditions implied by the HS model. In the GAUSS files `ads_tim.fmt`, `bmw_tim.fmt` and `dcx_tim.fmt` you find trade data for the three stocks over a period from 1st February 2004 to 10th February 2004. The estimable equation which can be derived from the theoretical HS framework reads as:

$$\Delta P_t = \frac{S}{2} \cdot \Delta Q_t + \upsilon \cdot \frac{S}{2} \cdot Q_{t-1} + u_t$$

and implies the following moment conditions:

$$E \begin{bmatrix} u_t \\ u_t Q_t \\ u_t Q_{t-1} \end{bmatrix} = 0$$

where Q_t is a trade indicator taking the value 1 if the trade is a buy and -1 if the trade is a sell. ΔP_t is the price change from period $t-1$ to t. Note, that the spread S is estimated in this specification.

ii) Write a procedure which returns the moment conditions implied by the HS model taking into account different volume categories. The estimable equation which can be derived from the theoretical HS framework reads as:

$$\Delta P_t = \frac{S^s}{2} D_t^s + (\lambda_s - 1)\frac{S^s}{2} D_{t-1}^s + \frac{S^m}{2} D_t^m + (\lambda_m - 1)\frac{S^m}{2} D_{t-1}^m + \frac{S^l}{2} D_t^l + (\lambda_l - 1)\frac{S^l}{2} D_{t-1}^l + u_t$$

where

$$\begin{aligned} D_t^s &= Q_t && \text{if share volume at } t \leq 1000 \text{ shares} \\ &= 0 && \text{otherwise} \\ D_t^m &= Q_t && \text{if share volume at } t < 10000 \text{ shares} \\ &= 0 && \text{otherwise} \\ D_t^l &= Q_t && \text{if share volume at } t \geq 10000 \text{ shares} \\ &= 0 && \text{otherwise} \end{aligned}$$

and implies the following moment conditions:

$$E \begin{bmatrix} u_t \\ u_t D_t^s \\ u_t D_{t-1}^s \\ u_t D_t^m \\ u_t D_{t-1}^m \\ u_t D_t^l \\ u_t D_{t-1}^l \end{bmatrix} = 0$$

10th set GAUSS assignments Financial Econometrics

The GAUSS code `evntst.g` for this assignment sheet is based on chapter 5 and 6 of the book "Using SAS in Financial Research", written by Boehmer, Broussard, Kallunki (2002) and partly on chapter 4 of "The Econometrics of Financial Markets" from Campbell, Lo, MacKinlay (1997). The data set `returns.dat` contains the event date (`evntdate`), return data (`ret`), market return data (`mrktret`), a date variable (`dat`), a dummy variable for positive or negative earnings announcements (`evntdum`) and a firm indicator (`firm`).

1. Event study analysis

i) First, take a look how the data are structured. Therefore, read in the data from the file `return.dat`. You can use the read in steps from the program `evntst.g`. Create an indicator variable which takes the value 1 if the date in the date column is less than the event date and 0 otherwise.

ii) Then, write a procedure which conducts OLS estimation and returns the estimated parameters as well as the estimated error variance (or standard deviation).

iii) The following steps are done for each stock and each event separately:

1. Determine the estimation period and select the sub-matrix belonging to this period.
2. Then, estimate the market model with your OLS procedure:
$$R_{it} = \alpha + \beta R_t^m + \varepsilon_t$$
3. Determine the event period (take a look in the example program) and select the sub-matrix belonging to the event period.
4. Use your estimated parameters to calculate abnormal returns in the event period:
$$\widehat{AR}_{i\tau} = R_{i\tau} - \hat{\alpha} + \hat{\beta} R_\tau^m$$
5. Compute cumulative abnormal returns: $\widehat{CAR}_i = \sum_\tau \widehat{AR}_{i\tau}$ and the variance of the CAR:
$$\widehat{Var}(CAR_i) = \gamma' \hat{\mathbf{V}}_i \gamma$$
where
$$\hat{\mathbf{V}}_i = \hat{\sigma}_{\boldsymbol{\varepsilon}_i}(\mathbf{I} + \mathbf{X}_i^*(\mathbf{X}_i'\mathbf{X}_i)^{-1}\mathbf{X}_i^{*\prime})$$
$\mathbf{X}_i^*$ is the data matrix from the event period and $\mathbf{X}_i$ is the data matrix from the estimation period. $\mathbf{I}$ denotes the identity matrix and $\hat{\sigma}_{\boldsymbol{\varepsilon}_i}$ is the error variance.
6. Compute the standardized cumulative return:
$$\widehat{SCAR}_i = \frac{\widehat{CAR}_i}{\sqrt{\widehat{Var}(CAR_i)}}$$

....TO BE CONTINUED

11th set GAUSS assignments Financial Econometrics

The GAUSS code `GAUSS_session11.prg` for this assignment sheet is based on chapter 5 and 6 of the book "Using SAS in Financial Research", written by Boehmer, Broussard, Kallunki (2002) and partly on chapter 4 of "The Econometrics of Financial Markets" from Campbell, Lo, MacKinlay (1997). The data set `returns.dat` contains the event date (`evntdate`), return data (`ret`), market return data (`mrktret`), a date variable (`dat`), a dummy variable for positive or negative earnings announcements (`evntdum`) and a firm indicator (`firm`).

1. Event study analysis (continued)

i) Write a procedure which returns several test statistics designed for event study analysis as there are:

1. $t_{Patell} = \dfrac{\overline{SCAR_i}}{\sqrt{n}}$
2. $t_{cs} = \dfrac{\overline{CAR_i}}{\widehat{Var}(\overline{CAR_i})}$
3. $t_{BMP} = \dfrac{\overline{SCAR_i}}{\widehat{Var}(\overline{SCAR_i})}$

Compare the test statistics for the $SCAR$ calculated without taking into account parameter uncertainty (column 5 in the `out` matrix)and for the "correct" $SCAR$ which takes into account parameter uncertainty (column 6 in the `out` matrix).

12th set GAUSS assignments Financial Econometrics

The GAUSS code `GAUSS_session12.prg` for this assignment sheet uses a procedure collection written for VAR estimation (`var_code.src`) by Paul Fackler. The data set `asia_markets.txt` contains the return data of five stock markets over the sample period from 1/01/1985 to 4/29/1999: Hong Kong, Japan, Singapore, Korea and Thailand.

1. Vector Autoregression

You want to analyze the interdependence between South East Asian stock markets. Therefore, estimate a VAR model with GAUSS. We will only use the three markets Tokyo, Singapore and Korea. The model reads as:

$$
\begin{array}{rllll}
r_t^T = k^T & & +\beta_{12}^{(0)} r_t^S + & \beta_{13}^{(0)} r_t^K + & \beta_{11}^{(1)} r_{t-1}^T + \beta_{12}^{(1)} r_{t-1}^S + \beta_{13}^{(1)} r_{t-1}^K + u_t^T \\
r_t^S = k^S & +\beta_{21}^{(0)} r_t^T & + & \beta_{23}^{(0)} r_t^K + & \beta_{21}^{(1)} r_{t-1}^T + \beta_{22}^{(1)} r_{t-1}^S + \beta_{23}^{(1)} r_{t-1}^K + u_t^S \\
r_t^K = k^K & +\beta_{31}^{(0)} r_t^T & +\beta_{32}^{(0)} r_t^S + & & \beta_{31}^{(1)} r_{t-1}^T + \beta_{32}^{(1)} r_{t-1}^S + \beta_{33}^{(1)} r_{t-1}^K + u_t^K
\end{array}
$$

where r_t^T is the return of the Tokyo market, r_t^S is the return of the Singapore and r_t^K is the return of the Korea market.

- The return data are provided as a single column, i.e. the first n observations are from HongKong, then n for Tokyo, the next n from Singapore the next n from Korea and the last n from Thailand. $n = 3737$ in our example. Reshape the data matrix to obtain 5 columns, for each country one. Hint: Use the `reshape()` function.
- First, use the procedure `var()` to estimate the VAR model. (read the documentation of the procedure code to apply the correct global settings)
- Use the procedure `vma()` to back out the VMA parameters.
- Use the procedure `reca0()` to perform Cholesky decomposition of the innovation covariance matrix.
- In order to examine the effect of a shock in one market on the other markets compute impulse response functions with the procedure `impulse()`. Plot your results in a comprehensive way.
- Conduct a variance decomposition with the procedure `fedecomp` for each market and plot your results.