Ancillary Results and Estimation Code for Dynamic Stock Market Covariances in the Eurozone

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1. Introduction

This paper provides additional tables, estimation code and estimation output for the paper "Dynamic Stock Market Covariance in the Eurozone." It should be read in conjunction with that paper. Some familiarity with RATS statistical programming language is necessary for understanding the estimation code and estimation output. This code may be useful for researchers doing empirical analysis involving GARCH, Midas-Garch, or DCC-Midas-Garch, particularly if they use RATS. The code could be translated with suitable modifications to other programming languages.

2. Ancillary Tables

Table A1 shows the sample correlation matrix of standardized returns (return divided by the square root of Garch-based dynamic variance). This matrix is used for the initial parameter values of the unconditional correlation matrix in the estimation of the DCC model (see the main paper for details).

Table A1: Unconditional sample correlation matrix of standardized returns

	R_{1t}	R_{2t}	R_{3t}	R_{4t}	R_{5t}	R_{6t}	R_{7t}	R_{8t}	R_{9t}	R_{10t}	R_{11t}
R_{1t}	1	0.5208	0.4587	0.5201	0.5724	0.3210	0.4653	0.4734	0.5511	0.4149	0.5037
R_{2t}	0.5208	1	0.5438	0.6952	0.6749	0.3488	0.5204	0.6125	0.7299	0.4932	0.6415
R_{3t}	0.4587	0.5438	1	0.6207	0.6175	0.3165	0.4904	0.5519	0.6512	0.4763	0.5818
R_{4t}	0.5201	0.6952	0.6207	1	0.7792	0.3476	0.5412	0.7460	0.8224	0.5293	0.7803
R_{5t}	0.5724	0.6749	0.6175	0.7792	1	0.3312	0.5340	0.6894	0.7920	0.5208	0.7133
R_{6t}	0.3210	0.3488	0.3165	0.3476	0.3312	1	0.3117	0.3059	0.3518	0.3248	0.3274
R_{7t}	0.4653	0.5204	0.4904	0.5412	0.5340	0.3117	1	0.4776	0.5670	0.4175	0.4963
R_{8t}	0.4734	0.6125	0.5519	0.7460	0.6894	0.3059	0.4776	1	0.7100	0.4791	0.7074
R_{9t}	0.5511	0.7299	0.6512	0.8224	0.7920	0.3518	0.5670	0.7100	1	0.5269	0.7417
R_{10t}	0.4149	0.4932	0.4763	0.5293	0.5208	0.3248	0.4175	0.4791	0.5269	1	0.5417
R_{11t}	0.5037	0.6415	0.5818	0.7803	0.7133	0.3274	0.4963	0.7074	0.7417	0.5417	1

Notes: The unconditional sample correlation matrix of standardized returns (return divided by the square root of Garch-based dynamic variance)

Tables A2-A8 show the final estimates of the unconditional correlation matrix for specification one through seven in Table 6 of the paper.

Table A2: Final estimates of the unconditional correlation matrix: Model 1

	R_{1t}	R_{2t}	R_{3t}	R_{4t}	R_{5t}	R_{6t}	R_{7t}	R_{8t}	R_{9t}	R_{10t}	R_{11t}
R_{1t}	1	0.5087	0.4598	0.5071	0.5506	0.3244	0.4465	0.4711	0.5348	0.4096	0.4928
R_{2t}	0.5087	1	0.5450	0.7082	0.6826	0.3371	0.5034	0.6315	0.7358	0.4833	0.6458
R_{3t}	0.4598	0.5450	1	0.6289	0.6213	0.3136	0.4775	0.5610	0.6503	0.4600	0.5796
R_{4t}	0.5071	0.7082	0.6289	1	0.8053	0.3285	0.5221	0.7702	0.8354	0.5132	0.7862
R_{5t}	0.5506	0.6826	0.6213	0.8053	1	0.3240	0.5160	0.7171	0.8020	0.5086	0.7268
R_{6t}	0.3244	0.3371	0.3136	0.3285	0.3240	1	0.3022	0.3046	0.3383	0.3124	0.3168
R_{7t}	0.4465	0.5034	0.4775	0.5221	0.5160	0.3022	1	0.4690	0.5438	0.3995	0.4805
R_{8t}	0.4711	0.6315	0.5610	0.7702	0.7171	0.3046	0.4690	1	0.7278	0.4778	0.7255
R_{9t}	0.5348	0.7358	0.6503	0.8354	0.8020	0.3383	0.5438	0.7278	1	0.5073	0.7398
R_{10t}	0.4096	0.4833	0.4600	0.5132	0.5086	0.3124	0.3995	0.4778	0.5073	1	0.5324
R_{11t}	0.4928	0.6458	0.5796	0.7862	0.7268	0.3168	0.4805	0.7255	0.7398	0.5324	1

Table A3: Final estimates of the unconditional correlation matrix: Model 2

	R_{1t}	R_{2t}	R_{3t}	R_{4t}	R_{5t}	R_{6t}	R_{7t}	R_{8t}	R_{9t}	R_{10t}	R_{11t}
R_{1t}	1	0.5092	0.4602	0.5075	0.5511	0.3246	0.4467	0.4715	0.5353	0.4096	0.4931
R_{2t}	0.5092	1	0.5452	0.7085	0.6829	0.3373	0.5035	0.6318	0.7359	0.4834	0.6459
R_{3t}	0.4602	0.5452	1	0.6289	0.6214	0.3138	0.4778	0.5610	0.6503	0.4598	0.5795
R_{4t}	0.5075	0.7085	0.6289	1	0.8054	0.3287	0.5222	0.7702	0.8353	0.5131	0.7860
R_{5t}	0.5511	0.6829	0.6214	0.8054	1	0.3241	0.5164	0.7172	0.8021	0.5086	0.7268
R_{6t}	0.3246	0.3373	0.3138	0.3287	0.3241	1	0.3022	0.3049	0.3384	0.3123	0.3170
R_{7t}	0.4467	0.5035	0.4778	0.5222	0.5164	0.3022	1	0.4692	0.5439	0.3997	0.4805
R_{8t}	0.4715	0.6318	0.5610	0.7702	0.7172	0.3049	0.4692	1	0.7277	0.4778	0.7255
R_{9t}	0.5353	0.7359	0.6503	0.8353	0.8021	0.3384	0.5439	0.7277	1	0.5071	0.7397
R_{10t}	0.4096	0.4834	0.4598	0.5131	0.5086	0.3123	0.3997	0.4778	0.5071	1	0.5324
R_{11t}	0.4931	0.6459	0.5795	0.7860	0.7268	0.3170	0.4805	0.7255	0.7397	0.5324	1

Table A4: Final estimates of the unconditional correlation matrix: Model 3

	R_{1t}	R_{2t}	R_{3t}	R_{4t}	R_{5t}	R_{6t}	R_{7t}	R_{8t}	R_{9t}	R_{10t}	R_{11t}
R_{1t}	1	0.5085	0.4594	0.5068	0.5502	0.3239	0.4463	0.4708	0.5345	0.4094	0.4924
R_{2t}	0.5085	1	0.5448	0.7080	0.6823	0.3366	0.5030	0.6313	0.7356	0.4833	0.6456
R_{3t}	0.4594	0.5448	1	0.6288	0.6212	0.3131	0.4773	0.5610	0.6503	0.4600	0.5795
R_{4t}	0.5068	0.7080	0.6288	1	0.8053	0.3280	0.5219	0.7701	0.8354	0.5133	0.7862
R_{5t}	0.5502	0.6823	0.6212	0.8053	1	0.3236	0.5157	0.7171	0.8020	0.5086	0.7267
R_{6t}	0.3239	0.3366	0.3131	0.3280	0.3236	1	0.3018	0.3041	0.3379	0.3120	0.3164
R_{7t}	0.4463	0.5030	0.4773	0.5219	0.5157	0.3018	1	0.4687	0.5435	0.3994	0.4803
R_{8t}	0.4708	0.6313	0.5610	0.7701	0.7171	0.3041	0.4687	1	0.7278	0.4779	0.7255
R_{9t}	0.5345	0.7356	0.6503	0.8354	0.8020	0.3379	0.5435	0.7278	1	0.5074	0.7399
R_{10t}	0.4094	0.4833	0.4600	0.5133	0.5086	0.3120	0.3994	0.4779	0.5074	1	0.5324
R_{11t}	0.4924	0.6456	0.5795	0.7862	0.7267	0.3164	0.4803	0.7255	0.7399	0.5324	1

Table A5: Final estimates of the unconditional correlation matrix: Model 4

	R_{1t}	R_{2t}	R_{3t}	R_{4t}	R_{5t}	R_{6t}	R_{7t}	R_{8t}	R_{9t}	R_{10t}	R_{11t}
R_{1t}	1	0.5090	0.4603	0.5072	0.5508	0.3263	0.4474	0.4717	0.5349	0.4098	0.4932
R_{2t}	0.5090	1	0.5447	0.7081	0.6825	0.3388	0.5034	0.6315	0.7353	0.4832	0.6457
R_{3t}	0.4603	0.5447	1	0.6284	0.6211	0.3149	0.4778	0.5609	0.6498	0.4595	0.5793
R_{4t}	0.5072	0.7081	0.6284	1	0.8050	0.3298	0.5221	0.7699	0.8350	0.5128	0.7858
R_{5t}	0.5508	0.6825	0.6211	0.8050	1	0.3253	0.5166	0.7170	0.8019	0.5083	0.7265
R_{6t}	0.3263	0.3388	0.3149	0.3298	0.3253	1	0.3039	0.3063	0.3392	0.3136	0.3184
R_{7t}	0.4474	0.5034	0.4778	0.5221	0.5166	0.3039	1	0.4695	0.5436	0.4003	0.4806
R_{8t}	0.4717	0.6315	0.5609	0.7699	0.7170	0.3063	0.4695	1	0.7275	0.4778	0.7254
R_{9t}	0.5349	0.7353	0.6498	0.8350	0.8019	0.3392	0.5436	0.7275	1	0.5067	0.7393
R_{10t}	0.4098	0.4832	0.4595	0.5128	0.5083	0.3136	0.4003	0.4778	0.5067	1	0.5322
R_{11t}	0.4932	0.6457	0.5793	0.7858	0.7265	0.3184	0.4806	0.7254	0.7393	0.5322	1

Table A6: Final estimates of the unconditional correlation matrix: Model 5

	R_{1t}	R_{2t}	R_{3t}	R_{4t}	R_{5t}	R_{6t}	R_{7t}	R_{8t}	R_{9t}	R_{10t}	R_{11t}
R_{1t}	1	0.5033	0.4540	0.5001	0.5443	0.3151	0.4400	0.4654	0.5279	0.4017	0.4877
R_{2t}	0.5033	1	0.5408	0.7061	0.6804	0.3305	0.4982	0.6298	0.7349	0.4773	0.6442
R_{3t}	0.4540	0.5408	1	0.6256	0.6180	0.3044	0.4707	0.5574	0.6469	0.4547	0.5765
R_{4t}	0.5001	0.7061	0.6256	1	0.8025	0.3191	0.5162	0.7692	0.8340	0.5063	0.7855
R_{5t}	0.5443	0.6804	0.6180	0.8025	1	0.3155	0.5104	0.7153	0.7996	0.5028	0.7243
R_{6t}	0.3151	0.3305	0.3044	0.3191	0.3155	1	0.2933	0.2968	0.3280	0.3051	0.3089
R_{7t}	0.4400	0.4982	0.4707	0.5162	0.5104	0.2933	1	0.4635	0.5371	0.3913	0.4738
R_{8t}	0.4654	0.6298	0.5574	0.7692	0.7153	0.2968	0.4635	1	0.7259	0.4728	0.7240
R_{9t}	0.5279	0.7349	0.6469	0.8340	0.7996	0.3280	0.5371	0.7259	1	0.5014	0.7379
R_{10t}	0.4017	0.4773	0.4547	0.5063	0.5028	0.3051	0.3913	0.4728	0.5014	1	0.5268
R_{11t}	0.4877	0.6442	0.5765	0.7855	0.7243	0.3089	0.4738	0.7240	0.7379	0.5268	1

Table A7: Final estimates of the unconditional correlation matrix: Model 6

	R_{1t}	R_{2t}	R_{3t}	R_{4t}	R_{5t}	R_{6t}	R_{7t}	R_{8t}	R_{9t}	R_{10t}	R_{11t}
R_{1t}	1	0.50855	0.45956	0.50657	0.55015	0.32542	0.4471	0.47115	0.53431	0.40956	0.49257
R_{2t}	0.50855	1	0.54417	0.70749	0.68188	0.3378	0.50261	0.63108	0.73482	0.48318	0.64529
R_{3t}	0.45956	0.54417	1	0.62811	0.62074	0.3138	0.47731	0.5607	0.64958	0.45947	0.57902
R_{4t}	0.50657	0.70749	0.62811	1	0.80494	0.32875	0.52159	0.76988	0.83492	0.51284	0.78572
R_{5t}	0.55015	0.68188	0.62074	0.80494	1	0.32437	0.51597	0.71689	0.80185	0.50826	0.72626
R_{6t}	0.32542	0.3378	0.3138	0.32875	0.32437	1	0.30316	0.30536	0.33824	0.31277	0.3175
R_{7t}	0.4471	0.50261	0.47731	0.52159	0.51597	0.30316	1	0.46905	0.54302	0.40011	0.48016
R_{8t}	0.47115	0.63108	0.5607	0.76988	0.71689	0.30536	0.46905	1	0.72751	0.47794	0.72532
R_{9t}	0.53431	0.73482	0.64958	0.83492	0.80185	0.33824	0.54302	0.72751	1	0.50692	0.73934
R_{10t}	0.40956	0.48318	0.45947	0.51284	0.50826	0.31277	0.40011	0.47794	0.50692	1	0.53226
R_{11t}	0.49257	0.64529	0.57902	0.78572	0.72626	0.3175	0.48016	0.72532	0.73934	0.53226	1

Table A8: Final estimates of the unconditional correlation matrix: Model 7

	R_{1t}	R_{2t}	R_{3t}	R_{4t}	R_{5t}	R_{6t}	R_{7t}	R_{8t}	R_{9t}	R_{10t}	R_{11t}
R_{1t}	1	0.50298	0.45338	0.49948	0.54368	0.31415	0.43989	0.46497	0.52725	0.40171	0.48711
R_{2t}	0.50298	1	0.54032	0.70538	0.67975	0.32947	0.49723	0.62937	0.73436	0.47777	0.64386
R_{3t}	0.45338	0.54032	1	0.6253	0.61773	0.30333	0.47026	0.55736	0.64679	0.45486	0.57627
R_{4t}	0.49948	0.70538	0.6253	1	0.80233	0.31796	0.51551	0.76919	0.83392	0.50666	0.78539
R_{5t}	0.54368	0.67975	0.61773	0.80233	1	0.31447	0.50981	0.71525	0.79964	0.50298	0.724
R_{6t}	0.31415	0.32947	0.30333	0.31796	0.31447	1	0.29244	0.29584	0.32684	0.30432	0.30791
R_{7t}	0.43989	0.49723	0.47026	0.51551	0.50981	0.29244	1	0.46306	0.53643	0.39133	0.47325
R_{8t}	0.46497	0.62937	0.55736	0.76919	0.71525	0.29584	0.46306	1	0.72608	0.47332	0.72397
R_{9t}	0.52725	0.73436	0.64679	0.83392	0.79964	0.32684	0.53643	0.72608	1	0.50204	0.7379
R_{10t}	0.40171	0.47777	0.45486	0.50666	0.50298	0.30432	0.39133	0.47332	0.50204	1	0.52734
R_{11t}	0.48711	0.64386	0.57627	0.78539	0.724	0.30791	0.47325	0.72397	0.7379	0.52734	1

Table A9 shows the correlation matrix of the quarterly-frequency explanatory variables used in Table 8 in the main paper.

Table A9: Correlation matrix of the quarterly-frequency explanatory variables

	$trend_t$	$ratio_{t-1}$	$cumret_t$	$signal_t$	$avegrowth_t$	$avevar_t$
$trend_t$	1	0.81	-0.20	0.43	-0.35	0.19
$ratio_{t-1}$	0.81	1	-0.10	0.48	-0.42	0.30
$cumret_t$	-0.20	-0.10	1	-0.34	0.33	-0.61
$signal_t$	0.43	0.48	-0.34	1	-0.89	0.62
$avegrowth_t$	-0.35	-0.42	0.33	-0.89	1	-0.60
$avevar_t$	0.19	0.30	-0.61	0.62	-0.60	1

Note that many other ancillary estimation results can be found directly in the estimation output in section 4 below.

3. RATS Estimation Code

The step one data used in the paper consists of the log returns to eleven Eurozone countries over the period 1st of January 1992 to 31st of December 2010. Daily adjusted stock index prices are downloaded from Datastream for the period 31st of December 1991 to 31st of December 2010, the panel dataset is balanced across trading days as described in the paper, log returns calculated and then the data is written to a free-format file rets.txt.

The step two data consists of standardised residuals from the Midas-Garch models, a time trend, the average cumulative returns to the eleven indices using the previous 65 days of returns, the proportion of the eleven markets which had negative real GDP growth during the current quarter, the lagged correlation ratio using the previous 65 days of daily returns, the lagged average sample variance using the previous 65 daily returns and the cross-sectional average of national GDP growth in the current quarter. These are obtained from midasgarch.txt, qlinreg5models.txt and truedailysignals.txt. The data is stored in 3 free-format files eta.txt, dailysignals.txt, and truedailysigs.txt. See the estimation code for details.

All the programs use the subdirectory c:\eurovol\programs for storage of estimation code and c:\eurovol\output for storage of input/output files, except the raw data files which originate in c:\eurovol\data. This can be changed easily using search/replace depending on the computer configuration of the user.

1) **makerets.txt -** this program makes euro index returns from euro index prices

   input: pricesDec1991toDec2010.txt

   datesDec1991toDec2010.txt

   output: rets.txt

   rrets.txt

   rdates.txt

2) **basicstats.txt -** this programme estimates some basic statistics on 11 eurozone national equity indices

   Input: rets.txt (we only use descriptive statistics generated by this program, therefore, there is no output file)

   rawcormat.txt

   crosscormat.txt

   crosscovmat.txt

   adjcormat.txt

   adjcovmat.txt

adjvar.txt

Used in: Table 1, Table 2, Table 3

3) **sqrautocorrs.txt -** this programme estimates autocorrelations for squared returns at ten lags

input: rets.txt

output: sqrautocorrs.txt

Used in: Table 1

4) **garch11.txt -** this programme estimates the garch(1,1) model on 11 eurozone national equity indices

input: rets.txt

output: pvar

garchcoeffs.txt

der.txt

Used in: Table 5, Figure 2

5) **midasgarch.txt -** this programme estimates the midasgarch model on 11 eurozone national equity indices

input: rets.txt

output: eta.txt

predvar.txt

theta.txt

xx.txt

fsdrvs.txt

Used in: Table 4, Figure 2

6) **midasctheta.txt -** this program creates a block diagonal matrix ctheta from the 11 4x4 covariance matrices of the estimated parameters from Midas-Garch step

input: xx.txt

output: ctheta.txt

7) **qlinreg5models.txt**- this program estimates a quarterly model of dynamic correlation magnitudes

input: gdpQ41991toQ42010.txt

rdates.txt

rets.txt

output: qavecorr.txt

dailysignals.txt

quarterly model regression results generated within the output file

Used in: Table 8

8) **truedailysignals.txt** – this program computes daily signals

input: rets.txt

output: truedailysigs.txt

9) **maxlike5models.txt**– this program estimates dynamic models of the correlation magnitudes using maximum likelihood. It covers models 1 -5 in table 6.

input: eta.txt

dailysignals.txt

truedailysigs.txt

output: see Tables and graphs newest.xlsx for maximum likelihood regression results

phicoeffs.txt

covs.txt

corr0

ssdrvs.txt

Used in: Table 6

10) **maxlikemodel6.txt**– this program estimates a dynamic model of the correlation magnitudes using maximum likelihood. It covers model 6 in table 6.

input: eta.txt

dailysignals.txt

truedailysigs.txt

output: see Tables and graphs newest.xlsx for maximum likelihood regression results

phicoeffs.txt

covs.txt

corr0

ssdrvs.txt

Used in: Table 6

11) **maxlikemodel7.txt**– this program estimates a dynamic model of the correlation magnitudes using maximum likelihood. It covers model 7 in table 6.

input: eta.txt

dailysignals.txt

truedailysigs.txt

output: see Tables and graphs newest.xlsx for maximum likelihood regression results

phicoeffs.txt

covs.txt

corr0

ssdrvs.txt

Used in: Table 6

12) **switchorgobs.txt -** this program switches the 44 scores from the first-step estimation to store them as organization=observations rather than organization = variates so that they can be vectorized by a later program

input: fsdrvs.txt

ouput: fsdrvsorgobs.txt

13) **crossmarginalstep1.txt -** this program computes the outputs (standardized outcomes) of the first-stage estimation when the pre-estimated parameters are perturbed by epsilon (a small amount) from their pre-estimated values

input: theta.txt

eta.txt

dailysignals.txt

truedailysignals.txt

epsilons.txt (created in the same program, reopen to do further operations)

alteta.txt

rets.txt

output: epsilons.txt (output file for the epsilons in derivative computation)

m.txt (output file for unconditional variances)

14) **crossmarginalstep2mod6.txt -** this program estimates second-step log likelihood scores using perturbed outputs from step 1 estimation and finds the expected cross-marginals by

taking differences between perturbed and un-perturbed log likelihood scores for model 6 from table 6.

input: eta.txt

dailysignals.txt

truedailysignals.txt

phicoeffs.txt

alteta.txt

ssdrvs.txt

epsilons.txt (output file for the epsilons in derivative computation)

corr0.txt

output: gmat.txt

15) **crossmarginalstep2mod7.txt -** this program estimates second-step log likelihood scores using perturbed outputs from step 1 estimation and finds the expected cross-marginals by taking differences between perturbed and un-perturbed log likelihood scores for model 7 from table 6.

input: eta.txt

dailysignals.txt

truedailysignals.txt

phicoeffs.txt

alteta.txt

ssdrvs.txt

epsilons.txt (output file for the epsilons in derivative computation)

corr0.txt

output: gmat.txt

16) **adjcovmat.txt -** this program estimates the adjusted covariance matrix of the second-step parameters

input: gmat.txt

ctheta.txt

fsdrvsorgobs.txt

fsdrvs.txt

ssdrvs.txt

covs.txt

output: results comparing the adjusted and unadjusted variance generated within the output file

Used in: Table 6, **Table 7**

```
*makerets.txt this program makes euro index returns from euro index prices

alloc 22 4959

open prices c:\eurovol\data\pricesDec1991toDec2010.txt

open pricedates c:\eurovol\data\datesDec1991toDec2010.txt

data(unit=prices,format=free,org=obs) / 1 2 3 4 5 6 7 8 9 10 11

data(unit=pricedates,format=free,org=obs) / day month year

declare real rret rday rmonth ryear

declare integer gooddates

open rrets c:\eurovol\output\rrets.txt

open rdates c:\eurovol\output\rdates.txt


do j=1,11

compute jj = j+11

set price / = [series] j

set [series] jj / = log(price/price{1})

set rets / = [series] jj

display "index" j

display "price statistics"

statistics price

display "return statistics"

statistics rets

end do j


compute gooddates = 0


set count 1 4959 = 0.0

do j = 1,11
```

```
compute jj = j + 11
set rets / = [series] jj
set count 2 4959 = count + %if(rets == 0.0,1.0,0.0)
end do j

statistics count
open zerocount c:\eurovol\output\zerocount.txt
copy(unit=zerocount,format='(f10.5)') 2 4959 count

open alldayrets c:\eurovol\output\alldayrets.txt
copy(unit=alldayrets,format='(11(f15.10))',org=obs) 2 4959 $
12 13 14 15 16 17 18 19 20 21 22

compute rcount = 0.0
open rets c:\eurovol\output\rets.txt
open opendates c:\eurovol\output\opendates.txt
* eliminate days with most markets closed and add any return to the next day return
* eliminate the missing date and assign the later date to the returns in the dating file

do i = 2,4959
compute rcount = count(i)
if rcount >= 4.0
{
display "baddate i count" i rcount
do j = 1,11
compute jj = j + 11
set rets / = [series] jj
```

```
set rets i+1 i+1 = rets(i)+rets(i+1)

set [series] jj / = rets

end do j

}

if rcount <= 3.0

{

*display "good date i count" i rcount


do j = 1,11

compute jj = j + 11

set ret / = [series] jj

compute rret = ret(i)

display(unit=rrets) rret

end do j


compute rday = day(i)

compute rmonth = month(i)

compute ryear = year(i)

display(unit=rdates) rday rmonth ryear


compute gooddates = gooddates + 1


}


*display "end the i loop"

end do i
```

```
display "number of good dates" gooddates

close rrets

open rrets c:\eurovol\output\rrets.txt

data(unit=rrets,format=free,org=obs) 1 gooddates 12 13 14 15 16 17 18 19 20 21 22

copy(unit=rets,format='(11(f15.10))',org=obs) 1 gooddates 12 13 14 15 16 17 18 19 20 21 22
```

```
* basicstats.txt this programme estimates some basic statistics on 11 eurozone  national equity indices

alloc 11 4788
*read in 11 equity index returns, de-mean and square
open rets c:\eurovol\output\rets.txt
data(unit=rets,format=free,org=obs) / 1 2 3 4 5 6 7 8 9 10 11

open autocorrs c:\eurovol\output\autocorrs.txt
open rawcormat c:\eurovol\output\rawcormat.txt
open crosscormat c:\eurovol\output\crosscormat.txt
open crosscovmat c:\eurovol\output\crosscovmat.txt
open adjcormat c:\eurovol\output\adjcormat.txt
open adjcovmat c:\eurovol\output\adjcovmat.txt
open adjvar c:\eurovol\output\adjvar.txt

declare rectangular adjcormat(11,11) rawcormat(11,11) crosscovmat(11,11) crosscormat(11,11)
declare rectangular rawcovmat(11,11) adjcovmat(11,11)
declare vector rawvar(11) adjvar(11)

* get basic stats on each individual returns
do j=1,11
set ret / = [series] j
display 'county' j
statistics ret /
compute rawvar(j) = %variance
```

```
correlate(number=5) ret / autocorrs

copy(unit=autocorrs,format='(5(f10.5))') 1 5 autocorrs

correlate(number=1,noprint,covariances) ret / autocov

compute adjvar(j) = rawvar(j)+autocov(2)

compute adjcovmat(j,j) = adjvar(j)

compute adjcormat(j,j) = 1.0

end do j

*compute the unadjusted correlation matrix

cmoment(corr,center) /

# 1 2 3 4 5 6 7 8 9 10 11

compute rawcormat = %cmom


* get contemporaneous and lagged/led covariance matrices of the returns

do j=1,10

set retj / = [series] j

compute jp1 = j + 1

do jj = jp1,11

set retjj / = [series] jj

cross(from=-1,to=1,results=crosscors,noprint) retj retjj /

compute crosscormat(j,jj) = crosscors(1)

compute crosscormat(jj,j) = crosscors(3)

cross(from=-1,to=1,results=crosscovs,covariances,noprint) retj retjj /

compute crosscovmat(j,jj) = crosscovs(1)

compute rawcovmat(j,jj) = crosscovs(2)

compute crosscovmat(jj,j) = crosscovs(3)

end do jj

end do j
```

```
* create the adjusted covariance matrix and correlation matrix with a newey-west correction
do j=1,10
compute jp1 = j + 1
do jj = jp1,11
compute adjcovmat(j,jj) = rawcovmat(j,jj) + crosscovmat(j,jj)+crosscovmat(jj,j)
compute adjcormat(j,jj) = adjcovmat(j,jj)/((adjvar(j)*adjvar(jj))**.5)
compute adjcormat(jj,j) = adjcormat(j,jj)
end do jj
end do j

write(unit=rawcormat,format='(11(f12.7))') rawcormat
write(unit=adjcormat,format='(11(f12.7))') adjcormat
write(unit=adjcovmat,format='(11(f12.7))') adjcovmat
write(unit=adjvar,format='(11(f12.7))') adjvar
write(unit=crosscormat,format='(11(f12.7))') crosscormat
write(unit=crosscovmat,format='(11(f12.7))') crosscovmat
end
```

```
* sqrautocorrs.txt this programme estimates autocorrelations for squared returns at ten lags

alloc 33 4788

*read in 11 equity index returns, de-mean and square

open rets c:\eurovol\output\rets.txt

open sqrautocorrs c:\eurovol\output\sqrautocorrs.txt


declare vector vautocorrs(10)


data(unit=rets,format=free,org=obs) / 1 2 3 4 5 6 7 8 9 10 11

do j=1,11

set ret / = [series] j

statistics(noprint) ret /

set ret / = ret - %mean

set [series] j = ret

compute jj = j + 11

set [series] jj = (ret)**2

set ret / = [series] jj

display 'country' j

statistics ret /

correlate(number=10) ret / sqrautocorrs

do jj = 1,10

compute jjp1 = jj + 1

compute vautocorrs(jj) = sqrautocorrs(jjp1)

end do jj

write(unit=sqrautocorrs,format='(10(f10.5))',noskip) vautocorrs

end do j
```

```
* garch11.txt this programme estimates the garch(1,1) model on 11 eurozone national equity indices

alloc 33 4788
*read in 11 equity index returns, de-mean and square
open rets c:\eurovol\output\rets.txt
open garchcoeffs c:\eurovol\output\garchcoeffs.txt
data(unit=rets,format=free,org=obs) / 1 2 3 4 5 6 7 8 9 10 11

* estimate the garch(1,1) using separate parameter sets for mean and variance models

do j=1,11
set ret / = [series] j
linreg ret
# constant

frml(lastreg,vector=beta) meanf
nonlin(parmset=meanparms) beta
*
set uu = %seesq
set h = %seesq
set u = 0.0
*
nonlin(parmset=garchparms) c a b
compute c = %seesq
compute a = 0.5
compute b = 0.5
```

```
frml varf = c+a*uu{1}+b*h{1}

frml L = (u(t)=ret-meanf),(uu(t)=u**2),(h(t)=varf(t)),%logdensity(h,u)

display 'security number' j

maximize(parmset=meanparms+garchparms,derives=der) L 3 *


write(unit=garchcoeffs, format=free) %beta


declare real %aic %sbc

compute %aic = -2.0*%logl/%nobs+2.0*%nreg/%nobs

compute %sbc = -2.0*%logl/%nobs+log(%nobs)*%nreg/%nobs

display 'aic = ' %aic ' bic = ' %sbc


compute jj=j+11

set [series] jj 261 4788 = h


* save the variance series

open pvar c:\eurovol\output\pvar.txt

copy(unit=pvar,format='(11(f20.10))', org=obs) 261 4788 12 13 14 15 16 17 18 19 20 21 22

open der c:\eurovol\output\der.txt

copy(unit=der,format='(11(f20.10))', org=obs) 261 4788 23 24 25 26 27 28 29 30 31 32 33

end do j
```

```
* midasgarch.txt this programme estimates the midasgarch model on 11 eurozone national equity indices
alloc 22 4788


*read in 11 equity index returns, de-mean and square
open rets c:\eurovol\output\rets.txt
open theta c:\eurovol\output\theta.txt
open xx c:\eurovol\output\xx.txt
open fsdrvs c:\eurovol\output\fsdrvs.txt
open eta c:\eurovol\output\eta.txt
open predvar c:\eurovol\output\predvar.txt


data(unit=rets,format=free,org=obs) / 1 2 3 4 5 6 7 8 9 10 11


do j=1,11
set ret / = [series] j
statistics(noprint) ret /
set ret / = ret - %mean
set [series] j = ret
compute jp11 = j + 11
set [series] jp11 = (ret)**2
end do j


do j=1,11
set ret / = [series] j
* calculate 65-day rolling window variance
compute jp11 = j + 11
```

```
set ret2 / = [series] jp11
statistics(noprint) ret2 1 65
set rv 65 65 = %mean
do date = 66, 4788
set rv date date = rv(date-1) + (1.0/65.0)*(ret2(date) - ret2(date-65))
end do date
statistics rv

* estimate the long-run parameters without GARCH for initial parameter values
set rvm65 / = rv{65}
set rvm130 / = rv{130}
set rvm195 / = rv{195}

nonlin theta w
statistics(noprint) ret2 /
compute theta = 0.8
compute w = 0.5
compute m = %mean
display "theta w m" theta w m

frml lrv = m*abs(1.0-theta) +theta*(1.0*rvm65+(exp(-w*1))*rvm130+(exp(-w*2))*rvm195)/(1.0+exp(-w*1)+exp(-w*2))
frml lrvlogl = -.5*(log(lrv) + ret2/lrv)
display "long-run only, security number" j
maximize(method=bhhh,iterations = 500) lrvlogl 260 4788
set longrunv / =  m*abs(1.0-theta) +theta*(1.0*rvm65+(exp(-w*1))*rvm130+(exp(-w*2))*rvm195)/(1.0+exp(-w*1)+exp(-w*2))
statistics(fractiles) longrunv
```

```
* estimate short-term garch with pre-estimated long run variance
nlpar(subiterations=100)

nonlin a1 a2
compute a1 = .2
compute a2 = .5
set sgv  / = 1.0
frml sgvar = abs((1.0-a1-a2)) + a1*ret2{1}/longrunv{1} + a2*sgv{1}
frml sglogl = (sgv(t) = sgvar(t)), -.5*(log(sgv)+ret2/(longrunv*sgv))
display 'short-term GARCH only, security number' j
maximize(method=bhhh,recursive,iterations = 500) sglogl 261 4788
set firststepsgv / = sgv

* estimate midas-GARCH based on initial values from above first-stage estimates
nonlin theta w a1 a2 theta>=0.0
frml lrv =  m*abs(1.0-theta) +theta*(1.0*rvm65+(exp(-w*1))*rvm130+(exp(-w*2))*rvm195)/(1.0+exp(-w*1)+exp(-w*2))
set sgv / = 1.0
frml sgvar = abs(1.0-a1-a2) + a1*ret2{1}/lrv{1} + a2*sgv{1}
frml fglogl = (sgv(t) = sgvar(t)), -.5*(log(sgv*lrv)+ret2/(sgv*lrv))
display 'security number' j
maximize(method=bhhh,recursive,iterations = 500,derives=pdrvs) fglogl 261 4788
display(unit=theta) %beta
display(unit=xx) %XX
```

```
declare real %aic %sbc

compute %aic = -2.0*%logl/%nobs+2.0*%nreg/%nobs

compute %sbc = -2.0*%logl/%nobs+log(%nobs)*%nreg/%nobs

display 'aic = ' %aic ' bic = ' %sbc


* create series of standardized outcomes

set eta 261 4788 = ret/((sgv*lrv)**.5)

set predvar 261 4788 = sgv*lrv


if %converged == 0

{

display "did not converge series" j

set eta 261 4788 = ret/((firststepsgv*longrunv)**.5)

set predvar 261 4788 = firststepsgv*longrunv

}

* save the maximum likelihood scores

do param=1,4

set scores / = pdrvs(param)

statistics scores

copy(unit=fsdrvs,format=free, org=obs) 261 4788 scores

end do param


* save the standardized outcomes

copy(unit=eta,format=free, org=obs) 261 4788 eta

* save the predicted variances

copy(unit=predvar,format=free, org=obs) 261 4788 predvar

end do j
```

```
*midasctheta.txt this program creates a block diagonal matrix ctheta from the 11 4x4 covariance matrices of the estimated parameters from Midas-Garch step


open xx c:\eurovol\output\xx.txt
open ctheta c:\eurovol\output\ctheta.txt


dec symmetric a(4,4) b(4,4) c(4,4) d(4,4) e(4,4) f(4,4) g(4,4) h(4,4) k(4,4) l(4,4) m(4,4)
dec rect ctheta(44,44)


dec rect n(44,44)
ewise n(i,j)=0
read(unit=xx,format=free) a b c d e f g h k l m


compute diag = a~\b~\c~\d~\e~\f~\g~\h~\k~\l~\m
compute ctheta = diag


write(unit=ctheta,format=free) ctheta
*display ctheta
```

```
*qlinreg5models.txt this program estimates a quarterly model of dynamic correlation magnitudes
alloc 22 4788
open qgdp c:\eurovol\data\gdpQ41991toQ42010.txt
open rdates c:\eurovol\output\rdates.txt
open rets c:\eurovol\output\rets.txt

* there are 77 quarters in total
data(unit=qgdp,format=free,org=obs) 1 77 1 2 3 4 5 6 7 8 9 10 11
data(unit=rdates,format=free,org=obs) 1 4788 day month year
data(unit=rets,format=free,org=obs) 1 4788 12 13 14 15 16 17 18 19 20 21 22

*create a signal equal to the proportion of negative-growth countries
set countries 1 77 = 0.0
set downs 1 77 = 0.0
set avegrowth 1 77 = 0.0
do j=1,11
set growth 1 77 = [series] j
set countries 1 77 = countries + %if(growth>-98.0,1.0,0.0)
set sampg 1 77 = %if(growth<-98.0,0.0,1.0)
display 'country' j
statistics(smpl=sampg,fractiles) growth
set growthshock 1 77 = growth
set downs 1 77 = downs + %if(growthshock<0.0,1.0,0.0) - %if(growthshock<-98.0,1.0,0.0)
set avegrowth 1 77 = avegrowth + %if(growth>-98.0,growth,0.0)
end do j
```

```
set qsignal 1 77 = downs/countries
set avegrowth 1 77 = avegrowth/countries
statistics(fractiles) qsignal


* assign each day to a quarter numbered 2 to 77
set quarter 1 4788 = 1.0 + %if(month>3.0,1.0,0.0) +
%if(month>6.0,1.0,0.0)+%if(month>9.0,1.0,0.0)
set qindex 1 4788 = (year - 1991.0)*4.0 + quarter - 3.0
statistics(fractiles) qindex
*compute the fixed-window sample correlation matrix for each calendar quarter
* and the average correlation within it
* also cumulative return for each quarter (starting with quarter 2)
do j = 2,77
set samp = %if(qindex == j,1.0,0.0)
*display 'j' j
*statistics samp
cmom(noprint,correlation,centered,smpl=samp)
# 12 13 14 15 16 17 18 19 20 21 22
compute correl = %cmom
compute avecorr = 0.0
*average correlation
do jj = 1,10
compute jjp1 = jj + 1
do jjj = jjp1,11
compute avecorr = avecorr + correl(jj,jjj)/55.0
end do jjj
end do jj
```

```
* now average variance

cmom(noprint,centered,smpl=samp)

# 12 13 14 15 16 17 18 19 20 21 22

compute cmom = %cmom

compute avevar = 0.0

*average variance

do jj = 1,11

compute avevar = avevar + cmom(jj,jj)/11.0

end do jj

set qavecorr j j = avecorr

set qavevar j j = avevar


* now equally-weighted cumulative return for the quarter

compute ewcumret = 0.0

do k = 12,22

set ret / = [series] k

statistics(noprint,smpl=samp) ret

compute ewcumret = ewcumret + %nobs*%mean

end do k

set qcumret j j = ewcumret

* set trend at 1 time unit per year

set trend j j = 0.25*j

end do j

* de-mean the variables

statistics(print) trend 2 77

set dmtrend / = trend - %mean

statistics(print) qcumret 2 77
```

```
set dmcumret / = qcumret - %mean

statistics(print) qsignal 2 77

set dmsignal / = qsignal - %mean

statistics(print) qavecorr 2 77

set dmratio 2 77  = (qavecorr-%mean)/(1-%mean)

statistics(print) qavevar 2 77

set dmavevar / = qavevar - %mean

* save the quarterly average correlations and average variance

open qavecorr c:\eurovol\output\qavecorr.txt

*copy(unit=qavecorr,format='(2(f15.10))',org=obs) 2 77 qavecorr qavevart


set lagdmratio / = dmratio{1}

set lagdmsignal / = dmsignal{1}

set gendistress 2 77 = %if(dmsignal>.5,1.0,0.0)

statistics gendistress 2 77

set gendistress 2 77 = gendistress - %mean

statistics avegrowth 2 77

set avegrowth 2 77 = avegrowth - %mean

statistics growthvar 2 77

set growthvar 2 77 = growthvar - %mean


cmom(corr,print) 2 77

#dmratio lagdmratio dmtrend dmcumret dmsignal dmavevar avegrowth growthvar


*model 1

linreg dmratio 2 77

#lagdmratio dmtrend
```

```
*model 2
linreg dmratio 2 77
#lagdmratio dmtrend dmcumret
*model 3
linreg dmratio 2 77
#lagdmratio dmtrend dmavevar
*model 4
linreg dmratio 2 77
#lagdmratio dmtrend dmsignal
*model 5
linreg dmratio 2 77
#lagdmratio dmtrend avegrowth
*model 6
linreg dmratio 2 77
#lagdmratio dmtrend dmcumret dmavevar dmsignal
*model 7
linreg dmratio 2 77
#lagdmratio dmtrend dmcumret dmavevar avegrowth
*test model 21
linreg dmratio 2 77
#lagdmratio dmtrend dmcumret dmavevar avegrowth growthvar
* correlation matrix of the explanatory variables
cmom(print,correlate) 2 77
#dmtrend lagdmratio dmcumret dmsignal avegrowth dmavevar growthvar
```

```
* create daily versions of the quarterly signals with values during each quarter

declare integer dayquarter lagdayquarter

statistics(fractiles) qindex


do i = 1,4788

compute dayquarter = fix(qindex(i))

compute lagdayquarter = fix(qindex(i))-1

set qcumretdaily i i = qcumret(dayquarter)

set qavevardaily i i = qavevar(dayquarter)

set qsignaldaily i i = qsignal(dayquarter)

set avegrowthdaily i i = avegrowth(dayquarter)

set qavecorrdaily i i = qavecorr(dayquarter)

set qtrenddaily i i = trend(dayquarter)

set lagqcumretdaily i i = qcumret(lagdayquarter)

set lagqavevardaily i i = qavevar(lagdayquarter)

set lagqsignaldaily i i = qsignal(lagdayquarter)

set lagqavecorrdaily i i = qavecorr(lagdayquarter)

end do i


open dailysignals c:\eurovol\output\dailysignals.txt

copy(unit=dailysignals,format='(9(f15.10))',org=obs) 1 4788 qcumretdaily qavevardaily
avegrowthdaily $

qsignaldaily qtrenddaily lagqcumretdaily lagqavevardaily lagqavecorrdaily lagqsignaldaily
```

```
*truedailysignals.txt this program computes daily signals

alloc 22 4788

open rets c:\eurovol\output\rets.txt

data(unit=rets,format=free,org=obs) 1 4788 1 2 3 4 5 6 7 8 9 10 11


do i= 260, 4788

compute end = i

compute start = end - 260

if start < 1

{

compute start = 1

}

*compute the rolling-window sample correlation matrix for a quarter-year and the average
correlation within it and also cumulative return within the quarter

set samp 1 4788 = 0.0

set samp start end = 1.0

cmom(noprint,correlation,centered,smpl=samp)

# 1 2 3 4 5 6 7 8 9 10 11

compute correl = %cmom

compute avecorr = 0.0

*average correlation

do jj = 1,10

compute jjp1 = jj + 1

do jjj = jjp1,11

compute avecorr = avecorr + correl(jj,jjj)/55.0

end do jjj

end do jj
```

```
* now average variance

cmom(noprint,centered,smpl=samp)

# 1 2 3 4 5 6 7 8 9 10 11

compute cmom = %cmom

compute avevar = 0.0

*average variance

do jj = 1,11

compute avevar = avevar + cmom(jj,jj)/11.0

end do jj


set qavecorr i i = avecorr

set qavevar i i = avevar

* now equally-weighted cumulative return for the quarter

compute ewcumret = 0.0

do k = 1,11

set ret / = [series] k

statistics(noprint,smpl=samp) ret

compute ewcumret = ewcumret + %nobs*%mean

end do k

set qcumret i i = ewcumret

end do j


* save the average correlations, average variance and average cumulative returns

open truedailysigs c:\eurovol\output\truedailysigs.txt

copy(unit=truedailysigs,format='(3(f15.10))',org=obs) 260 4788 qavecorr qavevar qcumret
```

```
*maxlike5models.txt this program estimates dynamic macroeconomic models of the
correlation magnitude using maximum likelihood with corr0 for five selected specifications


alloc 60 4788
open eta c:\eurovol\output\eta.txt
open dailysignals c:\eurovol\output\dailysignals.txt
open truedailysigs c:\eurovol\output\truedailysigs.txt
open phicoeffs6 c:\eurovol\output\phicoeffs6.txt
open phicoeffs7 c:\eurovol\output\phicoeffs7.txt
open covs6 c:\eurovol\output\covs6.txt
open covs7 c:\eurovol\output\covs7.txt
open corr0 c:\eurovol\output\corr0.txt
open ecorr0 c:\eurovol\output\ecorr0.txt
open ssdrvs6 c:\eurovol\output\ssdrvs6.txt
open ssdrvs7 c:\eurovol\output\ssdrvs7.txt


data(unit=eta,format=free,org=vars) 261 4788 e1 e2 e3 e4 e5 e6 e7 e8 e9 e10 e11
data(unit=dailysignals,format=free,org=obs) 1 4788 qcumret qavevar avegrowth $
qsignal qtrend lagqcumret lagqavevar lagqavecorr lagqsignal
data(unit=truedailysigs,format=free,org=obs) 260 4788 tdavecorr tdavevar tdcumret


* de-mean the six explanatory variables
statistics qsignal
set qsignal / = qsignal - %mean
statistics lagqsignal
set lagqsignal / = lagqsignal - %mean
```

```
statistics tdavecorr

set ratio / = (tdavecorr{1} - %mean)/(1.0-%mean)

statistics tdavevar

set avevar / = tdavevar{1} - %mean

statistics tdcumret

set cumret / = tdcumret{1} - %mean

statistics avegrowth

set avegrowth / = avegrowth - %mean


* set trend to match the annual scale per unit time

set trend / = t/261.0

statistics trend

set trend / = trend - %mean


*find the unconditional correlation matrix of standardized returns

cmom(corr,matrix=corr0) 261 4788

# e1 e2 e3 e4 e5 e6 e7 e8 e9 e10 e11


compute sampcorr0 = corr0

display(unit=corr0) corr0


*set up a unit matrix

declare symmetric unitmat(11,11)

do j = 1,11

do jj = 1,11

compute unitmat(j,jj) = 1.0

end do jj
```

```
end do j


* first do each estimation without corr0 and then with corr0

* model 1

compute b1 = 0.0

compute b2 = 0.0

compute corr0 = sampcorr0

nonlin b1 b2

frml m = (b1*ratio+b2*trend)


* set up the likelihood objective function

dec frml[vect] ufrml

frml ufrml = ||e1,e2,e3,e4,e5,e6,e7,e8,e9,e10,e11||

dec frml[symmetric] sigma

frml sigma = (m)*unitmat + (1.0 - m)*corr0

frml mvlike = %logdensity(sigma,ufrml)


display 'model 1 w/o corr0'

maximize(method=bhhh) mvlike 261 4788

compute corr0 = sampcorr0

nonlin b1 b2 corr0 corr0(1,1)==1.0 corr0(2,2)==1.0 corr0(3,3)==1.0 $

corr0(4,4)==1.0 corr0(5,5)==1.0 corr0(6,6)==1.0 corr0(7,7)==1.0 corr0(8,8)==1.0 $

corr0(9,9)==1.0 corr0(10,10)==1.0 corr0(11,11)==1.0

frml m = (b1*ratio+b2*trend)

display 'model 1 w corr0'

maximize(derives=ssdrvs1,method=bhhh) mvlike 261 4788
```

```
compute phicoeffs1 = %beta
display(unit=corr0) corr0

* output the scores, skipping the diagonal entries of the correlation matrix estimates
do param=1,2
compute jj = param
set [series] jj = ssdrvs1(param)
end do param
compute param = 2
compute place = 2

* write out the scores skipping the diagonal entries
do h=1,11
do hh = h,11
compute place = place +1
if hh > h
{
compute param = param+1
set [series] param / = ssdrvs1(place)
}
end do hh
end do h
cmom 261 4788
# 1 2 3 4 5 $
6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 $
21 22 23 24 25 26 27 28 29 30 $
31 32 33 34 35 36 37 38 39 40 $
```

```
41 42 43 44 45 46 47 48 49 50 $

51 52 53 54 55 56 57


compute covs1 = inv(%cmom)

display (covs1(1,1))**.5

display (covs1(2,2))**.5

display phicoeffs1(1)/(covs1(1,1))**.5

display phicoeffs1(2)/(covs1(2,2))**.5


*model 2

compute b1 = 0.0

compute b2 = 0.0

compute b3 = 0.0

compute corr0 = sampcorr0


nonlin b1 b2 b3

frml m = (b1*ratio+b2*trend+b3*cumret)

display 'model 2 w/o corr0'

maximize(method=bhhh) mvlike 261 4788

compute corr0 = sampcorr0

nonlin b1 b2 b3 corr0 corr0(1,1)==1.0 corr0(2,2)==1.0 corr0(3,3)==1.0 $

corr0(4,4)==1.0 corr0(5,5)==1.0 corr0(6,6)==1.0 corr0(7,7)==1.0 corr0(8,8)==1.0 $

corr0(9,9)==1.0 corr0(10,10)==1.0 corr0(11,11)==1.0

frml m = (b1*ratio+b2*trend+b3*cumret)

display 'model 2 w corr0'

maximize(derives=ssdrvs2,method=bhhh) mvlike 261 4788
```

```
compute phicoeffs2 = %beta

display(unit=corr0) corr0


* output the scores, skipping the diagonal entries of the correlation matrix estimates

do param=1,3

compute jj = param

set [series] jj = ssdrvs2(param)

end do param

compute param = 3

compute place = 3

* write out the scores skipping the diagonal entries

do h=1,11

do hh = h,11

compute place = place +1

if hh > h

{

compute param = param+1

set [series] param / = ssdrvs2(place)

}

end do hh

end do h


cmom 261 4788

# 1 2 3 4 5 $

6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 $

21 22 23 24 25 26 27 28 29 30 $

31 32 33 34 35 36 37 38 39 40 $
```

```
41 42 43 44 45 46 47 48 49 50 $

51 52 53 54 55 56 57 58


compute covs2 = inv(%cmom)

display (covs2(1,1))**.5

display (covs2(2,2))**.5

display (covs2(3,3))**.5

display phicoeffs2(1)/(covs2(1,1))**.5

display phicoeffs2(2)/(covs2(2,2))**.5

display phicoeffs2(3)/(covs2(3,3))**.5



*model 3

compute b1 = 0.0

compute b2 = 0.0

compute b4 = 0.0

compute corr0 = sampcorr0

nonlin b1 b2 b4

frml m = (b1*ratio+b2*trend+b4*avevar)

display 'model 3 w/o corr0'

maximize(method=bhhh) mvlike 261 4788

compute corr0 = sampcorr0


nonlin b1 b2 b4 corr0 corr0(1,1)==1.0 corr0(2,2)==1.0 corr0(3,3)==1.0 $

corr0(4,4)==1.0 corr0(5,5)==1.0 corr0(6,6)==1.0 corr0(7,7)==1.0 corr0(8,8)==1.0 $

corr0(9,9)==1.0 corr0(10,10)==1.0 corr0(11,11)==1.0

frml m = (b1*ratio+b2*trend+b4*avevar)
```

```
display 'model 3 w corr0'
maximize(derives=ssdrvs3,method=bhhh) mvlike 261 4788

compute phicoeffs3 = %beta
display(unit=corr0) corr0

* output the scores, skipping the diagonal entries of the correlation matrix estimates
do param=1,3
compute jj = param
set [series] jj = ssdrvs3(param)
end do param
compute param = 3
compute place = 3
* write out the scores skipping the diagonal entries
do h=1,11
do hh = h,11
compute place = place +1
if hh > h
{
compute param = param+1
set [series] param / = ssdrvs3(place)
}
end do hh
end do h
cmom 261 4788
# 1 2 3 4 5 $
6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 $
```

```
21 22 23 24 25 26 27 28 29 30 $
31 32 33 34 35 36 37 38 39 40 $
41 42 43 44 45 46 47 48 49 50 $
51 52 53 54 55 56 57 58

compute covs3 = inv(%cmom)
display (covs3(1,1))**.5
display (covs3(2,2))**.5
display (covs3(3,3))**.5
display phicoeffs3(1)/(covs3(1,1))**.5
display phicoeffs3(2)/(covs3(2,2))**.5
display phicoeffs3(3)/(covs3(3,3))**.5


* model 4
compute b1 = 0.0
compute b2 = 0.0
compute b5 = 0.0
compute corr0 = sampcorr0
nonlin b1 b2 b5
frml m = (b1*ratio+b2*trend+b5*qsignal)
display 'model 4 w/o corr0'
maximize(method=bhhh) mvlike 261 4788

compute phicoeffs4 = %beta
compute corr0 = sampcorr0
```

```
nonlin b1 b2 b5 corr0 corr0(1,1)==1.0 corr0(2,2)==1.0 corr0(3,3)==1.0 $
corr0(4,4)==1.0 corr0(5,5)==1.0 corr0(6,6)==1.0 corr0(7,7)==1.0 corr0(8,8)==1.0 $
corr0(9,9)==1.0 corr0(10,10)==1.0 corr0(11,11)==1.0
frml m = (b1*ratio+b2*trend+b5*qsignal)
display 'model 4 w corr0'
maximize(derives=ssdrvs4,method=bhhh) mvlike 261 4788
display(unit=corr0) corr0

* output the scores, skipping the diagonal entries of the correlation matrix estimates
do param=1,3
compute jj = param
set [series] jj = ssdrvs4(param)
end do param
compute param = 3
compute place = 3
* write out the scores skipping the diagonal entries
do h=1,11
do hh = h,11
compute place = place +1
if hh > h
{
compute param = param+1
set [series] param / = ssdrvs4(place)
}
end do hh
end do h
```

```
cmom 261 4788
# 1 2 3 4 5 $
6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 $
21 22 23 24 25 26 27 28 29 30 $
31 32 33 34 35 36 37 38 39 40 $
41 42 43 44 45 46 47 48 49 50 $
51 52 53 54 55 56 57 58

compute covs4 = inv(%cmom)
display (covs4(1,1))**.5
display (covs4(2,2))**.5
display (covs4(3,3))**.5
display phicoeffs4(1)/(covs4(1,1))**.5
display phicoeffs4(2)/(covs4(2,2))**.5
display phicoeffs4(3)/(covs4(3,3))**.5


* model 5
compute b1 = 0.0
compute b2 = 0.0
compute b6 = 0.0
compute corr0 = sampcorr0

nonlin b1 b2 b6
frml m = (b1*ratio+b2*trend+b6*avegrowth)
display 'model 5 w/o corr0'
```

```
maximize(method=bhhh) mvlike 261 4788

compute corr0 = sampcorr0

nonlin b1 b2 b6 corr0 corr0(1,1)==1.0 corr0(2,2)==1.0 corr0(3,3)==1.0 $

corr0(4,4)==1.0 corr0(5,5)==1.0 corr0(6,6)==1.0 corr0(7,7)==1.0 corr0(8,8)==1.0 $

corr0(9,9)==1.0 corr0(10,10)==1.0 corr0(11,11)==1.0

frml m = (b1*ratio+b2*trend+b6*avegrowth)

display 'model 5 w corr0'

maximize(derives=ssdrvs5,method=bhhh) mvlike 261 4788

compute phicoeffs5 = %beta

display(unit=corr0) corr0


* output the scores, skipping the diagonal entries of the correlation matrix estimates

do param=1,3

compute jj = param

set [series] jj = ssdrvs5(param)

end do param

compute param = 3

compute place = 3

* write out the scores skipping the diagonal entries

do h=1,11

do hh = h,11

compute place = place +1

if hh > h

{

compute param = param+1

set [series] param / = ssdrvs5(place)

}
```

```
end do hh
end do h

cmom 261 4788
# 1 2 3 4 5 $
6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 $
21 22 23 24 25 26 27 28 29 30 $
31 32 33 34 35 36 37 38 39 40 $
41 42 43 44 45 46 47 48 49 50 $
51 52 53 54 55 56 57 58

compute covs5 = inv(%cmom)
display (covs5(1,1))**.5
display (covs5(2,2))**.5
display (covs5(3,3))**.5
display phicoeffs5(1)/(covs5(1,1))**.5
display phicoeffs5(2)/(covs5(2,2))**.5
display phicoeffs5(3)/(covs5(3,3))**.5
end
```

```
*maxlikemodel6.txt this program estimates a dynamic macroeconomic model of the correlation magnitude using maximum likelihood with corr0 for a selected specification


alloc 60 4788
open eta c:\eurovol\output\eta.txt
open dailysignals c:\eurovol\output\dailysignals.txt
open truedailysigs c:\eurovol\output\truedailysigs.txt
open phi6 c:\eurovol\output\phi6.txt
open phi7 c:\eurovol\output\phi7.txt
open covs6 c:\eurovol\output\covs6.txt
open covs7 c:\eurovol\output\covs7.txt
open corr0 c:\eurovol\output\corr0.txt
open ecorr0 c:\eurovol\output\ecorr0.txt
open ssdrvs6 c:\eurovol\output\ssdrvs6.txt
open ssdrvs7 c:\eurovol\output\ssdrvs7.txt


data(unit=eta,format=free,org=vars) 261 4788 e1 e2 e3 e4 e5 e6 e7 e8 e9 e10 e11
data(unit=dailysignals,format=free,org=obs) 1 4788 qcumret qavevar avegrowth $
qsignal qtrend lagqcumret lagqavevar lagqavecorr lagqsignal
data(unit=truedailysigs,format=free,org=obs) 260 4788 tdavecorr tdavevar tdcumret


* de-mean the six explanatory variables
statistics qsignal
set qsignal / = qsignal - %mean


statistics lagqsignal
set lagqsignal / = lagqsignal - %mean
```

```
statistics tdavecorr

set ratio / = (tdavecorr{1} - %mean)/(1.0-%mean)

statistics tdavevar

set avevar / = tdavevar{1} - %mean

statistics tdcumret

set cumret / = tdcumret{1} - %mean

statistics avegrowth

set avegrowth / = avegrowth - %mean

* set trend to match the annual scale per unit time

set trend / = t/261.0

statistics trend

set trend / = trend - %mean

*find the unconditional correlation matrix of standardized returns

cmom(corr,matrix=corr0) 261 4788

# e1 e2 e3 e4 e5 e6 e7 e8 e9 e10 e11

compute sampcorr0 = corr0

display(unit=corr0) corr0

*set up a unit matrix

declare symmetric unitmat(11,11)

do j = 1,11

do jj = 1,11

compute unitmat(j,jj) = 1.0

end do jj

end do j

* first do each estimation without corr0 and then with corr0
```

```
*model 6
compute b1 = 0.494088720
compute b2 = 0.035752767
compute b3 = 0.000990222
compute b4 = 0.257101098
compute b5 = -0.069852139

compute corr0 = sampcorr0

nonlin b1 b2 b3 b4 b5
frml m = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*qsignal)

* set up the likelihood objective function
dec frml[vect] ufrml
frml ufrml = ||e1,e2,e3,e4,e5,e6,e7,e8,e9,e10,e11||
dec frml[symmetric] sigma
frml sigma = (m)*unitmat + (1.0 - m)*corr0
frml mvlike = %logdensity(sigma,ufrml)

display 'model 6 w/o corr0'
maximize(method=bhhh) mvlike 261 4788
compute corr0 = sampcorr0

nonlin b1 b2 b3 b4 b5 corr0 corr0(1,1)==1.0 corr0(2,2)==1.0 corr0(3,3)==1.0 $
corr0(4,4)==1.0 corr0(5,5)==1.0 corr0(6,6)==1.0 corr0(7,7)==1.0 corr0(8,8)==1.0 $
corr0(9,9)==1.0 corr0(10,10)==1.0 corr0(11,11)==1.0
frml m = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*qsignal)
```

```
display 'model 6 w corr0'

maximize(method=bhhh,derives=ssdrvs) mvlike 261 4788


compute phi6 = %beta

display(unit=corr0) corr0


* output the scores, skipping the diagonal entries of the correlation matrix estimates

do param=1,5

compute jj = param

set [series] jj = ssdrvs(param)

end do param

compute param = 5

compute place = 5

* write out the scores skipping the diagonal entries

do h=1,11

do hh = h,11

compute place = place +1

if hh > h

{

compute param = param+1

set [series] param / = ssdrvs(place)

}

end do hh

end do h


copy(unit=ssdrvs6,format= free,org=obs) 261 4788 1 2 3 4 5 $

6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 $
```

```
21 22 23 24 25 26 27 28 29 30 $
31 32 33 34 35 36 37 38 39 40 $
41 42 43 44 45 46 47 48 49 50 $
51 52 53 54 55 56 57 58 59 60
write(unit=phi6) phi6
end
```

```
*maxlikemodel7.txt this program estimates a dynamic macroeconomic model of the
correlation magnitude using maximum likelihood with corr0 for a selected specification

alloc 60 4788
open eta c:\eurovol\output\eta.txt
open dailysignals c:\eurovol\output\dailysignals.txt
open truedailysigs c:\eurovol\output\truedailysigs.txt
open phi6 c:\eurovol\output\phi6.txt
open phi7 c:\eurovol\output\phi7.txt
open covs6 c:\eurovol\output\covs6.txt
open covs7 c:\eurovol\output\covs7.txt
open corr0 c:\eurovol\output\corr0.txt
open ecorr0 c:\eurovol\output\ecorr0.txt
open ssdrvs6 c:\eurovol\output\ssdrvs6.txt
open ssdrvs7 c:\eurovol\output\ssdrvs7.txt

data(unit=eta,format=free,org=vars) 261 4788 e1 e2 e3 e4 e5 e6 $
e7 e8 e9 e10 e11
data(unit=dailysignals,format=free,org=obs) 1 4788 qcumret qavevar avegrowth $
qsignal qtrend lagqcumret lagqavevar lagqavecorr lagqsignal
data(unit=truedailysigs,format=free,org=obs) 260 4788 tdavecorr tdavevar tdcumret

* de-mean the six explanatory variables
statistics qsignal
set qsignal / = qsignal - %mean

statistics lagqsignal
```

```
set lagqsignal / = lagqsignal - %mean
statistics tdavecorr
set ratio / = (tdavecorr{1} - %mean)/(1.0-%mean)
statistics tdavevar
set avevar / = tdavevar{1} - %mean
statistics tdcumret
set cumret / = tdcumret{1} - %mean
statistics avegrowth
set avegrowth / = avegrowth - %mean

* set trend to match the annual scale per unit time
set trend / = t/261.0
statistics trend
set trend / = trend - %mean

*find the unconditional correlation matrix of standardized returns
cmom(corr,matrix=corr0) 261 4788
# e1 e2 e3 e4 e5 e6 e7 e8 e9 e10 e11
compute sampcorr0 = corr0
display(unit=corr0) corr0
*set up a unit matrix
declare symmetric unitmat(11,11)
do j = 1,11
do jj = 1,11
compute unitmat(j,jj) = 1.0
end do jj
end do j
```

```
* first do the estimation without corr0 and then with corr0


*model 7

compute b1 = 0.0

compute b2 = 0.0

compute b3 = 0.0

compute b4 = 0.0

compute b6 = 0.0

compute corr0 = sampcorr0


nonlin b1 b2 b3 b4 b6

frml m = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b6*avegrowth)


* set up the likelihood objective function

dec frml[vect] ufrml

frml ufrml = ||e1,e2,e3,e4,e5,e6,e7,e8,e9,e10,e11||

dec frml[symmetric] sigma

frml sigma = (m)*unitmat + (1.0 - m)*corr0

frml mvlike = %logdensity(sigma,ufrml)


display 'model 7 w/o corr0'

maximize(method=bhhh) mvlike 261 4788

compute corr0 = sampcorr0


nonlin b1 b2 b3 b4 b6 corr0 corr0(1,1)==1.0 corr0(2,2)==1.0 corr0(3,3)==1.0 $

corr0(4,4)==1.0 corr0(5,5)==1.0 corr0(6,6)==1.0 corr0(7,7)==1.0 corr0(8,8)==1.0 $

corr0(9,9)==1.0 corr0(10,10)==1.0 corr0(11,11)==1.0
```

```
frml m = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b6*avegrowth)

display 'model 7 w corr0'

maximize(method=bhhh,derives=ssdrvs) mvlike 261 4788


compute phi7 = %beta

display(unit=corr0) corr0


* output the scores, skipping the diagonal entries of the correlation matrix estimates

do param=1,5

compute jj = param

set [series] jj = ssdrvs(param)

end do param

compute param = 5

compute place = 5

* write out the scores skipping the diagonal entries

do h=1,11

do hh = h,11

compute place = place +1

if hh > h

{

compute param = param+1

set [series] param / = ssdrvs(place)

}

end do hh

end do h


copy(unit=ssdrvs7,format='(10(f20.10))',org=obs) 261 4788 1 2 3 4 5 $
```

```
6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 $
21 22 23 24 25 26 27 28 29 30 $
31 32 33 34 35 36 37 38 39 40 $
41 42 43 44 45 46 47 48 49 50 $
51 52 53 54 55 56 57 58 59 60
write(unit=phi7) phi7
end
```

```
*switchorgobs.txt this program switches the 44 scores from the first-step estimation to store them as organization=observations rather than organization = variates so that they can be vectorized by a later program


alloc 44 4788


open fsdrvs c:\eurovol\output\fsdrvs.txt
open fsdrvsorgobs c:\eurovol\output\fsdrvsorgobs.txt


data(unit=fsdrvs,format=free,org=vars) 261 4788 1 2 3 4 5 6 7 8 9 10 $
11 12 13 14 15 16 17 18 19 20 $
21 22 23 24 25 26 27 28 29 30 $
31 32 33 34 35 36 37 38 39 40 $
41 42 43 44


copy(unit=fsdrvsorgobs,format=free,org=obs) 261 4788 1 2 3 4 5 6 7 8 9 10 $
11 12 13 14 15 16 17 18 19 20 $
21 22 23 24 25 26 27 28 29 30 $
31 32 33 34 35 36 37 38 39 40 $
41 42 43 44
```

```
*crossmarginalstep1.txt this program computes the outputs (standardized outcomes) of the first-stage estimation when the pre-estimated parameters are perturbed by epsilon (a small amount) from their pre-estimated values


alloc 22 4788


* read in the pre-estimated parameters
open theta c:\eurovol\output\theta.txt
declare vector onetheta(4)
declare vector alltheta(44)
declare real epsilon m
read(unit=theta) alltheta


* file for the epsilons in derivative computation
open epsilons c:\eurovol\output\epsilons.txt


* output file for unconditional variances
open m c:\eurovol\output\m.txt


*read in the data for maximum likelihood calculations
open eta c:\eurovol\output\eta.txt
open dailysignals c:\eurovol\output\dailysignals.txt
open truedailysigs c:\eurovol\output\truedailysigs.txt
open epsilons c:\eurovol\output\epsilons.txt
open alteta c:\eurovol\output\alteta.txt


data(unit=eta,format=free,org=vars) 261 4788 e1 e2 e3 e4 e5 e6 $
 e7 e8 e9 e10 e11
```

```
data(unit=dailysignals,format=free,org=obs) 1 4788 qcumret qavevar qavecorr $

qsignal qtrend lagqcumret lagqavevar lagqavecorr lagqsignal

data(unit=truedailysigs,format=free,org=obs) 260 4788 tdavecorr tdavevar tdcumret


*read in 11 equity index returns, de-mean and square

open rets c:\eurovol\output\rets.txt

data(unit=rets,format=free,org=obs) / 1 2 3 4 5 6 7 8 9 10 11


do j=1,11

set ret / = [series] j

statistics(noprint) ret /

set ret / = ret - %mean

set [series] j = ret

compute jp11 = j + 11

set [series] jp11 = (ret)**2

end do j


* compute the etas using positively-perturbed parameter values (four parameters) for each
country (eleven countries)

do j=1,11

set ret / = [series] j

* calculate 65-day rolling window variance

compute jp11 = j + 11

set ret2 / = [series] jp11

statistics(noprint) ret2 1 65

set rv 65 65 = %mean

compute m = %mean
```

```
display(unit=m) m
do date = 66, 4788
set rv date date = rv(date-1) + (1.0/65.0)*(ret2(date) - ret2(date-65))
end do date
statistics rv

* define rolling window variances at 3 lag lengths, to be used as explanatory variables
set rvm65 / = rv{65}
set rvm130 / = rv{130}
set rvm195 / = rv{195}

* read in the un-perturbed parameters for the jth country
do param = 1,4
compute paramplace = (j-1)*4 + param
compute onetheta(param) = alltheta(paramplace)
end do param

* estimate the perturbed first-step etas by marginally changing the pre-estimated parameters for each of four parameters
do param = 1,4
compute epsilon = %max(.0001, .001*onetheta(param))
display(unit=epsilons) epsilon
* perturb one parameter
compute onetheta(param) = onetheta(param)+epsilon
* label the parameters
compute theta = onetheta(1)
compute w = onetheta(2)
```

```
compute a1 = onetheta(3)
compute a2 = onetheta(4)

* midas-GARCH eta using perturbed pre-estimated parameters
set lrv / =  m*abs(1.0-theta) +theta*(1.0*rvm65+(exp(-w*1))*rvm130+(exp(-w*2))*rvm195)/(1.0+exp(-w*1)+exp(-w*2))
set sgvar / = 1.0
do i=261,4788
set sgvar i i  = abs(1.0-a1-a2) + a1*ret2{1}/lrv{1} + a2*sgvar{1}
end do i

set fglogl / = -.5*(log(sgvar*lrv)+ret2/(sgvar*lrv))

* create series of standardized outcomes
set alteta 261 4788 = ret/((sgvar*lrv)**.5)

* save the standardized outcomes of the perturbed maximum likelihood estimation
copy(unit=alteta,format= free, org=obs) 261 4788 alteta

* un-perturb a parameter and go back to the beginning of the parameter loop
compute onetheta(param) = onetheta(param)- epsilon
end do param
end do j

display 'positive perturbations done'

* next compute the etas using negatively-perturbed parameter values (four parameters) for each country (eleven countries)
```

```
do j=1,11
set ret / = [series] j
* calculate 65-day rolling window variance
compute jp11 = j + 11
set ret2 / = [series] jp11
statistics(noprint) ret2 1 65
set rv 65 65 = %mean
compute m = %mean
display(unit=m) m
do date = 66, 4788
set rv date date = rv(date-1) + (1.0/65.0)*(ret2(date) - ret2(date-65))
end do date
statistics rv

* define rolling window variances at 3 lag lengths, to be used as explanatory variables
set rvm65 / = rv{65}
set rvm130 / = rv{130}
set rvm195 / = rv{195}

* read in the un-perturbed parameters for the jth country
do param = 1,4
compute paramplace = (j-1)*4 + param
compute onetheta(param) = alltheta(paramplace)
end do param

* estimate the perturbed first-step etas by marginally changing the pre-estimated parameters for each of four parameters
```

```
do param = 1,4
compute epsilon = %max(.0001, .001*onetheta(param))
display(unit=epsilons) epsilon
* perturb one parameter
compute onetheta(param) = onetheta(param)-epsilon
* label the parameters
compute theta = onetheta(1)
compute w = onetheta(2)
compute a1 = onetheta(3)
compute a2 = onetheta(4)

* midas-GARCH eta using perturbed pre-estimated parameters
set lrv / =  m*abs(1.0-theta) +theta*(1.0*rvm65+(exp(-w*1))*rvm130+(exp(-w*2))*rvm195)/(1.0+exp(-w*1)+exp(-w*2))
set sgvar / = 1.0
do i=261,4788
set sgvar i i  = abs(1.0-a1-a2) + a1*ret2{1}/lrv{1} + a2*sgvar{1}
end do i
set fglogl / = -.5*(log(sgvar*lrv)+ret2/(sgvar*lrv))

* create series of standardized outcomes
set alteta 261 4788 = ret/((sgvar*lrv)**.5)

* save the standardized outcomes of the perturbed maximum likelihood estimation
copy(unit=alteta,format= free, org=obs) 261 4788 alteta

* un-perturb a parameter and go back to the beginning of the parameter loop
```

```
compute onetheta(param) = onetheta(param) + epsilon
end do param
end do j

display 'all done'
```

```
*crossmarginalstep2m6.txt this program estimates second-step cross-marginal log likelihood scores
* using perturbed and unperturbed etas from step 1 estimation
* and perturbed and unperturbed second step likelihood values
* and finds the expected cross-marginals of the likelihood function
* by taking difference-combinations of
* perturbed and un-perturbed log likelihood values
* d2f/dxdy = lim(1/(4*e1*e2))*[(f(x+e1,y+e2)-f(x+e1,y-e2)-(f(x-e1,y+e2)-f(x-e1,y-e2))]
* the four terms in the square bracket are term1, term2, term3 and term4 below
* these are expected values of the likelihood function at perturbed and/or unperturbed
* first step and second step parameter estimates
* using model 6 from table 6

alloc 110 4788
* numbered variates 1 - 11 are for unperturbed etas
* 12 - 55 are the positive-perturbed etas
* 56 - 99 are the negative-perturbed etas
* 100 - 110 are for temporary storage

open eta c:\eurovol\output\eta.txt
open alteta c:\eurovol\output\alteta.txt
open dailysignals c:\eurovol\output\dailysignals.txt
open truedailysigs c:\eurovol\output\truedailysigs.txt
open phi6 c:\eurovol\output\phi6.txt
open corr0 c:\eurovol\output\corr0.txt
open covs6 c:\eurovol\output\covs6.txt
open covs c:\eurovol\output\covs.txt
```

```
open ssdrvs6 c:\eurovol\output\ssdrvs6.txt
open ssdrvs6 c:\eurovol\output\ssdrvs.txt

* input file for the first-step epsilons of the numerical derivatives
open epsilons c:\eurovol\output\epsilons.txt
declare vector epsilon1(44)
read(unit=epsilons) epsilon1
*second-step parameter epsilon vector
declare vector epsilon2(60)

* output file for the expected cross-marginal matrix of the log
*  likelihood function
open gmat6 c:\eurovol\output\gmat6.txt
declare rectangular gmat(44,60)

* the four terms of the cross-partial derivative matrix
declare rectangular term1(44,60)
declare rectangular term2(44,60)
declare rectangular term3(44,60)
declare rectangular term4(44,60)

* read in the unperturbed etas
data(unit=eta,format=free,org=vars) 261 4788 $
1 2 3 4 5 6 7 8 9 10 11

* read in the perturbed etas
data(unit=alteta,format=free,org=vars) 261 4788 $
```

```
12 13 14 15 16 17 18 19 $

20 21 22 23 24 25 26 27 28 29 $

30 31 32 33 34 35 36 37 38 39 $

40 41 42 43 44 45 46 47 48 49 $

50 51 52 53 54 55 56 57 58 59 $

60 61 62 63 64 65 66 67 68 69 $

70 71 72 73 74 75 76 77 78 79 $

80 81 82 83 84 85 86 87 88 89 $

90 91 92 93 94 95 96 97 98 99


* compare the perturbed and unperturbed etas

* positive perturbations

do j = 1,11

do k=1,4

compute altetaplace = (j-1)*4 +k + 11

set eta / = [series] j

set alteta / = [series] altetaplace

linreg(noprint) eta

#alteta

*display k j %rsquared

end do k

end do j


* negative perturbations

do j = 1,11

do k=1,4

compute altetaplace = (j-1)*4 +k + 55
```

```
set eta / = [series] j
set alteta / = [series] altetaplace
linreg(noprint) eta
# alteta
*display k j %rsquared
end do k
end do j

data(unit=dailysignals,format=free,org=obs) 1 4788 qcumret qavevar avegrowth $
qsignal qtrend lagqcumret lagqavevar lagqavecorr lagqsignal
data(unit=truedailysigs,format=free,org=obs) 260 4788 tdavecorr tdavevar tdcumret

* de-mean the explanatory variables
statistics qsignal
set qsignal / = qsignal - %mean
statistics avegrowth
set avegrowth / = avegrowth - %mean
statistics tdavecorr
set ratio / = (tdavecorr{1} - %mean)/(1.0-%mean)
statistics tdavevar
set avevar / = tdavevar{1} - %mean
statistics tdcumret
set cumret / = tdcumret{1} - %mean

* set trend to match the annual scale per unit time
set trend / = t/261.0
statistics trend
```

```
set trend / = trend - %mean


* read in the second-step estimated parameter values

* both phi and corr0

declare vector phi(5)

declare real b1 b2 b3 b4 b5

read(unit=phi6) phi

display "phi" phi

compute b1 = phi(1)

compute b2 = phi(2)

compute b3 = phi(3)

compute b4 = phi(4)

compute b5 = phi(5)

declare symmetric corr0(11,11)

read(unit=corr0) corr0


* create a unit matrix

declare symmetric unitmat(11,11)

do j = 1,11

do jj = 1,11

compute unitmat(j,jj) = 1.0

end do jj

end do j


* place the unperturbed etas into the temporary storage slots as default values

do j=1,11

compute jp99 = j + 99
```

```
set [series] jp99 / = [series] j
end do j

* iteratively run over the eleven countries and then in an inner loop
* iteratively replace one eta series with a positively-perturbed eta series and re-estimate
* the expected log likelihood

* iterate over countries
do j = 1, 11

* iterate over first-step parameters
do k = 1,4

* first deal with term1 and term2 where the first-step parameter is perturbed positively
* replace one eta with a perturbed eta for country j based on first-step perturbed parameter k

compute countryplace = j + 99
computer altetaplace = (j-1)*4 +k + 11
set [series] countryplace / = [series] altetaplace

* label the etas using the mixture of ten unperturbed and one perturbed eta
set e1 / = [series] 100
set e2 / = [series] 101
set e3 / = [series] 102
set e4 / = [series] 103
set e5 / = [series] 104
set e6 / = [series] 105
```

```
set e7 / = [series] 106

set e8 / = [series] 107

set e9 / = [series] 108

set e10 / = [series] 109

set e11 / = [series] 110


* now an inner loop over second step parameters

do step2param = 1,5


* term 1 first where the second-step parameter is also perturbed positively

compute newphi = phi

compute epsilon = %max(.0001,.001*phi(step2param))

compute newphi(step2param) = phi(step2param)+epsilon

compute b1 = newphi(1)

compute b2 = newphi(2)

compute b3 = newphi(3)

compute b4 = newphi(4)

compute b5 = newphi(5)

compute epsilon2(step2param) = epsilon


* compute second-step likelihood and save the term

set m / = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*qsignal)

do i=261,4788

compute ut = ||e1(i),e2(i),e3(i),e4(i),e5(i),e6(i),e7(i),e8(i),e9(i),e10(i),e11(i)||

compute sigmat = (m(i))*unitmat + (1.0 - m(i))*corr0

set mvlike i i = %logdensity(sigmat,ut)

end do i
```

```
statistics(noprint) mvlike 261 4788
compute paramplace = (j-1)*4+k
*display 'paramplace step2param1' paramplace step2param
compute term1(paramplace,step2param) = %mean

* term 2 next where the second-step parameter is perturbed negatively
compute newphi = phi
compute epsilon = %max(.0001,.001*phi(step2param))
compute newphi(step2param) = phi(step2param)-epsilon
compute b1 = newphi(1)
compute b2 = newphi(2)
compute b3 = newphi(3)
compute b4 = newphi(4)
compute b5 = newphi(5)
compute epsilon2(step2param) = epsilon

* compute second-step likelihood and save the term
set m / = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*qsignal)
do i=261,4788
compute ut = ||e1(i),e2(i),e3(i),e4(i),e5(i),e6(i),e7(i),e8(i),e9(i),e10(i),e11(i)||
compute sigmat = (m(i))*unitmat + (1.0 - m(i))*corr0
set mvlike i i = %logdensity(sigmat,ut)
end do i
statistics(noprint) mvlike 261 4788
compute paramplace = (j-1)*4+k
*display 'paramplace step2param1' paramplace step2param
```

```
compute term2(paramplace,step2param) = %mean

end do step2param

compute step2param = 5


* now separately do step 2 for the parameters of the unconditional correlation matrix

do row = 1,10

compute rowp1 = row + 1

do col = rowp1,11

compute step2param = step2param + 1

compute pcorr0 = corr0

compute epsilon = %max(.0001,.001*corr0(row,col))

compute epsilon2(step2param) = epsilon


* term 1 first where the second-step parameter is also perturbed positively

compute pcorr0(row,col) = corr0(row,col)+epsilon


* compute second-step likelihood and save the term

set m / = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*qsignal)

do i=261,4788

compute ut = ||e1(i),e2(i),e3(i),e4(i),e5(i),e6(i),e7(i),e8(i),e9(i),e10(i),e11(i)||

compute sigmat = (m(i))*unitmat + (1.0 - m(i))*pcorr0

set mvlike i i = %logdensity(sigmat,ut)

end do i

statistics(noprint) mvlike 261 4788

compute paramplace = (j-1)*4+k

*display 'paramplace step2param1' paramplace step2param

compute term1(paramplace,step2param) = %mean
```

```
* term 2 next where the second-step parameter is perturbed negatively
compute pcorr0(row,col) = corr0(row,col)-epsilon

* compute second-step likelihood and save the term
set m / = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*qsignal)
do i=261,4788
compute ut = ||e1(i),e2(i),e3(i),e4(i),e5(i),e6(i),e7(i),e8(i),e9(i),e10(i),e11(i)||
compute sigmat = (m(i))*unitmat + (1.0 - m(i))*pcorr0
set mvlike i i = %logdensity(sigmat,ut)
end do i
statistics(noprint) mvlike 261 4788
compute paramplace = (j-1)*4+k
*display 'paramplace step2param1' paramplace step2param
compute term2(paramplace,step2param) = %mean
end do row
end do col

* restore the perturbed eta to its unperturbed value
set [series] countryplace / = [series] j

* close the first-step parameter and country loops
end do k
end do j

* now repeat the last block with negatively-perturbed step one etas
* to compute terms 3 and 4
```

```
* iteratively run over the eleven countries and then in an inner loop
* iteratively replace one eta series with a negatively-perturbed eta series and re-estimate
* the expected log likelihood

* iterate over countries
do j = 1, 11

* iterate over first-step parameters
do k = 1,4

* term3 and term4 where the first-step parameter is perturbed negatively
* replace one eta with a perturbed eta for country j based on first-step perturbed parameter k

compute countryplace = j + 99
computer altetaplace = (j-1)*4 +k + 55
set [series] countryplace / = [series] altetaplace

* label the etas using the mixture of ten unperturbed and one perturbed eta
set e1 / = [series] 100
set e2 / = [series] 101
set e3 / = [series] 102
set e4 / = [series] 103
set e5 / = [series] 104
set e6 / = [series] 105
set e7 / = [series] 106
```

```
set e8 / = [series] 107
set e9 / = [series] 108
set e10 / = [series] 109
set e11 / = [series] 110

* now an inner loop over second step parameters
do step2param = 1,5

* term 3 first where the second-step parameter is perturbed positively
compute newphi = phi
compute epsilon = %max(.0001,.001*phi(step2param))
compute newphi(step2param) = phi(step2param)+epsilon
compute b1 = newphi(1)
compute b2 = newphi(2)
compute b3 = newphi(3)
compute b4 = newphi(4)
compute b5 = newphi(5)
compute epsilon2(step2param) = epsilon

* compute second-step likelihood and save the term
set m / = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*qsignal)
do i=261,4788
compute ut = ||e1(i),e2(i),e3(i),e4(i),e5(i),e6(i),e7(i),e8(i),e9(i),e10(i),e11(i)||
compute sigmat = (m(i))*unitmat + (1.0 - m(i))*corr0
set mvlike i i = %logdensity(sigmat,ut)
end do i
statistics(noprint) mvlike 261 4788
```

```
*display 'paramplace step2param1' paramplace step2param
compute paramplace = (j-1)*4+k
compute term3(paramplace,step2param) = %mean

* now term 4 where the second-step parameter is perturbed negatively
compute newphi = phi
compute epsilon = %max(.0001,.001*phi(step2param))
compute newphi(step2param) = phi(step2param)-epsilon
compute b1 = newphi(1)
compute b2 = newphi(2)
compute b3 = newphi(3)
compute b4 = newphi(4)
compute b5 = newphi(5)
compute epsilon2(step2param) = epsilon

* compute second-step likelihood and save the term
set m / = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*qsignal)
do i=261,4788
compute ut = ||e1(i),e2(i),e3(i),e4(i),e5(i),e6(i),e7(i),e8(i),e9(i),e10(i),e11(i)||
compute sigmat = (m(i))*unitmat + (1.0 - m(i))*corr0
set mvlike i i = %logdensity(sigmat,ut)
end do i
statistics(noprint) mvlike 261 4788
*display 'paramplace step2param1' paramplace step2param
compute paramplace = (j-1)*4+k
compute term4(paramplace,step2param) = %mean
```

```
end do step2param

compute step2param = 5


* now separately do step 2 for the parameters of the unconditional correlation matrix

do row = 1,10

compute rowp1 = row + 1

do col = rowp1,11

compute step2param = step2param + 1

compute pcorr0 = corr0

compute epsilon = %max(.0001,.001*corr0(row,col))

compute epsilon2(step2param) = epsilon


* term 3 where the second-step parameter is perturbed positively

compute pcorr0(row,col) = corr0(row,col)+epsilon


* compute second-step likelihood and save the term

set m / = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*qsignal)

do i=261,4788

compute ut = ||e1(i),e2(i),e3(i),e4(i),e5(i),e6(i),e7(i),e8(i),e9(i),e10(i),e11(i)||

compute sigmat = (m(i))*unitmat + (1.0 - m(i))*pcorr0

set mvlike i i = %logdensity(sigmat,ut)

end do i

statistics(noprint) mvlike 261 4788

compute paramplace = (j-1)*4+k

*display 'paramplace step2param1' paramplace step2param

compute term3(paramplace,step2param) = %mean
```

```
* term 4 where the second-step parameter is perturbed negatively
compute pcorr0(row,col) = corr0(row,col)-epsilon

* compute second-step likelihood and save the term
set m / = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*qsignal)
do i=261,4788
compute ut = ||e1(i),e2(i),e3(i),e4(i),e5(i),e6(i),e7(i),e8(i),e9(i),e10(i),e11(i)||
compute sigmat = (m(i))*unitmat + (1.0 - m(i))*pcorr0
set mvlike i i = %logdensity(sigmat,ut)
end do i
statistics(noprint) mvlike 261 4788
compute paramplace = (j-1)*4+k
*display 'paramplace step2param1' paramplace step2param
compute term4(paramplace,step2param) = %mean
end do row
end do col

* restore the perturbed eta to its unperturbed value
set [series] countryplace / = [series] j

* close the first-step parameter and country loops
end do k
end do j

* now fill up the cross-marginal matrix of the likelihood function
* using the four components term1,term2, term3 and term4
* and scaled by the reciprocal of the infinitesimals epsilon1xepsilon2
```

```
display 'term4' term4

display 'term3' term3

display 'term2' term2

display 'term1' term1

display 'epsilon1' epsilon1

display 'epsilon2' epsilon2


do step1 = 1,44

do step2 = 1,60


compute gmat(step1,step2) = (1.0/(4.0*epsilon1(step1)*epsilon2(step2)))* $

(term1(step1,step2)- term2(step1,step2) - term3(step1,step2) + term4(step1,step2))


end do step2

end do step1


display gmat

write(unit=gmat6) gmat
```

```
*crossmarginalstep2m7.txt this program estimates second-step cross-marginal log likelihood scores
* using perturbed and unperturbed etas from step 1 estimation
* and perturbed and unperturbed second step likelihood values
* and finds the expected cross-marginals of the likelihood function
* by taking difference-combinations of
* perturbed and un-perturbed log likelihood values
* d2f/dxdy = lim(1/(4*e1*e2))*[(f(x+e1,y+e2)-f(x+e1,y-e2)-(f(x-e1,y+e2)-f(x-e1,y-e2))]
* the four terms in the square bracket are term1, term2, term3 and term4 below
* these are expected values of the likelihood function at perturbed and/or unperturbed
* first step and second step parameter estimates
* using model 7 from table 6

alloc 110 4788
* numbered variates 1 - 11 are for unperturbed etas
* 12 - 55 are the positive-perturbed etas
* 56 - 99 are the negative-perturbed etas
* 100 - 110 are for temporary storage

open eta c:\eurovol\output\eta.txt
open alteta c:\eurovol\output\alteta.txt
open dailysignals c:\eurovol\output\dailysignals.txt
open truedailysigs c:\eurovol\output\truedailysigs.txt
open phi7 c:\eurovol\output\phi7.txt
open corr0 c:\eurovol\output\corr0.txt
```

```
* input file for the first-step epsilons of the numerical derivatives
open epsilons c:\eurovol\output\epsilons.txt
declare vector epsilon1(44)
read(unit=epsilons) epsilon1
*second-step parameter epsilon vector
declare vector epsilon2(60)


* output file for the expected cross-marginal matrix of the log
*  likelihood function
open gmat7 c:\eurovol\output\gmat7.txt
declare rectangular gmat(44,60)

* the four terms of the cross-partial derivative matrix
declare rectangular term1(44,60)
declare rectangular term2(44,60)
declare rectangular term3(44,60)
declare rectangular term4(44,60)

* read in the unperturbed etas
data(unit=eta,format=free,org=vars) 261 4788 $
1 2 3 4 5 6 7 8 9 10 11

* read in the perturbed etas
data(unit=alteta,format=free,org=vars) 261 4788 $
12 13 14 15 16 17 18 19 $
20 21 22 23 24 25 26 27 28 29 $
```

```
30 31 32 33 34 35 36 37 38 39 $
40 41 42 43 44 45 46 47 48 49 $
50 51 52 53 54 55 56 57 58 59 $
60 61 62 63 64 65 66 67 68 69 $
70 71 72 73 74 75 76 77 78 79 $
80 81 82 83 84 85 86 87 88 89 $
90 91 92 93 94 95 96 97 98 99

* compare the perturbed and unperturbed etas
* positive perturbations
do j = 1,11
do k=1,4
compute altetaplace = (j-1)*4 +k + 11
set eta / = [series] j
set alteta / = [series] altetaplace
linreg(noprint) eta
#alteta
*display k j %rsquared
end do k
end do j

* negative perturbations
do j = 1,11
do k=1,4
compute altetaplace = (j-1)*4 +k + 55
set eta / = [series] j
set alteta / = [series] altetaplace
```

```
linreg(noprint) eta

# alteta

*display k j %rsquared

end do k

end do j


data(unit=dailysignals,format=free,org=obs) 1 4788 qcumret qavevar avegrowth $

qsignal qtrend lagqcumret lagqavevar lagqavecorr lagqsignal

data(unit=truedailysigs,format=free,org=obs) 260 4788 tdavecorr tdavevar tdcumret


* de-mean the explanatory variables


statistics qsignal

set qsignal / = qsignal - %mean


statistics avegrowth

set avegrowth / = avegrowth - %mean


statistics tdavecorr

set ratio / = (tdavecorr{1} - %mean)/(1.0-%mean)


statistics tdavevar

set avevar / = tdavevar{1} - %mean


statistics tdcumret

set cumret / = tdcumret{1} - %mean
```

```
* set trend to match the annual scale per unit time

set trend / = t/261.0

statistics trend

set trend / = trend - %mean


* read in the second-step estimated parameter values

* both phi and corr0

declare vector phi(5)

declare real b1 b2 b3 b4 b5

read(unit=phi7) phi

display "phi" phi

compute b1 = phi(1)

compute b2 = phi(2)

compute b3 = phi(3)

compute b4 = phi(4)

compute b5 = phi(5)

declare symmetric corr0(11,11)

read(unit=corr0) corr0


* create a unit matrix

declare symmetric unitmat(11,11)

do j = 1,11

do jj = 1,11

compute unitmat(j,jj) = 1.0

end do jj

end do j
```

```
* place the unperturbed etas into the temporary storage slots as default values
do j=1,11
compute jp99 = j + 99
set [series] jp99 / = [series] j
end do j

* iteratively run over the eleven countries and then in an inner loop
* iteratively replace one eta series with a positively-perturbed eta series and re-estimate
* the expected log likelihood

* iterate over countries
do j = 1, 11

* iterate over first-step parameters
do k = 1,4

* first deal with term1 and term2 where the first-step parameter is perturbed positively
* replace one eta with a perturbed eta for country j based on first-step perturbed parameter k

compute countryplace = j + 99
computer altetaplace = (j-1)*4 +k + 11
set [series] countryplace / = [series] altetaplace

* label the etas using the mixture of ten unperturbed and one perturbed eta
set e1 / = [series] 100
set e2 / = [series] 101
set e3 / = [series] 102
```

```
set e4 / = [series] 103

set e5 / = [series] 104

set e6 / = [series] 105

set e7 / = [series] 106

set e8 / = [series] 107

set e9 / = [series] 108

set e10 / = [series] 109

set e11 / = [series] 110


* now an inner loop over second step parameters

do step2param = 1,5


* term 1 first where the second-step parameter is also perturbed positively

compute newphi = phi

compute epsilon = %max(.0001,.001*phi(step2param))

compute newphi(step2param) = phi(step2param)+epsilon

compute b1 = newphi(1)

compute b2 = newphi(2)

compute b3 = newphi(3)

compute b4 = newphi(4)

compute b5 = newphi(5)

compute epsilon2(step2param) = epsilon


* compute second-step likelihood and save the term

set m / = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*avegrowth)

do i=261,4788

compute ut = ||e1(i),e2(i),e3(i),e4(i),e5(i),e6(i),e7(i),e8(i),e9(i),e10(i),e11(i)||
```

```
compute sigmat = (m(i))*unitmat + (1.0 - m(i))*corr0
set mvlike i i = %logdensity(sigmat,ut)
end do i
statistics(noprint) mvlike 261 4788
compute paramplace = (j-1)*4+k
*display 'paramplace step2param1' paramplace step2param
compute term1(paramplace,step2param) = %mean

* term 2 next where the second-step parameter is perturbed negatively
compute newphi = phi
compute epsilon = %max(.0001,.001*phi(step2param))
compute newphi(step2param) = phi(step2param)-epsilon
compute b1 = newphi(1)
compute b2 = newphi(2)
compute b3 = newphi(3)
compute b4 = newphi(4)
compute b5 = newphi(5)
compute epsilon2(step2param) = epsilon

* compute second-step likelihood and save the term
set m / = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*avegrowth)
do i=261,4788
compute ut = ||e1(i),e2(i),e3(i),e4(i),e5(i),e6(i),e7(i),e8(i),e9(i),e10(i),e11(i)||
compute sigmat = (m(i))*unitmat + (1.0 - m(i))*corr0
set mvlike i i = %logdensity(sigmat,ut)
end do i
statistics(noprint) mvlike 261 4788
```

```
compute paramplace = (j-1)*4+k

*display 'paramplace step2param1' paramplace step2param

compute term2(paramplace,step2param) = %mean

end do step2param

compute step2param = 5


* now separately do step 2 for the parameters of the unconditional correlation matrix

do row = 1,10

compute rowp1 = row + 1

do col = rowp1,11

compute step2param = step2param + 1

compute pcorr0 = corr0

compute epsilon = %max(.0001,.001*corr0(row,col))

compute epsilon2(step2param) = epsilon


* term 1 first where the second-step parameter is also perturbed positively

compute pcorr0(row,col) = corr0(row,col)+epsilon


* compute second-step likelihood and save the term

set m / = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*avegrowth)

do i=261,4788

compute ut = ||e1(i),e2(i),e3(i),e4(i),e5(i),e6(i),e7(i),e8(i),e9(i),e10(i),e11(i)||

compute sigmat = (m(i))*unitmat + (1.0 - m(i))*pcorr0

set mvlike i i = %logdensity(sigmat,ut)

end do i

statistics(noprint) mvlike 261 4788

compute paramplace = (j-1)*4+k
```

```
*display 'paramplace step2param1' paramplace step2param
compute term1(paramplace,step2param) = %mean

* term 2 next where the second-step parameter is perturbed negatively
compute pcorr0(row,col) = corr0(row,col)-epsilon

* compute second-step likelihood and save the term
set m / = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*avegrowth)
do i=261,4788
compute ut = ||e1(i),e2(i),e3(i),e4(i),e5(i),e6(i),e7(i),e8(i),e9(i),e10(i),e11(i)||
compute sigmat = (m(i))*unitmat + (1.0 - m(i))*pcorr0
set mvlike i i = %logdensity(sigmat,ut)
end do i
statistics(noprint) mvlike 261 4788
compute paramplace = (j-1)*4+k
*display 'paramplace step2param1' paramplace step2param
compute term2(paramplace,step2param) = %mean
end do row
end do col

* restore the perturbed eta to its unperturbed value
set [series] countryplace / = [series] j

* close the first-step parameter and country loops
end do k
end do j
```

```
* now repeat the last block with negatively-perturbed step one etas
* to compute terms 3 and 4

* iteratively run over the eleven countries and then in an inner loop
* iteratively replace one eta series with a negatively-perturbed eta series and re-estimate
* the expected log likelihood

* iterate over countries
do j = 1, 11

* iterate over first-step parameters
do k = 1,4

* term3 and term4 where the first-step parameter is perturbed negatively
* replace one eta with a perturbed eta for country j based on first-step perturbed parameter k

compute countryplace = j + 99
computer altetaplace = (j-1)*4 +k + 55
set [series] countryplace / = [series] altetaplace

* label the etas using the mixture of ten unperturbed and one perturbed eta
set e1 / = [series] 100
set e2 / = [series] 101
set e3 / = [series] 102
set e4 / = [series] 103
set e5 / = [series] 104
```

```
set e6 / = [series] 105
set e7 / = [series] 106
set e8 / = [series] 107
set e9 / = [series] 108
set e10 / = [series] 109
set e11 / = [series] 110

* now an inner loop over second step parameters
do step2param = 1,5

* term 3 first where the second-step parameter is perturbed positively
compute newphi = phi
compute epsilon = %max(.0001,.001*phi(step2param))
compute newphi(step2param) = phi(step2param)+epsilon
compute b1 = newphi(1)
compute b2 = newphi(2)
compute b3 = newphi(3)
compute b4 = newphi(4)
compute b5 = newphi(5)
compute epsilon2(step2param) = epsilon

* compute second-step likelihood and save the term
set m / = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*avegrowth)
do i=261,4788
compute ut = ||e1(i),e2(i),e3(i),e4(i),e5(i),e6(i),e7(i),e8(i),e9(i),e10(i),e11(i)||
compute sigmat = (m(i))*unitmat + (1.0 - m(i))*corr0
set mvlike i i = %logdensity(sigmat,ut)
```

```
end do i

statistics(noprint) mvlike 261 4788

*display 'paramplace step2param1' paramplace step2param

compute paramplace = (j-1)*4+k

compute term3(paramplace,step2param) = %mean


* now term 4 where the second-step parameter is perturbed negatively

compute newphi = phi

compute epsilon = %max(.0001,.001*phi(step2param))

compute newphi(step2param) = phi(step2param)-epsilon

compute b1 = newphi(1)

compute b2 = newphi(2)

compute b3 = newphi(3)

compute b4 = newphi(4)

compute b5 = newphi(5)

compute epsilon2(step2param) = epsilon


* compute second-step likelihood and save the term

set m / = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*avegrowth)

do i=261,4788

compute ut = ||e1(i),e2(i),e3(i),e4(i),e5(i),e6(i),e7(i),e8(i),e9(i),e10(i),e11(i)||

compute sigmat = (m(i))*unitmat + (1.0 - m(i))*corr0

set mvlike i i = %logdensity(sigmat,ut)

end do i

statistics(noprint) mvlike 261 4788

*display 'paramplace step2param1' paramplace step2param

compute paramplace = (j-1)*4+k
```

```
compute term4(paramplace,step2param) = %mean
end do step2param
compute step2param = 5

* now separately do step 2 for the parameters of the unconditional correlation matrix
do row = 1,10
compute rowp1 = row + 1
do col = rowp1,11
compute step2param = step2param + 1
compute pcorr0 = corr0
compute epsilon = %max(.0001,.001*corr0(row,col))
compute epsilon2(step2param) = epsilon

* term 3 where the second-step parameter is perturbed positively
compute pcorr0(row,col) = corr0(row,col)+epsilon

* compute second-step likelihood and save the term
set m / = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*avegrowth)
do i=261,4788
compute ut = ||e1(i),e2(i),e3(i),e4(i),e5(i),e6(i),e7(i),e8(i),e9(i),e10(i),e11(i)||
compute sigmat = (m(i))*unitmat + (1.0 - m(i))*pcorr0
set mvlike i i = %logdensity(sigmat,ut)
end do i
statistics(noprint) mvlike 261 4788
compute paramplace = (j-1)*4+k
*display 'paramplace step2param1' paramplace step2param
compute term3(paramplace,step2param) = %mean
```

```
* term 4 where the second-step parameter is perturbed negatively
compute pcorr0(row,col) = corr0(row,col)-epsilon

* compute second-step likelihood and save the term
set m / = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*avegrowth)
do i=261,4788
compute ut = ||e1(i),e2(i),e3(i),e4(i),e5(i),e6(i),e7(i),e8(i),e9(i),e10(i),e11(i)||
compute sigmat = (m(i))*unitmat + (1.0 - m(i))*pcorr0
set mvlike i i = %logdensity(sigmat,ut)
end do i
statistics(noprint) mvlike 261 4788
compute paramplace = (j-1)*4+k
*display 'paramplace step2param1' paramplace step2param
compute term4(paramplace,step2param) = %mean
end do row
end do col

* restore the perturbed eta to its unperturbed value
set [series] countryplace / = [series] j

* close the first-step parameter and country loops
end do k
end do j

* now fill up the cross-marginal matrix of the likelihood function
* using the four components term1,term2, term3 and term4
```

```
* and scaled by the reciprocal of the infinitesimals epsilon1xepsilon2

display 'term4' term4
display 'term3' term3
display 'term2' term2
display 'term1' term1
display 'epsilon1' epsilon1
display 'epsilon2' epsilon2

do step1 = 1,44
do step2 = 1,60

compute gmat(step1,step2) = (1.0/(4.0*epsilon1(step1)*epsilon2(step2)))* $
(term1(step1,step2)- term2(step1,step2) - term3(step1,step2) + term4(step1,step2))

end do step2
end do step1

display gmat
display(unit=gmat7) gmat
```

```
*adjcovmat.txt this program estimates the adjusted covariance matrix of the second-step parameters and compares adjusted and unadjusted standard errors

alloc 180 4788

* first model 6
open gmat6 c:\eurovol\output\gmat6.txt
open adjcovphi c:\eurovol\output\covphi.txt
open ctheta c:\eurovol\output\ctheta.txt
open unadjcovphi c:\eurovola\output\unadjcovphi.txt
open ssdrvs6 c:\eurovol\output\ssdrvs6.txt
open fsdrvsorgobs c:\eurovol\output\fsdrvsorgobs.txt
open covs6 c:\eurovol\output\covs6.txt
open phi6 c:\eurovol\output\phi6.txt

declare rectangular gmat(60,44)
declare rectangular ctheta(44,44)
declare vector zadj(60)
declare vector scorevec(44)
declare symmetric covs(60,60)
declare vector phi(60)

* zadj = gmat*covtheta*scorevec
* this is the adjustment term in the computation of zeta

read(unit=gmat6) gmat
read(unit=ctheta) ctheta
```

```
* do over observations treating each cross-section of observations as a vector

do i=261,4788
read(unit=fsdrvsorgobs) scorevec
compute zadj = gmat*ctheta*scorevec
do j = 1,60
set [series] j i i = zadj(j)
end do j
end do i

data(unit=ssdrvs6,format=free,org=obs) 261 4788 61 62 63 64 65 66 67 68 69 70 $
71 72 73 74 75 76 77 78 79 80 $
81 82 83 84 85 86 87 88 89 90 $
91 92 93 94 95 96 97 98 99 100 $
101 102 103 104 105 106 107 108 109 110 $
111 112 113 114 115 116 117 118 119 120

* uncorrected opg estimated covariance matrix
cmom 261 4788
# 61 62 63 64 65 66 67 68 69 70 $
71 72 73 74 75 76 77 78 79 80 $
81 82 83 84 85 86 87 88 89 90 $
91 92 93 94 95 96 97 98 99 100 $
101 102 103 104 105 106 107 108 109 110 $
111 112 113 114 115 116 117 118 119 120

compute covs = inv(%cmom)
```

```
read(unit=phi6) phi


display (covs(1,1))**.5

display (covs(2,2))**.5

display (covs(3,3))**.5

display (covs(4,4))**.5

display (covs(5,5))**.5

display phi(1)/(covs(1,1))**.5

display phi(2)/(covs(2,2))**.5

display phi(3)/(covs(3,3))**.5

display phi(4)/(covs(4,4))**.5

display phi(5)/(covs(5,5))**.5


* now engle-corrected estimated covariance matrix

do j = 1,60

compute jp60 = j + 60

compute jp120 = j + 120

set [series] jp120 = ([series] jp60) - ([series] j)

end do j


cmom 261 4788

# 121 122 123 124 125 126 127 128 129 130 $

131 132 133 134 135 136 137 138 139 140 $

141 142 143 144 145 146 147 148 149 150 $

151 152 153 154 155 156 157 158 159 160 $

161 162 163 164 165 166 167 168 169 170 $

171 172 173 174 175 176 177 178 179 180
```

```
compute mmat = %cmom
compute covmat = covs*mmat*covs

* adjusted standard errors
write(format='(f20.10)') covmat(1,1)**.5
write(format='(f20.10)') covmat(2,2)**.5
write(format='(f20.10)') covmat(3,3)**.5
write(format='(f20.10)') covmat(4,4)**.5
write(format='(f20.10)') covmat(5,5)**.5

* unadjusted standard errors
write(format='(f20.10)') covs(1,1)**.5
write(format='(f20.10)') covs(2,2)**.5
write(format='(f20.10)') covs(3,3)**.5
write(format='(f20.10)') covs(4,4)**.5
write(format='(f20.10)') covs(5,5)**.5

* proportional difference in standard errors
compute diff1 = (covs(1,1)/covmat(1,1))**.5 -1
compute diff2 = (covs(2,2)/covmat(2,2))**.5 -1
compute diff3 = (covs(3,3)/covmat(3,3))**.5 -1
compute diff4 = (covs(4,4)/covmat(4,4))**.5 -1
compute diff5 = (covs(5,5)/covmat(5,5))**.5 -1

display "diffs 1 - 5"
display diff1
display diff2
```

```
display diff3
display diff4
display diff5

* now model 7

rewind fsdrvsorgobs
open gmat7 c:\eurovol\output\gmat7.txt
open ssdrvs7 c:\eurovol\output\ssdrvs7.txt
open phi7 c:\eurovol\output\phi7.txt

* zadj = gmat*covtheta*scorevec
* this is the adjustment term in the computation of zeta

read(unit=gmat7) gmat

* do over observations treating each cross-section of observations as a vector
do i=261,4788
read(unit=fsdrvsorgobs) scorevec
compute zadj = gmat*ctheta*scorevec
do j = 1,60
set [series] j i i = zadj(j)
end do j
end do i

data(unit=ssdrvs7,format=free,org=obs) 261 4788 61 62 63 64 65 66 67 68 69 70 $
71 72 73 74 75 76 77 78 79 80 $
```

```
81 82 83 84 85 86 87 88 89 90 $
91 92 93 94 95 96 97 98 99 100 $
101 102 103 104 105 106 107 108 109 110 $
111 112 113 114 115 116 117 118 119 120

* uncorrected opg estimated covariance matrix
cmom 261 4788
# 61 62 63 64 65 66 67 68 69 70 $
71 72 73 74 75 76 77 78 79 80 $
81 82 83 84 85 86 87 88 89 90 $
91 92 93 94 95 96 97 98 99 100 $
101 102 103 104 105 106 107 108 109 110 $
111 112 113 114 115 116 117 118 119 120

compute covs = inv(%cmom)
read(unit=phi7) phi

display (covs(1,1))**.5
display (covs(2,2))**.5
display (covs(3,3))**.5
display (covs(4,4))**.5
display (covs(5,5))**.5
display phi(1)/(covs(1,1))**.5
display phi(2)/(covs(2,2))**.5
display phi(3)/(covs(3,3))**.5
display phi(4)/(covs(4,4))**.5
display phi(5)/(covs(5,5))**.5
```

```
* now engle-corrected estimated covariance matrix
do j = 1,60
compute jp60 = j + 60
compute jp120 = j + 120
set [series] jp120 = ([series] jp60) - ([series] j)
end do j

cmom 261 4788
# 121 122 123 124 125 126 127 128 129 130 $
131 132 133 134 135 136 137 138 139 140 $
141 142 143 144 145 146 147 148 149 150 $
151 152 153 154 155 156 157 158 159 160 $
161 162 163 164 165 166 167 168 169 170 $
171 172 173 174 175 176 177 178 179 180

compute mmat = %cmom
compute covmat = covs*mmat*covs

* adjusted standard errors
write(format='(f20.10)') covmat(1,1)**.5
write(format='(f20.10)') covmat(2,2)**.5
write(format='(f20.10)') covmat(3,3)**.5
write(format='(f20.10)') covmat(4,4)**.5
write(format='(f20.10)') covmat(5,5)**.5

* unadjusted standard errors
write(format='(f20.10)') covs(1,1)**.5
```

```
write(format='(f20.10)') covs(2,2)**.5
write(format='(f20.10)') covs(3,3)**.5
write(format='(f20.10)') covs(4,4)**.5
write(format='(f20.10)') covs(5,5)**.5

* proportional difference in standard errors
compute diff1 = (covs(1,1)/covmat(1,1))**.5 -1
compute diff2 = (covs(2,2)/covmat(2,2))**.5 -1
compute diff3 = (covs(3,3)/covmat(3,3))**.5 -1
compute diff4 = (covs(4,4)/covmat(4,4))**.5 -1
compute diff5 = (covs(5,5)/covmat(5,5))**.5 -1

display "diffs 1 - 5"
display diff1
display diff2
display diff3
display diff4
display diff5
```

4. RATS Estimation Output

This section shows the estimation code output presented in the same order as the RATS estimation code in the section 3.

RATS Estimation code list

1) **makerets.txt**
2) **basicstats.txt**
3) **sqrautocorrs.txt**
4) **garch11.txt**
5) **midasgarch.txt**
6) **midasctheta.txt**
7) **qlinreg5models.txt**
8) **truedailysignals.txt**
9) **maxlike5models.txt**
10) **maxlikemodel6.txt**
11) **maxlikemodel7.txt**
12) **switchorgobs.txt**
13) **crossmarginalstep1.txt**
14) **crossmarginalstep2mod6.txt**
15) **crossmarginalstep2mod7.txt**
16) **adjcovmat.txt**

```
*makerets.txt this program makes euro index returns from euro index prices
alloc 22 3393
open prices c:\eurovol\data\pricesDec1997toDec2010.txt
open pricedates c:\eurovol\data\datesDec1997toDec2010.txt
data(unit=prices,format=free,org=obs) / 1 2 3 4 5 6 7 8 9 10 11
date(unit=pricedates,format=free,org=obs) / day month year
declare real rret rday rmonth ryear
declare integer gooddates
open rrets c:\eurovol\output\rrets.txt
open rdates c:\eurovol\output\rdates.txt

do j=1,11
(01.0041) compute jj = j+11
(01.0064) set price / = [series] j
(01.0096) set [series] jj / = log(price/price{1})
(01.0140) set rets / = [series] jj
(01.0172) display "index" j
(01.0200) display "price statistics"
(01.0219) statistics price
(01.0233) display "return statistics"
(01.0252) statistics rets
(01.0266) end do j
index 1
price statistics

Statistics on Series PRICE
Observations          3393
```

```
Sample Mean          2220.297103      Variance           1400472.387821
Standard Error       1183.415560      of Sample Mean      20.316334
t-Statistic (Mean=0)  109.286306      Signif Level        0.000000
Skewness                0.809713      Signif Level (Sk=0) 0.000000
Kurtosis (excess)      -0.706201      Signif Level (Ku=0) 0.000000
Jarque-Bera           441.268066      Signif Level (JB=0) 0.000000
```

return statistics

```
Statistics on Series RETS
Observations                 3392
Sample Mean             0.000238      Variance           0.000208
Standard Error          0.014409      of Sample Mean      0.000247
t-Statistic (Mean=0)    0.962608      Signif Level        0.335813
Skewness               -0.365971      Signif Level (Sk=0) 0.000000
Kurtosis (excess)       8.465852      Signif Level (Ku=0) 0.000000
Jarque-Bera         10205.169525      Signif Level (JB=0) 0.000000
```

index 2

price statistics

```
Statistics on Series PRICE
Observations                 3393
Sample Mean          2950.683666      Variance           502671.839980
Standard Error        708.993540      of Sample Mean      12.171675
t-Statistic (Mean=0)  242.422153      Signif Level        0.000000
Skewness                0.461019      Signif Level (Sk=0) 0.000000
Kurtosis (excess)      -0.260778      Signif Level (Ku=0) 0.001952
Jarque-Bera           129.804560      Signif Level (JB=0) 0.000000
```

return statistics

```
Statistics on Series RETS
Observations              3392
Sample Mean           0.000019      Variance          0.000173
Standard Error        0.013137      of Sample Mean      0.000226
t-Statistic (Mean=0)    0.083820      Signif Level        0.933205
Skewness              0.059869      Signif Level (Sk=0) 0.154775
Kurtosis (excess)       6.121081      Signif Level (Ku=0) 0.000000
Jarque-Bera          5297.451283      Signif Level (JB=0) 0.000000
```

index 3

price statistics

```
Statistics on Series PRICE
Observations              3393
Sample Mean         7876.089856      Variance          8090194.821169
Standard Error       2844.326778      of Sample Mean      48.830094
t-Statistic (Mean=0)  161.295816      Signif Level        0.000000
Skewness              1.295927      Signif Level (Sk=0) 0.000000
Kurtosis (excess)       1.466452      Signif Level (Ku=0) 0.000000
Jarque-Bera          1253.740581      Signif Level (JB=0) 0.000000
```

return statistics

```
Statistics on Series RETS
Observations              3392
Sample Mean           0.000248      Variance          0.000416
```

```
Standard Error          0.020397      of Sample Mean      0.000350

t-Statistic (Mean=0)    0.708484      Signif Level        0.478693

Skewness               -0.335750      Signif Level (Sk=0) 0.000000

Kurtosis (excess)       6.086050      Signif Level (Ku=0) 0.000000

Jarque-Bera          5298.716940      Signif Level (JB=0) 0.000000
```

index 4

price statistics

```
Statistics on Series PRICE

Observations                3393

Sample Mean          4358.539281      Variance            977702.884591

Standard Error        988.788594      of Sample Mean      16.975068

t-Statistic (Mean=0)  256.761229      Signif Level        0.000000

Skewness                0.466653      Signif Level (Sk=0) 0.000000

Kurtosis (excess)      -0.691808      Signif Level (Ku=0) 0.000000

Jarque-Bera           190.808161      Signif Level (JB=0) 0.000000
```

return statistics

```
Statistics on Series RETS

Observations                3392

Sample Mean             0.000070      Variance            0.000235

Standard Error          0.015331      of Sample Mean      0.000263

t-Statistic (Mean=0)    0.266557      Signif Level        0.789826

Skewness                0.019716      Signif Level (Sk=0) 0.639381

Kurtosis (excess)       4.827992      Signif Level (Ku=0) 0.000000

Jarque-Bera          3294.629448      Signif Level (JB=0) 0.000000
```

index 5

price statistics

```
Statistics on Series PRICE
Observations              3393
Sample Mean          5377.608450      Variance           1687175.075765
Standard Error       1298.913036      of Sample Mean      22.299142
t-Statistic (Mean=0)  241.157644      Signif Level        0.000000
Skewness             -0.008954      Signif Level (Sk=0) 0.831461
Kurtosis (excess)      -0.652920      Signif Level (Ku=0) 0.000000
Jarque-Bera           60.314209      Signif Level (JB=0) 0.000000
```

return statistics

```
Statistics on Series RETS
Observations              3392
Sample Mean            0.000143      Variance           0.000261
Standard Error         0.016153      of Sample Mean      0.000277
t-Statistic (Mean=0)    0.517361      Signif Level        0.604938
Skewness             -0.035425      Signif Level (Sk=0) 0.399839
Kurtosis (excess)       4.118452      Signif Level (Ku=0) 0.000000
Jarque-Bera          2397.955615      Signif Level (JB=0) 0.000000
```

index 6

price statistics

```
Statistics on Series PRICE
Observations              3393
Sample Mean          3063.552706      Variance           1324828.669258
Standard Error       1151.012020      of Sample Mean      19.760045
```

```
t-Statistic (Mean=0)  155.037739      Signif Level        0.000000
Skewness               0.612034      Signif Level (Sk=0) 0.000000
Kurtosis (excess)      -0.571652      Signif Level (Ku=0) 0.000000
Jarque-Bera          258.027195      Signif Level (JB=0) 0.000000
```

return statistics

```
Statistics on Series RETS
Observations               3392
Sample Mean           -0.000024      Variance            0.000305
Standard Error         0.017455      of Sample Mean      0.000300
t-Statistic (Mean=0)   -0.079644      Signif Level        0.936525
Skewness              -0.142057      Signif Level (Sk=0) 0.000735
Kurtosis (excess)       3.745250      Signif Level (Ku=0) 0.000000
Jarque-Bera         1993.876731      Signif Level (JB=0) 0.000000
```

index 7

price statistics

```
Statistics on Series PRICE
Observations               3393
Sample Mean          5316.441627      Variance            3044296.645375
Standard Error       1744.791290      of Sample Mean      29.953774
t-Statistic (Mean=0)  177.488204      Signif Level        0.000000
Skewness               0.478864      Signif Level (Sk=0) 0.000000
Kurtosis (excess)       0.029733      Signif Level (Ku=0) 0.723965
Jarque-Bera          129.800366      Signif Level (JB=0) 0.000000
```

return statistics

```
Statistics on Series RETS
Observations              3392
Sample Mean          -0.000100      Variance           0.000213
Standard Error        0.014602      of Sample Mean      0.000251
t-Statistic (Mean=0)   -0.399913      Signif Level        0.689246
Skewness             -0.571583      Signif Level (Sk=0) 0.000000
Kurtosis (excess)       7.679726      Signif Level (Ku=0) 0.000000
Jarque-Bera         8520.282070      Signif Level (JB=0) 0.000000
```

index 8

price statistics

```
Statistics on Series PRICE
Observations               3393
Sample Mean         31759.641553      Variance           62376931.334902
Standard Error       7897.906769      of Sample Mean      135.587631
t-Statistic (Mean=0)   234.237012      Signif Level        0.000000
Skewness               0.063047      Signif Level (Sk=0) 0.133974
Kurtosis (excess)       -0.834344      Signif Level (Ku=0) 0.000000
Jarque-Bera          100.663104      Signif Level (JB=0) 0.000000
```

return statistics

```
Statistics on Series RETS
Observations              3392
Sample Mean          -0.000056      Variance           0.000227
Standard Error        0.015069      of Sample Mean      0.000259
t-Statistic (Mean=0)   -0.216816      Signif Level        0.828365
```

```
Skewness             -0.008421      Signif Level (Sk=0) 0.841370

Kurtosis (excess)      5.224883      Signif Level (Ku=0) 0.000000

Jarque-Bera         3858.356188      Signif Level (JB=0) 0.000000
```

index 9

price statistics

```
Statistics on Series PRICE

Observations              3393

Sample Mean          438.596849      Variance           14229.795612

Standard Error       119.288707      of Sample Mean      2.047894

t-Statistic (Mean=0) 214.169738      Signif Level        0.000000

Skewness              0.245246      Signif Level (Sk=0) 0.000000

Kurtosis (excess)     -0.885579      Signif Level (Ku=0) 0.000000

Jarque-Bera          144.885706      Signif Level (JB=0) 0.000000
```

return statistics

```
Statistics on Series RETS

Observations               3392

Sample Mean            -0.000046      Variance           0.000252

Standard Error          0.015862      of Sample Mean      0.000272

t-Statistic (Mean=0)   -0.169333      Signif Level        0.865545

Skewness              -0.096121      Signif Level (Sk=0) 0.022346

Kurtosis (excess)       5.499835      Signif Level (Ku=0) 0.000000

Jarque-Bera          4280.300792      Signif Level (JB=0) 0.000000
```

index 10

price statistics

```
Statistics on Series PRICE

Observations             3393

Sample Mean         2538.589573      Variance           402998.579433

Standard Error       634.821691      of Sample Mean      10.898327

t-Statistic (Mean=0)  232.933882      Signif Level        0.000000

Skewness               0.760309      Signif Level (Sk=0) 0.000000

Kurtosis (excess)       0.341109      Signif Level (Ku=0) 0.000051

Jarque-Bera           343.348264      Signif Level (JB=0) 0.000000
```

return statistics

```
Statistics on Series RETS

Observations              3392

Sample Mean              0.000102      Variance           0.000125

Standard Error           0.011184      of Sample Mean      0.000192

t-Statistic (Mean=0)     0.533670      Signif Level        0.593605

Skewness               -0.314109      Signif Level (Sk=0) 0.000000

Kurtosis (excess)       10.765199      Signif Level (Ku=0) 0.000000

Jarque-Bera          16434.827450      Signif Level (JB=0) 0.000000
```

index 11

price statistics

```
Statistics on Series PRICE

Observations              3393
```

```
Sample Mean          10015.536127      Variance            5322870.872572
Standard Error        2307.134776      of Sample Mean      39.607829
t-Statistic (Mean=0)   252.867588      Signif Level        0.000000
Skewness                 0.451729      Signif Level (Sk=0) 0.000000
Kurtosis (excess)       -0.213030      Signif Level (Ku=0) 0.011395
Jarque-Bera            121.811338      Signif Level (JB=0) 0.000000
```

return statistics

```
Statistics on Series RETS
Observations                3392
Sample Mean             0.000090      Variance            0.000234
Standard Error          0.015292      of Sample Mean      0.000263
t-Statistic (Mean=0)    0.344311      Signif Level        0.730633
Skewness                0.024191      Signif Level (Sk=0) 0.565332
Kurtosis (excess)       5.713971      Signif Level (Ku=0) 0.000000
Jarque-Bera          4614.788261      Signif Level (JB=0) 0.000000
```

```
compute gooddates = 0
set count 1 3393 = 0.0
do j = 1,11
(01.0041) compute jj = j + 11
(01.0064) set rets / = [series] jj
(01.0097) set count 2 3393 = count + %if(rets == 0.0,1.0,0.0)
(01.0175) end do j
```

```
statistics count

Statistics on Series COUNT
Observations                  3393
Sample Mean              0.358974      Variance           2.543859
Standard Error           1.594948      of Sample Mean      0.027381
t-Statistic (Mean=0)     13.110186      Signif Level        0.000000
Skewness                 5.744268      Signif Level (Sk=0) 0.000000
Kurtosis (excess)        33.628297      Signif Level (Ku=0) 0.000000
Jarque-Bera          178535.249385      Signif Level (JB=0) 0.000000

open zerocount c:\eurovol\output\zerocount.txt
copy(unit=zerocount,format='(f10.5)') 2 3393 count

open alldayrets c:\eurovol\output\alldayrets.txt
copy(unit=alldayrets,format='(11(f15.10))',org=obs) 2 3393 $
12 13 14 15 16 17 18 19 20 21 22

compute rcount = 0.0

open rets c:\eurovol\output\rets.txt
open opendates c:\eurovol\output\opendates.txt

* eliminate days with most markets closed and add any return to the next day return
* eliminate the missing date and assign the later date to the returns in the dating file

do i = 2,3393
```

```
(01.0041) compute rcount = count(i)

(01.0064) if rcount >= 4.0

(02.0084) {

(03.0084) display "baddate i count" i rcount

(03.0126) do j = 1,11

(04.0161) compute jj = j + 11

(04.0184) set rets / = [series] jj

(04.0217) set rets i+1 i+1 = rets(i)+rets(i+1)

(04.0295) set [series] jj / = rets

(04.0327) end do j

(03.0329) }

(02.0329) if rcount <= 3.0

(02.0349) {

(03.0349) *display "good date i count" i rcount

(03.0392)

(03.0392) do j = 1,11

(04.0427) compute jj = j + 11

(04.0450) set ret / = [series] jj

(04.0482) compute rret = ret(i)

(04.0505) display(unit=rrets) rret

(04.0537) end do j

(03.0539)

(03.0539) compute rday = day(i)

(03.0562) compute rmonth = month(i)

(03.0585) compute ryear = year(i)

(03.0608) display(unit=rdates) rday rmonth ryear

(03.0664)
```

```
(03.0664) compute gooddates = gooddates + 1
(03.0687)
(03.0687) }
(02.0687)
(02.0687) *display "end the i loop"
(02.0687) end do i

display "number of good dates" gooddates
number of good dates 3290
close rrets
open rrets c:\eurovol\output\rrets.txt
data(unit=rrets,format=free,org=obs) 1 gooddates 12 13 14 15 16 17 18 19 20 21 22
copy(unit=rets,format='(11(f15.10))',org=obs) 1 gooddates 12 13 14 15 16 17 18 19 20 21 22
```

```
* basicstats.txt this programme estimates some basic statistics on 11 eurozone national equity indices


alloc 11 4788
*read in 11 equity index returns, de-mean and square
open rets c:\eurovol\output\rets.txt
data(unit=rets,format=free,org=obs) / 1 2 3 4 5 6 7 8 9 10 11


open autocorrs c:\eurovol\output\autocorrs.txt
open rawcormat c:\eurovol\output\rawcormat.txt
open crosscormat c:\eurovol\output\crosscormat.txt
open crosscovmat c:\eurovol\output\crosscovmat.txt
open adjcormat c:\eurovol\output\adjcormat.txt
open adjcovmat c:\eurovol\output\adjcovmat.txt
open adjvar c:\eurovol\output\adjvar.txt


declare rectangular adjcormat(11,11) rawcormat(11,11) crosscovmat(11,11) crosscormat(11,11)
declare rectangular rawcovmat(11,11) adjcovmat(11,11)
declare vector rawvar(11) adjvar(11)


* get basic stats on each individual returns
do j=1,11
(01.0041) set ret / = [series] j
(01.0073) display 'county' j
(01.0101) statistics ret /
(01.0117) compute rawvar(j) = %variance
(01.0140) correlate(number=5) ret / autocorrs
```

```
(01.0177) copy(unit=autocorrs,format='(5(f10.5))') 1 5 autocorrs
(01.0241) correlate(number=1,noprint,covariances) ret / autocov
(01.0282) compute adjvar(j) = rawvar(j)+autocov(2)
(01.0320) compute adjcovmat(j,j) = adjvar(j)
(01.0352) compute adjcormat(j,j) = 1.0
(01.0378) end do j
county 1
Statistics on Series RET
Observations                4788
Sample Mean             0.000249      Variance           0.000182
Standard Error          0.013491      of Sample Mean      0.000195
t-Statistic (Mean=0)     1.275345      Signif Level        0.202249
Skewness               -0.366100      Signif Level (Sk=0) 0.000000
Kurtosis (excess)        8.707568      Signif Level (Ku=0) 0.000000
Jarque-Bera          15233.391411      Signif Level (JB=0) 0.000000

Correlations of Series RET
Autocorrelations
   1        2        3        4        5
 0.07446 -0.03537 -0.00644  0.01616  0.02227
county 2
Statistics on Series RET
Observations                4788
Sample Mean             0.000180      Variance           0.000140
Standard Error          0.011813      of Sample Mean      0.000171
t-Statistic (Mean=0)     1.055862      Signif Level        0.291085
Skewness                0.039834      Signif Level (Sk=0) 0.260629
```

```
Kurtosis (excess)        7.198249      Signif Level (Ku=0) 0.000000
Jarque-Bera          10338.316454      Signif Level (JB=0) 0.000000

Correlations of Series RET
Autocorrelations
   1        2        3        4        5
 0.08863 -0.00974 -0.04465  0.02302 -0.03312

county 3
Statistics on Series RET
Observations               4788
Sample Mean             0.000477      Variance            0.000347
Standard Error          0.018619      of Sample Mean      0.000269
t-Statistic (Mean=0)    1.771632      Signif Level        0.076519
Skewness               -0.361675      Signif Level (Sk=0) 0.000000
Kurtosis (excess)       6.760785      Signif Level (Ku=0) 0.000000
Jarque-Bera          9223.174261      Signif Level (JB=0) 0.000000

Correlations of Series RET
Autocorrelations
   1        2        3        4        5
 0.02857 -0.02090 -0.01611  0.03349  0.00163

county 4
Statistics on Series RET
Observations               4788
Sample Mean             0.000163      Variance            0.000205
```

```
Standard Error          0.014333      of Sample Mean       0.000207
t-Statistic (Mean=0)    0.786304      Signif Level         0.431728
Skewness                0.010189      Signif Level (Sk=0) 0.773556
Kurtosis (excess)       4.781190      Signif Level (Ku=0) 0.000000
Jarque-Bera          4560.608085      Signif Level (JB=0) 0.000000

Correlations of Series RET
Autocorrelations
   1        2        3        4        5
-0.01193 -0.04136 -0.05411  0.03725 -0.04262
```

county 5

```
Statistics on Series RET
Observations                4788
Sample Mean             0.000309      Variance             0.000218
Standard Error          0.014769      of Sample Mean       0.000213
t-Statistic (Mean=0)    1.445542      Signif Level         0.148371
Skewness               -0.113934      Signif Level (Sk=0) 0.001293
Kurtosis (excess)       4.828228      Signif Level (Ku=0) 0.000000
Jarque-Bera          4661.059151      Signif Level (JB=0) 0.000000

Correlations of Series RET
Autocorrelations
   1        2        3        4        5
-0.01637 -0.03288 -0.01797  0.04178 -0.02165
```

county 6

```
Statistics on Series RET
```

```
Observations               4788
Sample Mean             0.000110      Variance            0.000282
Standard Error          0.016805      of Sample Mean      0.000243
t-Statistic (Mean=0)    0.454768      Signif Level        0.649297
Skewness               -0.116575      Signif Level (Sk=0) 0.000994
Kurtosis (excess)       3.891091      Signif Level (Ku=0) 0.000000
Jarque-Bera          3031.391892      Signif Level (JB=0) 0.000000

Correlations of Series RET
Autocorrelations
   1       2       3       4       5
 0.13046 -0.01593 -0.01287  0.02778  0.00942
```

county 7

```
Statistics on Series RET
Observations               4788
Sample Mean             0.000153      Variance            0.000169
Standard Error          0.013017      of Sample Mean      0.000188
t-Statistic (Mean=0)    0.815872      Signif Level        0.414614
Skewness               -0.619436      Signif Level (Sk=0) 0.000000
Kurtosis (excess)       9.528294      Signif Level (Ku=0) 0.000000
Jarque-Bera         18418.476363      Signif Level (JB=0) 0.000000

Correlations of Series RET
Autocorrelations
   1       2       3       4       5
 0.06647  0.00072  0.00182  0.01240 -0.02153
```

county 8

```
Statistics on Series RET

Observations              4788

Sample Mean           0.000147      Variance           0.000216

Standard Error        0.014709      of Sample Mean      0.000213

t-Statistic (Mean=0)    0.690230      Signif Level        0.490083

Skewness              -0.020052      Signif Level (Sk=0) 0.571202

Kurtosis (excess)       4.104700      Signif Level (Ku=0) 0.000000

Jarque-Bera          3361.609685      Signif Level (JB=0) 0.000000


Correlations of Series RET

Autocorrelations

   1        2        3        4        5

 0.02698 -0.00288 -0.02326  0.06972 -0.05090
```

county 9

```
Statistics on Series RET

Observations              4788

Sample Mean           0.000218      Variance           0.000204

Standard Error        0.014286      of Sample Mean      0.000206

t-Statistic (Mean=0)    1.053894      Signif Level        0.291984

Skewness              -0.126282      Signif Level (Sk=0) 0.000362

Kurtosis (excess)       6.543647      Signif Level (Ku=0) 0.000000

Jarque-Bera          8555.180723      Signif Level (JB=0) 0.000000


Correlations of Series RET
```

```
Autocorrelations
   1        2        3        4        5
-0.00360 -0.02266 -0.05699  0.04793 -0.05487

county 10
Statistics on Series RET
Observations                 4788
Sample Mean              0.000309      Variance            0.000102
Standard Error           0.010092      of Sample Mean      0.000146
t-Statistic (Mean=0)     2.121654      Signif Level        0.033918
Skewness                -0.332666      Signif Level (Sk=0) 0.000000
Kurtosis (excess)       12.857559      Signif Level (Ku=0) 0.000000
Jarque-Bera          33069.020865      Signif Level (JB=0) 0.000000

Correlations of Series RET
Autocorrelations
   1        2        3        4        5
 0.10527  0.01839  0.02481  0.04381 -0.00044
county 11

Statistics on Series RET
Observations                 4788
Sample Mean              0.000278      Variance            0.000202
Standard Error           0.014225      of Sample Mean      0.000206
t-Statistic (Mean=0)     1.352771      Signif Level        0.176193
Skewness                -0.016709      Signif Level (Sk=0) 0.637016
Kurtosis (excess)        5.750546      Signif Level (Ku=0) 0.000000
```

```
Jarque-Bera          6597.444429      Signif Level (JB=0) 0.000000

Correlations of Series RET

Autocorrelations

   1        2        3        4        5

 0.01911 -0.03936 -0.03228  0.02023 -0.01634
```

```
*compute the unadjusted correlation matrix

cmoment(corr,center) /

# 1 2 3 4 5 6 7 8 9 10 11

compute rawcormat = %cmom


* get contemporaneous and lagged/led covariance matrices of the returns

do j=1,10

(01.0041) set retj / = [series] j

(01.0073) compute jp1 = j + 1

(01.0096) do jj = jp1,11

(02.0133) set retjj / = [series] jj

(02.0165) cross(from=-1,to=1,results=crosscors,noprint) retj retjj /

(02.0228) compute crosscormat(j,jj) = crosscors(1)

(02.0258) compute crosscormat(jj,j) = crosscors(3)

(02.0288) cross(from=-1,to=1,results=crosscovs,covariances,noprint) retj retjj /

(02.0353) compute crosscovmat(j,jj) = crosscovs(1)

(02.0383) compute rawcovmat(j,jj) = crosscovs(2)

(02.0413) compute crosscovmat(jj,j) = crosscovs(3)

(02.0443) end do jj

(01.0445) end do j
```

```
* create the adjusted covariance matrix and correlation matrix with a newey-west correction
do j=1,10
(01.0041) compute jp1 = j + 1
(01.0064) do jj = jp1,11
(02.0101) compute adjcovmat(j,jj) = rawcovmat(j,jj) + crosscovmat(j,jj)+crosscovmat(jj,j)
(02.0169) compute adjcormat(j,jj) = adjcovmat(j,jj)/((adjvar(j)*adjvar(jj))**.5)
(02.0235) compute adjcormat(jj,j) = adjcormat(j,jj)
(02.0271) end do jj
(01.0273) end do j

write(unit=rawcormat,format='(11(f12.7))') rawcormat
write(unit=adjcormat,format='(11(f12.7))') adjcormat
write(unit=adjcovmat,format='(11(f12.7))') adjcovmat
write(unit=adjvar,format='(11(f12.7))') adjvar
write(unit=crosscormat,format='(11(f12.7))') crosscormat
write(unit=crosscovmat,format='(11(f12.7))') crosscovmat
* basicstats.txt this programme estimates some basic statistics on 11 eurozone
* national equity indices

alloc 11 4788
*read in 11 equity index returns, de-mean and square
open rets c:\eurovol\output\rets.txt
data(unit=rets,format=free,org=obs) / 1 2 3 4 5 $
6 7 8 9 10 11

open autocorrs c:\eurovol\output\autocorrs.txt
open rawcormat c:\eurovol\output\rawcormat.txt
```

```
open crosscormat c:\eurovol\output\crosscormat.txt
open crosscovmat c:\eurovol\output\crosscovmat.txt
open adjcormat c:\eurovol\output\adjcormat.txt
open adjcovmat c:\eurovol\output\adjcovmat.txt
open adjvar c:\eurovol\output\adjvar.txt

declare rectangular adjcormat(11,11) rawcormat(11,11) crosscovmat(11,11) crosscormat(11,11)
declare rectangular rawcovmat(11,11) adjcovmat(11,11)
declare vector rawvar(11) adjvar(11)

* get basic stats on each individual returns
do j=1,11
(01.0041) set ret / = [series] j
(01.0073) display 'county' j
(01.0101) statistics ret /
(01.0117) compute rawvar(j) = %variance
(01.0140) correlate(number=5) ret / autocorrs
(01.0177) copy(unit=autocorrs,format='(5(f10.5))') 1 5 autocorrs
(01.0241) correlate(number=1,noprint,covariances) ret / autocov
(01.0282) compute adjvar(j) = rawvar(j)+autocov(2)
(01.0320) compute adjcovmat(j,j) = adjvar(j)
(01.0352) compute adjcormat(j,j) = 1.0
(01.0378) end do j
county 1

Statistics on Series RET
```

```
Observations              4788
Sample Mean             0.000249      Variance           0.000182
Standard Error          0.013491      of Sample Mean      0.000195
t-Statistic (Mean=0)     1.275345      Signif Level        0.202249
Skewness               -0.366100      Signif Level (Sk=0) 0.000000
Kurtosis (excess)        8.707568      Signif Level (Ku=0) 0.000000
Jarque-Bera          15233.391411      Signif Level (JB=0) 0.000000

Correlations of Series RET
Autocorrelations
   1        2        3        4        5
 0.07446 -0.03537 -0.00644  0.01616  0.02227
```

county 2

```
Statistics on Series RET
Observations              4788
Sample Mean             0.000180      Variance           0.000140
Standard Error          0.011813      of Sample Mean      0.000171
t-Statistic (Mean=0)     1.055862      Signif Level        0.291085
Skewness                0.039834      Signif Level (Sk=0) 0.260629
Kurtosis (excess)        7.198249      Signif Level (Ku=0) 0.000000
Jarque-Bera          10338.316454      Signif Level (JB=0) 0.000000


Correlations of Series RET
Autocorrelations
   1        2        3        4        5
```

```
 0.08863 -0.00974 -0.04465  0.02302 -0.03312
```

county 3

```
Statistics on Series RET
Observations                 4788
Sample Mean              0.000477      Variance            0.000347
Standard Error          0.018619      of Sample Mean       0.000269
t-Statistic (Mean=0)     1.771632      Signif Level        0.076519
Skewness               -0.361675      Signif Level (Sk=0) 0.000000
Kurtosis (excess)        6.760785      Signif Level (Ku=0) 0.000000
Jarque-Bera          9223.174261      Signif Level (JB=0) 0.000000
```

```
Correlations of Series RET
Autocorrelations
   1        2        3        4        5
 0.02857 -0.02090 -0.01611  0.03349  0.00163
```

county 4

```
Statistics on Series RET
Observations                 4788
Sample Mean              0.000163      Variance            0.000205
Standard Error          0.014333      of Sample Mean       0.000207
t-Statistic (Mean=0)     0.786304      Signif Level        0.431728
Skewness                 0.010189      Signif Level (Sk=0) 0.773556
Kurtosis (excess)        4.781190      Signif Level (Ku=0) 0.000000
Jarque-Bera          4560.608085      Signif Level (JB=0) 0.000000
```

```
Correlations of Series RET


Autocorrelations

   1        2        3        4        5

-0.01193 -0.04136 -0.05411  0.03725 -0.04262
```

county 5

```
Statistics on Series RET

Observations               4788

Sample Mean            0.000309      Variance           0.000218

Standard Error         0.014769      of Sample Mean      0.000213

t-Statistic (Mean=0)    1.445542      Signif Level        0.148371

Skewness              -0.113934      Signif Level (Sk=0) 0.001293

Kurtosis (excess)       4.828228      Signif Level (Ku=0) 0.000000

Jarque-Bera          4661.059151      Signif Level (JB=0) 0.000000



Correlations of Series RET


Autocorrelations

   1        2        3        4        5

-0.01637 -0.03288 -0.01797  0.04178 -0.02165
```

county 6

```
Statistics on Series RET

Observations               4788

Sample Mean            0.000110      Variance           0.000282

Standard Error         0.016805      of Sample Mean      0.000243

t-Statistic (Mean=0)    0.454768      Signif Level        0.649297

Skewness              -0.116575      Signif Level (Sk=0) 0.000994

Kurtosis (excess)       3.891091      Signif Level (Ku=0) 0.000000

Jarque-Bera         3031.391892      Signif Level (JB=0) 0.000000


Correlations of Series RET

Autocorrelations

   1        2        3        4        5

 0.13046 -0.01593 -0.01287  0.02778  0.00942
```

county 7

```
Statistics on Series RET

Observations               4788

Sample Mean             0.000153      Variance           0.000169

Standard Error          0.013017      of Sample Mean      0.000188

t-Statistic (Mean=0)     0.815872      Signif Level        0.414614

Skewness               -0.619436      Signif Level (Sk=0) 0.000000

Kurtosis (excess)        9.528294      Signif Level (Ku=0) 0.000000

Jarque-Bera         18418.476363      Signif Level (JB=0) 0.000000



Correlations of Series RET
```

```
Autocorrelations
   1        2        3        4        5
 0.06647  0.00072  0.00182  0.01240 -0.02153

county 8
Statistics on Series RET
Observations                4788
Sample Mean             0.000147      Variance            0.000216
Standard Error          0.014709      of Sample Mean      0.000213
t-Statistic (Mean=0)    0.690230      Signif Level        0.490083
Skewness               -0.020052      Signif Level (Sk=0) 0.571202
Kurtosis (excess)       4.104700      Signif Level (Ku=0) 0.000000
Jarque-Bera          3361.609685      Signif Level (JB=0) 0.000000

Correlations of Series RET
Autocorrelations
   1        2        3        4        5
 0.02698 -0.00288 -0.02326  0.06972 -0.05090

county 9
Statistics on Series RET
Observations                4788
Sample Mean             0.000218      Variance            0.000204
Standard Error          0.014286      of Sample Mean      0.000206
t-Statistic (Mean=0)    1.053894      Signif Level        0.291984
Skewness               -0.126282      Signif Level (Sk=0) 0.000362
Kurtosis (excess)       6.543647      Signif Level (Ku=0) 0.000000
```

```
Jarque-Bera          8555.180723      Signif Level (JB=0) 0.000000


Correlations of Series RET

Autocorrelations

   1        2        3        4        5

-0.00360 -0.02266 -0.05699  0.04793 -0.05487
```

county 10

```
Statistics on Series RET

Observations                  4788

Sample Mean              0.000309      Variance            0.000102

Standard Error           0.010092      of Sample Mean      0.000146

t-Statistic (Mean=0)     2.121654      Signif Level        0.033918

Skewness                -0.332666      Signif Level (Sk=0) 0.000000

Kurtosis (excess)       12.857559      Signif Level (Ku=0) 0.000000

Jarque-Bera          33069.020865      Signif Level (JB=0) 0.000000


Correlations of Series RET

Autocorrelations

   1        2        3        4        5

 0.10527  0.01839  0.02481  0.04381 -0.00044
```

county 11

```
Statistics on Series RET

Observations                 4788

Sample Mean             0.000278      Variance            0.000202

Standard Error          0.014225      of Sample Mean      0.000206
```

```
t-Statistic (Mean=0)    1.352771      Signif Level        0.176193

Skewness               -0.016709      Signif Level (Sk=0) 0.637016

Kurtosis (excess)       5.750546      Signif Level (Ku=0) 0.000000

Jarque-Bera          6597.444429      Signif Level (JB=0) 0.000000


Correlations of Series RET

Autocorrelations

   1        2        3        4        5

 0.01911 -0.03936 -0.03228  0.02023 -0.01634
```

```
*compute the unadjusted correlation matrix

cmoment(corr,center) /

# 1 2 3 4 5 6 7 8 9 10 11

compute rawcormat = %cmom


* get contemporaneous and lagged/led covariance matrices of the returns

do j=1,10

(01.0041) set retj / = [series] j

(01.0073) compute jp1 = j + 1

(01.0096) do jj = jp1,11

(02.0133) set retjj / = [series] jj

(02.0165) cross(from=-1,to=1,results=crosscors,noprint) retj retjj /

(02.0228) compute crosscormat(j,jj) = crosscors(1)

(02.0258) compute crosscormat(jj,j) = crosscors(3)

(02.0288) cross(from=-1,to=1,results=crosscovs,covariances,noprint) retj retjj /

(02.0353) compute crosscovmat(j,jj) = crosscovs(1)

(02.0383) compute rawcovmat(j,jj) = crosscovs(2)
```

```
(02.0413) compute crosscovmat(jj,j) = crosscovs(3)

(02.0443) end do jj

(01.0445) end do j


* create the adjusted covariance matrix and correlation matrix with a newey-west correction

do j=1,10

(01.0041) compute jp1 = j + 1

(01.0064) do jj = jp1,11

(02.0101) compute adjcovmat(j,jj) = rawcovmat(j,jj) + crosscovmat(j,jj)+crosscovmat(jj,j)

(02.0169) compute adjcormat(j,jj) = adjcovmat(j,jj)/((adjvar(j)*adjvar(jj))**.5)

(02.0235) compute adjcormat(jj,j) = adjcormat(j,jj)

(02.0271) end do jj

(01.0273) end do j


write(unit=rawcormat,format='(11(f12.7))') rawcormat

write(unit=adjcormat,format='(11(f12.7))') adjcormat

write(unit=adjcovmat,format='(11(f12.7))') adjcovmat

write(unit=adjvar,format='(11(f12.7))') adjvar

write(unit=crosscormat,format='(11(f12.7))') crosscormat

write(unit=crosscovmat,format='(11(f12.7))') crosscovmat
```

```
* garch11.txt this programme estimates the garch(1,1) model on 11 eurozone national equity indices

alloc 33 4788

*read in 11 equity index returns, de-mean and square
open rets c:\eurovol\output\rets.txt
open garchcoeffs c:\eurovol\output\garchcoeffs.txt
data(unit=rets,format=free,org=obs) / 1 2 3 4 5 6 7 8 9 10 11

* estimate the garch(1,1) using separate parameter sets
* for mean and variance models

do j=1,11
(01.0041) set ret / = [series] j
(01.0073) linreg ret
(01.0087) # constant
(01.0098)
(01.0098) frml(lastreg,vector=beta) meanf
(01.0125) nonlin(parmset=meanparms) beta
(01.0154) *
(01.0154) set uu = %seesq
(01.0181) set h = %seesq
(01.0208) set u = 0.0
(01.0234) *
(01.0234) nonlin(parmset=garchparms) c a b
(01.0280) compute c = %seesq
```

```
(01.0298) compute a = 0.5
(01.0315) compute b = 0.5
(01.0332) frml varf = c+a*uu{1}+b*h{1}
(01.0395) frml L = (u(t)=ret-meanf),(uu(t)=u**2),(h(t)=varf(t)),%logdensity(h,u)
(01.0511) display 'security number' j
(01.0541) maximize(parmset=meanparms+garchparms,derives=der) L 3 *
(01.0595)
(01.0595) write(unit=garchcoeffs, format=free) %beta
(01.0639)
(01.0639) declare real %aic %sbc
(01.0639) compute %aic = -2.0*%logl/%nobs+2.0*%nreg/%nobs
(01.0696) compute %sbc = -2.0*%logl/%nobs+log(%nobs)*%nreg/%nobs
(01.0757) display 'aic = ' %aic ' bic = ' %sbc
(01.0809) *graph(key=below,klabels=||"GARCH(1,1)"||) 1
(01.0809) *# h
(01.0809)
(01.0809) *env gsave="C:\eurovol\output\graphs\graphs*.rgf" gformat=rgf
(01.0809)
(01.0809) compute jj=j+11
(01.0832) set [series] jj 261 4788 = h
(01.0880)
(01.0880)
(01.0880) * save the variance series
(01.0880) open pvar c:\eurovol\output\pvar.txt
(01.0913) copy(unit=pvar,format='(11(f20.10))', org=obs) 261 4788 12 13 14 15 16 17 18 19
20 21 22
(01.1099) open der c:\eurovol\output\der.txt
```

```
(01.1131) copy(unit=der,format='(11(f20.10))', org=obs) 261 4788 23 24 25 26 27 28 29 30
31 32 33

(01.1316)

(01.1316)

(01.1316) end do j


Linear Regression - Estimation by Least Squares

Dependent Variable RET

Usable Observations   4788      Degrees of Freedom  4787

Centered R**2    -0.000000      R Bar **2  -0.000000

Uncentered R**2   0.000340      T x R**2       1.626

Mean of Dependent Variable      0.0002486510

Std Error of Dependent Variable 0.0134908562

Standard Error of Estimate      0.0134908562

Sum of Squared Residuals        0.8712493198

Log Likelihood                  13822.52053

Durbin-Watson Statistic            1.850902


   Variable                  Coeff      Std Error      T-Stat      Signif

*******************************************************************************

1.  Constant                0.0002486510 0.0001949676      1.27535  0.20224891


security number 1


MAXIMIZE - Estimation by BFGS

Convergence in    16 Iterations. Final criterion was  0.0000005 <=  0.0000100

Usable Observations   4786
```

```
Function Value                 14842.44065359


    Variable                    Coeff       Std Error       T-Stat       Signif
****************************************************************************
*****
1.  BETA(1)                 7.25628e-004 1.49130e-004      4.86573  0.00000114
2.  C                    2.92702e-006 5.09476e-007      5.74516  0.00000001
3.  A                          0.10555       0.00998     10.57369  0.00000000
4.  B                          0.87705       0.01113     78.78563  0.00000000


aic =       -6.20077  bic =       -6.19536


Linear Regression - Estimation by Least Squares
Dependent Variable RET
Usable Observations   4788      Degrees of Freedom  4787
Centered R**2     0.000000      R Bar **2   0.000000
Uncentered R**2   0.000233      T x R**2       1.115
Mean of Dependent Variable      0.0001802564
Std Error of Dependent Variable 0.0118130146
Standard Error of Estimate      0.0118130146
Sum of Squared Residuals        0.6680129958
Log Likelihood                  14458.41613
Durbin-Watson Statistic            1.822658


    Variable                    Coeff       Std Error       T-Stat       Signif
****************************************************************************
*****
1.  Constant                0.0001802564 0.0001707197      1.05586  0.29108460
```

security number 2

```
MAXIMIZE - Estimation by BFGS
Convergence in    16 Iterations. Final criterion was  0.0000078 <=  0.0000100
Usable Observations   4786
Function Value                  15543.90898299

    Variable                    Coeff      Std Error      T-Stat      Signif
*******************************************************************************
1.  BETA(1)                 6.41530e-004 1.22080e-004      5.25499  0.00000015
2.  C                       1.84733e-006 3.11617e-007      5.92821  0.00000000
3.  A                            0.11518      0.01002     11.49548  0.00000000
4.  B                            0.87163      0.01058     82.40897  0.00000000

aic =       -6.49390  bic =       -6.48849

Linear Regression - Estimation by Least Squares
Dependent Variable RET
Usable Observations   4788      Degrees of Freedom  4787
Centered R**2     0.000000      R Bar **2   0.000000
Uncentered R**2   0.000655      T x R**2       3.137
Mean of Dependent Variable      0.0004767121
Std Error of Dependent Variable 0.0186191474
Standard Error of Estimate      0.0186191474
Sum of Squared Residuals        1.6595219800
```

```
Log Likelihood                 12279.93060

Durbin-Watson Statistic            1.942828


    Variable                    Coeff      Std Error      T-Stat      Signif

***************************************************************************
*****

1.  Constant                0.0004767121 0.0002690808      1.77163  0.07651934


security number 3


MAXIMIZE - Estimation by BFGS

Convergence in    20 Iterations. Final criterion was  0.0000028 <=  0.0000100

Usable Observations   4786

Function Value                  13193.58495109


    Variable                    Coeff      Std Error      T-Stat      Signif

***************************************************************************
*****

1.  BETA(1)                 9.70848e-004 1.84258e-004      5.26896  0.00000014

2.  C                     1.32678e-006 3.56888e-007      3.71763  0.00020110

3.  A                          0.06143      0.00662      9.28664  0.00000000

4.  B                          0.93627      0.00667    140.46377  0.00000000


aic =       -5.51174  bic =       -5.50633


Linear Regression - Estimation by Least Squares

Dependent Variable RET

Usable Observations   4788      Degrees of Freedom  4787
```

```
Centered R**2     0.000000      R Bar **2   0.000000

Uncentered R**2   0.000129      T x R**2       0.618

Mean of Dependent Variable      0.0001628686

Std Error of Dependent Variable 0.0143325624

Standard Error of Estimate      0.0143325624

Sum of Squared Residuals        0.9833567620

Log Likelihood                  13532.74166

Durbin-Watson Statistic            2.023658


   Variable                  Coeff      Std Error      T-Stat      Signif

******************************************************************************
*****

1.  Constant                0.0001628686 0.0002071318      0.78630  0.43172835
```

security number 4

```
MAXIMIZE - Estimation by BFGS

Convergence in    17 Iterations. Final criterion was  0.0000022 <=  0.0000100

Usable Observations   4786

Function Value                  14228.51593142


   Variable                  Coeff      Std Error      T-Stat      Signif

******************************************************************************
*****

1.  BETA(1)                  5.33912e-004 1.58818e-004      3.36179  0.00077439

2.  C                     1.77690e-006 4.16126e-007      4.27009  0.00001954

3.  A                           0.07283      0.00691     10.53463  0.00000000

4.  B                           0.91872      0.00780    117.83467  0.00000000
```

```
aic =       -5.94422  bic =       -5.93881


Linear Regression - Estimation by Least Squares

Dependent Variable RET

Usable Observations   4788      Degrees of Freedom  4787

Centered R**2     0.000000      R Bar **2   0.000000

Uncentered R**2   0.000436      T x R**2       2.089

Mean of Dependent Variable      0.0003085286

Std Error of Dependent Variable 0.0147686837

Standard Error of Estimate      0.0147686837

Sum of Squared Residuals        1.0441118024

Log Likelihood                  13389.22168

Durbin-Watson Statistic            2.032397


    Variable                   Coeff      Std Error      T-Stat      Signif

*******************************************************************************

1.  Constant               0.0003085286 0.0002134345      1.44554  0.14837120


security number 5


MAXIMIZE - Estimation by BFGS

Convergence in    20 Iterations. Final criterion was  0.0000065 <=  0.0000100

Usable Observations   4786

Function Value                  14279.95902608
```

```
    Variable                    Coeff      Std Error      T-Stat      Signif
**************************************************************************************
*****
1.  BETA(1)                 7.28334e-004 1.54738e-004      4.70689  0.00000252
2.  C                     2.26788e-006 4.04574e-007      5.60561  0.00000002
3.  A                          0.09303      0.00826     11.25567  0.00000000
4.  B                          0.89689      0.00846    105.96646  0.00000000


aic =       -5.96572  bic =       -5.96031


Linear Regression - Estimation by Least Squares
Dependent Variable RET
Usable Observations   4788      Degrees of Freedom  4787
Centered R**2     0.000000      R Bar **2   0.000000
Uncentered R**2   0.000043      T x R**2       0.207
Mean of Dependent Variable      0.0001104486
Std Error of Dependent Variable 0.0168053314
Standard Error of Estimate      0.0168053314
Sum of Squared Residuals        1.3519405393
Log Likelihood                  12770.67331
Durbin-Watson Statistic            1.739003


    Variable                    Coeff      Std Error      T-Stat      Signif
**************************************************************************************
*****
1.  Constant                0.0001104486 0.0002428678      0.45477  0.64929663


security number 6
```

```
MAXIMIZE - Estimation by BFGS

Convergence in    17 Iterations. Final criterion was  0.0000003 <=  0.0000100

Usable Observations   4786

Function Value                  13495.31103910


    Variable                    Coeff      Std Error      T-Stat      Signif

*******************************************************************************

1.  BETA(1)                 4.42845e-004 1.87341e-004      2.36384  0.01808642

2.  C                       5.55109e-006 9.70255e-007      5.72127  0.00000001

3.  A                          0.14314      0.01252     11.42946  0.00000000

4.  B                          0.84510      0.01282     65.91914  0.00000000


aic =       -5.63782  bic =       -5.63241


Linear Regression - Estimation by Least Squares

Dependent Variable RET

Usable Observations   4788      Degrees of Freedom  4787

Centered R**2    -0.000000      R Bar **2  -0.000000

Uncentered R**2   0.000139      T x R**2       0.666

Mean of Dependent Variable      0.0001534799

Std Error of Dependent Variable 0.0130168702

Standard Error of Estimate      0.0130168702

Sum of Squared Residuals        0.8111040653

Log Likelihood                  13993.76770

Durbin-Watson Statistic            1.866703
```

```
   Variable                    Coeff      Std Error      T-Stat      Signif
*******************************************************************************
*****
1.  Constant                0.0001534799 0.0001881176      0.81587  0.41461404


security number 7


MAXIMIZE - Estimation by BFGS
Convergence in    19 Iterations. Final criterion was  0.0000043 <=  0.0000100
Usable Observations   4786
Function Value                    15110.03119251


   Variable                    Coeff      Std Error      T-Stat      Signif
*******************************************************************************
*****
1.  BETA(1)                  6.43096e-004 1.30210e-004      4.93890  0.00000079
2.  C                     1.54471e-006 2.89718e-007      5.33178  0.00000010
3.  A                          0.08373      0.00812     10.30869  0.00000000
4.  B                          0.90773      0.00864    105.00950  0.00000000


aic =       -6.31259  bic =       -6.30718


Linear Regression - Estimation by Least Squares
Dependent Variable RET
Usable Observations   4788      Degrees of Freedom  4787
Centered R**2    -0.000000      R Bar **2  -0.000000
Uncentered R**2   0.000100      T x R**2       0.476
```

```
Mean of Dependent Variable      0.0001467214

Std Error of Dependent Variable 0.0147087926

Standard Error of Estimate      0.0147087926

Sum of Squared Residuals        1.0356606568

Log Likelihood                  13408.67780

Durbin-Watson Statistic            1.945812


    Variable                    Coeff      Std Error      T-Stat      Signif

*******************************************************************************

1.  Constant                0.0001467214 0.0002125690      0.69023  0.49008321


security number 8


MAXIMIZE - Estimation by BFGS

Convergence in    21 Iterations. Final criterion was  0.0000035 <=  0.0000100

Usable Observations   4786

Function Value                  14148.85888371


    Variable                    Coeff      Std Error      T-Stat      Signif

*******************************************************************************

1.  BETA(1)                  4.36516e-004 1.51138e-004      2.88820  0.00387450

2.  C                      1.90894e-006 4.24158e-007      4.50054  0.00000678

3.  A                          0.10842      0.00988     10.96920  0.00000000

4.  B                          0.88726      0.00982     90.31441  0.00000000


aic =       -5.91093  bic =       -5.90552
```

```
Linear Regression - Estimation by Least Squares
Dependent Variable RET
Usable Observations   4788      Degrees of Freedom  4787
Centered R**2    -0.000000      R Bar **2  -0.000000
Uncentered R**2   0.000232      T x R**2       1.111
Mean of Dependent Variable      0.0002175929
Std Error of Dependent Variable 0.0142864595
Standard Error of Estimate      0.0142864595
Sum of Squared Residuals        0.9770407013
Log Likelihood                 13548.16782
Durbin-Watson Statistic           2.007060

    Variable                   Coeff      Std Error      T-Stat      Signif
**************************************************************************************
*****
1.  Constant                0.0002175929 0.0002064655      1.05389  0.29198442

security number 9

MAXIMIZE - Estimation by BFGS
Convergence in    16 Iterations. Final criterion was  0.0000039 <=  0.0000100
Usable Observations   4786
Function Value                 14766.15130604

    Variable                   Coeff      Std Error      T-Stat      Signif
**************************************************************************************
*****
```

```
1.  BETA(1)                6.37931e-004 1.37318e-004      4.64564  0.00000339
2.  C                   1.45805e-006 2.98789e-007      4.87987  0.00000106
3.  A                        0.09861      0.00836     11.79373  0.00000000
4.  B                        0.89498      0.00838    106.86060  0.00000000


aic =       -6.16889  bic =       -6.16348


Linear Regression - Estimation by Least Squares
Dependent Variable RET
Usable Observations   4788      Degrees of Freedom  4787
Centered R**2    -0.000000      R Bar **2  -0.000000
Uncentered R**2   0.000939      T x R**2       4.498
Mean of Dependent Variable      0.0003094509
Std Error of Dependent Variable 0.0100923950
Standard Error of Estimate      0.0100923950
Sum of Squared Residuals        0.4875867634
Log Likelihood                  15212.14160
Durbin-Watson Statistic            1.788923


    Variable                   Coeff      Std Error      T-Stat      Signif
***************************************************************************
*****
1.  Constant                0.0003094509 0.0001458536      2.12165  0.03391804


security number 10


MAXIMIZE - Estimation by BFGS
```

```
Convergence in    19 Iterations. Final criterion was  0.0000042 <=  0.0000100

Usable Observations   4786

Function Value                  16491.03933061


    Variable                    Coeff      Std Error      T-Stat      Signif

***************************************************************************
*****

1.  BETA(1)                5.45509e-004 9.07460e-005      6.01138  0.00000000

2.  C                    1.08516e-006 1.92748e-007      5.62993  0.00000002

3.  A                          0.18657      0.01584     11.77815  0.00000000

4.  B                          0.82250      0.01324     62.13775  0.00000000


aic =       -6.88969  bic =       -6.88428


Linear Regression - Estimation by Least Squares

Dependent Variable RET

Usable Observations   4788      Degrees of Freedom  4787

Centered R**2     0.000000      R Bar **2   0.000000

Uncentered R**2   0.000382      T x R**2       1.830

Mean of Dependent Variable      0.0002781069

Std Error of Dependent Variable 0.0142254016

Standard Error of Estimate      0.0142254016

Sum of Squared Residuals        0.9687071426

Log Likelihood                  13568.67475

Durbin-Watson Statistic            1.960175


    Variable                    Coeff      Std Error      T-Stat      Signif
```

```
******************************************************************************
*****
1.  Constant                 0.0002781069 0.0002055831      1.35277  0.17619270


security number 11


MAXIMIZE - Estimation by BFGS
Convergence in    19 Iterations. Final criterion was  0.0000011 <=  0.0000100
Usable Observations   4786
Function Value                  14348.85323292


    Variable                   Coeff      Std Error      T-Stat      Signif
******************************************************************************
*****
1.  BETA(1)                  7.91650e-004 1.55377e-004      5.09503  0.00000035
2.  C                      2.78946e-006 5.13879e-007      5.42824  0.00000006
3.  A                          0.10290      0.01027     10.02327  0.00000000
4.  B                          0.88467      0.01087     81.35059  0.00000000


aic =       -5.99451  bic =       -5.98910
```

```
* midasgarch.txt this programme estimates the midasgarch model on 11 eurozone national equity indices


alloc 22 4788


*read in 11 equity index returns, de-mean and square


open rets c:\eurovol\output\rets.txt
open theta c:\eurovol\output\theta.txt
open xx c:\eurovol\output\xx.txt
open fsdrvs c:\eurovol\output\fsdrvs.txt
open eta c:\eurovol\output\eta.txt
open predvar c:\eurovol\output\predvar.txt


data(unit=rets,format=free,org=obs) / 1 2 3 4 5 6 7 8 9 10 11



do j=1,11
(01.0041) set ret / = [series] j
(01.0073) statistics(noprint) ret /
(01.0091) set ret / = ret - %mean
(01.0128) set [series] j = ret
(01.0160) compute jp11 = j + 11
(01.0183) set [series] jp11 = (ret)**2
(01.0221) end do j
```

```
do j=1,11

(01.0041) set ret / = [series] j

(01.0074) * calculate 65-day rolling window variance

(01.0074) compute jp11 = j + 11

(01.0097) set ret2 / = [series] jp11

(01.0129) statistics(noprint) ret2 1 65

(01.0163) set rv 65 65 = %mean

(01.0206) do date = 66, 4788

(02.0241) set rv date date = rv(date-1) + (1.0/65.0)*(ret2(date) - ret2(date-65))

(02.0336) end do date

(01.0338) statistics rv

(01.0352)

(01.0352) * estimate the long-run parameters without GARCH for initial parameter values

(01.0352)

(01.0352) set rvm65 / = rv{65}

(01.0383) set rvm130 / = rv{130}

(01.0414) set rvm195 / = rv{195}

(01.0445)

(01.0445) nonlin theta w

(01.0469) statistics(noprint) ret2 /

(01.0487) compute theta = 0.8

(01.0504) compute w = 0.5

(01.0521) compute m = %mean

(01.0539) display "theta w m" theta w m

(01.0592)

(01.0592) frml lrv = m*abs(1.0-theta) +theta*(1.0*rvm65+(exp(-w*1))*rvm130+(exp(-
w*2))*rvm195)/(1.0+exp(-w*1)+exp(-w*2))
```

```
(01.0739) frml lrvlogl = -.5*(log(lrv) + ret2/lrv)
(01.0787) display "long-run only, security number" j
(01.0821) maximize(method=bhhh,iterations = 500) lrvlogl 260 4788
(01.0866) set longrunv / =  m*abs(1.0-theta) +theta*(1.0*rvm65+(exp(-
w*1))*rvm130+(exp(-w*2))*rvm195)/(1.0+exp(-w*1)+exp(-w*2))
(01.1013) statistics(fractiles) longrunv
(01.1029)
(01.1029) * estimate short-term garch with pre-estimated long run variance
(01.1029) nlpar(subiterations=100)
(01.1043)
(01.1043) nonlin a1 a2
(01.1067) compute a1 = .2
(01.1084) compute a2 = .5
(01.1101) set sgv  / = 1.0
(01.1127) frml sgvar = abs((1.0-a1-a2)) + a1*ret2{1}/longrunv{1} + a2*sgv{1}
(01.1215) frml sglogl = (sgv(t) = sgvar(t)), -.5*(log(sgv)+ret2/(longrunv*sgv))
(01.1300) display 'short-term GARCH only, security number' j
(01.1336) maximize(method=bhhh,recursive,iterations = 500) sglogl 261 4788
(01.1383)
(01.1383) set firststepsgv / = sgv
(01.1412)
(01.1412) * estimate midas-GARCH based on initial values from above first-stage estimates
(01.1412) nonlin theta w a1 a2 theta>=0.0
(01.1473)
(01.1473) frml lrv =  m*abs(1.0-theta) +theta*(1.0*rvm65+(exp(-w*1))*rvm130+(exp(-
w*2))*rvm195)/(1.0+exp(-w*1)+exp(-w*2))
(01.1621) set sgv / = 1.0
(01.1648) frml sgvar = abs(1.0-a1-a2) + a1*ret2{1}/lrv{1} + a2*sgv{1}
```

```
(01.1736) frml fglogl = (sgv(t) = sgvar(t)), -.5*(log(sgv*lrv)+ret2/(sgv*lrv))

(01.1824) display 'security number' j

(01.1854) maximize(method=bhhh,recursive,iterations = 500,derives=pdrvs) fglogl 261 4788

(01.1913)

(01.1913)

(01.1913) display(unit=theta) %beta

(01.1945) display(unit=xx) %XX

(01.1976)

(01.1976) declare real %aic %sbc

(01.1976) compute %aic = -2.0*%logl/%nobs+2.0*%nreg/%nobs

(01.2033) compute %sbc = -2.0*%logl/%nobs+log(%nobs)*%nreg/%nobs

(01.2094)

(01.2094) display 'aic = ' %aic ' bic = ' %sbc

(01.2146)

(01.2146)

(01.2146) * create series of standardized outcomes

(01.2146) set eta 261 4788 = ret/((sgv*lrv)**.5)

(01.2212) set predvar 261 4788 = sgv*lrv

(01.2263)

(01.2263) if %converged == 0

(02.2284) {

(03.2284) display "did not converge series" j

(03.2316) set eta 261 4788 = ret/((firststepsgv*longrunv)**.5)

(03.2386) set predvar 261 4788 = firststepsgv*longrunv

(03.2441)

(03.2441) }

(02.2441)
```

```
(02.2441) * save the maximum likelihood scores

(02.2441)

(02.2441)

(02.2441)

(02.2441)

(02.2441)

(02.2441)

(02.2441)

(02.2441) do param=1,4

(02.2476) set scores / = pdrvs(param)

(02.2510) statistics scores

(02.2524) copy(unit=fsdrvs,format=free, org=obs) 261 4788 scores

(02.2588) end do param

(01.2590)

(01.2590) * save the standardized outcomes

(01.2590) copy(unit=eta,format=free, org=obs) 261 4788 eta

(01.2653) * save the predicted variances

(01.2653)

(01.2653) copy(unit=predvar,format=free, org=obs) 261 4788 predvar

(01.2717)

(01.2717)

(01.2717)

(01.2717) end do j
```

```
Statistics on Series RV

Observations            4724

Sample Mean           0.000183     Variance           0.000000
```

```
Standard Error           0.000294      of Sample Mean      0.000004
t-Statistic (Mean=0)     42.788958      Signif Level        0.000000
Skewness                 5.357170      Signif Level (Sk=0) 0.000000
Kurtosis (excess)        34.415253      Signif Level (Ku=0) 0.000000
Jarque-Bera          255727.182767      Signif Level (JB=0) 0.000000

theta w m       0.80000       0.50000  1.81965e-004
long-run only, security number 1

MAXIMIZE - Estimation by BHHH
Convergence in    26 Iterations. Final criterion was  0.0000087 <=  0.0000100
Usable Observations   4529
Function Value                 17638.99161174

    Variable                  Coeff      Std Error      T-Stat      Signif
********************************************************************************
*****
1.  THETA                   0.7623205638 0.0111711286     68.24025  0.00000000
2.  W                       0.1564919964 0.0812657191      1.92568  0.05414399


Statistics on Series LONGRUNV
Observations                 4529
Sample Mean              0.000182      Variance           0.000000
Standard Error           0.000180      of Sample Mean      0.000003
t-Statistic (Mean=0)     68.042423      Signif Level        0.000000
Skewness                 3.432080      Signif Level (Sk=0) 0.000000
```

```
Kurtosis (excess)       11.822342      Signif Level (Ku=0) 0.000000

Jarque-Bera          35266.657501      Signif Level (JB=0) 0.000000


Minimum                  0.000077      Maximum            0.001033

01-%ile                0.000079      99-%ile            0.001002

05-%ile                0.000083      95-%ile            0.000515

10-%ile                0.000088      90-%ile            0.000267

25-%ile                0.000099      75-%ile            0.000199

Median                 0.000114


short-term GARCH only, security number 1


MAXIMIZE - Estimation by BHHH

Convergence in    17 Iterations. Final criterion was  0.0000009 <=  0.0000100

Usable Observations   4528

Function Value                  -1760.99056639


    Variable                   Coeff      Std Error      T-Stat      Signif

******************************************************************************
*****

1.  A1                     0.1087362181 0.0064049080     16.97701  0.00000000

2.  A2                     0.8583419163 0.0095771250     89.62417  0.00000000


security number 1


MAXIMIZE - Estimation by BHHH

Convergence in    12 Iterations. Final criterion was  0.0000001 <=  0.0000100
```

```
Usable Observations   4528
Function Value                 18248.62199102

    Variable                    Coeff      Std Error      T-Stat      Signif
****************************************************************************
*****
1.  THETA                   0.544488316  0.080838274      6.73553  0.00000000
2.  W                    -0.003553949  0.341529847     -0.01041  0.99169739
3.  A1                    0.111273669  0.008448423     13.17094  0.00000000
4.  A2                    0.860219879  0.011464421     75.03387  0.00000000

aic =       -8.05858  bic =       -8.05291

Statistics on Series SCORES
Observations                  4528
Sample Mean              -0.000000      Variance            0.055695
Standard Error           0.235998      of Sample Mean      0.003507
t-Statistic (Mean=0)     -0.000001      Signif Level        0.999999
Skewness                 -5.420722      Signif Level (Sk=0) 0.000000
Kurtosis (excess)        68.269862      Signif Level (Ku=0) 0.000000
Jarque-Bera          901507.990507      Signif Level (JB=0) 0.000000


Statistics on Series SCORES
Observations                    4528
Sample Mean                 0.000000      Variance            0.003535
Standard Error             0.059459      of Sample Mean      0.000884
```

```
t-Statistic (Mean=0)       0.000042      Signif Level        0.999966
Skewness                  -8.638000      Signif Level (Sk=0) 0.000000
Kurtosis (excess)        411.066279      Signif Level (Ku=0) 0.000000
Jarque-Bera          31936351.159484      Signif Level (JB=0) 0.000000


Statistics on Series SCORES
Observations                  4528
Sample Mean                0.000007      Variance            66.232362
Standard Error             8.138327      of Sample Mean       0.120943
t-Statistic (Mean=0)       0.000062      Signif Level        0.999951
Skewness                  -9.802109      Signif Level (Sk=0) 0.000000
Kurtosis (excess)        191.915061      Signif Level (Ku=0) 0.000000
Jarque-Bera           7021365.094189      Signif Level (JB=0) 0.000000


Statistics on Series SCORES
Observations                  4528
Sample Mean                0.000002      Variance            33.120221
Standard Error             5.755017      of Sample Mean       0.085525
t-Statistic (Mean=0)       0.000023      Signif Level        0.999982
Skewness                  -8.855490      Signif Level (Sk=0) 0.000000
Kurtosis (excess)        144.598124      Signif Level (Ku=0) 0.000000
Jarque-Bera           4003939.881362      Signif Level (JB=0) 0.000000


Statistics on Series RV
```

```
Observations                4724
Sample Mean             0.000140      Variance            0.000000
Standard Error          0.000184      of Sample Mean      0.000003
t-Statistic (Mean=0)    52.337948      Signif Level        0.000000
Skewness                3.778069      Signif Level (Sk=0) 0.000000
Kurtosis (excess)       18.636863      Signif Level (Ku=0) 0.000000
Jarque-Bera          79604.886654      Signif Level (JB=0) 0.000000

theta w m       0.80000       0.50000  1.39518e-004
long-run only, security number 2

MAXIMIZE - Estimation by BHHH
Convergence in    29 Iterations. Final criterion was  0.0000078 <=  0.0000100
Usable Observations   4529
Function Value                  18088.87044423

    Variable                   Coeff      Std Error      T-Stat      Signif
***************************************************************************
*****
1.  THETA                   0.7998142737 0.0130828490     61.13456  0.00000000
2.  W                       0.3456227144 0.0624723898      5.53241  0.00000003


Statistics on Series LONGRUNV
Observations                4529
Sample Mean             0.000141      Variance            0.000000
Standard Error          0.000116      of Sample Mean      0.000002
```

```
t-Statistic (Mean=0)   81.729251      Signif Level        0.000000

Skewness                2.243044      Signif Level (Sk=0) 0.000000

Kurtosis (excess)       5.225358      Signif Level (Ku=0) 0.000000

Jarque-Bera          8950.313472      Signif Level (JB=0) 0.000000


Minimum                 0.000050      Maximum             0.000664

01-%ile               0.000051      99-%ile             0.000593

05-%ile               0.000054      95-%ile             0.000403

10-%ile               0.000057      90-%ile             0.000271

25-%ile               0.000064      75-%ile             0.000176

Median                0.000098


short-term GARCH only, security number 2


MAXIMIZE - Estimation by BHHH

Convergence in    14 Iterations. Final criterion was  0.0000000 <=  0.0000100

Usable Observations   4528

Function Value                   -1798.64224905


    Variable                    Coeff      Std Error      T-Stat      Signif

***************************************************************************
*****

1.  A1                      0.1251431514 0.0070819072     17.67083  0.00000000

2.  A2                      0.8481114333 0.0094232428     90.00208  0.00000000


security number 2
```

```
MAXIMIZE - Estimation by BHHH

Convergence in     9 Iterations. Final criterion was  0.0000000 <=  0.0000100

Usable Observations   4528

Function Value                  18806.16794678


    Variable                    Coeff      Std Error      T-Stat      Signif

*****************************************************************************
*****

1.  THETA                   0.4677557672 0.0761730547      6.14070  0.00000000

2.  W                      0.8966479169 0.4858386401      1.84557  0.06495506

3.  A1                     0.1326837532 0.0078396315     16.92474  0.00000000

4.  A2                     0.8425640337 0.0102660151     82.07313  0.00000000


aic =       -8.30484  bic =       -8.29917


Statistics on Series SCORES

Observations                    4528

Sample Mean                0.000000      Variance            0.063429

Standard Error            0.251852      of Sample Mean      0.003743

t-Statistic (Mean=0)       0.000005      Signif Level        0.999996

Skewness                  -5.979277      Signif Level (Sk=0) 0.000000

Kurtosis (excess)        112.364790      Signif Level (Ku=0) 0.000000

Jarque-Bera          2409056.926102      Signif Level (JB=0) 0.000000



Statistics on Series SCORES

Observations                    4528
```

```
Sample Mean              -0.000000      Variance            0.001337
Standard Error            0.036563      of Sample Mean      0.000543
t-Statistic (Mean=0)     -0.000031      Signif Level        0.999975
Skewness                 -4.536609      Signif Level (Sk=0) 0.000000
Kurtosis (excess)       172.306832      Signif Level (Ku=0) 0.000000
Jarque-Bera         5616977.907539      Signif Level (JB=0) 0.000000
```

```
Statistics on Series SCORES
Observations                  4528
Sample Mean               0.000003      Variance           74.501643
Standard Error            8.631433      of Sample Mean      0.128271
t-Statistic (Mean=0)      0.000022      Signif Level        0.999982
Skewness                 -9.526607      Signif Level (Sk=0) 0.000000
Kurtosis (excess)       190.679113      Signif Level (Ku=0) 0.000000
Jarque-Bera         6928132.261585      Signif Level (JB=0) 0.000000
```

```
Statistics on Series SCORES
Observations                  4528
Sample Mean               0.000001      Variance           45.829220
Standard Error            6.769728      of Sample Mean      0.100605
t-Statistic (Mean=0)      0.000014      Signif Level        0.999989
Skewness                 -9.827148      Signif Level (Sk=0) 0.000000
Kurtosis (excess)       200.282160      Signif Level (Ku=0) 0.000000
Jarque-Bera         7640855.662338      Signif Level (JB=0) 0.000000
```

```
Statistics on Series RV

Observations              4724

Sample Mean            0.000350      Variance           0.000000

Standard Error         0.000357      of Sample Mean      0.000005

t-Statistic (Mean=0)   67.441538      Signif Level        0.000000

Skewness               1.740323      Signif Level (Sk=0) 0.000000

Kurtosis (excess)       2.568932      Signif Level (Ku=0) 0.000000

Jarque-Bera          3683.601168      Signif Level (JB=0) 0.000000


theta w m       0.80000       0.50000  3.46600e-004

long-run only, security number 3


MAXIMIZE - Estimation by BHHH

Convergence in    28 Iterations. Final criterion was  0.0000082 <=  0.0000100

Usable Observations   4529

Function Value                  16219.18408507


    Variable                    Coeff      Std Error      T-Stat      Signif

******************************************************************************
*****

1.  THETA                    0.8010346506 0.0115705497     69.23047  0.00000000

2.  W                        0.8533482647 0.0992961907      8.59397  0.00000000



Statistics on Series LONGRUNV

Observations              4529
```

```
Sample Mean            0.000357      Variance           0.000000

Standard Error         0.000268      of Sample Mean      0.000004

t-Statistic (Mean=0)   89.467863      Signif Level        0.000000

Skewness               1.567286      Signif Level (Sk=0) 0.000000

Kurtosis (excess)       1.749763      Signif Level (Ku=0) 0.000000

Jarque-Bera         2431.922849      Signif Level (JB=0) 0.000000


Minimum                0.000110      Maximum            0.001288

01-%ile               0.000114      99-%ile            0.001155

05-%ile               0.000123      95-%ile            0.001065

10-%ile               0.000134      90-%ile            0.000723

25-%ile               0.000165      75-%ile            0.000487

Median                0.000256


short-term GARCH only, security number 3


MAXIMIZE - Estimation by BHHH

Convergence in    27 Iterations. Final criterion was  0.0000001 <=  0.0000100

Usable Observations   4528

Function Value                 -1865.40833821


    Variable                     Coeff      Std Error      T-Stat      Signif

**************************************************************************
*****

1.  A1                      0.0776091157 0.0036279238     21.39216  0.00000000

2.  A2                      0.8990594185 0.0051172763    175.69101  0.00000000
```

security number 3

```
MAXIMIZE - Estimation by BHHH
Convergence in    15 Iterations. Final criterion was  0.0000039 <=  0.0000100
Usable Observations   4528
Function Value                  16621.09926971

    Variable                   Coeff      Std Error      T-Stat      Signif
****************************************************************************
*****
1.  THETA                   0.8193028924 0.0553493526     14.80239  0.00000000
2.  W                  0.4206430756 0.2668834062      1.57613  0.11499573
3.  A1                 0.0751812552 0.0036412179     20.64728  0.00000000
4.  A2                 0.9030603161 0.0061931283    145.81650  0.00000000

aic =       -7.33971  bic =       -7.33404

Statistics on Series SCORES
Observations                   4528
Sample Mean               0.000000      Variance           0.159423
Standard Error            0.399278      of Sample Mean      0.005934
t-Statistic (Mean=0)       0.000053      Signif Level        0.999957
Skewness                 -4.007306      Signif Level (Sk=0) 0.000000
Kurtosis (excess)        185.849681      Signif Level (Ku=0) 0.000000
Jarque-Bera          6528685.072058      Signif Level (JB=0) 0.000000
```

```
Statistics on Series SCORES

Observations                 4528

Sample Mean               0.000000      Variance           0.004050

Standard Error           0.063643      of Sample Mean      0.000946

t-Statistic (Mean=0)       0.000023      Signif Level        0.999982

Skewness                 -4.259071      Signif Level (Sk=0) 0.000000

Kurtosis (excess)        105.872501      Signif Level (Ku=0) 0.000000

Jarque-Bera          2128451.530065      Signif Level (JB=0) 0.000000
```

```
Statistics on Series SCORES

Observations                  4528

Sample Mean               -0.000009      Variance           122.566372

Standard Error            11.070970      of Sample Mean      0.164525

t-Statistic (Mean=0)       -0.000055      Signif Level        0.999956

Skewness                 -15.927091      Signif Level (Sk=0) 0.000000

Kurtosis (excess)         395.100910      Signif Level (Ku=0) 0.000000

Jarque-Bera          29643196.880303      Signif Level (JB=0) 0.000000
```

```
Statistics on Series SCORES

Observations                  4528

Sample Mean               -0.000001      Variance           64.450470

Standard Error             8.028105      of Sample Mean      0.119305

t-Statistic (Mean=0)       -0.000009      Signif Level        0.999993

Skewness                 -10.992399      Signif Level (Sk=0) 0.000000

Kurtosis (excess)         294.824154      Signif Level (Ku=0) 0.000000
```

```
Jarque-Bera          16490337.056513      Signif Level (JB=0) 0.000000



Statistics on Series RV

Observations                 4724

Sample Mean              0.000207      Variance            0.000000

Standard Error           0.000226      of Sample Mean      0.000003

t-Statistic (Mean=0)    62.992115      Signif Level        0.000000

Skewness                 3.538138      Signif Level (Sk=0) 0.000000

Kurtosis (excess)       15.981624      Signif Level (Ku=0) 0.000000

Jarque-Bera          60129.822983      Signif Level (JB=0) 0.000000


theta w m       0.80000       0.50000  2.05379e-004

long-run only, security number 4


MAXIMIZE - Estimation by BHHH

Convergence in    19 Iterations. Final criterion was  0.0000096 <=  0.0000100

Usable Observations   4529

Function Value                  17082.56895471


    Variable                   Coeff      Std Error      T-Stat      Signif

*****************************************************************************
*****

1.  THETA                    0.7262141481 0.0242251745     29.97766  0.00000000

2.  W                     0.1474688577 0.0836898956      1.76209  0.07805464
```

```
Statistics on Series LONGRUNV
Observations               4529
Sample Mean            0.000207      Variance           0.000000
Standard Error         0.000126      of Sample Mean      0.000002
t-Statistic (Mean=0)  110.429703      Signif Level        0.000000
Skewness               2.034314      Signif Level (Sk=0) 0.000000
Kurtosis (excess)       3.875756      Signif Level (Ku=0) 0.000000
Jarque-Bera          5958.506892      Signif Level (JB=0) 0.000000

Minimum                0.000087      Maximum            0.000682
01-%ile               0.000089      99-%ile            0.000655
05-%ile               0.000095      95-%ile            0.000519
10-%ile               0.000103      90-%ile            0.000356
25-%ile               0.000128      75-%ile            0.000237
Median                0.000170

short-term GARCH only, security number 4

MAXIMIZE - Estimation by BHHH
Convergence in     8 Iterations. Final criterion was  0.0000071 <=  0.0000100
Usable Observations   4528
Function Value                  -1899.58843110

    Variable                    Coeff      Std Error      T-Stat      Signif
***************************************************************************
*****
1.  A1                      0.0787595852 0.0058327521     13.50299  0.00000000
```

```
2.  A2                      0.9054893046 0.0076508940    118.35078  0.00000000


security number 4


MAXIMIZE - Estimation by BHHH

Convergence in     7 Iterations. Final criterion was  0.0000060 <=  0.0000100

Usable Observations   4528

Function Value                  17606.10473778


    Variable                    Coeff      Std Error      T-Stat      Signif

****************************************************************************
*****

1.  THETA                  0.3579459223 0.1385778693      2.58299  0.00979468

2.  W                       0.3114758833 0.5594686895      0.55674  0.57770840

3.  A1                      0.0775805144 0.0066698058     11.63160  0.00000000

4.  A2                      0.9091196263 0.0088729592    102.45957  0.00000000


aic =       -7.77478  bic =       -7.76911


Statistics on Series SCORES

Observations                    4528

Sample Mean                0.000001      Variance           0.019818

Standard Error            0.140777      of Sample Mean      0.002092

t-Statistic (Mean=0)       0.000305      Signif Level        0.999757

Skewness                   -4.816369      Signif Level (Sk=0) 0.000000

Kurtosis (excess)        108.491015      Signif Level (Ku=0) 0.000000

Jarque-Bera          2238169.658203      Signif Level (JB=0) 0.000000
```

```
Statistics on Series SCORES
Observations                  4528
Sample Mean               0.000000      Variance             0.000868
Standard Error            0.029467      of Sample Mean       0.000438
t-Statistic (Mean=0)      0.000010      Signif Level         0.999992
Skewness                 -1.942841      Signif Level (Sk=0)  0.000000
Kurtosis (excess)        75.604349      Signif Level (Ku=0)  0.000000
Jarque-Bera         1081270.573695      Signif Level (JB=0)  0.000000
```

```
Statistics on Series SCORES
Observations                  4528
Sample Mean               0.000043      Variance            88.750536
Standard Error            9.420750      of Sample Mean       0.140001
t-Statistic (Mean=0)      0.000306      Signif Level         0.999756
Skewness                 -8.838706      Signif Level (Sk=0)  0.000000
Kurtosis (excess)       195.994289      Signif Level (Ku=0)  0.000000
Jarque-Bera         7306352.928691      Signif Level (JB=0)  0.000000
```

```
Statistics on Series SCORES
Observations                  4528
Sample Mean               0.000024      Variance            55.796280
Standard Error            7.469691      of Sample Mean       0.111007
t-Statistic (Mean=0)      0.000216      Signif Level         0.999828
```

```
Skewness                  -9.005932      Signif Level (Sk=0) 0.000000

Kurtosis (excess)        195.062770      Signif Level (Ku=0) 0.000000

Jarque-Bera          7239877.962975      Signif Level (JB=0) 0.000000



Statistics on Series RV

Observations                4724

Sample Mean             0.000220      Variance            0.000000

Standard Error          0.000247      of Sample Mean      0.000004

t-Statistic (Mean=0)    61.258911      Signif Level        0.000000

Skewness                 2.633320      Signif Level (Sk=0) 0.000000

Kurtosis (excess)        7.680507      Signif Level (Ku=0) 0.000000

Jarque-Bera          17070.900028      Signif Level (JB=0) 0.000000


theta w m       0.80000       0.50000  2.18068e-004

long-run only, security number 5


MAXIMIZE - Estimation by BHHH

Convergence in    19 Iterations. Final criterion was  0.0000089 <=  0.0000100

Usable Observations   4529

Function Value                  17022.94236637


   Variable                   Coeff      Std Error      T-Stat      Signif

*******************************************************************************
*****

1.  THETA                   0.789791070  0.016978089     46.51825  0.00000000

2.  W                      -0.012121107  0.066850138     -0.18132  0.85611828
```

```
Statistics on Series LONGRUNV
Observations               4529
Sample Mean            0.000224      Variance           0.000000
Standard Error         0.000157      of Sample Mean      0.000002
t-Statistic (Mean=0)   95.643279      Signif Level        0.000000
Skewness               1.742190      Signif Level (Sk=0) 0.000000
Kurtosis (excess)       2.543919      Signif Level (Ku=0) 0.000000
Jarque-Bera         3512.320472      Signif Level (JB=0) 0.000000

Minimum                0.000083      Maximum            0.000818
01-%ile               0.000085      99-%ile            0.000739
05-%ile               0.000093      95-%ile            0.000625
10-%ile               0.000098      90-%ile            0.000434
25-%ile               0.000115      75-%ile            0.000266
Median                0.000172

short-term GARCH only, security number 5

MAXIMIZE - Estimation by BHHH
Convergence in    14 Iterations. Final criterion was  0.0000060 <=  0.0000100
Usable Observations   4528
Function Value                 -1883.76732521

    Variable                    Coeff      Std Error      T-Stat      Signif
```

```
***************************************************************************
*****

1.  A1                  0.0910869054 0.0064824342     14.05134  0.00000000

2.  A2                  0.8884868234 0.0082153229    108.14996  0.00000000


security number 5


MAXIMIZE - Estimation by BHHH

Convergence in    10 Iterations. Final criterion was  0.0000000 <=  0.0000100

Usable Observations   4528

Function Value                 17578.18024864


   Variable                Coeff      Std Error      T-Stat      Signif

***************************************************************************
*****

1.  THETA                0.4795688914 0.1073777147      4.46619  0.00000796

2.  W                   0.4114731058 0.4718625133      0.87202  0.38319798

3.  A1                  0.0938721877 0.0067657514     13.87461  0.00000000

4.  A2                  0.8873132982 0.0089976579     98.61603  0.00000000


aic =       -7.76245  bic =       -7.75678


Statistics on Series SCORES

Observations                  4528

Sample Mean               0.000000      Variance           0.047639

Standard Error            0.218265      of Sample Mean      0.003244

t-Statistic (Mean=0)       0.000070      Signif Level        0.999944

Skewness                 -10.047669      Signif Level (Sk=0) 0.000000
```

```
Kurtosis (excess)       181.768987      Signif Level (Ku=0) 0.000000

Jarque-Bera          6309727.878233      Signif Level (JB=0) 0.000000



Statistics on Series SCORES

Observations                    4528

Sample Mean                 0.000000      Variance              0.001264

Standard Error              0.035551      of Sample Mean       0.000528

t-Statistic (Mean=0)        0.000016      Signif Level          0.999987

Skewness                   -2.719063      Signif Level (Sk=0) 0.000000

Kurtosis (excess)          63.948292      Signif Level (Ku=0) 0.000000

Jarque-Bera           777109.946780      Signif Level (JB=0) 0.000000



Statistics on Series SCORES

Observations                    4528

Sample Mean                 0.000012      Variance             91.335125

Standard Error              9.556941      of Sample Mean       0.142025

t-Statistic (Mean=0)        0.000084      Signif Level          0.999933

Skewness                  -11.238705      Signif Level (Sk=0) 0.000000

Kurtosis (excess)         226.917349      Signif Level (Ku=0) 0.000000

Jarque-Bera          9810047.294527      Signif Level (JB=0) 0.000000



Statistics on Series SCORES

Observations                    4528

Sample Mean                 0.000009      Variance             60.346956
```

```
Standard Error           7.768330     of Sample Mean      0.115445

t-Statistic (Mean=0)       0.000074     Signif Level        0.999941

Skewness                -12.359714     Signif Level (Sk=0) 0.000000

Kurtosis (excess)        259.503539     Signif Level (Ku=0) 0.000000

Jarque-Bera         12820491.819657     Signif Level (JB=0) 0.000000



Statistics on Series RV

Observations              4724

Sample Mean            0.000283     Variance            0.000000

Standard Error         0.000235     of Sample Mean      0.000003

t-Statistic (Mean=0)   82.887883     Signif Level        0.000000

Skewness               1.543151     Signif Level (Sk=0) 0.000000

Kurtosis (excess)       3.168734     Signif Level (Ku=0) 0.000000

Jarque-Bera          3851.267794     Signif Level (JB=0) 0.000000


theta w m       0.80000       0.50000  2.82360e-004

long-run only, security number 6


MAXIMIZE - Estimation by BHHH

Convergence in    27 Iterations. Final criterion was  0.0000090 <=  0.0000100

Usable Observations   4529

Function Value                  16534.88311482


   Variable                  Coeff      Std Error      T-Stat      Signif

****************************************************************************
*****
```

```
1.  THETA                    0.7469455236 0.0119249015     62.63746  0.00000000
2.  W                    1.5506796504 0.2020524992      7.67464  0.00000000



Statistics on Series LONGRUNV
Observations                4529
Sample Mean             0.000285      Variance             0.000000
Standard Error          0.000163      of Sample Mean       0.000002
t-Statistic (Mean=0)  117.292264      Signif Level         0.000000
Skewness                1.175313      Signif Level (Sk=0) 0.000000
Kurtosis (excess)       1.376397      Signif Level (Ku=0) 0.000000
Jarque-Bera          1400.198369      Signif Level (JB=0) 0.000000

Minimum                 0.000106      Maximum              0.000967
01-%ile                 0.000111      99-%ile              0.000845
05-%ile                 0.000119      95-%ile              0.000603
10-%ile                 0.000125      90-%ile              0.000508
25-%ile                 0.000146      75-%ile              0.000389
Median                  0.000249

short-term GARCH only, security number 6

MAXIMIZE - Estimation by BHHH
Convergence in    17 Iterations. Final criterion was  0.0000005 <=  0.0000100
Usable Observations   4528
Function Value                  -1858.46430733
```

```
    Variable                    Coeff      Std Error      T-Stat      Signif
******************************************************************************
*****
1.  A1                     0.1444694118 0.0074511728     19.38882  0.00000000
2.  A2                     0.7971403558 0.0116453741     68.45125  0.00000000


security number 6


MAXIMIZE - Estimation by BHHH
Convergence in     8 Iterations. Final criterion was  0.0000057 <=  0.0000100
Usable Observations   4528
Function Value                  16972.62077259


    Variable                    Coeff      Std Error      T-Stat      Signif
******************************************************************************
*****
1.  THETA                      0.7974672319 0.0410452212     19.42899  0.00000000
2.  W                      0.3265112219 0.2187191651      1.49283  0.13548087
3.  A1                     0.1440965550 0.0101247750     14.23207  0.00000000
4.  A2                     0.7959256584 0.0142294343     55.93516  0.00000000


aic =       -7.49497  bic =       -7.48930


Statistics on Series SCORES
Observations                    4528
Sample Mean               -0.000001      Variance            0.186964
Standard Error            0.432393      of Sample Mean      0.006426
t-Statistic (Mean=0)       -0.000132      Signif Level        0.999895
```

```
Skewness               -14.508404      Signif Level (Sk=0) 0.000000

Kurtosis (excess)        401.122812      Signif Level (Ku=0) 0.000000

Jarque-Bera          30515226.963090      Signif Level (JB=0) 0.000000



Statistics on Series SCORES

Observations                  4528

Sample Mean              -0.000000      Variance           0.005204

Standard Error            0.072136      of Sample Mean      0.001072

t-Statistic (Mean=0)      -0.000006      Signif Level        0.999995

Skewness               -0.376815      Signif Level (Sk=0) 0.000000

Kurtosis (excess)        111.330910      Signif Level (Ku=0) 0.000000

Jarque-Bera          2338549.664451      Signif Level (JB=0) 0.000000



Statistics on Series SCORES

Observations                  4528

Sample Mean              -0.000010      Variance           23.791739

Standard Error            4.877678      of Sample Mean      0.072487

t-Statistic (Mean=0)      -0.000132      Signif Level        0.999894

Skewness              -10.553265      Signif Level (Sk=0) 0.000000

Kurtosis (excess)        218.876182      Signif Level (Ku=0) 0.000000

Jarque-Bera          9122461.341759      Signif Level (JB=0) 0.000000



Statistics on Series SCORES

Observations                  4528
```

```
Sample Mean              -0.000008      Variance           9.541323

Standard Error           3.088903      of Sample Mean      0.045904

t-Statistic (Mean=0)      -0.000174      Signif Level        0.999861

Skewness                 -8.543264      Signif Level (Sk=0) 0.000000

Kurtosis (excess)        205.562809      Signif Level (Ku=0) 0.000000

Jarque-Bera          8027392.731782      Signif Level (JB=0) 0.000000



Statistics on Series RV

Observations                  4724

Sample Mean               0.000171      Variance           0.000000

Standard Error            0.000262      of Sample Mean      0.000004

t-Statistic (Mean=0)     44.724195      Signif Level        0.000000

Skewness                  4.734735      Signif Level (Sk=0) 0.000000

Kurtosis (excess)        27.172494      Signif Level (Ku=0) 0.000000

Jarque-Bera          162981.007074      Signif Level (JB=0) 0.000000


theta w m       0.80000       0.50000  1.69404e-004

long-run only, security number 7


MAXIMIZE - Estimation by BHHH

Convergence in    20 Iterations. Final criterion was  0.0000097 <=  0.0000100

Usable Observations   4529

Function Value                 17924.66115124


    Variable                    Coeff      Std Error      T-Stat      Signif
```

```
**********************************************************************************
*****
1.  THETA                  0.8535221674 0.0066174227    128.98106  0.00000000
2.  W                      0.5192254843 0.0682001835      7.61326  0.00000000



Statistics on Series LONGRUNV
Observations                 4529
Sample Mean             0.000171      Variance             0.000000
Standard Error          0.000193      of Sample Mean       0.000003
t-Statistic (Mean=0)    59.735014      Signif Level         0.000000
Skewness                3.355275      Signif Level (Sk=0) 0.000000
Kurtosis (excess)       12.041160      Signif Level (Ku=0) 0.000000
Jarque-Bera          35858.548181      Signif Level (JB=0) 0.000000

Minimum                 0.000043      Maximum              0.001197
01-%ile                 0.000044      99-%ile              0.001079
05-%ile                 0.000050      95-%ile              0.000542
10-%ile                 0.000054      90-%ile              0.000316
25-%ile                 0.000071      75-%ile              0.000176
Median                  0.000114

short-term GARCH only, security number 7

MAXIMIZE - Estimation by BHHH
Convergence in    24 Iterations. Final criterion was  0.0000082 <=  0.0000100
Usable Observations   4528
```

```
Function Value                    -1987.48366500


    Variable                        Coeff       Std Error       T-Stat       Signif
*****************************************************************************
*****
1.  A1                        0.0814301301 0.0037310012      21.82528  0.00000000
2.  A2                        0.8891584375 0.0063381977     140.28569  0.00000000


security number 7


MAXIMIZE - Estimation by BHHH
Convergence in    27 Iterations. Final criterion was  0.0000045 <=  0.0000100
Usable Observations   4528
Function Value                    18387.20200859


    Variable                        Coeff       Std Error       T-Stat       Signif
*****************************************************************************
*****
1.  THETA                      0.552632453  0.067329235       8.20791  0.00000000
2.  W                         -0.049278724  0.310471814      -0.15872  0.87388786
3.  A1                         0.082385720  0.005138472      16.03312  0.00000000
4.  A2                         0.898039909  0.007051842     127.34827  0.00000000


aic =       -8.11979  bic =       -8.11412


Statistics on Series SCORES
Observations                    4528
Sample Mean                 -0.000000      Variance            0.398648
```

```
Standard Error              0.631386      of Sample Mean      0.009383
t-Statistic (Mean=0)        -0.000034      Signif Level        0.999973
Skewness                  -40.420737      Signif Level (Sk=0) 0.000000
Kurtosis (excess)         2042.646080      Signif Level (Ku=0) 0.000000
Jarque-Bera          788426368.836727      Signif Level (JB=0) 0.000000
```

```
Statistics on Series SCORES
Observations                   4528
Sample Mean                0.000000      Variance            0.003066
Standard Error             0.055369      of Sample Mean      0.000823
t-Statistic (Mean=0)        0.000068      Signif Level        0.999946
Skewness                  -6.860932      Signif Level (Sk=0) 0.000000
Kurtosis (excess)         254.752718      Signif Level (Ku=0) 0.000000
Jarque-Bera           12279791.991925      Signif Level (JB=0) 0.000000
```

```
Statistics on Series SCORES
Observations                    4528
Sample Mean               -0.000002      Variance           364.471392
Standard Error            19.091134      of Sample Mean      0.283713
t-Statistic (Mean=0)        -0.000009      Signif Level        0.999993
Skewness                  -33.221789      Signif Level (Sk=0) 0.000000
Kurtosis (excess)         1474.092209      Signif Level (Ku=0) 0.000000
Jarque-Bera          410795741.999338      Signif Level (JB=0) 0.000000
```

```
Statistics on Series SCORES
Observations                4528
Sample Mean               0.000002      Variance           181.921948
Standard Error           13.487844      of Sample Mean      0.200442
t-Statistic (Mean=0)        0.000010      Signif Level        0.999992
Skewness                -30.071796      Signif Level (Sk=0) 0.000000
Kurtosis (excess)        1223.552894      Signif Level (Ku=0) 0.000000
Jarque-Bera          283131866.042757      Signif Level (JB=0) 0.000000



Statistics on Series RV
Observations                4724
Sample Mean               0.000218      Variance           0.000000
Standard Error           0.000207      of Sample Mean      0.000003
t-Statistic (Mean=0)    72.405100      Signif Level        0.000000
Skewness                2.861645      Signif Level (Sk=0) 0.000000
Kurtosis (excess)       11.760999      Signif Level (Ku=0) 0.000000
Jarque-Bera          33673.683078      Signif Level (JB=0) 0.000000


theta w m       0.80000       0.50000  2.16303e-004
long-run only, security number 8


MAXIMIZE - Estimation by BHHH
Convergence in    16 Iterations. Final criterion was  0.0000065 <=  0.0000100
Usable Observations   4529
Function Value                   17001.94070974
```

```
   Variable                   Coeff      Std Error      T-Stat      Signif
**************************************************************************
*****
1.  THETA                  0.7796404456 0.0188689725     41.31865  0.00000000
2.  W                    0.5897226172 0.0961749634      6.13177  0.00000000



Statistics on Series LONGRUNV
Observations                4529
Sample Mean             0.000218      Variance            0.000000
Standard Error          0.000129      of Sample Mean      0.000002
t-Statistic (Mean=0)  114.294656      Signif Level        0.000000
Skewness                1.782331      Signif Level (Sk=0) 0.000000
Kurtosis (excess)       3.959265      Signif Level (Ku=0) 0.000000
Jarque-Bera          5356.031453      Signif Level (JB=0) 0.000000

Minimum                 0.000069      Maximum             0.000776
01-%ile                 0.000072      99-%ile             0.000703
05-%ile                 0.000078      95-%ile             0.000501
10-%ile                 0.000085      90-%ile             0.000348
25-%ile                 0.000143      75-%ile             0.000268
Median                  0.000187

short-term GARCH only, security number 8

MAXIMIZE - Estimation by BHHH
Convergence in     8 Iterations. Final criterion was  0.0000074 <=  0.0000100
```

```
Usable Observations   4528
Function Value                  -1831.42805316

    Variable                    Coeff      Std Error      T-Stat      Signif
***************************************************************************
*****
1.  A1                     0.1108250237 0.0076328085     14.51956  0.00000000
2.  A2                     0.8652850731 0.0099505562     86.95846  0.00000000

security number 8

MAXIMIZE - Estimation by BHHH
Convergence in     8 Iterations. Final criterion was  0.0000000 <=  0.0000100
Usable Observations   4528
Function Value                  17585.84207209

    Variable                    Coeff      Std Error      T-Stat      Signif
***************************************************************************
*****
1.  THETA                     0.5966515843 0.0854468921      6.98272  0.00000000
2.  W                      0.5801577355 0.4020637057      1.44295  0.14903462
3.  A1                     0.1106844111 0.0088964250     12.44145  0.00000000
4.  A2                     0.8688675238 0.0118109749     73.56442  0.00000000

aic =       -7.76583  bic =       -7.76016

Statistics on Series SCORES
Observations                    4528
```

```
Sample Mean                0.000000      Variance            0.053910
Standard Error             0.232185      of Sample Mean      0.003450
t-Statistic (Mean=0)       0.000097      Signif Level        0.999922
Skewness                 -12.113069      Signif Level (Sk=0) 0.000000
Kurtosis (excess)        281.123992      Signif Level (Ku=0) 0.000000
Jarque-Bera         15021188.039025      Signif Level (JB=0) 0.000000
```

```
Statistics on Series SCORES
Observations                  4528
Sample Mean               -0.000000      Variance            0.001581
Standard Error             0.039763      of Sample Mean      0.000591
t-Statistic (Mean=0)      -0.000059      Signif Level        0.999953
Skewness                  -2.706848      Signif Level (Sk=0) 0.000000
Kurtosis (excess)         77.703845      Signif Level (Ku=0) 0.000000
Jarque-Bera          1144677.586614      Signif Level (JB=0) 0.000000
```

```
Statistics on Series SCORES
Observations                  4528
Sample Mean                0.000009      Variance           60.128841
Standard Error             7.754279      of Sample Mean      0.115236
t-Statistic (Mean=0)       0.000074      Signif Level        0.999941
Skewness                  -8.663475      Signif Level (Sk=0) 0.000000
Kurtosis (excess)        156.288969      Signif Level (Ku=0) 0.000000
Jarque-Bera          4665059.762324      Signif Level (JB=0) 0.000000
```

```
Statistics on Series SCORES

Observations                    4528

Sample Mean              -0.000001      Variance            38.116594

Standard Error            6.173864      of Sample Mean      0.091750

t-Statistic (Mean=0)      -0.000007      Signif Level        0.999995

Skewness                  -9.081755      Signif Level (Sk=0) 0.000000

Kurtosis (excess)        165.450651      Signif Level (Ku=0) 0.000000

Jarque-Bera          5226789.466613      Signif Level (JB=0) 0.000000
```

```
Statistics on Series RV

Observations                  4724

Sample Mean              0.000206      Variance            0.000000

Standard Error           0.000281      of Sample Mean      0.000004

t-Statistic (Mean=0)    50.322435      Signif Level        0.000000

Skewness                 3.278113      Signif Level (Sk=0) 0.000000

Kurtosis (excess)       12.975939      Signif Level (Ku=0) 0.000000

Jarque-Bera          41602.515020      Signif Level (JB=0) 0.000000
```

```
theta w m       0.80000       0.50000  2.04060e-004

long-run only, security number 9
```

```
MAXIMIZE - Estimation by BHHH

Convergence in    20 Iterations. Final criterion was  0.0000071 <=  0.0000100

Usable Observations   4529

Function Value                   17289.98338015
```

```
   Variable                    Coeff      Std Error      T-Stat      Signif
*******************************************************************************
1.  THETA                   0.8549067867 0.0130107683     65.70763  0.00000000
2.  W                       0.3835998469 0.0575628774      6.66401  0.00000000


Statistics on Series LONGRUNV
Observations                 4529
Sample Mean              0.000209      Variance              0.000000
Standard Error           0.000193      of Sample Mean        0.000003
t-Statistic (Mean=0)    72.793542      Signif Level          0.000000
Skewness                 1.966208      Signif Level (Sk=0)   0.000000
Kurtosis (excess)        3.229876      Signif Level (Ku=0)   0.000000
Jarque-Bera           4886.788317      Signif Level (JB=0)   0.000000

Minimum                  0.000058      Maximum               0.000945
01-%ile                  0.000060      99-%ile               0.000860
05-%ile                  0.000063      95-%ile               0.000691
10-%ile                  0.000066      90-%ile               0.000482
25-%ile                  0.000082      75-%ile               0.000240
Median                   0.000134

short-term GARCH only, security number 9

MAXIMIZE - Estimation by BHHH
```

```
Convergence in    10 Iterations. Final criterion was  0.0000057 <=  0.0000100

Usable Observations   4528

Function Value                  -1850.68617695


    Variable                    Coeff      Std Error      T-Stat      Signif

**************************************************************************
*****

1.  A1                    0.1028887951 0.0065581851     15.68861  0.00000000

2.  A2                    0.8780302419 0.0085016806    103.27726  0.00000000


security number 9


MAXIMIZE - Estimation by BHHH

Convergence in     7 Iterations. Final criterion was  0.0000018 <=  0.0000100

Usable Observations   4528

Function Value                  18031.47022949


    Variable                    Coeff      Std Error      T-Stat      Signif

**************************************************************************
*****

1.  THETA                     0.5775576655 0.0863999042      6.68470  0.00000000

2.  W                     0.6395435738 0.4319841605      1.48048  0.13874540

3.  A1                    0.1072007149 0.0075582999     14.18318  0.00000000

4.  A2                    0.8757151625 0.0094545264     92.62391  0.00000000


aic =       -7.96266  bic =       -7.95699


Statistics on Series SCORES
```

```
Observations                4528
Sample Mean            -0.000000     Variance          0.050360
Standard Error          0.224410     of Sample Mean     0.003335
t-Statistic (Mean=0)    -0.000011     Signif Level       0.999991
Skewness               -6.204932     Signif Level (Sk=0) 0.000000
Kurtosis (excess)       85.816420     Signif Level (Ku=0) 0.000000
Jarque-Bera        1418483.282997     Signif Level (JB=0) 0.000000
```

```
Statistics on Series SCORES
Observations                4528
Sample Mean            -0.000000     Variance          0.001359
Standard Error          0.036869     of Sample Mean     0.000548
t-Statistic (Mean=0)    -0.000013     Signif Level       0.999990
Skewness               -2.245780     Signif Level (Sk=0) 0.000000
Kurtosis (excess)       78.599774     Signif Level (Ku=0) 0.000000
Jarque-Bera        1169374.598450     Signif Level (JB=0) 0.000000
```

```
Statistics on Series SCORES
Observations                4528
Sample Mean            -0.000005     Variance          80.640002
Standard Error          8.979978     of Sample Mean     0.133451
t-Statistic (Mean=0)    -0.000038     Signif Level       0.999970
Skewness               -7.486925     Signif Level (Sk=0) 0.000000
Kurtosis (excess)      115.098922     Signif Level (Ku=0) 0.000000
Jarque-Bera        2541713.201674     Signif Level (JB=0) 0.000000
```

```
Statistics on Series SCORES

Observations                4528

Sample Mean              -0.000004      Variance           52.155272

Standard Error           7.221861      of Sample Mean      0.107324

t-Statistic (Mean=0)      -0.000035      Signif Level        0.999972

Skewness                -7.271782      Signif Level (Sk=0) 0.000000

Kurtosis (excess)        105.770976      Signif Level (Ku=0) 0.000000

Jarque-Bera          2150614.107030      Signif Level (JB=0) 0.000000



Statistics on Series RV

Observations                4724

Sample Mean              0.000102      Variance           0.000000

Standard Error           0.000140      of Sample Mean      0.000002

t-Statistic (Mean=0)     50.449362      Signif Level        0.000000

Skewness                4.028607      Signif Level (Sk=0) 0.000000

Kurtosis (excess)        21.262904      Signif Level (Ku=0) 0.000000

Jarque-Bera          101768.697219      Signif Level (JB=0) 0.000000


theta w m       0.80000       0.50000  1.01835e-004

long-run only, security number 10


MAXIMIZE - Estimation by BHHH

Convergence in    35 Iterations. Final criterion was  0.0000090 <=  0.0000100

Usable Observations   4529
```

```
Function Value                    18921.05603201


    Variable                     Coeff      Std Error      T-Stat      Signif
*****************************************************************************
*****
1.  THETA                    0.8157615696 0.0071683259    113.80085  0.00000000
2.  W                      2.3990387001 0.1779224882     13.48362  0.00000000



Statistics on Series LONGRUNV
Observations                 4529
Sample Mean              0.000105      Variance            0.000000
Standard Error           0.000110      of Sample Mean       0.000002
t-Statistic (Mean=0)    64.279197      Signif Level         0.000000
Skewness                 3.732971      Signif Level (Sk=0) 0.000000
Kurtosis (excess)       18.557086      Signif Level (Ku=0) 0.000000
Jarque-Bera          75503.289302      Signif Level (JB=0) 0.000000

Minimum                  0.000025      Maximum             0.000862
01-%ile                  0.000026      99-%ile             0.000720
05-%ile                  0.000029      95-%ile             0.000283
10-%ile                  0.000033      90-%ile             0.000204
25-%ile                  0.000041      75-%ile             0.000124
Median                   0.000069

short-term GARCH only, security number 10
```

```
MAXIMIZE - Estimation by BHHH
Convergence in    20 Iterations. Final criterion was  0.0000011 <=  0.0000100
Usable Observations   4528
Function Value                 -1888.67861937

    Variable                     Coeff      Std Error      T-Stat      Signif
**********************************************************************************
*****
1.  A1                       0.1554875332 0.0057341022     27.11628  0.00000000
2.  A2                       0.8081950427 0.0073486538    109.97865  0.00000000

security number 10

MAXIMIZE - Estimation by BHHH
Convergence in    18 Iterations. Final criterion was  0.0000000 <=  0.0000100
Usable Observations   4528
Function Value                 19580.60383825

    Variable                     Coeff      Std Error      T-Stat      Signif
**********************************************************************************
*****
1.  THETA                    0.5841092711 0.0579408686     10.08113  0.00000000
2.  W                        0.6873089933 0.3219270091      2.13498  0.03276232
3.  A1                       0.1660665929 0.0064873287     25.59861  0.00000000
4.  A2                       0.8036230127 0.0082942342     96.88936  0.00000000

aic =       -8.64691  bic =       -8.64124
```

```
Statistics on Series SCORES

Observations                  4528

Sample Mean               -0.000000      Variance            0.175729

Standard Error             0.419200      of Sample Mean      0.006230

t-Statistic (Mean=0)       -0.000050      Signif Level        0.999960

Skewness                 -12.938937      Signif Level (Sk=0) 0.000000

Kurtosis (excess)         267.002495      Signif Level (Ku=0) 0.000000

Jarque-Bera          13576452.741607      Signif Level (JB=0) 0.000000
```

```
Statistics on Series SCORES

Observations                 4528

Sample Mean              -0.000000      Variance            0.002432

Standard Error            0.049311      of Sample Mean      0.000733

t-Statistic (Mean=0)      -0.000013      Signif Level        0.999990

Skewness                 -1.988910      Signif Level (Sk=0) 0.000000

Kurtosis (excess)        124.570121      Signif Level (Ku=0) 0.000000

Jarque-Bera          2930660.852021      Signif Level (JB=0) 0.000000
```

```
Statistics on Series SCORES

Observations                 4528

Sample Mean              -0.000003      Variance            72.543395

Standard Error            8.517241      of Sample Mean      0.126574

t-Statistic (Mean=0)      -0.000026      Signif Level        0.999979

Skewness                 -8.455015      Signif Level (Sk=0) 0.000000

Kurtosis (excess)        124.267062      Signif Level (Ku=0) 0.000000
```

```
Jarque-Bera          2967396.848861      Signif Level (JB=0) 0.000000



Statistics on Series SCORES

Observations                    4528

Sample Mean                -0.000008      Variance            48.813123

Standard Error             6.986639      of Sample Mean      0.103828

t-Statistic (Mean=0)      -0.000075      Signif Level        0.999940

Skewness                  -9.229247      Signif Level (Sk=0) 0.000000

Kurtosis (excess)        157.767934      Signif Level (Ku=0) 0.000000

Jarque-Bera          4760331.108537      Signif Level (JB=0) 0.000000



Statistics on Series RV

Observations                  4724

Sample Mean               0.000203      Variance            0.000000

Standard Error            0.000214      of Sample Mean      0.000003

t-Statistic (Mean=0)     65.224975      Signif Level        0.000000

Skewness                  3.101575      Signif Level (Sk=0) 0.000000

Kurtosis (excess)        12.676916      Signif Level (Ku=0) 0.000000

Jarque-Bera           39205.909354      Signif Level (JB=0) 0.000000


theta w m       0.80000       0.50000  2.02320e-004

long-run only, security number 11


MAXIMIZE - Estimation by BHHH

Convergence in    19 Iterations. Final criterion was  0.0000094 <=  0.0000100
```

```
Usable Observations   4529

Function Value                  17189.97379175


    Variable                   Coeff      Std Error      T-Stat      Signif

****************************************************************************
*****

1.  THETA                   0.8303636149 0.0165254976     50.24742  0.00000000

2.  W                      0.6754557666 0.0958629389      7.04606  0.00000000




Statistics on Series LONGRUNV

Observations                4529

Sample Mean             0.000203      Variance            0.000000

Standard Error          0.000141      of Sample Mean       0.000002

t-Statistic (Mean=0)   96.713942      Signif Level        0.000000

Skewness                1.887117      Signif Level (Sk=0) 0.000000

Kurtosis (excess)       4.136927      Signif Level (Ku=0) 0.000000

Jarque-Bera          5917.707417      Signif Level (JB=0) 0.000000


Minimum                 0.000062      Maximum             0.000876

01-%ile               0.000066      99-%ile             0.000752

05-%ile               0.000069      95-%ile             0.000483

10-%ile               0.000085      90-%ile             0.000406

25-%ile               0.000103      75-%ile             0.000246

Median                 0.000160


short-term GARCH only, security number 11
```

```
MAXIMIZE - Estimation by BHHH

Convergence in    13 Iterations. Final criterion was  0.0000070 <=  0.0000100

Usable Observations   4528

Function Value                 -1979.34133002


    Variable                     Coeff      Std Error      T-Stat      Signif

*****************************************************************************
*****

1.  A1                      0.1002394502 0.0071643921     13.99134  0.00000000

2.  A2                      0.8697968822 0.0103313443     84.19010  0.00000000


security number 11


MAXIMIZE - Estimation by BHHH

Convergence in    13 Iterations. Final criterion was  0.0000058 <=  0.0000100

Usable Observations   4528

Function Value                 17706.19681235


    Variable                     Coeff      Std Error      T-Stat      Signif

*****************************************************************************
*****

1.  THETA                       0.5195673933 0.0757689205      6.85726  0.00000000

2.  W                       0.9648586258 0.6615276199      1.45853  0.14469420

3.  A1                      0.1035260221 0.0078243255     13.23130  0.00000000

4.  A2                      0.8709140626 0.0109528594     79.51477  0.00000000


aic =       -7.81899  bic =       -7.81332
```

```
Statistics on Series SCORES

Observations              4528

Sample Mean            -0.000000      Variance           0.081461

Standard Error          0.285415      of Sample Mean      0.004242

t-Statistic (Mean=0)   -0.000048      Signif Level        0.999962

Skewness              -13.203867      Signif Level (Sk=0) 0.000000

Kurtosis (excess)     330.033914      Signif Level (Ku=0) 0.000000

Jarque-Bera       20681593.328719      Signif Level (JB=0) 0.000000
```

```
Statistics on Series SCORES

Observations             4528

Sample Mean             0.000000      Variance           0.001117

Standard Error          0.033424      of Sample Mean      0.000497

t-Statistic (Mean=0)    0.000074      Signif Level        0.999941

Skewness                0.100907      Signif Level (Sk=0) 0.005587

Kurtosis (excess)     108.341670      Signif Level (Ku=0) 0.000000

Jarque-Bera       2214561.428018      Signif Level (JB=0) 0.000000
```

```
Statistics on Series SCORES

Observations              4528

Sample Mean            -0.000007      Variance           93.065005

Standard Error          9.647021      of Sample Mean      0.143364

t-Statistic (Mean=0)   -0.000052      Signif Level        0.999959

Skewness              -14.733266      Signif Level (Sk=0) 0.000000
```

```
Kurtosis (excess)        349.025727      Signif Level (Ku=0) 0.000000

Jarque-Bera          23146991.611999      Signif Level (JB=0) 0.000000



Statistics on Series SCORES

Observations                    4528

Sample Mean               -0.000006      Variance           50.891426

Standard Error             7.133823      of Sample Mean      0.106015

t-Statistic (Mean=0)       -0.000055      Signif Level        0.999956

Skewness                 -14.737447      Signif Level (Sk=0) 0.000000

Kurtosis (excess)        343.420029      Signif Level (Ku=0) 0.000000

Jarque-Bera          22414748.214414      Signif Level (JB=0) 0.000000
```

```
*midasctheta.txt this program creates a block diagonal matrix ctheta from
*the 11 4x4 covariance matrices of
*the estimated parameters from Midas-Garch step

open xx c:\eurovol\output\xx.txt
open ctheta c:\eurovol\output\ctheta.txt

dec symmetric a(4,4) b(4,4) c(4,4) d(4,4) e(4,4) f(4,4) g(4,4) h(4,4) k(4,4) l(4,4) m(4,4)
dec rect ctheta(44,44)

dec rect n(44,44)
ewise n(i,j)=0

read(unit=xx,format=free) a b c d e f g h k l m


compute diag = a~\b~\c~\d~\e~\f~\g~\h~\k~\l~\m
compute ctheta = diag

write(unit=ctheta,format=free) ctheta
```

```
*qlinreg5models.txt this program estimates a quarterly model of dynamic correlation magnitudes
alloc 22 4788
open qgdp c:\eurovol\data\gdpQ41991toQ42010.txt
open rdates c:\eurovol\output\rdates.txt
open rets c:\eurovol\output\rets.txt

* there are 77 quarters in total
data(unit=qgdp,format=free,org=obs) 1 74 1 2 3 4 5 6 7 8 9 10 11
data(unit=rdates,format=free,org=obs) 1 4788 day month year
data(unit=rets,format=free,org=obs) 1 4788 12 13 14 15 16 17 18 19 20 21 22

*create a signal equal to the proportion of negative-growth countries
set countries 1 77 = 0.0
set downs 1 77 = 0.0
set avegrowth 1 77 = 0.0
do j=1,11
(01.0042) set growth 1 77 = [series] j
(01.0089) set countries 1 77 = countries + %if(growth>-98.0,1.0,0.0)
(01.0167) set sampg 1 77 = %if(growth<-98.0,0.0,1.0)
(01.0235) display 'country' j
(01.0263) statistics(smpl=sampg,fractiles) growth
(01.0295) set growthshock 1 77 = growth
(01.0340) set downs 1 77 = downs + %if(growthshock<0.0,1.0,0.0) - %if(growthshock<-98.0,1.0,0.0)
(01.0450) set avegrowth 1 77 = avegrowth + %if(growth>-98.0,growth,0.0)
(01.0531) end do j
country 1
```

```
Statistics on Series GROWTH
Observations              74
Sample Mean           0.463326      Variance              0.465907
Standard Error        0.682574      SE of Sample Mean     0.079348
t-Statistic (Mean=0)  5.839196      Signif Level (Mean=0) 0.000000
Skewness             -1.206353      Signif Level (Sk=0)   0.000033
Kurtosis (excess)     2.776643      Signif Level (Ku=0)   0.000003
Jarque-Bera          41.720251      Signif Level (JB=0)   0.000000

Minimum              -2.041757      Maximum               1.908224
01-%ile              -1.796651      99-%ile               1.672455
05-%ile              -0.791920      95-%ile               1.358778
10-%ile              -0.364679      90-%ile               1.223296
25-%ile               0.208368      75-%ile               0.881856
Median                0.549408
```

country 2

```
Statistics on Series GROWTH
Observations              60      Skipped/Missing          14
Sample Mean           0.452589      Variance              0.423384
Standard Error        0.650680      SE of Sample Mean     0.084002
t-Statistic (Mean=0)  5.387810      Signif Level (Mean=0) 0.000001
Skewness             -1.446539      Signif Level (Sk=0)   0.000008
Kurtosis (excess)     4.846557      Signif Level (Ku=0)   0.000000
Jarque-Bera          79.647547      Signif Level (JB=0)   0.000000
```

```
Minimum            -2.152341      Maximum             1.822524
01-%ile            -1.876219      99-%ile             1.561238
05-%ile            -0.410923      95-%ile             1.314883
10-%ile            -0.131159      90-%ile             1.229096
25-%ile             0.164194      75-%ile             0.778250
Median              0.497208
```

country 3

```
Statistics on Series GROWTH
Observations                 74
Sample Mean            0.575652      Variance              1.490021
Standard Error         1.220664      SE of Sample Mean     0.141899
t-Statistic (Mean=0)   4.056763      Signif Level (Mean=0) 0.000123
Skewness              -2.310850      Signif Level (Sk=0)   0.000000
Kurtosis (excess)      8.562794      Signif Level (Ku=0)   0.000000
Jarque-Bera          291.934795      Signif Level (JB=0)   0.000000

Minimum            -5.473005      Maximum             2.452256
01-%ile            -3.935671      99-%ile             2.386230
05-%ile            -1.379612      95-%ile             1.913880
10-%ile            -0.389218      90-%ile             1.623748
25-%ile             0.194123      75-%ile             1.298352
Median              0.804731
```

country 4

```
Statistics on Series GROWTH

Observations              74

Sample Mean          0.389758      Variance             0.265516

Standard Error       0.515283      SE of Sample Mean     0.059900

t-Statistic (Mean=0)  6.506770      Signif Level (Mean=0) 0.000000

Skewness            -1.423910      Signif Level (Sk=0)   0.000001

Kurtosis (excess)     3.468201      Signif Level (Ku=0)   0.000000

Jarque-Bera          62.093716      Signif Level (JB=0)   0.000000


Minimum              -1.524906      Maximum              1.350284

01-%ile            -1.476356      99-%ile              1.168391

05-%ile            -0.514110      95-%ile              1.031602

10-%ile            -0.166308      90-%ile              0.971253

25-%ile             0.159144      75-%ile              0.703940

Median              0.506593
```

country 5

```
Statistics on Series GROWTH

Observations              74

Sample Mean          0.311093      Variance             0.684140

Standard Error       0.827127      SE of Sample Mean     0.096152

t-Statistic (Mean=0)   3.235443      Signif Level (Mean=0) 0.001826

Skewness            -1.758576      Signif Level (Sk=0)   0.000000

Kurtosis (excess)     7.106938      Signif Level (Ku=0)   0.000000

Jarque-Bera         193.876682      Signif Level (JB=0)   0.000000
```

```
Minimum              -3.707813      Maximum               1.933248

01-%ile              -2.495357      99-%ile               1.660634

05-%ile              -0.806523      95-%ile               1.341853

10-%ile              -0.462685      90-%ile               1.190028

25-%ile              -0.031140      75-%ile               0.827084

Median                0.362000
```

country 6

```
Statistics on Series GROWTH

Observations                   40      Skipped/Missing              34

Sample Mean              0.651343      Variance               1.215746

Standard Error           1.102609      SE of Sample Mean      0.174338

t-Statistic (Mean=0)     3.736097      Signif Level (Mean=0)  0.000597

Skewness                 0.386096      Signif Level (Sk=0)    0.337342

Kurtosis (excess)        1.219523      Signif Level (Ku=0)    0.150032

Jarque-Bera              3.472529      Signif Level (JB=0)    0.176177


Minimum                 -1.888599      Maximum                3.791201

01-%ile                 -1.578243      99-%ile                3.552435

05-%ile                 -1.028860      95-%ile                2.130777

10-%ile                 -0.674317      90-%ile                1.712945

25-%ile                  0.100418      75-%ile                1.193915

Median                   0.647423
```

country 7

```
Statistics on Series GROWTH

Observations              40      Skipped/Missing           34

Sample Mean          0.779019      Variance             4.528518

Standard Error       2.128031      SE of Sample Mean     0.336471

t-Statistic (Mean=0)  2.315260      Signif Level (Mean=0) 0.025950

Skewness             0.166185      Signif Level (Sk=0)   0.679635

Kurtosis (excess)    -0.052141      Signif Level (Ku=0)   0.950927

Jarque-Bera          0.188647      Signif Level (JB=0)   0.909988


Minimum             -3.932979      Maximum              5.402603

01-%ile             -3.490740      99-%ile              5.374030

05-%ile             -2.664502      95-%ile              4.211864

10-%ile             -1.624899      90-%ile              3.543026

25-%ile             -0.542765      75-%ile              1.938833

Median               0.808152
```

country 8

```
Statistics on Series GROWTH

Observations              74

Sample Mean          0.215237      Variance             0.471935

Standard Error       0.686975      SE of Sample Mean     0.079859

t-Statistic (Mean=0)  2.695210      Signif Level (Mean=0) 0.008726

Skewness            -1.844745      Signif Level (Sk=0)   0.000000

Kurtosis (excess)     6.481900      Signif Level (Ku=0)   0.000000

Jarque-Bera        171.517697      Signif Level (JB=0)   0.000000
```

```
Minimum          -2.988348    Maximum          1.377699
01-%ile          -2.296937    99-%ile          1.304236
05-%ile          -0.631117    95-%ile          1.034500
10-%ile          -0.421553    90-%ile          0.952772
25-%ile          -0.183683    75-%ile          0.632590
Median            0.344991
```

country 9

```
Statistics on Series GROWTH
Observations              74
Sample Mean          0.557498    Variance             0.508812
Standard Error       0.713311    SE of Sample Mean    0.082921
t-Statistic (Mean=0)  6.723269    Signif Level (Mean=0) 0.000000
Skewness            -1.328735    Signif Level (Sk=0)   0.000005
Kurtosis (excess)    3.605794    Signif Level (Ku=0)   0.000000
Jarque-Bera         61.863672    Signif Level (JB=0)   0.000000

Minimum          -2.373939    Maximum          2.080733
01-%ile          -1.591282    99-%ile          1.749047
05-%ile          -0.654980    95-%ile          1.477294
10-%ile          -0.204347    90-%ile          1.331352
25-%ile           0.223417    75-%ile          0.966050
Median            0.669913
```

country 10

```
Statistics on Series GROWTH

Observations              60      Skipped/Missing           14

Sample Mean          0.472014      Variance            0.749101

Standard Error       0.865506      SE of Sample Mean     0.111736

t-Statistic (Mean=0)  4.224357      Signif Level (Mean=0) 0.000084

Skewness            -0.397454      Signif Level (Sk=0)   0.220427

Kurtosis (excess)     0.165084      Signif Level (Ku=0)   0.805682

Jarque-Bera          1.647825      Signif Level (JB=0)   0.438712


Minimum             -1.983774      Maximum             2.234996

01-%ile            -1.579663      99-%ile            2.210659

05-%ile            -1.092736      95-%ile            1.564098

10-%ile            -0.576437      90-%ile            1.464822

25-%ile            -0.052886      75-%ile            1.078247

Median              0.536299
```

country 11

```
Statistics on Series GROWTH

Observations              60      Skipped/Missing           14

Sample Mean          0.684047      Variance            0.373781

Standard Error       0.611376      SE of Sample Mean     0.078928

t-Statistic (Mean=0)  8.666688      Signif Level (Mean=0) 0.000000

Skewness            -1.883680      Signif Level (Sk=0)   0.000000

Kurtosis (excess)     4.178566      Signif Level (Ku=0)   0.000000

Jarque-Bera         79.133544      Signif Level (JB=0)   0.000000
```

```
Minimum              -1.595605      Maximum              1.543302

01-%ile              -1.287216      99-%ile              1.537366

05-%ile              -0.813948      95-%ile              1.511151

10-%ile              -0.053277      90-%ile              1.144942

25-%ile               0.628828      75-%ile              0.994188

Median                0.847836
```

```
set qsignal 1 77 = downs/countries

set avegrowth 1 77 = avegrowth/sampg
```

```
statistics(fractiles) qsignal
```

```
Statistics on Series QSIGNAL

Observations                   74

Sample Mean            0.205364      Variance              0.063583

Standard Error         0.252157      SE of Sample Mean     0.029313

t-Statistic (Mean=0)   7.005991      Signif Level (Mean=0) 0.000000

Skewness               1.678833      Signif Level (Sk=0)   0.000000

Kurtosis (excess)      2.391902      Signif Level (Ku=0)   0.000062

Jarque-Bera           52.401624      Signif Level (JB=0)   0.000000


Minimum               0.000000      Maximum              1.000000

01-%ile               0.000000      99-%ile              1.000000

05-%ile               0.000000      95-%ile              0.833333

10-%ile               0.000000      90-%ile              0.500000

25-%ile               0.000000      75-%ile              0.272727
```

```
Median              0.111111
```

```
* assign each day to a quarter numbered 2 to 77

set quarter 1 4788 = 1.0 + %if(month>3.0,1.0,0.0) +
%if(month>6.0,1.0,0.0)+%if(month>9.0,1.0,0.0)

set qindex 1 4788 = (year - 1991.0)*4.0 + quarter - 3.0

statistics(fractiles) qindex
```

```
Statistics on Series QINDEX

Observations              4788

Sample Mean          39.669382      Variance            482.045463

Standard Error        21.955534      SE of Sample Mean       0.317298

t-Statistic (Mean=0) 125.022593      Signif Level (Mean=0)   0.000000

Skewness              -0.011176      Signif Level (Sk=0)     0.752303

Kurtosis (excess)     -1.200888      Signif Level (Ku=0)     0.000000

Jarque-Bera          287.805065      Signif Level (JB=0)     0.000000


Minimum               2.000000      Maximum              77.000000

01-%ile              2.000000      99-%ile              77.000000

05-%ile              5.000000      95-%ile              74.000000

10-%ile              9.000000      90-%ile              70.000000

25-%ile             21.000000      75-%ile              59.000000

Median              40.000000
```

```
*compute the fixed-window sample correlation matrix for each calendar quarter

* and the average correlation within it
```

```
* also cumulative return for each quarter (starting with quarter 2)

do j = 2,77

(01.0042) set samp = %if(qindex == j,1.0,0.0)

(01.0096) *display 'j' j

(01.0096) *statistics samp

(01.0096) cmom(noprint,correlation,centered,smpl=samp)

(01.0121) # 12 13 14 15 16 17 18 19 20 21 22

(01.0223) compute correl = %cmom

(01.0241) compute avecorr = 0.0

(01.0258)

(01.0258)

(01.0258) *average correlation

(01.0258) do jj = 1,10

(02.0293) compute jjp1 = jj + 1

(02.0316) do jjj = jjp1,11

(03.0353) compute avecorr = avecorr + correl(jj,jjj)/55.0

(03.0393) end do jjj

(02.0395) end do jj

(01.0397)

(01.0397)

(01.0397) * now average variance

(01.0397) cmom(noprint,centered,smpl=samp)

(01.0420) # 12 13 14 15 16 17 18 19 20 21 22

(01.0522) compute cmom = %cmom

(01.0540) compute avevar = 0.0

(01.0557)

(01.0557)
```

```
(01.0557) *average variance

(01.0557) do jj = 1,11

(02.0592) compute avevar = avevar + cmom(jj,jj)/11.0

(02.0632) end do jj

(01.0634)

(01.0634)

(01.0634)

(01.0634) set qavecorr j j = avecorr

(01.0681) set qavevar j j = avevar

(01.0728)

(01.0728) * now equally-weighted cumulative return for the quarter

(01.0728) compute ewcumret = 0.0

(01.0745) do k = 12,22

(02.0780) set ret / = [series] k

(02.0811) statistics(noprint,smpl=samp) ret

(02.0843) compute ewcumret = ewcumret + %nobs*%mean

(02.0876) end do k

(01.0878) set qcumret j j = ewcumret

(01.0925)

(01.0925)

(01.0925) * set trend at 1 time unit per year

(01.0925) set trend j j = 0.25*j

(01.0979)

(01.0979)

(01.0979)

(01.0979) end do j
```

```
* de-mean the variables

statistics(print) trend 2 77

Statistics on Series TREND
Observations                76
Sample Mean           9.875000      Variance             30.479167
Standard Error        5.520794      SE of Sample Mean      0.633279
t-Statistic (Mean=0) 15.593455      Signif Level (Mean=0)  0.000000
Skewness              0.000000      Signif Level (Sk=0)    1.000000
Kurtosis (excess)    -1.200000      Signif Level (Ku=0)    0.041537
Jarque-Bera           4.560000      Signif Level (JB=0)    0.102284

set dmtrend / = trend - %mean
statistics(print) qcumret 2 77

Statistics on Series QCUMRET
Observations                76
Sample Mean           0.163347      Variance              1.467965
Standard Error        1.211596      SE of Sample Mean     0.138980
t-Statistic (Mean=0)  1.175334      Signif Level (Mean=0) 0.243579
Skewness             -0.649474      Signif Level (Sk=0)   0.023462
Kurtosis (excess)     0.666022      Signif Level (Ku=0)   0.257971
Jarque-Bera           6.747704      Signif Level (JB=0)   0.034257
```

```
set dmcumret / = qcumret - %mean

statistics(print) qsignal 2 77


Statistics on Series QSIGNAL

Observations               73      Skipped/Missing             3

Sample Mean          0.205895      Variance             0.064445

Standard Error       0.253861      SE of Sample Mean     0.029712

t-Statistic (Mean=0)  6.929639      Signif Level (Mean=0) 0.000000

Skewness             1.662358      Signif Level (Sk=0)   0.000000

Kurtosis (excess)     2.309541      Signif Level (Ku=0)   0.000125

Jarque-Bera          49.845955      Signif Level (JB=0)   0.000000


set dmsignal / = qsignal - %mean

statistics(print) qavecorr 2 77


Statistics on Series QAVECORR

Observations               76

Sample Mean          0.520309      Variance             0.035471

Standard Error       0.188336      SE of Sample Mean     0.021604

t-Statistic (Mean=0) 24.084318      Signif Level (Mean=0) 0.000000

Skewness            -0.190902      Signif Level (Sk=0)   0.505411

Kurtosis (excess)    -0.863074      Signif Level (Ku=0)   0.142681

Jarque-Bera           2.820456      Signif Level (JB=0)   0.244088


set dmratio 2 77  = (qavecorr-%mean)/(1-%mean)

statistics(print) qavevar 2 77
```

```
Statistics on Series QAVEVAR
Observations                 76
Sample Mean            0.012731      Variance             0.000156
Standard Error         0.012501      SE of Sample Mean     0.001434
t-Statistic (Mean=0)    8.877865      Signif Level (Mean=0) 0.000000
Skewness               3.610321      Signif Level (Sk=0)   0.000000
Kurtosis (excess)      19.301809      Signif Level (Ku=0)   0.000000
Jarque-Bera         1344.875452      Signif Level (JB=0)   0.000000
```

```
set dmavevar / = qavevar - %mean
```

```
* save the quarterly average correlations and average variance
open qavecorr c:\eurovol\output\qavecorr.txt
*copy(unit=qavecorr,format='(2(f15.10))',org=obs) 2 77 qavecorr qavevar
```

```
set lagdmratio / = dmratio{1}
set lagdmsignal / = dmsignal{1}
set gendistress 2 77 = %if(dmsignal>.5,1.0,0.0)
statistics gendistress 2 77
```

```
Statistics on Series GENDISTRESS
Observations                 76
Sample Mean            0.065789      Variance             0.062281
Standard Error         0.249561      SE of Sample Mean     0.028627
t-Statistic (Mean=0)   2.298193      Signif Level (Mean=0) 0.024339
```

```
Skewness             3.573843      Signif Level (Sk=0)   0.000000

Kurtosis (excess)     11.062882      Signif Level (Ku=0)   0.000000

Jarque-Bera          549.343134      Signif Level (JB=0)   0.000000


set gendistress 2 77 = gendistress - %mean

statistics avegrowth 2 77


Statistics on Series AVEGROWTH

Observations                 63      Skipped/Missing             13

Sample Mean           4.941456      Variance             45.731070

Standard Error         6.762475      SE of Sample Mean      0.851992

t-Statistic (Mean=0)   5.799887      Signif Level (Mean=0)  0.000000

Skewness             -2.681378      Signif Level (Sk=0)    0.000000

Kurtosis (excess)     10.492002      Signif Level (Ku=0)    0.000000

Jarque-Bera          364.458281      Signif Level (JB=0)    0.000000


set avegrowth 2 77 = avegrowth - %mean


cmom(corr,print) 2 77

#dmratio lagdmratio dmtrend dmcumret dmsignal lagdmsignal dmavevar


Covariance\Correlation Matrix of Coefficients

            DMRATIO     LAGDMRATIO    DMTREND      DMCUMRET     DMSIGNAL
LAGDMSIGNAL    DMAVEVAR

DMRATIO      1.000000000  0.827814554  0.860812287 -0.301450815  0.159364669
0.151421402  0.431762313

LAGDMRATIO   0.827814554  1.000000000  0.865982962 -0.098711769  0.235199352
0.182017357  0.360423983
```

```
DMTREND      0.860812287  0.865982962  1.000000000 -0.147176256  0.197705393
0.227949499  0.265795108

DMCUMRET    -0.301450815 -0.098711769 -0.147176256  1.000000000 -0.282669513 -
0.158184913 -0.564608019

DMSIGNAL     0.159364669  0.235199352  0.197705393 -0.282669513  1.000000000
0.647301849  0.519930739

LAGDMSIGNAL  0.151421402  0.182017357  0.227949499 -0.158184913  0.647301849
1.000000000  0.426143572

DMAVEVAR     0.431762313  0.360423983  0.265795108 -0.564608019  0.519930739
0.426143572  1.000000000
```

```
*model 1


linreg dmratio 2 77

#lagdmratio dmtrend
```

```
Linear Regression - Estimation by Least Squares

Dependent Variable DMRATIO

Usable Observations                      75

Degrees of Freedom                       73

Skipped/Missing (from 76)                  1

Centered R^2                     0.7770851

R-Bar^2                          0.7740315

Uncentered R^2                   0.7771948

Mean of Dependent Variable       0.0085525036

Std Error of Dependent Variable  0.3880719939

Standard Error of Estimate       0.1844744569

Sum of Squared Residuals         2.4842502441
```

```
Log Likelihood                   21.3615
Durbin-Watson Statistic              2.1134

    Variable                      Coeff      Std Error      T-Stat      Signif
****************************************************************************
*********
1.  LAGDMRATIO                 0.3085226369 0.1121844600      2.75014  0.00750536
2.  DMTREND                   0.0424061374 0.0080910538      5.24111  0.00000149



*model 2


linreg dmratio 2 77
#lagdmratio dmtrend dmcumret


Linear Regression - Estimation by Least Squares
Dependent Variable DMRATIO
Usable Observations                        75
Degrees of Freedom                         72
Skipped/Missing (from 76)                   1
Centered R^2                       0.8137229
R-Bar^2                          0.8085485
Uncentered R^2                     0.8138146
Mean of Dependent Variable       0.0085525036
Std Error of Dependent Variable  0.3880719939
Standard Error of Estimate       0.1698015483
Sum of Squared Residuals         2.0759447389
```

```
Log Likelihood                    28.0948
Durbin-Watson Statistic            2.0044

    Variable                        Coeff      Std Error      T-Stat      Signif
*******************************************************************************
*********
1.  LAGDMRATIO                    0.338201091  0.103562156      3.26568  0.00167351
2.  DMTREND                     0.038418507  0.007522507      5.10714  0.00000258
3.  DMCUMRET                    -0.061881296  0.016444036     -3.76315  0.00033932
```

```
*model 3
linreg dmratio 2 77
#lagdmratio dmtrend dmavevar
```

```
Linear Regression - Estimation by Least Squares
Dependent Variable DMRATIO
Usable Observations                       75
Degrees of Freedom                        72
Skipped/Missing (from 76)                  1
Centered R^2                    0.8100984
R-Bar^2                       0.8048234
Uncentered R^2                  0.8101919
Mean of Dependent Variable       0.0085525036
Std Error of Dependent Variable  0.3880719939
Standard Error of Estimate       0.1714455427
Sum of Squared Residuals         2.1163373350
```

```
Log Likelihood                    27.3722

Durbin-Watson Statistic            1.8963


   Variable                      Coeff      Std Error      T-Stat      Signif

*******************************************************************************
*********

1.  LAGDMRATIO                0.2145626571 0.1075905490      1.99425  0.04991185

2.  DMTREND                 0.0446668680 0.0075467071      5.91872  0.00000010

3.  DMAVEVAR                6.0117448283 1.6992380476      3.53791  0.00071047




*model 4

linreg dmratio 2 77

#lagdmratio dmtrend dmsignal


Linear Regression - Estimation by Least Squares

Dependent Variable DMRATIO

Usable Observations                      72

Degrees of Freedom                       69

Skipped/Missing (from 76)                   4

Centered R^2                      0.7688847

R-Bar^2                         0.7621857

Uncentered R^2                    0.7691475

Mean of Dependent Variable       -0.012739036

Std Error of Dependent Variable   0.380218266

Standard Error of Estimate        0.185418031
```

```
Sum of Squared Residuals        2.3722093933

Log Likelihood                  20.6988

Durbin-Watson Statistic              2.1335


   Variable                     Coeff      Std Error      T-Stat      Signif

***************************************************************************
*********

1.  LAGDMRATIO                  0.332001672  0.115184274      2.88235  0.00525788

2.  DMTREND                   0.041834314  0.008408306      4.97536  0.00000458

3.  DMSIGNAL                 -0.049673309  0.088944938     -0.55847  0.57832957




*model 5

linreg dmratio 2 77

#lagdmratio dmtrend avegrowth


Linear Regression - Estimation by Least Squares

Dependent Variable DMRATIO

Usable Observations                      63

Degrees of Freedom                       60

Skipped/Missing (from 76)                13

Centered R^2                     0.6726303

R-Bar^2                          0.6617180

Uncentered R^2                   0.7054927

Mean of Dependent Variable       0.1096396588

Std Error of Dependent Variable  0.3308571671

Standard Error of Estimate       0.1924332060
```

```
Sum of Squared Residuals        2.2218323266

Log Likelihood                     15.9682

Durbin-Watson Statistic              2.1310


   Variable                     Coeff      Std Error      T-Stat      Signif

****************************************************************************
*********

1.  LAGDMRATIO                 0.3008615942 0.1282126838      2.34658  0.02226644

2.  DMTREND                  0.0412887954 0.0089877542      4.59389  0.00002284

3.  AVEGROWTH                  0.0006464969 0.0039994535      0.16165  0.87212748




*model 6

linreg dmratio 2 77

#lagdmratio dmtrend dmcumret dmavevar dmsignal


Linear Regression - Estimation by Least Squares

Dependent Variable DMRATIO

Usable Observations                        72

Degrees of Freedom                         67

Skipped/Missing (from 76)                   4

Centered R^2                       0.8256182

R-Bar^2                          0.8152074

Uncentered R^2                     0.8258165

Mean of Dependent Variable       -0.012739036

Std Error of Dependent Variable   0.380218266
```

```
Standard Error of Estimate      0.163446380

Sum of Squared Residuals        1.7898861746

Log Likelihood                30.8389

Durbin-Watson Statistic             2.0269


   Variable                      Coeff      Std Error      T-Stat      Signif

*******************************************************************************
*********

1.  LAGDMRATIO                0.282971894  0.108179523      2.61576  0.01099022

2.  DMTREND                   0.041774329  0.007642832      5.46582  0.00000073

3.  DMCUMRET                 -0.039918718  0.019852742     -2.01074  0.04837985

4.  DMAVEVAR                  5.502498155  2.252280468      2.44308  0.01720464

5.  DMSIGNAL                 -0.228126413  0.089474761     -2.54962  0.01307859
```

```
*model 7

linreg dmratio 2 77

#lagdmratio dmtrend dmcumret dmavevar avegrowth
```

```
Linear Regression - Estimation by Least Squares

Dependent Variable DMRATIO

Usable Observations                     63

Degrees of Freedom                      58

Skipped/Missing (from 76)               13

Centered R^2                    0.7676571

R-Bar^2                       0.7516334
```

```
Uncentered R^2                  0.7909804
Mean of Dependent Variable       0.1096396588
Std Error of Dependent Variable  0.3308571671
Standard Error of Estimate       0.1648872746
Sum of Squared Residuals         1.5768931734
Log Likelihood                   26.7687
Durbin-Watson Statistic            2.0517


   Variable                  Coeff      Std Error      T-Stat      Signif
********************************************************************************
*********
1.  LAGDMRATIO                0.301517756  0.118245412      2.54993  0.01343889
2.  DMTREND                  0.040708337  0.008250931      4.93379  0.00000714
3.  DMCUMRET                 -0.039713942  0.022275231     -1.78287  0.07984007
4.  DMAVEVAR                  6.423558097  2.447267353      2.62479  0.01106567
5.  AVEGROWTH                 0.010940105  0.004131525      2.64796  0.01041254
```

```
* correlation matrix of the explanatory variables


cmom(print,correlate) 2 77
#dmtrend lagdmratio dmcumret dmsignal avegrowth dmavevar
```

```
Covariance\Correlation Matrix of Coefficients
           DMTREND    LAGDMRATIO    DMCUMRET    DMSIGNAL    AVEGROWTH
DMAVEVAR
```

```
DMTREND     1.000000000  0.799204734 -0.203558028  0.461532597 -0.353475804
0.193584914

LAGDMRATIO  0.799204734  1.000000000 -0.103080974  0.498454687 -0.423458091
0.320578341

DMCUMRET   -0.203558028 -0.103080974  1.000000000 -0.345041419  0.353708220 -
0.600976259

DMSIGNAL    0.461532597  0.498454687 -0.345041419  1.000000000 -0.891578359
0.630229733

AVEGROWTH  -0.353475804 -0.423458091  0.353708220 -0.891578359  1.000000000 -
0.623205531

DMAVEVAR    0.193584914  0.320578341 -0.600976259  0.630229733 -0.623205531
1.000000000
```

```
* create daily versions of the quarterly signals with  values during each quarter


declare integer dayquarter lagdayquarter


statistics(fractiles) qindex
```

```
Statistics on Series QINDEX

Observations              4788

Sample Mean           39.669382      Variance             482.045463

Standard Error        21.955534      SE of Sample Mean       0.317298

t-Statistic (Mean=0) 125.022593      Signif Level (Mean=0)   0.000000

Skewness             -0.011176      Signif Level (Sk=0)     0.752303

Kurtosis (excess)     -1.200888      Signif Level (Ku=0)     0.000000

Jarque-Bera          287.805065      Signif Level (JB=0)     0.000000


Minimum               2.000000      Maximum               77.000000
```

```
01-%ile          2.000000     99-%ile          77.000000
05-%ile          5.000000     95-%ile          74.000000
10-%ile          9.000000     90-%ile          70.000000
25-%ile         21.000000     75-%ile          59.000000
Median          40.000000
```

```
do i = 1,4788
(01.0042)
(01.0042) compute dayquarter = fix(qindex(i))
(01.0066) compute lagdayquarter = fix(qindex(i))-1
(01.0095)
(01.0095) set qcumretdaily i i = qcumret(dayquarter)
(01.0147) set qavevardaily i i = qavevar(dayquarter)
(01.0199) set qsignaldaily i i = qsignal(dayquarter)
(01.0251) set avegrowthdaily i i = avegrowth(dayquarter)
(01.0303) set qavecorrdaily i i = qavecorr(dayquarter)
(01.0355) set qtrenddaily i i = trend(dayquarter)
(01.0407) set lagqcumretdaily i i = qcumret(lagdayquarter)
(01.0459) set lagqavevardaily i i = qavevar(lagdayquarter)
(01.0511) set lagqsignaldaily i i = qsignal(lagdayquarter)
(01.0563) set lagqavecorrdaily i i = qavecorr(lagdayquarter)
(01.0615)
(01.0615) end do i
open dailysignals c:\eurovol\output\dailysignals.txt
copy(unit=dailysignals,format='(9(f15.10))',org=obs) 1 4788 qcumretdaily qavevardaily avegrowthdaily $
qsignaldaily qtrenddaily lagqcumretdaily lagqavevardaily lagqavecorrdaily lagqsignaldaily
```

```
*truedailysignals.txt this program computes daily signals

alloc 22 4788

open rets c:\eurovol\output\rets.txt

data(unit=rets,format=free,org=obs) 1 4788 1 2 3 4 5 6 7 8 9 10 11


do i= 260, 4788

(01.0041)

(01.0041) compute end = i

(01.0059) compute start = end - 260

(01.0082)

(01.0082) if start < 1

(02.0103) {

(03.0103) compute start = 1

(03.0119) }

(02.0119)

(02.0119)

(02.0119) *compute the rolling-window sample correlation matrix for a quarter-year

(02.0119) * and the average correlation within it

(02.0119) * also cumulative return within the quarter

(02.0119)

(02.0119) set samp 1 4788 = 0.0

(01.0161) set samp start end = 1.0

(01.0208)

(01.0208) cmom(noprint,correlation,centered,smpl=samp)

(01.0233) # 1 2 3 4 5 6 7 8 9 10 11

(01.0335) compute correl = %cmom

(01.0353) compute avecorr = 0.0
```

```
(01.0370)

(01.0370)

(01.0370) *average correlation

(01.0370) do jj = 1,10

(02.0405) compute jjp1 = jj + 1

(02.0428) do jjj = jjp1,11

(03.0465) compute avecorr = avecorr + correl(jj,jjj)/55.0

(03.0505) end do jjj

(02.0507) end do jj

(01.0509)

(01.0509) * now average variance

(01.0509) cmom(noprint,centered,smpl=samp)

(01.0532) # 1 2 3 4 5 6 7 8 9 10 11

(01.0634) compute cmom = %cmom

(01.0652) compute avevar = 0.0

(01.0669)

(01.0669)

(01.0669) *average variance

(01.0669) do jj = 1,11

(02.0704) compute avevar = avevar + cmom(jj,jj)/11.0

(02.0744) end do jj

(01.0746)

(01.0746)

(01.0746)

(01.0746) set qavecorr i i = avecorr

(01.0793) set qavevar i i = avevar

(01.0840)
```

```
(01.0840) * now equally-weighted cumulative return for the quarter
(01.0840) compute ewcumret = 0.0
(01.0857) do k = 1,11
(02.0892) set ret / = [series] k
(02.0924) statistics(noprint,smpl=samp) ret
(02.0956) compute ewcumret = ewcumret + %nobs*%mean
(02.0990) end do k
(01.0992) set qcumret i i = ewcumret
(01.1039)
(01.1039)
(01.1039) end do j

* save the average correlations, average variance and average cumulative returns
open truedailysigs c:\eurovol\output\truedailysigs.txt
copy(unit=truedailysigs,format='(3(f15.10))',org=obs) 260 4788 qavecorr qavevar qcumret
```

```
*maxlike5models.txt this program estimates dynamic macroeconomic models of the correlation magnitude
* using maximum likelihood
* with corr0
* for five selected specifications

alloc 60 4788
open eta c:\eurovol\output\eta.txt
open dailysignals c:\eurovol\output\dailysignals.txt
open truedailysigs c:\eurovol\output\truedailysigs.txt
open phicoeffs6 c:\eurovol\output\phicoeffs6.txt
open phicoeffs7 c:\eurovol\output\phicoeffs7.txt
open covs6 c:\eurovol\output\covs6.txt
open covs7 c:\eurovol\output\covs7.txt
open corr0 c:\eurovol\output\corr0.txt
open ecorr0 c:\eurovol\output\ecorr0.txt
open ssdrvs6 c:\eurovol\output\ssdrvs6.txt
open ssdrvs7 c:\eurovol\output\ssdrvs7.txt



data(unit=eta,format=free,org=vars) 261 4788 e1 e2 e3 e4 e5 e6 $
e7 e8 e9 e10 e11
data(unit=dailysignals,format=free,org=obs) 1 4788 qcumret qavevar avegrowth $
qsignal qtrend lagqcumret lagqavevar lagqavecorr lagqsignal
data(unit=truedailysigs,format=free,org=obs) 260 4788 tdavecorr tdavevar tdcumret
```

```
* de-mean the six explanatory variables


statistics qsignal


Statistics on Series QSIGNAL

Observations              4788

Sample Mean            0.205696      Variance           0.061052

Standard Error         0.247087      of Sample Mean      0.003571

t-Statistic (Mean=0)   57.604146      Signif Level        0.000000

Skewness               1.657506      Signif Level (Sk=0) 0.000000

Kurtosis (excess)       2.278704      Signif Level (Ku=0) 0.000000

Jarque-Bera          3228.269338      Signif Level (JB=0) 0.000000


set qsignal / = qsignal - %mean


statistics lagqsignal


Statistics on Series LAGQSIGNAL

Observations              4788

Sample Mean            0.205322      Variance           0.061082

Standard Error         0.247148      of Sample Mean      0.003572

t-Statistic (Mean=0)   57.485019      Signif Level        0.000000

Skewness               1.666989      Signif Level (Sk=0) 0.000000

Kurtosis (excess)       2.280875      Signif Level (Ku=0) 0.000000

Jarque-Bera          3255.402356      Signif Level (JB=0) 0.000000
```

```
set lagqsignal / = lagqsignal - %mean


statistics tdavecorr


Statistics on Series TDAVECORR
Observations              4529
Sample Mean           0.535547      Variance           0.030712
Standard Error        0.175249      of Sample Mean      0.002604
t-Statistic (Mean=0) 205.656653      Signif Level        0.000000
Skewness             -0.261659      Signif Level (Sk=0) 0.000000
Kurtosis (excess)     -1.036007      Signif Level (Ku=0) 0.000000
Jarque-Bera          254.222779      Signif Level (JB=0) 0.000000


set ratio / = (tdavecorr{1} - %mean)/(1.0-%mean)


statistics tdavevar


Statistics on Series TDAVEVAR
Observations               4529
Sample Mean            0.054274      Variance           0.001500
Standard Error         0.038725      of Sample Mean      0.000575
t-Statistic (Mean=0)   94.320011      Signif Level        0.000000
Skewness               1.492091      Signif Level (Sk=0) 0.000000
Kurtosis (excess)       2.374317      Signif Level (Ku=0) 0.000000
Jarque-Bera          2744.332817      Signif Level (JB=0) 0.000000


set avevar / = tdavevar{1} - %mean
```

```
statistics tdcumret


Statistics on Series TDCUMRET
Observations              4529
Sample Mean           0.711834      Variance           8.208044
Standard Error        2.864968      of Sample Mean      0.042571
t-Statistic (Mean=0)  16.720919      Signif Level        0.000000
Skewness             -1.010469      Signif Level (Sk=0) 0.000000
Kurtosis (excess)      0.936317      Signif Level (Ku=0) 0.000000
Jarque-Bera          936.159656      Signif Level (JB=0) 0.000000


set cumret / = tdcumret{1} - %mean


statistics avegrowth


Statistics on Series AVEGROWTH
Observations                3973
Sample Mean             0.002014      Variance           44.297485
Standard Error          6.655636      of Sample Mean      0.105592
t-Statistic (Mean=0)     0.019075      Signif Level        0.984782
Skewness               -2.724543      Signif Level (Sk=0) 0.000000
Kurtosis (excess)       10.191524      Signif Level (Ku=0) 0.000000
Jarque-Bera          22109.692376      Signif Level (JB=0) 0.000000


set avegrowth / = avegrowth - %mean
```

```
* set trend to match the annual scale per unit time

set trend / = t/261.0

statistics trend


Statistics on Series TREND

Observations              4788

Sample Mean           9.174330      Variance           28.050249

Standard Error        5.296249      of Sample Mean      0.076540

t-Statistic (Mean=0) 119.862421      Signif Level        0.000000

Skewness              0.000000      Signif Level (Sk=0) 1.000000

Kurtosis (excess)     -1.200000      Signif Level (Ku=0) 0.000000

Jarque-Bera          287.280000      Signif Level (JB=0) 0.000000


set trend / = trend - %mean




*find the unconditional correlation matrix of standardized returns

cmom(corr,matrix=corr0) 261 4788

# e1 e2 e3 e4 e5 e6 e7 e8 e9 e10 e11


compute sampcorr0 = corr0


display(unit=corr0) corr0


*set up a unit matrix

declare symmetric unitmat(11,11)

do j = 1,11
```

```
(01.0041) do jj = 1,11

(02.0076) compute unitmat(j,jj) = 1.0

(02.0102) end do jj

(01.0104) end do j



* first do each estimation without corr0 and then with corr0


* model 1


compute b1 = 0.0

compute b2 = 0.0


compute corr0 = sampcorr0


nonlin b1 b2

frml m = (b1*ratio+b2*trend)


* set up the likelihood objective function


dec frml[vect] ufrml

frml ufrml = ||e1,e2,e3,e4,e5,e6,e7,e8,e9,e10,e11||

dec frml[symmetric] sigma

frml sigma = (m)*unitmat + (1.0 - m)*corr0

frml mvlike = %logdensity(sigma,ufrml)


display 'model 1 w/o corr0'
```

```
model 1 w/o corr0

maximize(method=bhhh) mvlike 261 4788


MAXIMIZE - Estimation by BHHH

Convergence in    27 Iterations. Final criterion was  0.0000084 <=  0.0000100

Usable Observations   4528

Function Value                 -52041.46258432


    Variable                   Coeff      Std Error      T-Stat      Signif

******************************************************************************

1.  B1                    0.5204831482 0.0230291303     22.60108  0.00000000

2.  B2                    0.0313344074 0.0015525932     20.18198  0.00000000



compute corr0 = sampcorr0



nonlin b1 b2 corr0 corr0(1,1)==1.0 corr0(2,2)==1.0 corr0(3,3)==1.0 $

corr0(4,4)==1.0 corr0(5,5)==1.0 corr0(6,6)==1.0 corr0(7,7)==1.0 corr0(8,8)==1.0 $

corr0(9,9)==1.0 corr0(10,10)==1.0 corr0(11,11)==1.0


frml m = (b1*ratio+b2*trend)

display 'model 1 w corr0'

model 1 w corr0

maximize(derives=ssdrvs1,method=bhhh) mvlike 261 4788
```

```
MAXIMIZE - Estimation by BHHH

Convergence in    19 Iterations. Final criterion was  0.0000060 <=  0.0000100

Usable Observations   4528

Function Value                 -51990.23251982


    Variable                   Coeff      Std Error      T-Stat      Signif

*****************************************************************************
*****

1.  B1                    0.5180756581 0.0256643153     20.18662  0.00000000

2.  B2                    0.0319794298 0.0018377156     17.40173  0.00000000

3.  CORR0(1,1)            1.0000000000 0.0000000000      0.00000  0.00000000

4.  CORR0(2,1)            0.5087212137 0.0080216014     63.41891  0.00000000

5.  CORR0(2,2)            1.0000000000 0.0000000000      0.00000  0.00000000

6.  CORR0(3,1)            0.4597543740 0.0089375095     51.44099  0.00000000

7.  CORR0(3,2)            0.5449841242 0.0069424063     78.50075  0.00000000

8.  CORR0(3,3)            1.0000000000 0.0000000000      0.00000  0.00000000

9.  CORR0(4,1)            0.5071193224 0.0089188335     56.85938  0.00000000

10. CORR0(4,2)            0.7082391973 0.0048166160    147.04083  0.00000000

11. CORR0(4,3)            0.6288964167 0.0058664853    107.20157  0.00000000

12. CORR0(4,4)            1.0000000000 0.0000000000      0.00000  0.00000000

13. CORR0(5,1)            0.5505656453 0.0072482594     75.95833  0.00000000

14. CORR0(5,2)            0.6825646859 0.0052381875    130.30551  0.00000000

15. CORR0(5,3)            0.6212707095 0.0059586014    104.26452  0.00000000

16. CORR0(5,4)            0.8053230593 0.0029731693    270.86350  0.00000000

17. CORR0(5,5)            1.0000000000 0.0000000000      0.00000  0.00000000

18. CORR0(6,1)            0.3244047904 0.0100151883     32.39128  0.00000000

19. CORR0(6,2)            0.3370737178 0.0103200619     32.66199  0.00000000
```

```
20. CORR0(6,3)          0.3135878194 0.0105796731     29.64060  0.00000000
21. CORR0(6,4)          0.3284631995 0.0107065134     30.67882  0.00000000
22. CORR0(6,5)          0.3239723310 0.0103215825     31.38785  0.00000000
23. CORR0(6,6)          1.0000000000 0.0000000000      0.00000  0.00000000
24. CORR0(7,1)          0.4464489662 0.0090437286     49.36559  0.00000000
25. CORR0(7,2)          0.5033462798 0.0082447670     61.05039  0.00000000
26. CORR0(7,3)          0.4775227499 0.0080527792     59.29912  0.00000000
27. CORR0(7,4)          0.5221301770 0.0089716257     58.19794  0.00000000
28. CORR0(7,5)          0.5159762385 0.0083459681     61.82341  0.00000000
29. CORR0(7,6)          0.3021505764 0.0102634543     29.43946  0.00000000
30. CORR0(7,7)          1.0000000000 0.0000000000      0.00000  0.00000000
31. CORR0(8,1)          0.4711140245 0.0092391681     50.99096  0.00000000
32. CORR0(8,2)          0.6314842305 0.0062372984    101.24323  0.00000000
33. CORR0(8,3)          0.5610312064 0.0069164307     81.11571  0.00000000
34. CORR0(8,4)          0.7701504627 0.0035883724    214.62390  0.00000000
35. CORR0(8,5)          0.7171145317 0.0044367415    161.63090  0.00000000
36. CORR0(8,6)          0.3045953596 0.0109070713     27.92641  0.00000000
37. CORR0(8,7)          0.4689463066 0.0093300870     50.26173  0.00000000
38. CORR0(8,8)          1.0000000000 0.0000000000      0.00000  0.00000000
39. CORR0(9,1)          0.5348447331 0.0078447421     68.17875  0.00000000
40. CORR0(9,2)          0.7357978700 0.0039844410    184.66778  0.00000000
41. CORR0(9,3)          0.6503092754 0.0054908000    118.43616  0.00000000
42. CORR0(9,4)          0.8353957650 0.0026939965    310.09534  0.00000000
43. CORR0(9,5)          0.8020151249 0.0031588956    253.89099  0.00000000
44. CORR0(9,6)          0.3382846257 0.0105513213     32.06088  0.00000000
45. CORR0(9,7)          0.5437496617 0.0080479383     67.56385  0.00000000
46. CORR0(9,8)          0.7277744613 0.0043661400    166.68601  0.00000000
```

```
47. CORR0(9,9)               1.0000000000 0.0000000000      0.00000  0.00000000
48. CORR0(10,1)              0.4095472835 0.0091647309     44.68732  0.00000000
49. CORR0(10,2)              0.4833264128 0.0077873640     62.06547  0.00000000
50. CORR0(10,3)              0.4599993702 0.0082246837     55.92913  0.00000000
51. CORR0(10,4)              0.5131922883 0.0081564025     62.91895  0.00000000
52. CORR0(10,5)              0.5085989412 0.0081018211     62.77588  0.00000000
53. CORR0(10,6)              0.3123846021 0.0106551358     29.31775  0.00000000
54. CORR0(10,7)              0.3995175615 0.0092352437     43.26010  0.00000000
55. CORR0(10,8)              0.4778262674 0.0083827614     57.00106  0.00000000
56. CORR0(10,9)              0.5072978322 0.0077064296     65.82787  0.00000000
57. CORR0(10,10)             1.0000000000 0.0000000000      0.00000  0.00000000
58. CORR0(11,1)              0.4927464561 0.0092460896     53.29242  0.00000000
59. CORR0(11,2)              0.6457450858 0.0058526689    110.33344  0.00000000
60. CORR0(11,3)              0.5796053050 0.0067563997     85.78612  0.00000000
61. CORR0(11,4)              0.7861526906 0.0032105356    244.86653  0.00000000
62. CORR0(11,5)              0.7267741794 0.0043240787    168.07607  0.00000000
63. CORR0(11,6)              0.3168232200 0.0108221724     29.27538  0.00000000
64. CORR0(11,7)              0.4804842350 0.0091034529     52.78044  0.00000000
65. CORR0(11,8)              0.7255032120 0.0041616813    174.32936  0.00000000
66. CORR0(11,9)              0.7398400972 0.0036906181    200.46509  0.00000000
67. CORR0(11,10)             0.5323989959 0.0073221648     72.71060  0.00000000
68. CORR0(11,11)             1.0000000000 0.0000000000      0.00000  0.00000000
```

```
compute phicoeffs1 = %beta

display(unit=corr0) corr0
```

```
* output the scores, skipping the diagonal entries of the correlation matrix estimates

do param=1,2

(01.0041) compute jj = param

(01.0059) set [series] jj = ssdrvs1(param)

(01.0096) end do param

compute param = 2

compute place = 2

* write out the scores skipping the diagonal entries

do h=1,11

(01.0041) do hh = h,11

(02.0078) compute place = place +1

(02.0101) if hh > h

(03.0124) {

(04.0124) compute param = param+1

(04.0147) set [series] param / = ssdrvs1(place)

(04.0184) }

(03.0184)

(03.0184) end do hh

(01.0186) end do h



cmom 261 4788

# 1 2 3 4 5 $

6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 $

21 22 23 24 25 26 27 28 29 30 $

31 32 33 34 35 36 37 38 39 40 $
```

```
41 42 43 44 45 46 47 48 49 50 $

51 52 53 54 55 56 57


compute covs1 = inv(%cmom)

display (covs1(1,1))**.5

      0.02480

display (covs1(2,2))**.5

      0.00173

display phicoeffs1(1)/(covs1(1,1))**.5

     20.89177

display phicoeffs1(2)/(covs1(2,2))**.5

     18.46816


*model 2


compute b1 = 0.0

compute b2 = 0.0

compute b3 = 0.0


compute corr0 = sampcorr0


nonlin b1 b2 b3

frml m = (b1*ratio+b2*trend+b3*cumret)

display 'model 2 w/o corr0'

model 2 w/o corr0

maximize(method=bhhh) mvlike 261 4788
```

```
MAXIMIZE - Estimation by BHHH
Convergence in    27 Iterations. Final criterion was  0.0000088 <=  0.0000100
Usable Observations   4528
Function Value                 -52040.34023979

    Variable                    Coeff      Std Error      T-Stat      Signif
*******************************************************************************
1.  B1                    0.5354755766 0.0243720987     21.97084  0.00000000
2.  B2                    0.0309208998 0.0015805758     19.56306  0.00000000
3.  B3                    0.0024830985 0.0010402410      2.38704  0.01698457
```

```
compute corr0 = sampcorr0
```

```
nonlin b1 b2 b3 corr0 corr0(1,1)==1.0 corr0(2,2)==1.0 corr0(3,3)==1.0 $
corr0(4,4)==1.0 corr0(5,5)==1.0 corr0(6,6)==1.0 corr0(7,7)==1.0 corr0(8,8)==1.0 $
corr0(9,9)==1.0 corr0(10,10)==1.0 corr0(11,11)==1.0
frml m = (b1*ratio+b2*trend+b3*cumret)
display 'model 2 w corr0'
model 2 w corr0
maximize(derives=ssdrvs2,method=bhhh) mvlike 261 4788
```

```
MAXIMIZE - Estimation by BHHH
Convergence in    19 Iterations. Final criterion was  0.0000074 <=  0.0000100
Usable Observations   4528
```

```
Function Value              -51989.13682797


   Variable                Coeff     Std Error     T-Stat     Signif
****************************************************************************
*****
1.  B1                    0.532997     0.026547     20.07777  0.00000000
2.  B2                    0.031555     0.001817     17.36637  0.00000000
3.  B3                    0.002425     0.001224      1.98150  0.04753523
4.  CORR0(1,1)                1.000000     0.000000      0.00000  0.00000000
5.  CORR0(2,1)                0.509180     0.008029     63.41689  0.00000000
6.  CORR0(2,2)                1.000000     0.000000      0.00000  0.00000000
7.  CORR0(3,1)                0.460180     0.008936     51.49481  0.00000000
8.  CORR0(3,2)                0.545201     0.006931     78.66524  0.00000000
9.  CORR0(3,3)                1.000000     0.000000      0.00000  0.00000000
10. CORR0(4,1)                0.507509     0.008927     56.85292  0.00000000
11. CORR0(4,2)                0.708488     0.004818    147.04716  0.00000000
12. CORR0(4,3)                0.628871     0.005849    107.50955  0.00000000
13. CORR0(4,4)                1.000000     0.000000      0.00000  0.00000000
14. CORR0(5,1)                0.551073     0.007275     75.74931  0.00000000
15. CORR0(5,2)                0.682885     0.005237    130.40798  0.00000000
16. CORR0(5,3)                0.621404     0.005962    104.22400  0.00000000
17. CORR0(5,4)                0.805358     0.002976    270.61968  0.00000000
18. CORR0(5,5)                1.000000     0.000000      0.00000  0.00000000
19. CORR0(6,1)                0.324643     0.009991     32.49238  0.00000000
20. CORR0(6,2)                0.337341     0.010324     32.67470  0.00000000
21. CORR0(6,3)                0.313746     0.010572     29.67614  0.00000000
22. CORR0(6,4)                0.328665     0.010697     30.72547  0.00000000
```

```
23. CORR0(6,5)          0.324131    0.010302     31.46235  0.00000000
24. CORR0(6,6)          1.000000    0.000000 6.07400e+009  0.00000000
25. CORR0(7,1)          0.446714    0.008794     50.80006  0.00000000
26. CORR0(7,2)          0.503496    0.008010     62.86164  0.00000000
27. CORR0(7,3)          0.477762    0.008010     59.64544  0.00000000
28. CORR0(7,4)          0.522244    0.008874     58.84771  0.00000000
29. CORR0(7,5)          0.516370    0.008134     63.48671  0.00000000
30. CORR0(7,6)          0.302208    0.010188     29.66349  0.00000000
31. CORR0(7,7)          1.000000    0.000000      0.00000  0.00000000
32. CORR0(8,1)          0.471523    0.009251     50.97144  0.00000000
33. CORR0(8,2)          0.631774    0.006236    101.30671  0.00000000
34. CORR0(8,3)          0.561033    0.006921     81.05980  0.00000000
35. CORR0(8,4)          0.770166    0.003590    214.54870  0.00000000
36. CORR0(8,5)          0.717172    0.004469    160.48284  0.00000000
37. CORR0(8,6)          0.304927    0.010899     27.97739  0.00000000
38. CORR0(8,7)          0.469170    0.009178     51.11672  0.00000000
39. CORR0(8,8)          1.000000    0.000000      0.00000  0.00000000
40. CORR0(9,1)          0.535260    0.007849     68.19375  0.00000000
41. CORR0(9,2)          0.735922    0.003965    185.62490  0.00000000
42. CORR0(9,3)          0.650298    0.005471    118.86963  0.00000000
43. CORR0(9,4)          0.835273    0.002703    309.00646  0.00000000
44. CORR0(9,5)          0.802135    0.003153    254.38919  0.00000000
45. CORR0(9,6)          0.338378    0.010535     32.11872  0.00000000
46. CORR0(9,7)          0.543863    0.007957     68.34992  0.00000000
47. CORR0(9,8)          0.727742    0.004367    166.65307  0.00000000
48. CORR0(9,9)          1.000000    0.000000      0.00000  0.00000000
49. CORR0(10,1)          0.409627    0.009154     44.74797  0.00000000
```

```
50. CORR0(10,2)          0.483376    0.007797    61.99671  0.00000000
51. CORR0(10,3)          0.459770    0.008229    55.87230  0.00000000
52. CORR0(10,4)          0.513060    0.008169    62.80590  0.00000000
53. CORR0(10,5)          0.508635    0.008089    62.87641  0.00000000
54. CORR0(10,6)          0.312341    0.010640    29.35443  0.00000000
55. CORR0(10,7)          0.399659    0.009143    43.71083  0.00000000
56. CORR0(10,8)          0.477799    0.008409    56.81944  0.00000000
57. CORR0(10,9)          0.507139    0.007725    65.64866  0.00000000
58. CORR0(10,10)          1.000000    0.000000     0.00000  0.00000000
59. CORR0(11,1)          0.493119    0.009239    53.37427  0.00000000
60. CORR0(11,2)          0.645936    0.005844   110.53024  0.00000000
61. CORR0(11,3)          0.579497    0.006759    85.73904  0.00000000
62. CORR0(11,4)          0.786016    0.003215   244.45323  0.00000000
63. CORR0(11,5)          0.726760    0.004379   165.97414  0.00000000
64. CORR0(11,6)          0.317040    0.010802    29.34961  0.00000000
65. CORR0(11,7)          0.480503    0.009052    53.08061  0.00000000
66. CORR0(11,8)          0.725496    0.004164   174.24420  0.00000000
67. CORR0(11,9)          0.739664    0.003712   199.26375  0.00000000
68. CORR0(11,10)          0.532422    0.007304    72.89502  0.00000000
69. CORR0(11,11)          1.000000    0.000000     0.00000  0.00000000
```

```
compute phicoeffs2 = %beta

display(unit=corr0) corr0



* output the scores, skipping the diagonal entries of the correlation matrix estimates
```

```
do param=1,3

(01.0041) compute jj = param

(01.0059) set [series] jj = ssdrvs2(param)

(01.0096) end do param

compute param = 3

compute place = 3

* write out the scores skipping the diagonal entries

do h=1,11

(01.0041) do hh = h,11

(02.0078) compute place = place +1

(02.0101) if hh > h

(03.0124) {

(04.0124) compute param = param+1

(04.0147) set [series] param / = ssdrvs2(place)

(04.0184) }

(03.0184)

(03.0184) end do hh

(01.0186) end do h



cmom 261 4788

# 1 2 3 4 5 $

6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 $

21 22 23 24 25 26 27 28 29 30 $

31 32 33 34 35 36 37 38 39 40 $

41 42 43 44 45 46 47 48 49 50 $

51 52 53 54 55 56 57 58
```

```
compute covs2 = inv(%cmom)

display (covs2(1,1))**.5

      0.02596

display (covs2(2,2))**.5

      0.00174

display (covs2(3,3))**.5

      0.00107

display phicoeffs2(1)/(covs2(1,1))**.5

     20.52858

display phicoeffs2(2)/(covs2(2,2))**.5

     18.11304

display phicoeffs2(3)/(covs2(3,3))**.5

      2.26489



*model 3


compute b1 = 0.0

compute b2 = 0.0

compute b4 = 0.0



compute corr0 = sampcorr0



nonlin b1 b2 b4
```

```
frml m = (b1*ratio+b2*trend+b4*avevar)
display 'model 3 w/o corr0'
model 3 w/o corr0
maximize(method=bhhh) mvlike 261 4788

MAXIMIZE - Estimation by BHHH
Convergence in    37 Iterations. Final criterion was  0.0000091 <=  0.0000100
Usable Observations   4528
Function Value                 -52041.11106989

    Variable                   Coeff      Std Error      T-Stat      Signif
***************************************************************************
*****
1.  B1                    0.5120936810 0.0241635900     21.19278  0.00000000
2.  B2                    0.0315566756 0.0015878427     19.87393  0.00000000
3.  B4                    0.1013186592 0.0704940505      1.43727  0.15064260



compute corr0 = sampcorr0

nonlin b1 b2 b4 corr0 corr0(1,1)==1.0 corr0(2,2)==1.0 corr0(3,3)==1.0 $
corr0(4,4)==1.0 corr0(5,5)==1.0 corr0(6,6)==1.0 corr0(7,7)==1.0 corr0(8,8)==1.0 $
corr0(9,9)==1.0 corr0(10,10)==1.0 corr0(11,11)==1.0
frml m = (b1*ratio+b2*trend+b4*avevar)
display 'model 3 w corr0'
model 3 w corr0
```

```
maximize(derives=ssdrvs3,method=bhhh) mvlike 261 4788


MAXIMIZE - Estimation by BHHH

Convergence in    22 Iterations. Final criterion was  0.0000073 <=  0.0000100

Usable Observations   4528

Function Value              -51989.82988760


    Variable                    Coeff      Std Error      T-Stat      Signif

***************************************************************************
*****

1.  B1                      0.508626     0.027578     18.44301  0.00000000

2.  B2                      0.032252     0.001808     17.83584  0.00000000

3.  B4                      0.107742     0.091512      1.17736  0.23905179

4.  CORR0(1,1)                  1.000000     0.000000      0.00000  0.00000000

5.  CORR0(2,1)                  0.508448     0.008044     63.21061  0.00000000

6.  CORR0(2,2)                  1.000000     0.000000 3.50683e+009  0.00000000

7.  CORR0(3,1)                  0.459404     0.008909     51.56618  0.00000000

8.  CORR0(3,2)                  0.544766     0.006845     79.58217  0.00000000

9.  CORR0(3,3)                  1.000000     0.000000      0.00000  0.00000000

10. CORR0(4,1)                  0.506827     0.008926     56.77938  0.00000000

11. CORR0(4,2)                  0.707998     0.004813    147.08891  0.00000000

12. CORR0(4,3)                  0.628809     0.005565    112.98802  0.00000000

13. CORR0(4,4)                  1.000000     0.000000      0.00000  0.00000000

14. CORR0(5,1)                  0.550232     0.007273     75.65049  0.00000000

15. CORR0(5,2)                  0.682310     0.005292    128.93280  0.00000000

16. CORR0(5,3)                  0.621149     0.005778    107.49471  0.00000000

17. CORR0(5,4)                  0.805297     0.003003    268.20269  0.00000000
```

```
18. CORR0(5,5)          1.000000    0.000000     0.00000  0.00000000
19. CORR0(6,1)          0.323939    0.010060    32.19917  0.00000000
20. CORR0(6,2)          0.336600    0.010397    32.37503  0.00000000
21. CORR0(6,3)          0.313112    0.010582    29.58893  0.00000000
22. CORR0(6,4)          0.328000    0.010725    30.58206  0.00000000
23. CORR0(6,5)          0.323553    0.010353    31.25182  0.00000000
24. CORR0(6,6)          1.000000    0.000000     0.00000  0.00000000
25. CORR0(7,1)          0.446263    0.008429    52.94367  0.00000000
26. CORR0(7,2)          0.503028    0.006231    80.73452  0.00000000
27. CORR0(7,3)          0.477296    0.007891    60.48313  0.00000000
28. CORR0(7,4)          0.521911    0.008297    62.90322  0.00000000
29. CORR0(7,5)          0.515677    0.007582    68.01523  0.00000000
30. CORR0(7,6)          0.301768    0.009706    31.09152  0.00000000
31. CORR0(7,7)          1.000000    0.000000     0.00000  0.00000000
32. CORR0(8,1)          0.470828    0.009268    50.80244  0.00000000
33. CORR0(8,2)          0.631283    0.006272   100.65414  0.00000000
34. CORR0(8,3)          0.560968    0.006745    83.16582  0.00000000
35. CORR0(8,4)          0.770139    0.003624   212.53109  0.00000000
36. CORR0(8,5)          0.717078    0.004555   157.42230  0.00000000
37. CORR0(8,6)          0.304106    0.010933    27.81527  0.00000000
38. CORR0(8,7)          0.468725    0.008713    53.79379  0.00000000
39. CORR0(8,8)          1.000000    0.000000     0.00000  0.00000000
40. CORR0(9,1)          0.534542    0.007863    67.98347  0.00000000
41. CORR0(9,2)          0.735635    0.003973   185.17974  0.00000000
42. CORR0(9,3)          0.650272    0.005289   122.93793  0.00000000
43. CORR0(9,4)          0.835423    0.002690   310.55996  0.00000000
44. CORR0(9,5)          0.801986    0.003256   246.29738  0.00000000
```

```
45. CORR0(9,6)          0.337859    0.010591    31.90187  0.00000000

46. CORR0(9,7)          0.543540    0.006954    78.16013  0.00000000

47. CORR0(9,8)          0.727814    0.004400   165.41600  0.00000000

48. CORR0(9,9)          1.000000    0.000000     0.00000  0.00000000

49. CORR0(10,1)          0.409422    0.009275    44.14417  0.00000000

50. CORR0(10,2)          0.483332    0.008045    60.07885  0.00000000

51. CORR0(10,3)          0.460023    0.008361    55.02132  0.00000000

52. CORR0(10,4)          0.513257    0.008324    61.65645  0.00000000

53. CORR0(10,5)          0.508579    0.008178    62.18536  0.00000000

54. CORR0(10,6)          0.312035    0.010736    29.06415  0.00000000

55. CORR0(10,7)          0.399377    0.009118    43.79880  0.00000000

56. CORR0(10,8)          0.477883    0.008637    55.32912  0.00000000

57. CORR0(10,9)          0.507433    0.008024    63.24183  0.00000000

58. CORR0(10,10)          1.000000    0.000000     0.00000  0.00000000

59. CORR0(11,1)          0.492431    0.009270    53.12274  0.00000000

60. CORR0(11,2)          0.645584    0.005885   109.69341  0.00000000

61. CORR0(11,3)          0.579544    0.006558    88.37102  0.00000000

62. CORR0(11,4)          0.786182    0.003230   243.42438  0.00000000

63. CORR0(11,5)          0.726710    0.004350   167.04243  0.00000000

64. CORR0(11,6)          0.316372    0.010843    29.17708  0.00000000

65. CORR0(11,7)          0.480300    0.008742    54.93988  0.00000000

66. CORR0(11,8)          0.725504    0.004174   173.80982  0.00000000

67. CORR0(11,9)          0.739896    0.003692   200.41396  0.00000000

68. CORR0(11,10)          0.532443    0.007443    71.53751  0.00000000

69. CORR0(11,11)          1.000000    0.000000     0.00000  0.00000000
```

```
compute phicoeffs3 = %beta
display(unit=corr0) corr0


* output the scores, skipping the diagonal entries of the correlation matrix estimates
do param=1,3
(01.0041) compute jj = param
(01.0059) set [series] jj = ssdrvs3(param)
(01.0096) end do param
compute param = 3
compute place = 3
* write out the scores skipping the diagonal entries
do h=1,11
(01.0041) do hh = h,11
(02.0078) compute place = place +1
(02.0101) if hh > h
(03.0124) {
(04.0124) compute param = param+1
(04.0147) set [series] param / = ssdrvs3(place)
(04.0184) }
(03.0184)
(03.0184) end do hh
(01.0186) end do h


cmom 261 4788
# 1 2 3 4 5 $
```

```
6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 $
21 22 23 24 25 26 27 28 29 30 $
31 32 33 34 35 36 37 38 39 40 $
41 42 43 44 45 46 47 48 49 50 $
51 52 53 54 55 56 57 58

compute covs3 = inv(%cmom)
display (covs3(1,1))**.5
     0.02591
display (covs3(2,2))**.5
     0.00176
display (covs3(3,3))**.5
     0.07632
display phicoeffs3(1)/(covs3(1,1))**.5
    19.63100
display phicoeffs3(2)/(covs3(2,2))**.5
    18.36725
display phicoeffs3(3)/(covs3(3,3))**.5
     1.41180


* model 4

compute b1 = 0.0
compute b2 = 0.0
compute b5 = 0.0
```

```
compute corr0 = sampcorr0


nonlin b1 b2 b5

frml m = (b1*ratio+b2*trend+b5*qsignal)

display 'model 4 w/o corr0'

model 4 w/o corr0

maximize(method=bhhh) mvlike 261 4788


MAXIMIZE - Estimation by BHHH

Convergence in    27 Iterations. Final criterion was  0.0000082 <=  0.0000100

Usable Observations   4528

Function Value                 -52037.07170843


   Variable                   Coeff      Std Error      T-Stat      Signif

*****************************************************************************
*****

1.  B1                      0.542395290  0.023352880     23.22606  0.00000000

2.  B2                      0.031004892  0.001537893     20.16063  0.00000000

3.  B5                     -0.056672844  0.011933535     -4.74904  0.00000204



compute phicoeffs4 = %beta

compute corr0 = sampcorr0


nonlin b1 b2 b5 corr0 corr0(1,1)==1.0 corr0(2,2)==1.0 corr0(3,3)==1.0 $

corr0(4,4)==1.0 corr0(5,5)==1.0 corr0(6,6)==1.0 corr0(7,7)==1.0 corr0(8,8)==1.0 $
```

```
corr0(9,9)==1.0 corr0(10,10)==1.0 corr0(11,11)==1.0
frml m = (b1*ratio+b2*trend+b5*qsignal)
display 'model 4 w corr0'
model 4 w corr0
maximize(derives=ssdrvs4,method=bhhh) mvlike 261 4788

MAXIMIZE - Estimation by BHHH
Convergence in    19 Iterations. Final criterion was  0.0000062 <=  0.0000100
Usable Observations   4528
Function Value                -51985.92210602

   Variable                  Coeff      Std Error      T-Stat      Signif
*************************************************************************
*****
1.  B1                        0.542094     0.025989     20.85852  0.00000000
2.  B2                        0.031491     0.001788     17.61413  0.00000000
3.  B5                       -0.055485     0.013097     -4.23646  0.00002271
4.  CORR0(1,1)                1.000000     0.000000      0.00000  0.00000000
5.  CORR0(2,1)                0.509406     0.007994     63.72586  0.00000000
6.  CORR0(2,2)                1.000000     0.000000 3.50683e+009  0.00000000
7.  CORR0(3,1)                0.460710     0.008927     51.60595  0.00000000
8.  CORR0(3,2)                0.545303     0.006932     78.66928  0.00000000
9.  CORR0(3,3)                1.000000     0.000000 4.29497e+009  0.00000000
10. CORR0(4,1)                0.507656     0.008897     57.05672  0.00000000
11. CORR0(4,2)                0.708523     0.004813    147.20970  0.00000000
12. CORR0(4,3)                0.628757     0.005903    106.51295  0.00000000
13. CORR0(4,4)                1.000000     0.000000      0.00000  0.00000000
```

```
14. CORR0(5,1)            0.551196     0.007242     76.11233  0.00000000
15. CORR0(5,2)            0.682903     0.005235    130.45209  0.00000000
16. CORR0(5,3)            0.621388     0.005990    103.73439  0.00000000
17. CORR0(5,4)            0.805283     0.002980    270.26403  0.00000000
18. CORR0(5,5)            1.000000     0.000000      0.00000  0.00000000
19. CORR0(6,1)            0.326585     0.009913     32.94368  0.00000000
20. CORR0(6,2)            0.338706     0.010265     32.99769  0.00000000
21. CORR0(6,3)            0.315245     0.010527     29.94564  0.00000000
22. CORR0(6,4)            0.330016     0.010639     31.02064  0.00000000
23. CORR0(6,5)            0.325489     0.010236     31.79797  0.00000000
24. CORR0(6,6)            1.000000     0.000000      0.00000  0.00000000
25. CORR0(7,1)            0.447688     0.008852     50.57319  0.00000000
26. CORR0(7,2)            0.503987     0.008218     61.32868  0.00000000
27. CORR0(7,3)            0.478321     0.007934     60.28891  0.00000000
28. CORR0(7,4)            0.522747     0.008878     58.88081  0.00000000
29. CORR0(7,5)            0.516949     0.008229     62.81908  0.00000000
30. CORR0(7,6)            0.304191     0.010140     29.99776  0.00000000
31. CORR0(7,7)            1.000000     0.000000      0.00000  0.00000000
32. CORR0(8,1)            0.472026     0.009199     51.31166  0.00000000
33. CORR0(8,2)            0.631971     0.006236    101.34529  0.00000000
34. CORR0(8,3)            0.561185     0.006940     80.86365  0.00000000
35. CORR0(8,4)            0.770245     0.003607    213.54948  0.00000000
36. CORR0(8,5)            0.717259     0.004463    160.71830  0.00000000
37. CORR0(8,6)            0.306488     0.010841     28.27145  0.00000000
38. CORR0(8,7)            0.469969     0.009164     51.28497  0.00000000
39. CORR0(8,8)            1.000000     0.000000      0.00000  0.00000000
40. CORR0(9,1)            0.535310     0.007827     68.39705  0.00000000
```

```
41. CORR0(9,2)          0.735859     0.003980    184.86820  0.00000000
42. CORR0(9,3)          0.650235     0.005521    117.78390  0.00000000
43. CORR0(9,4)          0.835225     0.002698    309.58286  0.00000000
44. CORR0(9,5)          0.802150     0.003155    254.21616  0.00000000
45. CORR0(9,6)          0.339655     0.010495     32.36309  0.00000000
46. CORR0(9,7)          0.544212     0.007963     68.34231  0.00000000
47. CORR0(9,8)          0.727813     0.004368    166.63839  0.00000000
48. CORR0(9,9)          1.000000     0.000000      0.00000  0.00000000
49. CORR0(10,1)          0.410358     0.009124     44.97804  0.00000000
50. CORR0(10,2)          0.483737     0.007784     62.14340  0.00000000
51. CORR0(10,3)          0.459872     0.008336     55.16744  0.00000000
52. CORR0(10,4)          0.513241     0.008168     62.83884  0.00000000
53. CORR0(10,5)          0.508923     0.008068     63.08234  0.00000000
54. CORR0(10,6)          0.313942     0.010557     29.73875  0.00000000
55. CORR0(10,7)          0.400787     0.009082     44.13124  0.00000000
56. CORR0(10,8)          0.478135     0.008419     56.79289  0.00000000
57. CORR0(10,9)          0.507169     0.007716     65.73146  0.00000000
58. CORR0(10,10)          1.000000     0.000000      0.00000  0.00000000
59. CORR0(11,1)          0.493401     0.009209     53.57925  0.00000000
60. CORR0(11,2)          0.645881     0.005850    110.40167  0.00000000
61. CORR0(11,3)          0.579372     0.006835     84.76976  0.00000000
62. CORR0(11,4)          0.785838     0.003216    244.32525  0.00000000
63. CORR0(11,5)          0.726650     0.004338    167.49032  0.00000000
64. CORR0(11,6)          0.318410     0.010745     29.63398  0.00000000
65. CORR0(11,7)          0.480948     0.009019     53.32812  0.00000000
66. CORR0(11,8)          0.725562     0.004171    173.93881  0.00000000
67. CORR0(11,9)          0.739520     0.003704    199.63240  0.00000000
```

```
68. CORR0(11,10)              0.532616     0.007299     72.97234  0.00000000
69. CORR0(11,11)              1.000000     0.000000      0.00000  0.00000000
```

```
display(unit=corr0) corr0
```

```
* output the scores, skipping the diagonal entries of the correlation matrix estimates
do param=1,3
(01.0041) compute jj = param
(01.0059) set [series] jj = ssdrvs4(param)
(01.0096) end do param
compute param = 3
compute place = 3
* write out the scores skipping the diagonal entries
do h=1,11
(01.0041) do hh = h,11
(02.0078) compute place = place +1
(02.0101) if hh > h
(03.0124) {
(04.0124) compute param = param+1
(04.0147) set [series] param / = ssdrvs4(place)
(04.0184) }
(03.0184)
(03.0184) end do hh
(01.0186) end do h
```

```
cmom 261 4788
# 1 2 3 4 5 $
6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 $
21 22 23 24 25 26 27 28 29 30 $
31 32 33 34 35 36 37 38 39 40 $
41 42 43 44 45 46 47 48 49 50 $
51 52 53 54 55 56 57 58

compute covs4 = inv(%cmom)
display (covs4(1,1))**.5
      0.02513
display (covs4(2,2))**.5
      0.00171
display (covs4(3,3))**.5
      0.01234
display phicoeffs4(1)/(covs4(1,1))**.5
     21.58381
display phicoeffs4(2)/(covs4(2,2))**.5
     18.14967
display phicoeffs4(3)/(covs4(3,3))**.5
     -4.59373


* model 5


compute b1 = 0.0
```

```
compute b2 = 0.0

compute b6 = 0.0



compute corr0 = sampcorr0


nonlin b1 b2 b6

frml m = (b1*ratio+b2*trend+b6*avegrowth)

display 'model 5 w/o corr0'

model 5 w/o corr0

maximize(method=bhhh) mvlike 261 4788


MAXIMIZE - Estimation by BHHH

Convergence in    25 Iterations. Final criterion was  0.0000076 <=  0.0000100

Usable Observations   3973

 Total Observations   4528      Skipped/Missing      555

Function Value                  -44251.81359332


    Variable                    Coeff      Std Error      T-Stat      Signif

*****************************************************************************
*****

1.  B1                     0.6067379555 0.0242686643     25.00088  0.00000000

2.  B2                     0.0283169049 0.0015732394     17.99911  0.00000000

3.  B6                     0.0029658484 0.0004354991      6.81023  0.00000000



compute corr0 = sampcorr0
```

```
nonlin b1 b2 b6 corr0 corr0(1,1)==1.0 corr0(2,2)==1.0 corr0(3,3)==1.0 $

corr0(4,4)==1.0 corr0(5,5)==1.0 corr0(6,6)==1.0 corr0(7,7)==1.0 corr0(8,8)==1.0 $

corr0(9,9)==1.0 corr0(10,10)==1.0 corr0(11,11)==1.0

frml m = (b1*ratio+b2*trend+b6*avegrowth)

display 'model 5 w corr0'

model 5 w corr0

maximize(derives=ssdrvs5,method=bhhh) mvlike 261 4788
```

```
MAXIMIZE - Estimation by BHHH

Convergence in    20 Iterations. Final criterion was  0.0000041 <=  0.0000100

Usable Observations   3973

 Total Observations   4528      Skipped/Missing      555

Function Value                 -44079.90752267


    Variable                   Coeff      Std Error      T-Stat      Signif

*******************************************************************************
*****

1.  B1                      0.581723     0.027337     21.27962  0.00000000

2.  B2                      0.030539     0.001901     16.06723  0.00000000

3.  B6                      0.002966     0.000456      6.50699  0.00000000

4.  CORR0(1,1)                   1.000000     0.000000      0.00000  0.00000000

5.  CORR0(2,1)                   0.486854     0.009150     53.20947  0.00000000

6.  CORR0(2,2)                   1.000000     0.000000      0.00000  0.00000000

7.  CORR0(3,1)                   0.442622     0.009963     44.42605  0.00000000

8.  CORR0(3,2)                   0.533674     0.007538     70.79825  0.00000000

9.  CORR0(3,3)                   1.000000     0.000000      0.00000  0.00000000
```

```
10. CORR0(4,1)          0.495677    0.009858     50.28335  0.00000000
11. CORR0(4,2)          0.711924    0.005149    138.26515  0.00000000
12. CORR0(4,3)          0.644121    0.005544    116.18286  0.00000000
13. CORR0(4,4)          1.000000    0.000000 1.92077e+009  0.00000000
14. CORR0(5,1)          0.520944    0.008462     61.56439  0.00000000
15. CORR0(5,2)          0.682198    0.005696    119.76196  0.00000000
16. CORR0(5,3)          0.621759    0.006168    100.80037  0.00000000
17. CORR0(5,4)          0.823737    0.002878    286.20949  0.00000000
18. CORR0(5,5)          1.000000    0.000000      0.00000  0.00000000
19. CORR0(6,1)          0.295988    0.011504     25.73015  0.00000000
20. CORR0(6,2)          0.306784    0.012099     25.35667  0.00000000
21. CORR0(6,3)          0.285536    0.012454     22.92645  0.00000000
22. CORR0(6,4)          0.309905    0.012339     25.11679  0.00000000
23. CORR0(6,5)          0.302028    0.011902     25.37691  0.00000000
24. CORR0(6,6)          1.000000    0.000000      0.00000  0.00000000
25. CORR0(7,1)          0.413264    0.010405     39.71696  0.00000000
26. CORR0(7,2)          0.475690    0.009347     50.89260  0.00000000
27. CORR0(7,3)          0.453340    0.009337     48.55383  0.00000000
28. CORR0(7,4)          0.504638    0.009934     50.80138  0.00000000
29. CORR0(7,5)          0.496707    0.009422     52.72043  0.00000000
30. CORR0(7,6)          0.263922    0.012281     21.49095  0.00000000
31. CORR0(7,7)          1.000000    0.000000 3.50683e+009  0.00000000
32. CORR0(8,1)          0.463808    0.010317     44.95558  0.00000000
33. CORR0(8,2)          0.643260    0.006340    101.46230  0.00000000
34. CORR0(8,3)          0.569288    0.007322     77.75276  0.00000000
35. CORR0(8,4)          0.799332    0.003370    237.20579  0.00000000
36. CORR0(8,5)          0.738797    0.004369    169.08421  0.00000000
```

```
37. CORR0(8,6)          0.289277    0.012644    22.87803  0.00000000
38. CORR0(8,7)          0.456713    0.010384    43.98396  0.00000000
39. CORR0(8,8)          1.000000    0.000000     0.00000  0.00000000
40. CORR0(9,1)          0.518149    0.008843    58.59636  0.00000000
41. CORR0(9,2)          0.739896    0.004339   170.54135  0.00000000
42. CORR0(9,3)          0.659298    0.005421   121.63004  0.00000000
43. CORR0(9,4)          0.842241    0.002756   305.60121  0.00000000
44. CORR0(9,5)          0.809349    0.003207   252.40325  0.00000000
45. CORR0(9,6)          0.322337    0.012092    26.65649  0.00000000
46. CORR0(9,7)          0.522097    0.008924    58.50785  0.00000000
47. CORR0(9,8)          0.746183    0.004307   173.23785  0.00000000
48. CORR0(9,9)          1.000000    0.000000     0.00000  0.00000000
49. CORR0(10,1)          0.381401    0.010503    36.31479  0.00000000
50. CORR0(10,2)          0.462232    0.009013    51.28334  0.00000000
51. CORR0(10,3)          0.435671    0.009488    45.91977  0.00000000
52. CORR0(10,4)          0.514001    0.008900    57.75422  0.00000000
53. CORR0(10,5)          0.500513    0.009017    55.50948  0.00000000
54. CORR0(10,6)          0.269877    0.012390    21.78257  0.00000000
55. CORR0(10,7)          0.367786    0.010665    34.48606  0.00000000
56. CORR0(10,8)          0.476125    0.009352    50.90901  0.00000000
57. CORR0(10,9)          0.504698    0.008614    58.59148  0.00000000
58. CORR0(10,10)          1.000000    0.000000     0.00000  0.00000000
59. CORR0(11,1)          0.476757    0.010470    45.53614  0.00000000
60. CORR0(11,2)          0.643091    0.006508    98.80822  0.00000000
61. CORR0(11,3)          0.579036    0.007119    81.33119  0.00000000
62. CORR0(11,4)          0.793239    0.003432   231.14833  0.00000000
63. CORR0(11,5)          0.736794    0.004506   163.51030  0.00000000
```

```
64. CORR0(11,6)                0.296337     0.012592     23.53413  0.00000000

65. CORR0(11,7)                0.459479     0.010348     44.40468  0.00000000

66. CORR0(11,8)                0.745251     0.004000    186.33175  0.00000000

67. CORR0(11,9)                0.743731     0.004433    167.77980  0.00000000

68. CORR0(11,10)                0.527384     0.007986     66.03547  0.00000000

69. CORR0(11,11)                1.000000     0.000000      0.00000  0.00000000
```

```
compute phicoeffs5 = %beta

display(unit=corr0) corr0


* output the scores, skipping the diagonal entries of the correlation matrix estimates

do param=1,3

(01.0041) compute jj = param

(01.0059) set [series] jj = ssdrvs5(param)

(01.0096) end do param

compute param = 3

compute place = 3

* write out the scores skipping the diagonal entries

do h=1,11

(01.0041) do hh = h,11

(02.0078) compute place = place +1

(02.0101) if hh > h

(03.0124) {

(04.0124) compute param = param+1

(04.0147) set [series] param / = ssdrvs5(place)

(04.0184) }

(03.0184)
```

```
(03.0184) end do hh
(01.0186) end do h



cmom 261 4788
# 1 2 3 4 5 $
6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 $
21 22 23 24 25 26 27 28 29 30 $
31 32 33 34 35 36 37 38 39 40 $
41 42 43 44 45 46 47 48 49 50 $
51 52 53 54 55 56 57 58

compute covs5 = inv(%cmom)
display (covs5(1,1))**.5
      0.02568
display (covs5(2,2))**.5
      0.00174
display (covs5(3,3))**.5
 4.57472e-004
display phicoeffs5(1)/(covs5(1,1))**.5
     22.65296
display phicoeffs5(2)/(covs5(2,2))**.5
     17.55013
display phicoeffs5(3)/(covs5(3,3))**.5
      6.48380
```

```
*maxlikemodel6.txt this program estimates a dynamic macroeconomic model of the correlation magnitude
* using maximum likelihood
* with corr0
* for a selected specification

alloc 60 4788
open eta c:\eurovol\output\eta.txt
open dailysignals c:\eurovol\output\dailysignals.txt
open truedailysigs c:\eurovol\output\truedailysigs.txt
open phi6 c:\eurovol\output\phi6.txt
open phi7 c:\eurovol\output\phi7.txt
open covs6 c:\eurovol\output\covs6.txt
open covs7 c:\eurovol\output\covs7.txt
open corr0 c:\eurovol\output\corr0.txt
open ecorr0 c:\eurovol\output\ecorr0.txt
open ssdrvs6 c:\eurovol\output\ssdrvs6.txt
open ssdrvs7 c:\eurovol\output\ssdrvs7.txt



data(unit=eta,format=free,org=vars) 261 4788 e1 e2 e3 e4 e5 e6 $
e7 e8 e9 e10 e11
data(unit=dailysignals,format=free,org=obs) 1 4788 qcumret qavevar avegrowth $
qsignal qtrend lagqcumret lagqavevar lagqavecorr lagqsignal
data(unit=truedailysigs,format=free,org=obs) 260 4788 tdavecorr tdavevar tdcumret
```

```
* de-mean the six explanatory variables

statistics qsignal

Statistics on Series QSIGNAL
Observations              4788
Sample Mean            0.435200      Variance            0.085601
Standard Error         0.292576      of Sample Mean      0.004228
t-Statistic (Mean=0) 102.926397      Signif Level        0.000000
Skewness               0.352169      Signif Level (Sk=0) 0.000000
Kurtosis (excess)     -0.874474      Signif Level (Ku=0) 0.000000
Jarque-Bera          251.528696      Signif Level (JB=0) 0.000000

set qsignal / = qsignal - %mean

statistics lagqsignal

Statistics on Series LAGQSIGNAL
Observations              4788
Sample Mean            0.433446      Variance            0.085627
Standard Error         0.292622      of Sample Mean      0.004229
t-Statistic (Mean=0) 102.495600      Signif Level        0.000000
Skewness               0.376437      Signif Level (Sk=0) 0.000000
Kurtosis (excess)     -0.874592      Signif Level (Ku=0) 0.000000
Jarque-Bera          265.680343      Signif Level (JB=0) 0.000000
```

```
set lagqsignal / = lagqsignal - %mean


statistics tdavecorr


Statistics on Series TDAVECORR
Observations              4529
Sample Mean            0.535547      Variance             0.030712
Standard Error         0.175249      of Sample Mean       0.002604
t-Statistic (Mean=0) 205.656653      Signif Level         0.000000
Skewness              -0.261659      Signif Level (Sk=0) 0.000000
Kurtosis (excess)     -1.036007      Signif Level (Ku=0) 0.000000
Jarque-Bera          254.222779      Signif Level (JB=0) 0.000000


set ratio / = (tdavecorr{1} - %mean)/(1.0-%mean)


statistics tdavevar


Statistics on Series TDAVEVAR
Observations              4529
Sample Mean            0.054274      Variance             0.001500
Standard Error         0.038725      of Sample Mean       0.000575
t-Statistic (Mean=0)  94.320011      Signif Level         0.000000
Skewness               1.492091      Signif Level (Sk=0) 0.000000
Kurtosis (excess)      2.374317      Signif Level (Ku=0) 0.000000
Jarque-Bera         2744.332817      Signif Level (JB=0) 0.000000


set avevar / = tdavevar{1} - %mean
```

```
statistics tdcumret


Statistics on Series TDCUMRET
Observations              4529
Sample Mean           0.711834      Variance           8.208044
Standard Error        2.864968      of Sample Mean      0.042571
t-Statistic (Mean=0)  16.720919      Signif Level        0.000000
Skewness             -1.010469      Signif Level (Sk=0) 0.000000
Kurtosis (excess)      0.936317      Signif Level (Ku=0) 0.000000
Jarque-Bera         936.159656      Signif Level (JB=0) 0.000000


set cumret / = tdcumret{1} - %mean


statistics avegrowth


Statistics on Series AVEGROWTH
Observations              4788
Sample Mean           0.521804      Variance           0.034933
Standard Error        0.186904      of Sample Mean      0.002701
t-Statistic (Mean=0) 193.182261      Signif Level        0.000000
Skewness             -0.194089      Signif Level (Sk=0) 0.000000
Kurtosis (excess)     -0.881112      Signif Level (Ku=0) 0.000000
Jarque-Bera         184.944575      Signif Level (JB=0) 0.000000


set avegrowth / = avegrowth - %mean
```

```
* set trend to match the annual scale per unit time
set trend / = t/261.0
statistics trend

Statistics on Series TREND
Observations                4788
Sample Mean            9.174330      Variance            28.050249
Standard Error         5.296249      of Sample Mean      0.076540
t-Statistic (Mean=0) 119.862421      Signif Level        0.000000
Skewness               0.000000      Signif Level (Sk=0) 1.000000
Kurtosis (excess)     -1.200000      Signif Level (Ku=0) 0.000000
Jarque-Bera          287.280000      Signif Level (JB=0) 0.000000

set trend / = trend - %mean


*find the unconditional correlation matrix of standardized returns
cmom(corr,matrix=corr0) 261 4788
# e1 e2 e3 e4 e5 e6 e7 e8 e9 e10 e11

compute sampcorr0 = corr0

display(unit=corr0) corr0

*set up a unit matrix
declare symmetric unitmat(11,11)
do j = 1,11
```

```
(01.0041) do jj = 1,11

(02.0076) compute unitmat(j,jj) = 1.0

(02.0102) end do jj

(01.0104) end do j



* first do each estimation without corr0 and then with corr0



*model 6


compute b1 = 0.494088720

compute b2 = 0.035752767

compute b3 = 0.000990222

compute b4 = 0.257101098

compute b5 = -0.069852139


compute corr0 = sampcorr0



nonlin b1 b2 b3 b4 b5

frml m = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*qsignal)



* set up the likelihood objective function


dec frml[vect] ufrml
```

```
frml ufrml = ||e1,e2,e3,e4,e5,e6,e7,e8,e9,e10,e11||
dec frml[symmetric] sigma
frml sigma = (m)*unitmat + (1.0 - m)*corr0
frml mvlike = %logdensity(sigma,ufrml)

display 'model 6 w/o corr0'
model 6 w/o corr0
*maximize(method=bhhh) mvlike 261 4788


compute corr0 = sampcorr0

nonlin b1 b2 b3 b4 b5 corr0 corr0(1,1)==1.0 corr0(2,2)==1.0 corr0(3,3)==1.0 $
corr0(4,4)==1.0 corr0(5,5)==1.0 corr0(6,6)==1.0 corr0(7,7)==1.0 corr0(8,8)==1.0 $
corr0(9,9)==1.0 corr0(10,10)==1.0 corr0(11,11)==1.0
frml m = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*qsignal)
display 'model 6 w corr0'
model 6 w corr0
maximize(method=bhhh,derives=ssdrvs) mvlike 261 4788

MAXIMIZE - Estimation by BHHH
Convergence in    24 Iterations. Final criterion was  0.0000052 <=  0.0000100
Usable Observations   4528
Function Value                  -51982.87087442

    Variable                    Coeff      Std Error      T-Stat      Signif
```

```
*****************************************************************************
*****

1.  B1                    0.514403     0.026425     19.46683  0.00000000

2.  B2                    0.032911     0.001789     18.39136  0.00000000

3.  B3                    0.001021     0.002133      0.47839  0.63237436

4.  B4                    0.294422     0.108176      2.72168  0.00649508

5.  B5                   -0.066628     0.018223     -3.65630  0.00025588

6.  CORR0(1,1)                1.000000     0.000000      0.00000  0.00000000

7.  CORR0(2,1)                0.508553     0.008012     63.47085  0.00000000

8.  CORR0(2,2)                1.000000     0.000000      0.00000  0.00000000

9.  CORR0(3,1)                0.459564     0.008917     51.53968  0.00000000

10. CORR0(3,2)                0.544170     0.006886     79.03089  0.00000000

11. CORR0(3,3)                1.000000     0.000000      0.00000  0.00000000

12. CORR0(4,1)                0.506571     0.008915     56.81918  0.00000000

13. CORR0(4,2)                0.707489     0.004820    146.78371  0.00000000

14. CORR0(4,3)                0.628110     0.005646    111.25698  0.00000000

15. CORR0(4,4)                1.000000     0.000000      0.00000  0.00000000

16. CORR0(5,1)                0.550152     0.007271     75.66277  0.00000000

17. CORR0(5,2)                0.681876     0.005256    129.72937  0.00000000

18. CORR0(5,3)                0.620735     0.005899    105.21892  0.00000000

19. CORR0(5,4)                0.804937     0.003058    263.21044  0.00000000

20. CORR0(5,5)                1.000000     0.000000      0.00000  0.00000000

21. CORR0(6,1)                0.325423     0.009935     32.75639  0.00000000

22. CORR0(6,2)                0.337797     0.010313     32.75451  0.00000000

23. CORR0(6,3)                0.313796     0.010540     29.77295  0.00000000

24. CORR0(6,4)                0.328753     0.010640     30.89850  0.00000000

25. CORR0(6,5)                0.324375     0.010240     31.67580  0.00000000
```

```
26. CORR0(6,6)          1.000000    0.000000 3.50683e+009  0.00000000
27. CORR0(7,1)          0.447101    0.008479     52.72953  0.00000000
28. CORR0(7,2)          0.502613    0.006946     72.36474  0.00000000
29. CORR0(7,3)          0.477308    0.007907     60.36306  0.00000000
30. CORR0(7,4)          0.521591    0.008466     61.61093  0.00000000
31. CORR0(7,5)          0.515970    0.007657     67.38173  0.00000000
32. CORR0(7,6)          0.303161    0.009790     30.96739  0.00000000
33. CORR0(7,7)          1.000000    0.000000      0.00000  0.00000000
34. CORR0(8,1)          0.471154    0.009228     51.05958  0.00000000
35. CORR0(8,2)          0.631076    0.006251    100.95339  0.00000000
36. CORR0(8,3)          0.560697    0.006823     82.18002  0.00000000
37. CORR0(8,4)          0.769876    0.003635    211.79882  0.00000000
38. CORR0(8,5)          0.716886    0.004630    154.81967  0.00000000
39. CORR0(8,6)          0.305355    0.010851     28.14175  0.00000000
40. CORR0(8,7)          0.469053    0.008782     53.41278  0.00000000
41. CORR0(8,8)          1.000000    0.000000      0.00000  0.00000000
42. CORR0(9,1)          0.534309    0.007842     68.13637  0.00000000
43. CORR0(9,2)          0.734823    0.003973    184.95218  0.00000000
44. CORR0(9,3)          0.649583    0.005338    121.68579  0.00000000
45. CORR0(9,4)          0.834917    0.002706    308.52412  0.00000000
46. CORR0(9,5)          0.801849    0.003220    249.03855  0.00000000
47. CORR0(9,6)          0.338243    0.010520     32.15391  0.00000000
48. CORR0(9,7)          0.543023    0.007326     74.11918  0.00000000
49. CORR0(9,8)          0.727509    0.004392    165.64080  0.00000000
50. CORR0(9,9)          1.000000    0.000000      0.00000  0.00000000
51. CORR0(10,1)          0.409559    0.009370     43.71179  0.00000000
52. CORR0(10,2)          0.483177    0.007989     60.47701  0.00000000
```

```
53. CORR0(10,3)                 0.459474     0.008496     54.08201  0.00000000
54. CORR0(10,4)                 0.512843     0.008346     61.44846  0.00000000
55. CORR0(10,5)                 0.508262     0.008241     61.67702  0.00000000
56. CORR0(10,6)                 0.312772     0.010644     29.38471  0.00000000
57. CORR0(10,7)                 0.400112     0.009076     44.08226  0.00000000
58. CORR0(10,8)                 0.477941     0.008641     55.31262  0.00000000
59. CORR0(10,9)                 0.506920     0.007945     63.80460  0.00000000
60. CORR0(10,10)                 1.000000     0.000000      0.00000  0.00000000
61. CORR0(11,1)                 0.492571     0.009217     53.44297  0.00000000
62. CORR0(11,2)                 0.645291     0.005879    109.76675  0.00000000
63. CORR0(11,3)                 0.579023     0.006671     86.79174  0.00000000
64. CORR0(11,4)                 0.785720     0.003258    241.20170  0.00000000
65. CORR0(11,5)                 0.726264     0.004452    163.14439  0.00000000
66. CORR0(11,6)                 0.317504     0.010757     29.51463  0.00000000
67. CORR0(11,7)                 0.480156     0.008751     54.87031  0.00000000
68. CORR0(11,8)                 0.725317     0.004244    170.91534  0.00000000
69. CORR0(11,9)                 0.739339     0.003773    195.94892  0.00000000
70. CORR0(11,10)                 0.532259     0.007569     70.32389  0.00000000
71. CORR0(11,11)                 1.000000     0.000000 3.03700e+009  0.00000000
```

```
compute phi6 = %beta

display(unit=corr0) corr0
```

```
* output the scores, skipping the diagonal entries of the correlation matrix estimates
```

```
do param=1,5

(01.0041) compute jj = param

(01.0059) set [series] jj = ssdrvs(param)

(01.0096) end do param

compute param = 5

compute place = 5

* write out the scores skipping the diagonal entries

do h=1,11

(01.0041) do hh = h,11

(02.0078) compute place = place +1

(02.0101) if hh > h

(03.0124) {

(04.0124) compute param = param+1

(04.0147) set [series] param / = ssdrvs(place)

(04.0184) }

(03.0184)

(03.0184) end do hh

(01.0186) end do h




copy(unit=ssdrvs6,format= free,org=obs) 261 4788 1 2 3 4 5 $

6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 $

21 22 23 24 25 26 27 28 29 30 $

31 32 33 34 35 36 37 38 39 40 $

41 42 43 44 45 46 47 48 49 50 $

51 52 53 54 55 56 57 58 59 60

write(unit=phi6) phi6
```

```
*maxlikemodel7.txt this program estimates a dynamic macroeconomic model of the correlation magnitude
* using maximum likelihood
* with corr0
* for a selected specification

alloc 60 4788
open eta c:\eurovol\output\eta.txt
open dailysignals c:\eurovol\output\dailysignals.txt
open truedailysigs c:\eurovol\output\truedailysigs.txt
open phi6 c:\eurovol\output\phi6.txt
open phi7 c:\eurovol\output\phi7.txt
open covs6 c:\eurovol\output\covs6.txt
open covs7 c:\eurovol\output\covs7.txt
open corr0 c:\eurovol\output\corr0.txt
open ecorr0 c:\eurovol\output\ecorr0.txt
open ssdrvs6 c:\eurovol\output\ssdrvs6.txt
open ssdrvs7 c:\eurovol\output\ssdrvs7.txt



data(unit=eta,format=free,org=vars) 261 4788 e1 e2 e3 e4 e5 e6 $
e7 e8 e9 e10 e11
data(unit=dailysignals,format=free,org=obs) 1 4788 qcumret qavevar avegrowth $
qsignal qtrend lagqcumret lagqavevar lagqavecorr lagqsignal
data(unit=truedailysigs,format=free,org=obs) 260 4788 tdavecorr tdavevar tdcumret
```

```
* de-mean the six explanatory variables

statistics qsignal

Statistics on Series QSIGNAL
Observations            4788
Sample Mean           0.435200      Variance          0.085601
Standard Error        0.292576      of Sample Mean      0.004228
t-Statistic (Mean=0) 102.926397      Signif Level        0.000000
Skewness              0.352169      Signif Level (Sk=0) 0.000000
Kurtosis (excess)     -0.874474      Signif Level (Ku=0) 0.000000
Jarque-Bera          251.528696      Signif Level (JB=0) 0.000000

set qsignal / = qsignal - %mean

statistics lagqsignal

Statistics on Series LAGQSIGNAL
Observations            4788
Sample Mean           0.433446      Variance          0.085627
Standard Error        0.292622      of Sample Mean      0.004229
t-Statistic (Mean=0) 102.495600      Signif Level        0.000000
Skewness              0.376437      Signif Level (Sk=0) 0.000000
Kurtosis (excess)     -0.874592      Signif Level (Ku=0) 0.000000
Jarque-Bera          265.680343      Signif Level (JB=0) 0.000000
```

```
set lagqsignal / = lagqsignal - %mean


statistics tdavecorr


Statistics on Series TDAVECORR
Observations              4529
Sample Mean           0.535547      Variance           0.030712
Standard Error        0.175249      of Sample Mean      0.002604
t-Statistic (Mean=0) 205.656653      Signif Level        0.000000
Skewness             -0.261659      Signif Level (Sk=0) 0.000000
Kurtosis (excess)     -1.036007      Signif Level (Ku=0) 0.000000
Jarque-Bera          254.222779      Signif Level (JB=0) 0.000000


set ratio / = (tdavecorr{1} - %mean)/(1.0-%mean)


statistics tdavevar


Statistics on Series TDAVEVAR
Observations              4529
Sample Mean           0.054274      Variance           0.001500
Standard Error        0.038725      of Sample Mean      0.000575
t-Statistic (Mean=0)   94.320011      Signif Level        0.000000
Skewness              1.492091      Signif Level (Sk=0) 0.000000
Kurtosis (excess)       2.374317      Signif Level (Ku=0) 0.000000
Jarque-Bera          2744.332817      Signif Level (JB=0) 0.000000


set avevar / = tdavevar{1} - %mean
```

```
statistics tdcumret


Statistics on Series TDCUMRET

Observations              4529

Sample Mean           0.711834      Variance           8.208044

Standard Error        2.864968      of Sample Mean      0.042571

t-Statistic (Mean=0)  16.720919      Signif Level        0.000000

Skewness             -1.010469      Signif Level (Sk=0) 0.000000

Kurtosis (excess)      0.936317      Signif Level (Ku=0) 0.000000

Jarque-Bera          936.159656      Signif Level (JB=0) 0.000000


set cumret / = tdcumret{1} - %mean


statistics avegrowth


Statistics on Series AVEGROWTH

Observations              4788

Sample Mean           0.521804      Variance           0.034933

Standard Error        0.186904      of Sample Mean      0.002701

t-Statistic (Mean=0) 193.182261      Signif Level        0.000000

Skewness             -0.194089      Signif Level (Sk=0) 0.000000

Kurtosis (excess)     -0.881112      Signif Level (Ku=0) 0.000000

Jarque-Bera          184.944575      Signif Level (JB=0) 0.000000


set avegrowth / = avegrowth - %mean
```

```
* set trend to match the annual scale per unit time

set trend / = t/261.0

statistics trend


Statistics on Series TREND

Observations              4788

Sample Mean           9.174330      Variance           28.050249

Standard Error        5.296249      of Sample Mean      0.076540

t-Statistic (Mean=0) 119.862421      Signif Level        0.000000

Skewness              0.000000      Signif Level (Sk=0) 1.000000

Kurtosis (excess)     -1.200000      Signif Level (Ku=0) 0.000000

Jarque-Bera         287.280000      Signif Level (JB=0) 0.000000


set trend / = trend - %mean

*find the unconditional correlation matrix of standardized returns

cmom(corr,matrix=corr0) 261 4788

# e1 e2 e3 e4 e5 e6 e7 e8 e9 e10 e11


compute sampcorr0 = corr0


display(unit=corr0) corr0


*set up a unit matrix

declare symmetric unitmat(11,11)

do j = 1,11

(01.0041) do jj = 1,11

(02.0076) compute unitmat(j,jj) = 1.0
```

```
(02.0102) end do jj
(01.0104) end do j

* first do the estimation without corr0 and then with corr0

*model 7
compute b1 = 0.0
compute b2 = 0.0
compute b3 = 0.0
compute b4 = 0.0
compute b6 = 0.0

compute corr0 = sampcorr0

nonlin b1 b2 b3 b4 b6
frml m = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b6*avegrowth)

* set up the likelihood objective function

dec frml[vect] ufrml
frml ufrml = ||e1,e2,e3,e4,e5,e6,e7,e8,e9,e10,e11||
dec frml[symmetric] sigma
frml sigma = (m)*unitmat + (1.0 - m)*corr0
frml mvlike = %logdensity(sigma,ufrml)

display 'model 7 w/o corr0'
model 7 w/o corr0
```

```
maximize(method=bhhh) mvlike 261 4788


MAXIMIZE - Estimation by BHHH

Convergence in    35 Iterations. Final criterion was  0.0000085 <=  0.0000100

Usable Observations   4528

Function Value                  -51951.30484048


    Variable                    Coeff      Std Error      T-Stat      Signif

*******************************************************************************

1.  B1                    0.3041070825 0.0269878990     11.26828  0.00000000

2.  B2                    0.0206367986 0.0015720979     13.12692  0.00000000

3.  B3                    0.0036010010 0.0011889818      3.02864  0.00245655

4.  B4                    0.4713815869 0.0895424706      5.26434  0.00000014

5.  B6                    0.7986352120 0.0332736418     24.00204  0.00000000




compute corr0 = sampcorr0


nonlin b1 b2 b3 b4 b6 corr0 corr0(1,1)==1.0 corr0(2,2)==1.0 corr0(3,3)==1.0 $

corr0(4,4)==1.0 corr0(5,5)==1.0 corr0(6,6)==1.0 corr0(7,7)==1.0 corr0(8,8)==1.0 $

corr0(9,9)==1.0 corr0(10,10)==1.0 corr0(11,11)==1.0

frml m = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b6*avegrowth)

display 'model 7 w corr0'

model 7 w corr0

maximize(method=bhhh,derives=ssdrvs) mvlike 261 4788
```

```
MAXIMIZE - Estimation by BHHH

Convergence in    24 Iterations. Final criterion was  0.0000045 <=  0.0000100

Usable Observations   4528

Function Value                -51897.26457556


    Variable                    Coeff      Std Error      T-Stat      Signif

****************************************************************************
*****

1.  B1                      0.281523     0.029124      9.66644  0.00000000

2.  B2                      0.022452     0.002023     11.10037  0.00000000

3.  B3                      0.003194     0.001401      2.27951  0.02263649

4.  B4                      0.475776     0.107972      4.40647  0.00001051

5.  B6                      0.803790     0.045707     17.58569  0.00000000

6.  CORR0(1,1)                  1.000000     0.000000      0.00000  0.00000000

7.  CORR0(2,1)                  0.502980     0.008251     60.95740  0.00000000

8.  CORR0(2,2)                  1.000000     0.000000 4.29497e+009  0.00000000

9.  CORR0(3,1)                  0.453383     0.009139     49.61133  0.00000000

10. CORR0(3,2)                  0.540318     0.006952     77.71769  0.00000000

11. CORR0(3,3)                  1.000000     0.000000 4.29497e+009  0.00000000

12. CORR0(4,1)                  0.499485     0.009085     54.97707  0.00000000

13. CORR0(4,2)                  0.705378     0.004868    144.90728  0.00000000

14. CORR0(4,3)                  0.625304     0.005700    109.69301  0.00000000

15. CORR0(4,4)                  1.000000     0.000000      0.00000  0.00000000

16. CORR0(5,1)                  0.543682     0.007361     73.85832  0.00000000

17. CORR0(5,2)                  0.679753     0.005311    127.98970  0.00000000

18. CORR0(5,3)                  0.617726     0.005847    105.65105  0.00000000
```

```
19. CORR0(5,4)          0.802331    0.003028    264.98682  0.00000000

20. CORR0(5,5)          1.000000    0.000000      0.00000  0.00000000

21. CORR0(6,1)          0.314148    0.010148     30.95538  0.00000000

22. CORR0(6,2)          0.329473    0.010450     31.52963  0.00000000

23. CORR0(6,3)          0.303329    0.010814     28.05058  0.00000000

24. CORR0(6,4)          0.317961    0.010855     29.29067  0.00000000

25. CORR0(6,5)          0.314473    0.010451     30.08944  0.00000000

26. CORR0(6,6)          1.000000    0.000000      0.00000  0.00000000

27. CORR0(7,1)          0.439889    0.008957     49.10845  0.00000000

28. CORR0(7,2)          0.497233    0.006442     77.18701  0.00000000

29. CORR0(7,3)          0.470261    0.008155     57.66525  0.00000000

30. CORR0(7,4)          0.515507    0.008428     61.16319  0.00000000

31. CORR0(7,5)          0.509814    0.007709     66.13200  0.00000000

32. CORR0(7,6)          0.292443    0.009874     29.61748  0.00000000

33. CORR0(7,7)          1.000000    0.000000      0.00000  0.00000000

34. CORR0(8,1)          0.464974    0.009303     49.97914  0.00000000

35. CORR0(8,2)          0.629374    0.006307     99.78656  0.00000000

36. CORR0(8,3)          0.557362    0.006838     81.51109  0.00000000

37. CORR0(8,4)          0.769186    0.003628    211.99156  0.00000000

38. CORR0(8,5)          0.715248    0.004497    159.03408  0.00000000

39. CORR0(8,6)          0.295838    0.011036     26.80552  0.00000000

40. CORR0(8,7)          0.463056    0.008848     52.33406  0.00000000

41. CORR0(8,8)          1.000000    0.000000 4.29497e+009  0.00000000

42. CORR0(9,1)          0.527253    0.008055     65.45832  0.00000000

43. CORR0(9,2)          0.734356    0.004033    182.06838  0.00000000

44. CORR0(9,3)          0.646786    0.005357    120.73852  0.00000000

45. CORR0(9,4)          0.833917    0.002753    302.94930  0.00000000
```

```
46. CORR0(9,5)        0.799636   0.003199   249.93387  0.00000000

47. CORR0(9,6)        0.326843   0.010731    30.45804  0.00000000

48. CORR0(9,7)        0.536432   0.007161    74.90726  0.00000000

49. CORR0(9,8)        0.726081   0.004451   163.14028  0.00000000

50. CORR0(9,9)        1.000000   0.000000     0.00000  0.00000000

51. CORR0(10,1)        0.401713   0.009359    42.92317  0.00000000

52. CORR0(10,2)        0.477770   0.007958    60.03290  0.00000000

53. CORR0(10,3)        0.454856   0.008444    53.86447  0.00000000

54. CORR0(10,4)        0.506663   0.008324    60.86702  0.00000000

55. CORR0(10,5)        0.502983   0.008231    61.11037  0.00000000

56. CORR0(10,6)        0.304317   0.010773    28.24770  0.00000000

57. CORR0(10,7)        0.391335   0.009353    41.84279  0.00000000

58. CORR0(10,8)        0.473318   0.008576    55.18959  0.00000000

59. CORR0(10,9)        0.502038   0.007953    63.12266  0.00000000

60. CORR0(10,10)        1.000000   0.000000 4.29497e+009  0.00000000

61. CORR0(11,1)        0.487110   0.009289    52.44194  0.00000000

62. CORR0(11,2)        0.643860   0.005873   109.62168  0.00000000

63. CORR0(11,3)        0.576266   0.006683    86.23234  0.00000000

64. CORR0(11,4)        0.785395   0.003261   240.87426  0.00000000

65. CORR0(11,5)        0.724004   0.004384   165.15457  0.00000000

66. CORR0(11,6)        0.307910   0.010863    28.34432  0.00000000

67. CORR0(11,7)        0.473250   0.008723    54.25160  0.00000000

68. CORR0(11,8)        0.723974   0.004223   171.45340  0.00000000

69. CORR0(11,9)        0.737898   0.003873   190.52466  0.00000000

70. CORR0(11,10)        0.527345   0.007423    71.04554  0.00000000

71. CORR0(11,11)        1.000000   0.000000     0.00000  0.00000000
```

```
compute phi7 = %beta
display(unit=corr0) corr0



*
* output the scores, skipping the diagonal entries of the correlation matrix estimates
do param=1,5
(01.0041) compute jj = param
(01.0059) set [series] jj = ssdrvs(param)
(01.0096) end do param
compute param = 5
compute place = 5
* write out the scores skipping the diagonal entries
do h=1,11
(01.0041) do hh = h,11
(02.0078) compute place = place +1
(02.0101) if hh > h
(03.0124) {
(04.0124) compute param = param+1
(04.0147) set [series] param / = ssdrvs(place)
(04.0184) }
(03.0184)
(03.0184) end do hh
(01.0186) end do h
```

```
copy(unit=ssdrvs7,format='(10(f20.10))',org=obs) 261 4788 1 2 3 4 5 $

6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 $

21 22 23 24 25 26 27 28 29 30 $

31 32 33 34 35 36 37 38 39 40 $

41 42 43 44 45 46 47 48 49 50 $

51 52 53 54 55 56 57 58 59 60



write(unit=phi7) phi7
```

```
*switchorgobs.txt this program switches the 44 scores from the first-step estimation to store them as organization=observations rather than organization = variates  so that they can be vectorized by a later program


alloc 44 4788

open fsdrvs c:\eurovol\output\fsdrvs.txt

open fsdrvsorgobs c:\eurovol\output\fsdrvsorgobs.txt


data(unit=fsdrvs,format=free,org=vars) 261 4788 1 2 3 4 5 6 7 8 9 10 $

11 12 13 14 15 16 17 18 19 20 $

21 22 23 24 25 26 27 28 29 30 $

31 32 33 34 35 36 37 38 39 40 $

41 42 43 44


copy(unit=fsdrvsorgobs,format=free,org=obs) 261 4788 1 2 3 4 5 6 7 8 9 10 $

11 12 13 14 15 16 17 18 19 20 $

21 22 23 24 25 26 27 28 29 30 $

31 32 33 34 35 36 37 38 39 40 $

41 42 43 44
```

```
*crossmarginalstep1.txt this program computes the outputs (standardized outcomes) of the first-stage
* estimation when the pre-estimated parameters are perturbed by epsilon (a small amount)
* from their pre-estimated values

alloc 22 4788

* read in the pre-estimated parameters
open theta c:\eurovol\output\theta.txt
declare vector onetheta(4)
declare vector alltheta(44)
declare real epsilon m
read(unit=theta) alltheta

* file for the epsilons in derivative computation
open epsilons c:\eurovol\output\epsilons.txt

* output file for unconditional variances
open m c:\eurovol\output\m.txt



*read in the data for maximum likelihood calculations
open eta c:\eurovol\output\eta.txt
open dailysignals c:\eurovol\output\dailysignals.txt
open truedailysigs c:\eurovol\output\truedailysigs.txt
```

```
open epsilons c:\eurovol\output\epsilons.txt
open alteta c:\eurovol\output\alteta.txt

data(unit=eta,format=free,org=vars) 261 4788 e1 e2 e3 e4 e5 e6 $
 e7 e8 e9 e10 e11
data(unit=dailysignals,format=free,org=obs) 1 4788 qcumret qavevar qavecorr $
qsignal qtrend lagqcumret lagqavevar lagqavecorr lagqsignal
data(unit=truedailysigs,format=free,org=obs) 260 4788 tdavecorr tdavevar tdcumret


*read in 11 equity index returns, de-mean and square

open rets c:\eurovol\output\rets.txt
data(unit=rets,format=free,org=obs) / 1 2 3 4 5 $
6 7 8 9 10 11


do j=1,11
(01.0041) set ret / = [series] j
(01.0073) statistics(noprint) ret /
(01.0091) set ret / = ret - %mean
(01.0128) set [series] j = ret
(01.0160) compute jp11 = j + 11
(01.0183) set [series] jp11 = (ret)**2
(01.0221) end do j
```

```
* compute the etas using positively-perturbed parameter values (four parameters) for each country (eleven countries)


do j=1,11

(01.0041) set ret / = [series] j

(01.0074) * calculate 65-day rolling window variance

(01.0074) compute jp11 = j + 11

(01.0097) set ret2 / = [series] jp11

(01.0129) statistics(noprint) ret2 1 65

(01.0163) set rv 65 65 = %mean

(01.0206) compute m = %mean

(01.0224) display(unit=m) m

(01.0255) do date = 66, 4788

(02.0290) set rv date date = rv(date-1) + (1.0/65.0)*(ret2(date) - ret2(date-65))

(02.0385) end do date

(01.0387) statistics rv

(01.0401)

(01.0401) * define rolling window variances at 3 lag lengths, to be used as explanatory variables

(01.0401) set rvm65 / = rv{65}

(01.0432) set rvm130 / = rv{130}

(01.0463) set rvm195 / = rv{195}

(01.0494)

(01.0494)

(01.0494) * read in the un-perturbed parameters for the jth country

(01.0494) do param = 1,4

(02.0529) compute paramplace = (j-1)*4 + param

(02.0564) compute onetheta(param) = alltheta(paramplace)
```

```
(02.0592) end do param
(01.0594)
(01.0594) * estimate the perturbed first-step etas by marginally changing the pre-estimated parameters for each of four parameters
(01.0594)
(01.0594) do param = 1,4
(02.0629) compute epsilon = %max(.0001, .001*onetheta(param))
(02.0664) display(unit=epsilons) epsilon
(02.0697) * perturb one parameter
(02.0697) compute onetheta(param) = onetheta(param)+epsilon
(02.0732) * label the parameters
(02.0732) compute theta = onetheta(1)
(02.0753) compute w = onetheta(2)
(02.0774) compute a1 = onetheta(3)
(02.0795) compute a2 = onetheta(4)
(02.0816)
(02.0816)
(02.0816) * midas-GARCH eta using perturbed pre-estimated parameters
(02.0816)
(02.0816)
(02.0816) set lrv / =  m*abs(1.0-theta) +theta*(1.0*rvm65+(exp(-w*1))*rvm130+(exp(-w*2))*rvm195)/(1.0+exp(-w*1)+exp(-w*2))
(02.0963) set sgvar / = 1.0
(02.0989) do i=261,4788
(03.1024) set sgvar i i  = abs(1.0-a1-a2) + a1*ret2{1}/lrv{1} + a2*sgvar{1}
(03.1133) end do i
(02.1135)
(02.1135) set fglogl / = -.5*(log(sgvar*lrv)+ret2/(sgvar*lrv))
```

```
(02.1207)

(02.1207)

(02.1207)

(02.1207) * create series of standardized outcomes

(02.1207) set alteta 261 4788 = ret/((sgvar*lrv)**.5)

(02.1276)

(02.1276)

(02.1276) * save the standardized outcomes of the perturbed maximum likelihood estimation

(02.1276)

(02.1276) copy(unit=alteta,format= free, org=obs) 261 4788 alteta

(02.1340)

(02.1340) * un-perturb a parameter and go back to the beginning of the parameter loop

(02.1340) compute onetheta(param) = onetheta(param)- epsilon

(02.1375)

(02.1375) end do param

(01.1377)

(01.1377)

(01.1377) end do j


Statistics on Series RV

Observations                 4724

Sample Mean              0.000183      Variance            0.000000

Standard Error           0.000294      of Sample Mean      0.000004

t-Statistic (Mean=0)     42.788958      Signif Level        0.000000

Skewness                 5.357170      Signif Level (Sk=0) 0.000000

Kurtosis (excess)        34.415253      Signif Level (Ku=0) 0.000000

Jarque-Bera          255727.182767      Signif Level (JB=0) 0.000000
```

```
Statistics on Series RV

Observations                4724

Sample Mean              0.000140      Variance            0.000000

Standard Error           0.000184      of Sample Mean      0.000003

t-Statistic (Mean=0)    52.337948      Signif Level        0.000000

Skewness                 3.778069      Signif Level (Sk=0) 0.000000

Kurtosis (excess)       18.636863      Signif Level (Ku=0) 0.000000

Jarque-Bera          79604.886654      Signif Level (JB=0) 0.000000
```

```
Statistics on Series RV

Observations               4724

Sample Mean             0.000350      Variance            0.000000

Standard Error          0.000357      of Sample Mean      0.000005

t-Statistic (Mean=0)   67.441538      Signif Level        0.000000

Skewness                1.740323      Signif Level (Sk=0) 0.000000

Kurtosis (excess)       2.568932      Signif Level (Ku=0) 0.000000

Jarque-Bera          3683.601168      Signif Level (JB=0) 0.000000
```

```
Statistics on Series RV

Observations                4724

Sample Mean              0.000207      Variance            0.000000

Standard Error           0.000226      of Sample Mean      0.000003

t-Statistic (Mean=0)    62.992115      Signif Level        0.000000
```

```
Skewness              3.538138      Signif Level (Sk=0) 0.000000

Kurtosis (excess)       15.981624      Signif Level (Ku=0) 0.000000

Jarque-Bera         60129.822983      Signif Level (JB=0) 0.000000



Statistics on Series RV

Observations                 4724

Sample Mean              0.000220      Variance            0.000000

Standard Error          0.000247      of Sample Mean       0.000004

t-Statistic (Mean=0)    61.258911      Signif Level         0.000000

Skewness              2.633320      Signif Level (Sk=0) 0.000000

Kurtosis (excess)        7.680507      Signif Level (Ku=0) 0.000000

Jarque-Bera         17070.900028      Signif Level (JB=0) 0.000000



Statistics on Series RV

Observations                4724

Sample Mean             0.000283      Variance            0.000000

Standard Error         0.000235      of Sample Mean       0.000003

t-Statistic (Mean=0)   82.887883      Signif Level         0.000000

Skewness             1.543151      Signif Level (Sk=0) 0.000000

Kurtosis (excess)       3.168734      Signif Level (Ku=0) 0.000000

Jarque-Bera         3851.267794      Signif Level (JB=0) 0.000000



Statistics on Series RV

Observations                  4724
```

```
Sample Mean              0.000171      Variance           0.000000
Standard Error           0.000262      of Sample Mean      0.000004
t-Statistic (Mean=0)     44.724195      Signif Level        0.000000
Skewness                 4.734735      Signif Level (Sk=0) 0.000000
Kurtosis (excess)        27.172494      Signif Level (Ku=0) 0.000000
Jarque-Bera          162981.007074      Signif Level (JB=0) 0.000000



Statistics on Series RV
Observations                  4724
Sample Mean              0.000218      Variance           0.000000
Standard Error           0.000207      of Sample Mean      0.000003
t-Statistic (Mean=0)    72.405100      Signif Level        0.000000
Skewness                 2.861645      Signif Level (Sk=0) 0.000000
Kurtosis (excess)        11.760999      Signif Level (Ku=0) 0.000000
Jarque-Bera           33673.683078      Signif Level (JB=0) 0.000000



Statistics on Series RV
Observations                  4724
Sample Mean              0.000206      Variance           0.000000
Standard Error           0.000281      of Sample Mean      0.000004
t-Statistic (Mean=0)    50.322435      Signif Level        0.000000
Skewness                 3.278113      Signif Level (Sk=0) 0.000000
Kurtosis (excess)        12.975939      Signif Level (Ku=0) 0.000000
Jarque-Bera           41602.515020      Signif Level (JB=0) 0.000000
```

```
Statistics on Series RV
Observations                4724
Sample Mean             0.000102      Variance           0.000000
Standard Error          0.000140      of Sample Mean      0.000002
t-Statistic (Mean=0)    50.449362      Signif Level        0.000000
Skewness                4.028607      Signif Level (Sk=0) 0.000000
Kurtosis (excess)       21.262904      Signif Level (Ku=0) 0.000000
Jarque-Bera         101768.697219      Signif Level (JB=0) 0.000000


Statistics on Series RV
Observations                4724
Sample Mean             0.000203      Variance           0.000000
Standard Error          0.000214      of Sample Mean      0.000003
t-Statistic (Mean=0)    65.224975      Signif Level        0.000000
Skewness                3.101575      Signif Level (Sk=0) 0.000000
Kurtosis (excess)       12.676916      Signif Level (Ku=0) 0.000000
Jarque-Bera          39205.909354      Signif Level (JB=0) 0.000000


display 'positive perturbations done'
positive perturbations done
```

```
* next compute the etas using negatively-perturbed parameter values (four parameters) for
each country (eleven countries)


do j=1,11
(01.0041) set ret / = [series] j
(01.0074) * calculate 65-day rolling window variance
(01.0074) compute jp11 = j + 11
(01.0097) set ret2 / = [series] jp11
(01.0130) statistics(noprint) ret2 1 65
(01.0164) set rv 65 65 = %mean
(01.0208) compute m = %mean
(01.0226) display(unit=m) m
(01.0257) do date = 66, 4788
(02.0292) set rv date date = rv(date-1) + (1.0/65.0)*(ret2(date) - ret2(date-65))
(02.0387) end do date
(01.0389) statistics rv
(01.0403)
(01.0403) * define rolling window variances at 3 lag lengths, to be used as explanatory
variables
(01.0403) set rvm65 / = rv{65}
(01.0435) set rvm130 / = rv{130}
(01.0467) set rvm195 / = rv{195}
(01.0499)
(01.0499)
(01.0499) * read in the un-perturbed parameters for the jth country
(01.0499) do param = 1,4
(02.0534) compute paramplace = (j-1)*4 + param
(02.0569) compute onetheta(param) = alltheta(paramplace)
```

```
(02.0597) end do param
(01.0599)
(01.0599) * estimate the perturbed first-step etas by marginally changing the pre-estimated parameters for each of four parameters
(01.0599)
(01.0599) do param = 1,4
(02.0634) compute epsilon = %max(.0001, .001*onetheta(param))
(02.0669) display(unit=epsilons) epsilon
(02.0702) * perturb one parameter
(02.0702) compute onetheta(param) = onetheta(param)-epsilon
(02.0737) * label the parameters
(02.0737) compute theta = onetheta(1)
(02.0758) compute w = onetheta(2)
(02.0779) compute a1 = onetheta(3)
(02.0800) compute a2 = onetheta(4)
(02.0821)
(02.0821)
(02.0821) * midas-GARCH eta using perturbed pre-estimated parameters
(02.0821)
(02.0821)
(02.0821) set lrv / =  m*abs(1.0-theta) +theta*(1.0*rvm65+(exp(-w*1))*rvm130+(exp(-w*2))*rvm195)/(1.0+exp(-w*1)+exp(-w*2))
(02.0969) set sgvar / = 1.0
(02.0996) do i=261,4788
(03.1031) set sgvar i i  = abs(1.0-a1-a2) + a1*ret2{1}/lrv{1} + a2*sgvar{1}
(03.1140) end do i
(02.1142)
(02.1142) set fglogl / = -.5*(log(sgvar*lrv)+ret2/(sgvar*lrv))
```

```
(02.1215)

(02.1215)

(02.1215)

(02.1215) * create series of standardized outcomes

(02.1215) set alteta 261 4788 = ret/((sgvar*lrv)**.5)

(02.1285)

(02.1285)

(02.1285) * save the standardized outcomes of the perturbed maximum likelihood estimation

(02.1285)

(02.1285) copy(unit=alteta,format= free, org=obs) 261 4788 alteta

(02.1349)

(02.1349) * un-perturb a parameter and go back to the beginning of the parameter loop

(02.1349) compute onetheta(param) = onetheta(param) + epsilon

(02.1384)

(02.1384) end do param

(01.1386)

(01.1386)

(01.1386) end do j


Statistics on Series RV

Observations                   4724

Sample Mean              0.000183      Variance            0.000000

Standard Error           0.000294      of Sample Mean      0.000004

t-Statistic (Mean=0)     42.788958      Signif Level        0.000000

Skewness                 5.357170      Signif Level (Sk=0) 0.000000

Kurtosis (excess)        34.415253      Signif Level (Ku=0) 0.000000

Jarque-Bera          255727.182767      Signif Level (JB=0) 0.000000
```

```
Statistics on Series RV
Observations              4724
Sample Mean             0.000140      Variance            0.000000
Standard Error          0.000184      of Sample Mean      0.000003
t-Statistic (Mean=0)    52.337948      Signif Level        0.000000
Skewness                3.778069      Signif Level (Sk=0) 0.000000
Kurtosis (excess)       18.636863      Signif Level (Ku=0) 0.000000
Jarque-Bera          79604.886654      Signif Level (JB=0) 0.000000


Statistics on Series RV
Observations              4724
Sample Mean             0.000350      Variance            0.000000
Standard Error          0.000357      of Sample Mean      0.000005
t-Statistic (Mean=0)    67.441538      Signif Level        0.000000
Skewness                1.740323      Signif Level (Sk=0) 0.000000
Kurtosis (excess)       2.568932      Signif Level (Ku=0) 0.000000
Jarque-Bera          3683.601168      Signif Level (JB=0) 0.000000


Statistics on Series RV
Observations              4724
Sample Mean             0.000207      Variance            0.000000
Standard Error          0.000226      of Sample Mean      0.000003
t-Statistic (Mean=0)    62.992115      Signif Level        0.000000
```

```
Skewness                3.538138      Signif Level (Sk=0) 0.000000

Kurtosis (excess)       15.981624      Signif Level (Ku=0) 0.000000

Jarque-Bera          60129.822983      Signif Level (JB=0) 0.000000



Statistics on Series RV

Observations                 4724

Sample Mean              0.000220      Variance            0.000000

Standard Error           0.000247      of Sample Mean      0.000004

t-Statistic (Mean=0)    61.258911      Signif Level        0.000000

Skewness                 2.633320      Signif Level (Sk=0) 0.000000

Kurtosis (excess)        7.680507      Signif Level (Ku=0) 0.000000

Jarque-Bera          17070.900028      Signif Level (JB=0) 0.000000



Statistics on Series RV

Observations                 4724

Sample Mean              0.000283      Variance            0.000000

Standard Error           0.000235      of Sample Mean      0.000003

t-Statistic (Mean=0)    82.887883      Signif Level        0.000000

Skewness                 1.543151      Signif Level (Sk=0) 0.000000

Kurtosis (excess)        3.168734      Signif Level (Ku=0) 0.000000

Jarque-Bera           3851.267794      Signif Level (JB=0) 0.000000



Statistics on Series RV

Observations                 4724
```

```
Sample Mean            0.000171      Variance            0.000000
Standard Error         0.000262      of Sample Mean      0.000004
t-Statistic (Mean=0)   44.724195     Signif Level        0.000000
Skewness               4.734735      Signif Level (Sk=0) 0.000000
Kurtosis (excess)      27.172494     Signif Level (Ku=0) 0.000000
Jarque-Bera        162981.007074     Signif Level (JB=0) 0.000000


Statistics on Series RV
Observations                4724
Sample Mean            0.000218      Variance            0.000000
Standard Error         0.000207      of Sample Mean      0.000003
t-Statistic (Mean=0)   72.405100     Signif Level        0.000000
Skewness               2.861645      Signif Level (Sk=0) 0.000000
Kurtosis (excess)      11.760999     Signif Level (Ku=0) 0.000000
Jarque-Bera         33673.683078     Signif Level (JB=0) 0.000000


Statistics on Series RV
Observations                4724
Sample Mean            0.000206      Variance            0.000000
Standard Error         0.000281      of Sample Mean      0.000004
t-Statistic (Mean=0)   50.322435     Signif Level        0.000000
Skewness               3.278113      Signif Level (Sk=0) 0.000000
Kurtosis (excess)      12.975939     Signif Level (Ku=0) 0.000000
Jarque-Bera         41602.515020     Signif Level (JB=0) 0.000000
```

```
Statistics on Series RV

Observations                4724

Sample Mean             0.000102      Variance           0.000000

Standard Error          0.000140      of Sample Mean      0.000002

t-Statistic (Mean=0)     50.449362      Signif Level        0.000000

Skewness                4.028607      Signif Level (Sk=0) 0.000000

Kurtosis (excess)        21.262904      Signif Level (Ku=0) 0.000000

Jarque-Bera          101768.697219      Signif Level (JB=0) 0.000000



Statistics on Series RV

Observations                4724

Sample Mean             0.000203      Variance           0.000000

Standard Error          0.000214      of Sample Mean      0.000003

t-Statistic (Mean=0)    65.224975      Signif Level        0.000000

Skewness                3.101575      Signif Level (Sk=0) 0.000000

Kurtosis (excess)       12.676916      Signif Level (Ku=0) 0.000000

Jarque-Bera          39205.909354      Signif Level (JB=0) 0.000000


display 'all done'

all done
```

```
*crossmarginalstep2m6.txt this program estimates second-step cross-marginal log likelihood scores
* using perturbed and unperturbed etas from step 1 estimation
* and perturbed and unperturbed second step likelihood values
* and finds the expected cross-marginals of the likelihood function
* by taking difference-combinations of
* perturbed and un-perturbed log likelihood values
* d2f/dxdy = lim(1/(4*e1*e2))*[(f(x+e1,y+e2)-f(x+e1,y-e2)-(f(x-e1,y+e2)-f(x-e1,y-e2))]
* the four terms in the square bracket are term1, term2, term3 and term4 below
* these are expected values of the likelihood function at perturbed and/or unperturbed
* first step and second step parameter estimates
* using model 6 from table 6

alloc 110 4788
* numbered variates 1 - 11 are for unperturbed etas
* 12 - 55 are the positive-perturbed etas
* 56 - 99 are the negative-perturbed etas
* 100 - 110 are for temporary storage

open eta c:\eurovol\output\eta.txt
open alteta c:\eurovol\output\alteta.txt
open dailysignals c:\eurovol\output\dailysignals.txt
open truedailysigs c:\eurovol\output\truedailysigs.txt
open phi6 c:\eurovol\output\phi6.txt
open corr0 c:\eurovol\output\corr0.txt
open covs6 c:\eurovol\output\covs6.txt
open covs c:\eurovol\output\covs.txt
```

```
open ssdrvs6 c:\eurovol\output\ssdrvs6.txt
open ssdrvs6 c:\eurovol\output\ssdrvs.txt

* input file for the first-step epsilons of the numerical derivatives
open epsilons c:\eurovol\output\epsilons.txt
declare vector epsilon1(44)
read(unit=epsilons) epsilon1
*second-step parameter epsilon vector
declare vector epsilon2(60)



* output file for the expected cross-marginal matrix of the log
*  likelihood function
open gmat6 c:\eurovol\output\gmat6.txt
declare rectangular gmat(44,60)

* the four terms of the cross-partial derivative matrix
declare rectangular term1(44,60)
declare rectangular term2(44,60)
declare rectangular term3(44,60)
declare rectangular term4(44,60)




* read in the unperturbed etas
data(unit=eta,format=free,org=vars) 261 4788 $
1 2 3 4 5 6 7 8 9 10 11
```

```
* read in the perturbed etas
data(unit=alteta,format=free,org=vars) 261 4788 $
12 13 14 15 16 17 18 19 $
20 21 22 23 24 25 26 27 28 29 $
30 31 32 33 34 35 36 37 38 39 $
40 41 42 43 44 45 46 47 48 49 $
50 51 52 53 54 55 56 57 58 59 $
60 61 62 63 64 65 66 67 68 69 $
70 71 72 73 74 75 76 77 78 79 $
80 81 82 83 84 85 86 87 88 89 $
90 91 92 93 94 95 96 97 98 99


* compare the perturbed and unperturbed etas

* positive perturbations
do j = 1,11
(01.0041) do k=1,4
(02.0076) compute altetaplace = (j-1)*4 +k + 11
(02.0116) set eta / = [series] j
(02.0148) set alteta / = [series] altetaplace
(02.0180) linreg(noprint) eta
(02.0196) #alteta
(02.0210) *display k j %rsquared
(02.0210) end do k
```

```
(01.0212) end do j

* negative perturbations
do j = 1,11
(01.0041) do k=1,4
(02.0076) compute altetaplace = (j-1)*4 +k + 55
(02.0116) set eta / = [series] j
(02.0149) set alteta / = [series] altetaplace
(02.0182) linreg(noprint) eta
(02.0198) # alteta
(02.0212) *display k j %rsquared
(02.0212) end do k
(01.0214) end do j




data(unit=dailysignals,format=free,org=obs) 1 4788 qcumret qavevar avegrowth $
qsignal qtrend lagqcumret lagqavevar lagqavecorr lagqsignal
data(unit=truedailysigs,format=free,org=obs) 260 4788 tdavecorr tdavevar tdcumret

* de-mean the explanatory variables

statistics qsignal

Statistics on Series QSIGNAL
```

```
Observations              4788
Sample Mean           0.435200      Variance           0.085601
Standard Error        0.292576      of Sample Mean      0.004228
t-Statistic (Mean=0) 102.926397      Signif Level        0.000000
Skewness              0.352169      Signif Level (Sk=0) 0.000000
Kurtosis (excess)     -0.874474      Signif Level (Ku=0) 0.000000
Jarque-Bera          251.528696      Signif Level (JB=0) 0.000000

set qsignal / = qsignal - %mean


statistics avegrowth


Statistics on Series AVEGROWTH
Observations              4788
Sample Mean           0.521804      Variance           0.034933
Standard Error        0.186904      of Sample Mean      0.002701
t-Statistic (Mean=0) 193.182261      Signif Level        0.000000
Skewness             -0.194089      Signif Level (Sk=0) 0.000000
Kurtosis (excess)     -0.881112      Signif Level (Ku=0) 0.000000
Jarque-Bera          184.944575      Signif Level (JB=0) 0.000000

set avegrowth / = avegrowth - %mean


statistics tdavecorr


Statistics on Series TDAVECORR
Observations              4529
```

```
Sample Mean          0.535547     Variance          0.030712
Standard Error        0.175249     of Sample Mean     0.002604
t-Statistic (Mean=0) 205.656653     Signif Level       0.000000
Skewness             -0.261659     Signif Level (Sk=0) 0.000000
Kurtosis (excess)     -1.036007     Signif Level (Ku=0) 0.000000
Jarque-Bera         254.222779     Signif Level (JB=0) 0.000000

set ratio / = (tdavecorr{1} - %mean)/(1.0-%mean)

statistics tdavevar

Statistics on Series TDAVEVAR
Observations              4529
Sample Mean           0.054274     Variance          0.001500
Standard Error         0.038725     of Sample Mean     0.000575
t-Statistic (Mean=0)   94.320011     Signif Level       0.000000
Skewness              1.492091     Signif Level (Sk=0) 0.000000
Kurtosis (excess)      2.374317     Signif Level (Ku=0) 0.000000
Jarque-Bera         2744.332817     Signif Level (JB=0) 0.000000

set avevar / = tdavevar{1} - %mean

statistics tdcumret

Statistics on Series TDCUMRET
Observations              4529
Sample Mean          0.711834     Variance          8.208044
```

```
Standard Error         2.864968      of Sample Mean      0.042571
t-Statistic (Mean=0)  16.720919      Signif Level        0.000000
Skewness              -1.010469      Signif Level (Sk=0) 0.000000
Kurtosis (excess)      0.936317      Signif Level (Ku=0) 0.000000
Jarque-Bera          936.159656      Signif Level (JB=0) 0.000000

set cumret / = tdcumret{1} - %mean


* set trend to match the annual scale per unit time
set trend / = t/261.0
statistics trend


Statistics on Series TREND
Observations               4788
Sample Mean            9.174330      Variance           28.050249
Standard Error         5.296249      of Sample Mean      0.076540
t-Statistic (Mean=0) 119.862421      Signif Level        0.000000
Skewness               0.000000      Signif Level (Sk=0) 1.000000
Kurtosis (excess)     -1.200000      Signif Level (Ku=0) 0.000000
Jarque-Bera          287.280000      Signif Level (JB=0) 0.000000

set trend / = trend - %mean



* read in the second-step estimated parameter values
* both phi and corr0
declare vector phi(5)
```

```
declare real b1 b2 b3 b4 b5
read(unit=phi6) phi
display "phi" phi
phi      0.51440       0.03290       0.00102       0.29440      -0.06660
compute b1 = phi(1)
compute b2 = phi(2)
compute b3 = phi(3)
compute b4 = phi(4)
compute b5 = phi(5)
declare symmetric corr0(11,11)
read(unit=corr0) corr0


* create a unit matrix
declare symmetric unitmat(11,11)
do j = 1,11
(01.0041) do jj = 1,11
(02.0076) compute unitmat(j,jj) = 1.0
(02.0102) end do jj
(01.0104) end do j

* place the unperturbed etas into the temporary storage slots as default values
do j=1,11
(01.0041) compute jp99 = j + 99
(01.0064) set [series] jp99 / = [series] j
(01.0099) end do j
```

```
* iteratively run over the eleven countries and then in an inner loop

* iteratively replace one eta series with a positively-perturbed eta series and re-estimate

* the expected log likelihood


* iterate over countries

do j = 1, 11

(01.0041)

(01.0041) * iterate over first-step parameters

(01.0041) do k = 1,4

(02.0076)

(02.0076) * first deal with term1 and term2 where the first-step parameter is perturbed positively

(02.0076) * replace one eta with a perturbed eta for country j based on first-step perturbed parameter k

(02.0076)

(02.0076) compute countryplace = j + 99

(02.0099) computer altetaplace = (j-1)*4 +k + 11

(02.0139) set [series] countryplace / = [series] altetaplace

(02.0174)

(02.0174) * label the etas using the mixture of ten unperturbed and one perturbed eta

(02.0174) set e1 / = [series] 100

(02.0204) set e2 / = [series] 101

(02.0234) set e3 / = [series] 102

(02.0264) set e4 / = [series] 103

(02.0294) set e5 / = [series] 104

(02.0324) set e6 / = [series] 105
```

```
(02.0354) set e7 / = [series] 106

(02.0384) set e8 / = [series] 107

(02.0414) set e9 / = [series] 108

(02.0444) set e10 / = [series] 109

(02.0474) set e11 / = [series] 110

(02.0504)

(02.0504)

(02.0504) * now an inner loop over second step parameters

(02.0504) do step2param = 1,5

(03.0539)

(03.0539) * term 1 first where the second-step parameter is also perturbed positively

(03.0539) compute newphi = phi

(03.0557) compute epsilon = %max(.0001,.001*phi(step2param))

(03.0592) compute newphi(step2param) = phi(step2param)+epsilon

(03.0627) compute b1 = newphi(1)

(03.0648) compute b2 = newphi(2)

(03.0669) compute b3 = newphi(3)

(03.0690) compute b4 = newphi(4)

(03.0711) compute b5 = newphi(5)

(03.0732) compute epsilon2(step2param) = epsilon

(03.0755)

(03.0755) * compute second-step likelihood and save the term

(03.0755)

(03.0755) set m / = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*qsignal)

(03.0855) do i=261,4788

(04.0890) compute ut = ||e1(i),e2(i),e3(i),e4(i),e5(i),e6(i),e7(i),e8(i),e9(i),e10(i),e11(i)||

(04.1058) compute sigmat = (m(i))*unitmat + (1.0 - m(i))*corr0
```

```
(04.1115) set mvlike i i = %logdensity(sigmat,ut)

(04.1173) end do i

(03.1175) statistics(noprint) mvlike 261 4788

(03.1209) compute paramplace = (j-1)*4+k

(03.1244) *display 'paramplace step2param1' paramplace step2param

(03.1244) compute term1(paramplace,step2param) = %mean

(03.1271)

(03.1271) * term 2 next where the second-step parameter is perturbed negatively

(03.1271) compute newphi = phi

(03.1290) compute epsilon = %max(.0001,.001*phi(step2param))

(03.1325) compute newphi(step2param) = phi(step2param)-epsilon

(03.1360) compute b1 = newphi(1)

(03.1381) compute b2 = newphi(2)

(03.1402) compute b3 = newphi(3)

(03.1423) compute b4 = newphi(4)

(03.1444) compute b5 = newphi(5)

(03.1465) compute epsilon2(step2param) = epsilon

(03.1488)

(03.1488) * compute second-step likelihood and save the term

(03.1488)

(03.1488) set m / = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*qsignal)

(03.1589) do i=261,4788

(04.1624) compute ut = ||e1(i),e2(i),e3(i),e4(i),e5(i),e6(i),e7(i),e8(i),e9(i),e10(i),e11(i)||

(04.1773) compute sigmat = (m(i))*unitmat + (1.0 - m(i))*corr0

(04.1821) set mvlike i i = %logdensity(sigmat,ut)

(04.1880) end do i

(03.1882) statistics(noprint) mvlike 261 4788
```

```
(03.1916) compute paramplace = (j-1)*4+k
(03.1951) *display 'paramplace step2param1' paramplace step2param
(03.1951)
(03.1951) compute term2(paramplace,step2param) = %mean
(03.1978)
(03.1978) end do step2param
(02.1980)
(02.1980) compute step2param = 5
(02.1996)
(02.1996) * now separately do step 2 for the parameters of the unconditional correlation matrix
(02.1996) do row = 1,10
(03.2031) compute rowp1 = row + 1
(03.2054) do col = rowp1,11
(04.2091) compute step2param = step2param + 1
(04.2114) compute pcorr0 = corr0
(04.2132) compute epsilon = %max(.0001,.001*corr0(row,col))
(04.2171) compute epsilon2(step2param) = epsilon
(04.2194)
(04.2194) * term 1 first where the second-step parameter is also perturbed positively
(04.2194) compute pcorr0(row,col) = corr0(row,col)+epsilon
(04.2237)
(04.2237) * compute second-step likelihood and save the term
(04.2237) set m / = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*qsignal)
(04.2338) do i=261,4788
(05.2373) compute ut = ||e1(i),e2(i),e3(i),e4(i),e5(i),e6(i),e7(i),e8(i),e9(i),e10(i),e11(i)||
(05.2522) compute sigmat = (m(i))*unitmat + (1.0 - m(i))*pcorr0
```

```
(05.2570) set mvlike i i = %logdensity(sigmat,ut)
(05.2629) end do i
(04.2631) statistics(noprint) mvlike 261 4788
(04.2665) compute paramplace = (j-1)*4+k
(04.2700) *display 'paramplace step2param1' paramplace step2param
(04.2700) compute term1(paramplace,step2param) = %mean
(04.2727)
(04.2727) * term 2 next where the second-step parameter is perturbed negatively
(04.2727) compute pcorr0(row,col) = corr0(row,col)-epsilon
(04.2770)
(04.2770) * compute second-step likelihood and save the term
(04.2770) set m / = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*qsignal)
(04.2871) do i=261,4788
(05.2906) compute ut = ||e1(i),e2(i),e3(i),e4(i),e5(i),e6(i),e7(i),e8(i),e9(i),e10(i),e11(i)||
(05.3055) compute sigmat = (m(i))*unitmat + (1.0 - m(i))*pcorr0
(05.3103) set mvlike i i = %logdensity(sigmat,ut)
(05.3162) end do i
(04.3164) statistics(noprint) mvlike 261 4788
(04.3198) compute paramplace = (j-1)*4+k
(04.3233) *display 'paramplace step2param1' paramplace step2param
(04.3233) compute term2(paramplace,step2param) = %mean
(04.3260)
(04.3260) end do row
(03.3262) end do col
(02.3264)
(02.3264) * restore the perturbed eta to its unperturbed value
(02.3264) set [series] countryplace / = [series] j
```

```
(02.3299)
(02.3299) * close the first-step parameter and country loops
(02.3299) end do k
(01.3301) end do j


* now repeat the last block with negatively-perturbed step one etas
* to compute terms 3 and 4


* iteratively run over the eleven countries and then in an inner loop
* iteratively replace one eta series with a negatively-perturbed eta series and re-estimate
* the expected log likelihood

* iterate over countries
do j = 1, 11
(01.0041)
(01.0041) * iterate over first-step parameters
(01.0041) do k = 1,4
(02.0076)
(02.0076) * term3 and term4 where the first-step parameter is perturbed negatively
(02.0076) * replace one eta with a perturbed eta for country j based on first-step perturbed parameter k
(02.0076)
(02.0076) compute countryplace = j + 99
(02.0099) computer altetaplace = (j-1)*4 +k + 55
(02.0139) set [series] countryplace / = [series] altetaplace
```

```
(02.0174)
(02.0174) * label the etas using the mixture of ten unperturbed and one perturbed eta
(02.0174) set e1 / = [series] 100
(02.0205) set e2 / = [series] 101
(02.0236) set e3 / = [series] 102
(02.0267) set e4 / = [series] 103
(02.0298) set e5 / = [series] 104
(02.0329) set e6 / = [series] 105
(02.0360) set e7 / = [series] 106
(02.0391) set e8 / = [series] 107
(02.0422) set e9 / = [series] 108
(02.0453) set e10 / = [series] 109
(02.0484) set e11 / = [series] 110
(02.0515)
(02.0515)
(02.0515) * now an inner loop over second step parameters
(02.0515) do step2param = 1,5
(03.0550)
(03.0550) * term 3 first where the second-step parameter is perturbed positively
(03.0550) compute newphi = phi
(03.0569) compute epsilon = %max(.0001,.001*phi(step2param))
(03.0604) compute newphi(step2param) = phi(step2param)+epsilon
(03.0639) compute b1 = newphi(1)
(03.0660) compute b2 = newphi(2)
(03.0681) compute b3 = newphi(3)
(03.0702) compute b4 = newphi(4)
(03.0723) compute b5 = newphi(5)
```

```
(03.0744) compute epsilon2(step2param) = epsilon
(03.0767)
(03.0767) * compute second-step likelihood and save the term
(03.0767)
(03.0767) set m / = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*qsignal)
(03.0868) do i=261,4788
(04.0903) compute ut = ||e1(i),e2(i),e3(i),e4(i),e5(i),e6(i),e7(i),e8(i),e9(i),e10(i),e11(i)||
(04.1052) compute sigmat = (m(i))*unitmat + (1.0 - m(i))*corr0
(04.1100) set mvlike i i = %logdensity(sigmat,ut)
(04.1159) end do i
(03.1161) statistics(noprint) mvlike 261 4788
(03.1195) *display 'paramplace step2param1' paramplace step2param
(03.1195) compute paramplace = (j-1)*4+k
(03.1230) compute term3(paramplace,step2param) = %mean
(03.1257)
(03.1257) * now term 4 where the second-step parameter is perturbed negatively
(03.1257) compute newphi = phi
(03.1276) compute epsilon = %max(.0001,.001*phi(step2param))
(03.1311) compute newphi(step2param) = phi(step2param)-epsilon
(03.1346) compute b1 = newphi(1)
(03.1367) compute b2 = newphi(2)
(03.1388) compute b3 = newphi(3)
(03.1409) compute b4 = newphi(4)
(03.1430) compute b5 = newphi(5)
(03.1451) compute epsilon2(step2param) = epsilon
(03.1474)
(03.1474) * compute second-step likelihood and save the term
```

```
(03.1474)
(03.1474) set m / = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*qsignal)
(03.1575) do i=261,4788
(04.1610) compute ut = ||e1(i),e2(i),e3(i),e4(i),e5(i),e6(i),e7(i),e8(i),e9(i),e10(i),e11(i)||
(04.1759) compute sigmat = (m(i))*unitmat + (1.0 - m(i))*corr0
(04.1807) set mvlike i i = %logdensity(sigmat,ut)
(04.1866) end do i
(03.1868) statistics(noprint) mvlike 261 4788
(03.1902) *display 'paramplace step2param1' paramplace step2param
(03.1902) compute paramplace = (j-1)*4+k
(03.1937) compute term4(paramplace,step2param) = %mean
(03.1964)
(03.1964) end do step2param
(02.1966)
(02.1966) compute step2param = 5
(02.1982)
(02.1982) * now separately do step 2 for the parameters of the unconditional correlation matrix
(02.1982) do row = 1,10
(03.2017) compute rowp1 = row + 1
(03.2040) do col = rowp1,11
(04.2077) compute step2param = step2param + 1
(04.2100) compute pcorr0 = corr0
(04.2119) compute epsilon = %max(.0001,.001*corr0(row,col))
(04.2158) compute epsilon2(step2param) = epsilon
(04.2181)
(04.2181) * term 3 where the second-step parameter is perturbed positively
```

```
(04.2181) compute pcorr0(row,col) = corr0(row,col)+epsilon

(04.2224)

(04.2224) * compute second-step likelihood and save the term

(04.2224) set m / = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*qsignal)

(04.2325) do i=261,4788

(05.2360) compute ut = ||e1(i),e2(i),e3(i),e4(i),e5(i),e6(i),e7(i),e8(i),e9(i),e10(i),e11(i)||

(05.2509) compute sigmat = (m(i))*unitmat + (1.0 - m(i))*pcorr0

(05.2557) set mvlike i i = %logdensity(sigmat,ut)

(05.2616) end do i

(04.2618) statistics(noprint) mvlike 261 4788

(04.2652) compute paramplace = (j-1)*4+k

(04.2687) *display 'paramplace step2param1' paramplace step2param

(04.2687) compute term3(paramplace,step2param) = %mean

(04.2714)

(04.2714) * term 4 where the second-step parameter is perturbed negatively

(04.2714) compute pcorr0(row,col) = corr0(row,col)-epsilon

(04.2757)

(04.2757) * compute second-step likelihood and save the term

(04.2757) set m / = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*qsignal)

(04.2858) do i=261,4788

(05.2893) compute ut = ||e1(i),e2(i),e3(i),e4(i),e5(i),e6(i),e7(i),e8(i),e9(i),e10(i),e11(i)||

(05.3042) compute sigmat = (m(i))*unitmat + (1.0 - m(i))*pcorr0

(05.3090) set mvlike i i = %logdensity(sigmat,ut)

(05.3149) end do i

(04.3151) statistics(noprint) mvlike 261 4788

(04.3185) compute paramplace = (j-1)*4+k

(04.3220) *display 'paramplace step2param1' paramplace step2param
```

```
(04.3220) compute term4(paramplace,step2param) = %mean
(04.3247)
(04.3247) end do row
(03.3249) end do col
(02.3251)
(02.3251) * restore the perturbed eta to its unperturbed value
(02.3251) set [series] countryplace / = [series] j
(02.3286)
(02.3286) * close the first-step parameter and country loops
(02.3286) end do k
(01.3288) end do j



* now fill up the cross-marginal matrix of the likelihood function
* using the four components term1,term2, term3 and term4
* and scaled by the reciprocal of the infinitesimals epsilon1xepsilon2

*display 'term4' term4
*display 'term3' term3
*display 'term2' term2
*display 'term1' term1
display 'epsilon1' epsilon1
epsilon1  5.44490e-004  1.00000e-004  1.11270e-004  8.60220e-004  4.67760e-004
8.96650e-004  1.32680e-004  8.42560e-004  8.19300e-004  4.20640e-004  1.00000e-004
9.03060e-004  3.57950e-004  3.11480e-004  1.00000e-004  9.09120e-004  4.79570e-004
```

```
 4.11470e-004  1.00000e-004  8.87310e-004  7.97470e-004  3.26510e-004  1.44100e-004
7.95930e-004  5.52630e-004  1.00000e-004  1.00000e-004  8.98040e-004  5.96650e-004
5.80160e-004  1.10680e-004  8.68870e-004  5.77560e-004  6.39540e-004  1.07200e-004

 8.75720e-004  5.84110e-004  6.87310e-004  1.66070e-004  8.03620e-004  5.19570e-004
9.64860e-004  1.03530e-004  8.70910e-004

display 'epsilon2' epsilon2

epsilon2  5.14400e-004  1.00000e-004  1.00000e-004  2.94400e-004  1.00000e-004
5.20820e-004  4.58700e-004  5.20100e-004  5.72430e-004  3.20950e-004  4.65270e-004
4.73390e-004  5.51140e-004  4.14940e-004  5.03660e-004  5.43790e-004  6.95150e-004

 6.74940e-004  3.48750e-004  5.20440e-004  6.12520e-004  7.29870e-004  4.93190e-004
6.41510e-004  6.20650e-004  6.17470e-004  3.16540e-004  4.90430e-004  5.51940e-004
6.51210e-004  4.76260e-004  5.81810e-004  7.79150e-004  3.47600e-004  5.41230e-004

 7.46010e-004  8.22440e-004  5.29260e-004  7.80310e-004  3.31170e-004  5.34030e-004
6.89420e-004  7.92000e-004  5.20750e-004  7.13330e-004  3.11730e-004  3.05850e-004
3.51780e-004  3.24830e-004  3.27380e-004  4.77620e-004  5.67000e-004  4.17450e-004

 4.96340e-004  7.10000e-004  4.79130e-004  7.07400e-004  5.26880e-004  7.41740e-004
5.41710e-004


do step1 = 1,44

(01.0041) do step2 = 1,60

(02.0076)

(02.0076) compute gmat(step1,step2) = (1.0/(4.0*epsilon1(step1)*epsilon2(step2)))* $

(02.0079) (term1(step1,step2)- term2(step1,step2) - term3(step1,step2) + term4(step1,step2))

(02.0196)

(02.0196)

(02.0196) end do step2

(01.0198) end do step1


*display gmat

write(unit=gmat6) gmat
```

```
*crossmarginalstep2m7.txt this program estimates second-step cross-marginal log likelihood scores
* using perturbed and unperturbed etas from step 1 estimation
* and perturbed and unperturbed second step likelihood values
* and finds the expected cross-marginals of the likelihood function
* by taking difference-combinations of
* perturbed and un-perturbed log likelihood values
* d2f/dxdy = lim(1/(4*e1*e2))*[(f(x+e1,y+e2)-f(x+e1,y-e2)-(f(x-e1,y+e2)-f(x-e1,y-e2))]
* the four terms in the square bracket are term1, term2, term3 and term4 below
* these are expected values of the likelihood function at perturbed and/or unperturbed
* first step and second step parameter estimates
* using model 7 from table 6

alloc 110 4788
* numbered variates 1 - 11 are for unperturbed etas
* 12 - 55 are the positive-perturbed etas
* 56 - 99 are the negative-perturbed etas
* 100 - 110 are for temporary storage

open eta c:\eurovol\output\eta.txt
open alteta c:\eurovol\output\alteta.txt
open dailysignals c:\eurovol\output\dailysignals.txt
open truedailysigs c:\eurovol\output\truedailysigs.txt
open phi7 c:\eurovol\output\phi7.txt
open corr0 c:\eurovol\output\corr0.txt
```

```
* input file for the first-step epsilons of the numerical derivatives
open epsilons c:\eurovol\output\epsilons.txt
declare vector epsilon1(44)
read(unit=epsilons) epsilon1
*second-step parameter epsilon vector
declare vector epsilon2(60)


* output file for the expected cross-marginal matrix of the log
*  likelihood function
open gmat7 c:\eurovol\output\gmat7.txt
declare rectangular gmat(44,60)

* the four terms of the cross-partial derivative matrix
declare rectangular term1(44,60)
declare rectangular term2(44,60)
declare rectangular term3(44,60)
declare rectangular term4(44,60)



* read in the unperturbed etas
data(unit=eta,format=free,org=vars) 261 4788 $
1 2 3 4 5 6 7 8 9 10 11


* read in the perturbed etas
```

```
data(unit=alteta,format=free,org=vars) 261 4788 $

12 13 14 15 16 17 18 19 $

20 21 22 23 24 25 26 27 28 29 $

30 31 32 33 34 35 36 37 38 39 $

40 41 42 43 44 45 46 47 48 49 $

50 51 52 53 54 55 56 57 58 59 $

60 61 62 63 64 65 66 67 68 69 $

70 71 72 73 74 75 76 77 78 79 $

80 81 82 83 84 85 86 87 88 89 $

90 91 92 93 94 95 96 97 98 99



* compare the perturbed and unperturbed etas


* positive perturbations

do j = 1,11

(01.0041) do k=1,4

(02.0076) compute altetaplace = (j-1)*4 +k + 11

(02.0116) set eta / = [series] j

(02.0148) set alteta / = [series] altetaplace

(02.0180) linreg(noprint) eta

(02.0196) #alteta

(02.0210) *display k j %rsquared

(02.0210) end do k

(01.0212) end do j


* negative perturbations
```

```
do j = 1,11

(01.0041) do k=1,4

(02.0076) compute altetaplace = (j-1)*4 +k + 55

(02.0116) set eta / = [series] j

(02.0149) set alteta / = [series] altetaplace

(02.0182) linreg(noprint) eta

(02.0198) # alteta

(02.0212) *display k j %rsquared

(02.0212) end do k

(01.0214) end do j
```

```
data(unit=dailysignals,format=free,org=obs) 1 4788 qcumret qavevar avegrowth $

qsignal qtrend lagqcumret lagqavevar lagqavecorr lagqsignal

data(unit=truedailysigs,format=free,org=obs) 260 4788 tdavecorr tdavevar tdcumret


* de-mean the explanatory variables


statistics qsignal
```

```
Statistics on Series QSIGNAL

Observations              4788

Sample Mean            0.435200      Variance            0.085601

Standard Error         0.292576      of Sample Mean      0.004228
```

```
t-Statistic (Mean=0) 102.926397      Signif Level        0.000000
Skewness              0.352169      Signif Level (Sk=0) 0.000000
Kurtosis (excess)     -0.874474      Signif Level (Ku=0) 0.000000
Jarque-Bera         251.528696      Signif Level (JB=0) 0.000000

set qsignal / = qsignal - %mean

statistics avegrowth

Statistics on Series AVEGROWTH
Observations               4788
Sample Mean            0.521804      Variance           0.034933
Standard Error        0.186904      of Sample Mean      0.002701
t-Statistic (Mean=0) 193.182261      Signif Level        0.000000
Skewness             -0.194089      Signif Level (Sk=0) 0.000000
Kurtosis (excess)     -0.881112      Signif Level (Ku=0) 0.000000
Jarque-Bera         184.944575      Signif Level (JB=0) 0.000000

set avegrowth / = avegrowth - %mean

statistics tdavecorr

Statistics on Series TDAVECORR
Observations               4529
Sample Mean            0.535547      Variance           0.030712
Standard Error        0.175249      of Sample Mean      0.002604
t-Statistic (Mean=0) 205.656653      Signif Level        0.000000
```

```
Skewness              -0.261659      Signif Level (Sk=0) 0.000000
Kurtosis (excess)     -1.036007      Signif Level (Ku=0) 0.000000
Jarque-Bera          254.222779      Signif Level (JB=0) 0.000000

set ratio / = (tdavecorr{1} - %mean)/(1.0-%mean)

statistics tdavevar

Statistics on Series TDAVEVAR
Observations               4529
Sample Mean              0.054274      Variance             0.001500
Standard Error           0.038725      of Sample Mean       0.000575
t-Statistic (Mean=0)    94.320011      Signif Level         0.000000
Skewness                 1.492091      Signif Level (Sk=0) 0.000000
Kurtosis (excess)        2.374317      Signif Level (Ku=0) 0.000000
Jarque-Bera           2744.332817      Signif Level (JB=0) 0.000000

set avevar / = tdavevar{1} - %mean

statistics tdcumret

Statistics on Series TDCUMRET
Observations               4529
Sample Mean              0.711834      Variance             8.208044
Standard Error           2.864968      of Sample Mean       0.042571
t-Statistic (Mean=0)    16.720919      Signif Level         0.000000
Skewness                -1.010469      Signif Level (Sk=0) 0.000000
```

```
Kurtosis (excess)      0.936317      Signif Level (Ku=0) 0.000000

Jarque-Bera          936.159656      Signif Level (JB=0) 0.000000


set cumret / = tdcumret{1} - %mean


* set trend to match the annual scale per unit time

set trend / = t/261.0

statistics trend


Statistics on Series TREND

Observations                4788

Sample Mean            9.174330      Variance            28.050249

Standard Error         5.296249      of Sample Mean       0.076540

t-Statistic (Mean=0) 119.862421      Signif Level         0.000000

Skewness               0.000000      Signif Level (Sk=0) 1.000000

Kurtosis (excess)     -1.200000      Signif Level (Ku=0) 0.000000

Jarque-Bera          287.280000      Signif Level (JB=0) 0.000000


set trend / = trend - %mean




* read in the second-step estimated parameter values

* both phi and corr0

declare vector phi(5)

declare real b1 b2 b3 b4 b5

read(unit=phi7) phi

display "phi" phi
```

```
phi      0.28150      0.02250      0.00319      0.47580      0.80380
compute b1 = phi(1)
compute b2 = phi(2)
compute b3 = phi(3)
compute b4 = phi(4)
compute b5 = phi(5)
declare symmetric corr0(11,11)
read(unit=corr0) corr0


* create a unit matrix
declare symmetric unitmat(11,11)
do j = 1,11
(01.0041) do jj = 1,11
(02.0076) compute unitmat(j,jj) = 1.0
(02.0102) end do jj
(01.0104) end do j

* place the unperturbed etas into the temporary storage slots as default values
do j=1,11
(01.0041) compute jp99 = j + 99
(01.0064) set [series] jp99 / = [series] j
(01.0099) end do j



* iteratively run over the eleven countries and then in an inner loop
```

```
* iteratively replace one eta series with a positively-perturbed eta series and re-estimate

* the expected log likelihood


* iterate over countries

do j = 1, 11

(01.0041)

(01.0041) * iterate over first-step parameters

(01.0041) do k = 1,4

(02.0076)

(02.0076) * first deal with term1 and term2 where the first-step parameter is perturbed
positively

(02.0076) * replace one eta with a perturbed eta for country j based on first-step perturbed
parameter k

(02.0076)

(02.0076) compute countryplace = j + 99

(02.0099) computer altetaplace = (j-1)*4 +k + 11

(02.0139) set [series] countryplace / = [series] altetaplace

(02.0174)

(02.0174) * label the etas using the mixture of ten unperturbed and one perturbed eta

(02.0174) set e1 / = [series] 100

(02.0204) set e2 / = [series] 101

(02.0234) set e3 / = [series] 102

(02.0264) set e4 / = [series] 103

(02.0294) set e5 / = [series] 104

(02.0324) set e6 / = [series] 105

(02.0354) set e7 / = [series] 106

(02.0384) set e8 / = [series] 107

(02.0414) set e9 / = [series] 108
```

```
(02.0444) set e10 / = [series] 109

(02.0474) set e11 / = [series] 110

(02.0504)

(02.0504)

(02.0504) * now an inner loop over second step parameters

(02.0504) do step2param = 1,5

(03.0539)

(03.0539) * term 1 first where the second-step parameter is also perturbed positively

(03.0539) compute newphi = phi

(03.0557) compute epsilon = %max(.0001,.001*phi(step2param))

(03.0592) compute newphi(step2param) = phi(step2param)+epsilon

(03.0627) compute b1 = newphi(1)

(03.0648) compute b2 = newphi(2)

(03.0669) compute b3 = newphi(3)

(03.0690) compute b4 = newphi(4)

(03.0711) compute b5 = newphi(5)

(03.0732) compute epsilon2(step2param) = epsilon

(03.0755)

(03.0755) * compute second-step likelihood and save the term

(03.0755)

(03.0755) set m / = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*avegrowth)

(03.0855) do i=261,4788

(04.0890) compute ut = ||e1(i),e2(i),e3(i),e4(i),e5(i),e6(i),e7(i),e8(i),e9(i),e10(i),e11(i)||

(04.1058) compute sigmat = (m(i))*unitmat + (1.0 - m(i))*corr0

(04.1115) set mvlike i i = %logdensity(sigmat,ut)

(04.1173) end do i

(03.1175) statistics(noprint) mvlike 261 4788
```

```
(03.1209) compute paramplace = (j-1)*4+k

(03.1244) *display 'paramplace step2param1' paramplace step2param

(03.1244) compute term1(paramplace,step2param) = %mean

(03.1271)

(03.1271) * term 2 next where the second-step parameter is perturbed negatively

(03.1271) compute newphi = phi

(03.1290) compute epsilon = %max(.0001,.001*phi(step2param))

(03.1325) compute newphi(step2param) = phi(step2param)-epsilon

(03.1360) compute b1 = newphi(1)

(03.1381) compute b2 = newphi(2)

(03.1402) compute b3 = newphi(3)

(03.1423) compute b4 = newphi(4)

(03.1444) compute b5 = newphi(5)

(03.1465) compute epsilon2(step2param) = epsilon

(03.1488)

(03.1488) * compute second-step likelihood and save the term

(03.1488)

(03.1488) set m / = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*avegrowth)

(03.1589) do i=261,4788

(04.1624) compute ut = ||e1(i),e2(i),e3(i),e4(i),e5(i),e6(i),e7(i),e8(i),e9(i),e10(i),e11(i)||

(04.1773) compute sigmat = (m(i))*unitmat + (1.0 - m(i))*corr0

(04.1821) set mvlike i i = %logdensity(sigmat,ut)

(04.1880) end do i

(03.1882) statistics(noprint) mvlike 261 4788

(03.1916) compute paramplace = (j-1)*4+k

(03.1951) *display 'paramplace step2param1' paramplace step2param

(03.1951)
```

```
(03.1951) compute term2(paramplace,step2param) = %mean
(03.1978)
(03.1978) end do step2param
(02.1980)
(02.1980) compute step2param = 5
(02.1996)
(02.1996) * now separately do step 2 for the parameters of the unconditional correlation matrix
(02.1996) do row = 1,10
(03.2031) compute rowp1 = row + 1
(03.2054) do col = rowp1,11
(04.2091) compute step2param = step2param + 1
(04.2114) compute pcorr0 = corr0
(04.2132) compute epsilon = %max(.0001,.001*corr0(row,col))
(04.2171) compute epsilon2(step2param) = epsilon
(04.2194)
(04.2194) * term 1 first where the second-step parameter is also perturbed positively
(04.2194) compute pcorr0(row,col) = corr0(row,col)+epsilon
(04.2237)
(04.2237) * compute second-step likelihood and save the term
(04.2237) set m / = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*avegrowth)
(04.2338) do i=261,4788
(05.2373) compute ut = ||e1(i),e2(i),e3(i),e4(i),e5(i),e6(i),e7(i),e8(i),e9(i),e10(i),e11(i)||
(05.2522) compute sigmat = (m(i))*unitmat + (1.0 - m(i))*pcorr0
(05.2570) set mvlike i i = %logdensity(sigmat,ut)
(05.2629) end do i
(04.2631) statistics(noprint) mvlike 261 4788
```

```
(04.2665) compute paramplace = (j-1)*4+k

(04.2700) *display 'paramplace step2param1' paramplace step2param

(04.2700) compute term1(paramplace,step2param) = %mean

(04.2727)

(04.2727) * term 2 next where the second-step parameter is perturbed negatively

(04.2727) compute pcorr0(row,col) = corr0(row,col)-epsilon

(04.2770)

(04.2770) * compute second-step likelihood and save the term

(04.2770) set m / = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*avegrowth)

(04.2871) do i=261,4788

(05.2906) compute ut = ||e1(i),e2(i),e3(i),e4(i),e5(i),e6(i),e7(i),e8(i),e9(i),e10(i),e11(i)||

(05.3055) compute sigmat = (m(i))*unitmat + (1.0 - m(i))*pcorr0

(05.3103) set mvlike i i = %logdensity(sigmat,ut)

(05.3162) end do i

(04.3164) statistics(noprint) mvlike 261 4788

(04.3198) compute paramplace = (j-1)*4+k

(04.3233) *display 'paramplace step2param1' paramplace step2param

(04.3233) compute term2(paramplace,step2param) = %mean

(04.3260)

(04.3260) end do row

(03.3262) end do col

(02.3264)

(02.3264) * restore the perturbed eta to its unperturbed value

(02.3264) set [series] countryplace / = [series] j

(02.3299)

(02.3299) * close the first-step parameter and country loops

(02.3299) end do k
```

```
(01.3301) end do j


* now repeat the last block with negatively-perturbed step one etas
* to compute terms 3 and 4


* iteratively run over the eleven countries and then in an inner loop
* iteratively replace one eta series with a negatively-perturbed eta series and re-estimate
* the expected log likelihood

* iterate over countries
do j = 1, 11
(01.0041)
(01.0041) * iterate over first-step parameters
(01.0041) do k = 1,4
(02.0076)
(02.0076) * term3 and term4 where the first-step parameter is perturbed negatively
(02.0076) * replace one eta with a perturbed eta for country j based on first-step perturbed parameter k
(02.0076)
(02.0076) compute countryplace = j + 99
(02.0099) computer altetaplace = (j-1)*4 +k + 55
(02.0139) set [series] countryplace / = [series] altetaplace
(02.0174)
(02.0174) * label the etas using the mixture of ten unperturbed and one perturbed eta
(02.0174) set e1 / = [series] 100
```

```
(02.0205) set e2 / = [series] 101
(02.0236) set e3 / = [series] 102
(02.0267) set e4 / = [series] 103
(02.0298) set e5 / = [series] 104
(02.0329) set e6 / = [series] 105
(02.0360) set e7 / = [series] 106
(02.0391) set e8 / = [series] 107
(02.0422) set e9 / = [series] 108
(02.0453) set e10 / = [series] 109
(02.0484) set e11 / = [series] 110
(02.0515)
(02.0515)
(02.0515) * now an inner loop over second step parameters
(02.0515) do step2param = 1,5
(03.0550)
(03.0550) * term 3 first where the second-step parameter is perturbed positively
(03.0550) compute newphi = phi
(03.0569) compute epsilon = %max(.0001,.001*phi(step2param))
(03.0604) compute newphi(step2param) = phi(step2param)+epsilon
(03.0639) compute b1 = newphi(1)
(03.0660) compute b2 = newphi(2)
(03.0681) compute b3 = newphi(3)
(03.0702) compute b4 = newphi(4)
(03.0723) compute b5 = newphi(5)
(03.0744) compute epsilon2(step2param) = epsilon
(03.0767)
(03.0767) * compute second-step likelihood and save the term
```

```
(03.0767)
(03.0767) set m / = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*avegrowth)
(03.0868) do i=261,4788
(04.0903) compute ut = ||e1(i),e2(i),e3(i),e4(i),e5(i),e6(i),e7(i),e8(i),e9(i),e10(i),e11(i)||
(04.1052) compute sigmat = (m(i))*unitmat + (1.0 - m(i))*corr0
(04.1100) set mvlike i i = %logdensity(sigmat,ut)
(04.1159) end do i
(03.1161) statistics(noprint) mvlike 261 4788
(03.1195) *display 'paramplace step2param1' paramplace step2param
(03.1195) compute paramplace = (j-1)*4+k
(03.1230) compute term3(paramplace,step2param) = %mean
(03.1257)
(03.1257) * now term 4 where the second-step parameter is perturbed negatively
(03.1257) compute newphi = phi
(03.1276) compute epsilon = %max(.0001,.001*phi(step2param))
(03.1311) compute newphi(step2param) = phi(step2param)-epsilon
(03.1346) compute b1 = newphi(1)
(03.1367) compute b2 = newphi(2)
(03.1388) compute b3 = newphi(3)
(03.1409) compute b4 = newphi(4)
(03.1430) compute b5 = newphi(5)
(03.1451) compute epsilon2(step2param) = epsilon
(03.1474)
(03.1474) * compute second-step likelihood and save the term
(03.1474)
(03.1474) set m / = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*avegrowth)
(03.1575) do i=261,4788
```

```
(04.1610) compute ut = ||e1(i),e2(i),e3(i),e4(i),e5(i),e6(i),e7(i),e8(i),e9(i),e10(i),e11(i)||

(04.1759) compute sigmat = (m(i))*unitmat + (1.0 - m(i))*corr0

(04.1807) set mvlike i i = %logdensity(sigmat,ut)

(04.1866) end do i

(03.1868) statistics(noprint) mvlike 261 4788

(03.1902) *display 'paramplace step2param1' paramplace step2param

(03.1902) compute paramplace = (j-1)*4+k

(03.1937) compute term4(paramplace,step2param) = %mean

(03.1964)

(03.1964) end do step2param

(02.1966)

(02.1966) compute step2param = 5

(02.1982)

(02.1982) * now separately do step 2 for the parameters of the unconditional correlation matrix

(02.1982) do row = 1,10

(03.2017) compute rowp1 = row + 1

(03.2040) do col = rowp1,11

(04.2077) compute step2param = step2param + 1

(04.2100) compute pcorr0 = corr0

(04.2119) compute epsilon = %max(.0001,.001*corr0(row,col))

(04.2158) compute epsilon2(step2param) = epsilon

(04.2181)

(04.2181) * term 3 where the second-step parameter is perturbed positively

(04.2181) compute pcorr0(row,col) = corr0(row,col)+epsilon

(04.2224)

(04.2224) * compute second-step likelihood and save the term
```

```
(04.2224) set m / = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*avegrowth)

(04.2325) do i=261,4788

(05.2360) compute ut = ||e1(i),e2(i),e3(i),e4(i),e5(i),e6(i),e7(i),e8(i),e9(i),e10(i),e11(i)||

(05.2509) compute sigmat = (m(i))*unitmat + (1.0 - m(i))*pcorr0

(05.2557) set mvlike i i = %logdensity(sigmat,ut)

(05.2616) end do i

(04.2618) statistics(noprint) mvlike 261 4788

(04.2652) compute paramplace = (j-1)*4+k

(04.2687) *display 'paramplace step2param1' paramplace step2param

(04.2687) compute term3(paramplace,step2param) = %mean

(04.2714)

(04.2714) * term 4 where the second-step parameter is perturbed negatively

(04.2714) compute pcorr0(row,col) = corr0(row,col)-epsilon

(04.2757)

(04.2757) * compute second-step likelihood and save the term

(04.2757) set m / = (b1*ratio+b2*trend+b3*cumret+b4*avevar+b5*avegrowth)

(04.2858) do i=261,4788

(05.2893) compute ut = ||e1(i),e2(i),e3(i),e4(i),e5(i),e6(i),e7(i),e8(i),e9(i),e10(i),e11(i)||

(05.3042) compute sigmat = (m(i))*unitmat + (1.0 - m(i))*pcorr0

(05.3090) set mvlike i i = %logdensity(sigmat,ut)

(05.3149) end do i

(04.3151) statistics(noprint) mvlike 261 4788

(04.3185) compute paramplace = (j-1)*4+k

(04.3220) *display 'paramplace step2param1' paramplace step2param

(04.3220) compute term4(paramplace,step2param) = %mean

(04.3247)

(04.3247) end do row
```

```
(03.3249) end do col

(02.3251)

(02.3251) * restore the perturbed eta to its unperturbed value

(02.3251) set [series] countryplace / = [series] j

(02.3286)

(02.3286) * close the first-step parameter and country loops

(02.3286) end do k

(01.3288) end do j
```

```
* now fill up the cross-marginal matrix of the likelihood function

* using the four components term1,term2, term3 and term4

* and scaled by the reciprocal of the infinitesimals epsilon1xepsilon2


*display 'term4' term4

*display 'term3' term3

*display 'term2' term2

*display 'term1' term1


display 'epsilon1' epsilon1
```

```
epsilon1  5.44490e-004  1.00000e-004  1.11270e-004  8.60220e-004  4.67760e-004
8.96650e-004  1.32680e-004  8.42560e-004  8.19300e-004  4.20640e-004  1.00000e-004
9.03060e-004  3.57950e-004  3.11480e-004  1.00000e-004  9.09120e-004  4.79570e-004

 4.11470e-004  1.00000e-004  8.87310e-004  7.97470e-004  3.26510e-004  1.44100e-004
7.95930e-004  5.52630e-004  1.00000e-004  1.00000e-004  8.98040e-004  5.96650e-004
5.80160e-004  1.10680e-004  8.68870e-004  5.77560e-004  6.39540e-004  1.07200e-004

 8.75720e-004  5.84110e-004  6.87310e-004  1.66070e-004  8.03620e-004  5.19570e-004
9.64860e-004  1.03530e-004  8.70910e-004
```

```
display 'epsilon2' epsilon2

epsilon2  2.81500e-004  1.00000e-004  1.00000e-004  4.75800e-004  8.03800e-004
5.20820e-004  4.58700e-004  5.20100e-004  5.72430e-004  3.20950e-004  4.65270e-004
4.73390e-004  5.51140e-004  4.14940e-004  5.03660e-004  5.43790e-004  6.95150e-004

 6.74940e-004  3.48750e-004  5.20440e-004  6.12520e-004  7.29870e-004  4.93190e-004
6.41510e-004  6.20650e-004  6.17470e-004  3.16540e-004  4.90430e-004  5.51940e-004
6.51210e-004  4.76260e-004  5.81810e-004  7.79150e-004  3.47600e-004  5.41230e-004

 7.46010e-004  8.22440e-004  5.29260e-004  7.80310e-004  3.31170e-004  5.34030e-004
6.89420e-004  7.92000e-004  5.20750e-004  7.13330e-004  3.11730e-004  3.05850e-004
3.51780e-004  3.24830e-004  3.27380e-004  4.77620e-004  5.67000e-004  4.17450e-004

 4.96340e-004  7.10000e-004  4.79130e-004  7.07400e-004  5.26880e-004  7.41740e-004
5.41710e-004


do step1 = 1,44

(01.0041) do step2 = 1,60

(02.0076)

(02.0076) compute gmat(step1,step2) = (1.0/(4.0*epsilon1(step1)*epsilon2(step2)))* $

(02.0079) (term1(step1,step2)- term2(step1,step2) - term3(step1,step2) + term4(step1,step2))

(02.0196)

(02.0196)

(02.0196) end do step2

(01.0198) end do step1


display gmat


display(unit=gmat7) gmat
```

```
*adjcovmat.txt this program estimates the adjusted covariance matrix of the second-step parameters and compares adjusted and unadjusted standard errors
alloc 180 4788


* first model 6
open gmat6 c:\eurovol\output\gmat6.txt
open adjcovphi c:\eurovol\output\covphi.txt
open ctheta c:\eurovol\output\ctheta.txt
open unadjcovphi c:\eurovola\output\unadjcovphi.txt
open ssdrvs6 c:\eurovol\output\ssdrvs6.txt
open fsdrvsorgobs c:\eurovol\output\fsdrvsorgobs.txt
open covs6 c:\eurovol\output\covs6.txt
open phi6 c:\eurovol\output\phi6.txt


declare rectangular gmat(60,44)
declare rectangular ctheta(44,44)
declare vector zadj(60)
declare vector scorevec(44)
declare symmetric covs(60,60)
declare vector phi(60)


* zadj = gmat*covtheta*scorevec
* this is the adjustment term in the computation of zeta


read(unit=gmat6) gmat
read(unit=ctheta) ctheta
```

```
* do over observations treating each cross-section of observations as a vector
do i=261,4788
(01.0041)
(01.0041) read(unit=fsdrvsorgobs) scorevec
(01.0073)
(01.0073) compute zadj = gmat*ctheta*scorevec
(01.0102)
(01.0102) do j = 1,60
(02.0137) set [series] j i i = zadj(j)
(02.0192) end do j
(01.0194)
(01.0194) end do i

data(unit=ssdrvs6,format=free,org=obs) 261 4788 61 62 63 64 65 66 67 68 69 70 $
71 72 73 74 75 76 77 78 79 80 $
81 82 83 84 85 86 87 88 89 90 $
91 92 93 94 95 96 97 98 99 100 $
101 102 103 104 105 106 107 108 109 110 $
111 112 113 114 115 116 117 118 119 120

* uncorrected opg estimated covariance matrix
cmom 261 4788
# 61 62 63 64 65 66 67 68 69 70 $
71 72 73 74 75 76 77 78 79 80 $
81 82 83 84 85 86 87 88 89 90 $
91 92 93 94 95 96 97 98 99 100 $
101 102 103 104 105 106 107 108 109 110 $
```

```
111 112 113 114 115 116 117 118 119 120
compute covs = inv(%cmom)
read(unit=phi6) phi

display (covs(1,1))**.5
      0.02586
display (covs(2,2))**.5
      0.00173
display (covs(3,3))**.5
      0.00173
display (covs(4,4))**.5
      0.09741
display (covs(5,5))**.5
      0.01629
display phi(1)/(covs(1,1))**.5
     19.88815
display phi(2)/(covs(2,2))**.5
     18.98956
display phi(3)/(covs(3,3))**.5
      0.59007
display phi(4)/(covs(4,4))**.5
      3.02224
display phi(5)/(covs(5,5))**.5
     -4.08934

* now engle-corrected estimated covariance matrix
do j = 1,60
```

```
(01.0041) compute jp60 = j + 60

(01.0064) compute jp120 = j + 120

(01.0087) set [series] jp120 = ([series] jp60) - ([series] j)

(01.0134)

(01.0134) end do j


cmom 261 4788

# 121 122 123 124 125 126 127 128 129 130 $

131 132 133 134 135 136 137 138 139 140 $

141 142 143 144 145 146 147 148 149 150 $

151 152 153 154 155 156 157 158 159 160 $

161 162 163 164 165 166 167 168 169 170 $

171 172 173 174 175 176 177 178 179 180


compute mmat = %cmom

compute covmat = covs*mmat*covs

* adjusted standard errors

write(format='(f20.10)') covmat(1,1)**.5

        0.0258700577

write(format='(f20.10)') covmat(2,2)**.5

        0.0017324137

write(format='(f20.10)') covmat(3,3)**.5

        0.0017303529

write(format='(f20.10)') covmat(4,4)**.5

        0.0974389927

write(format='(f20.10)') covmat(5,5)**.5

        0.0162858758
```

```
* unadjusted standard errors
write(format='(f20.10)') covs(1,1)**.5
        0.0258646470
write(format='(f20.10)') covs(2,2)**.5
        0.0017325306
write(format='(f20.10)') covs(3,3)**.5
        0.0017296351
write(format='(f20.10)') covs(4,4)**.5
        0.0974111016
write(format='(f20.10)') covs(5,5)**.5
        0.0162862597
* proportional difference in standard errors
compute diff1 = (covs(1,1)/covmat(1,1))**.5 -1
compute diff2 = (covs(2,2)/covmat(2,2))**.5 -1
compute diff3 = (covs(3,3)/covmat(3,3))**.5 -1
compute diff4 = (covs(4,4)/covmat(4,4))**.5 -1
compute diff5 = (covs(5,5)/covmat(5,5))**.5 -1

display "diffs 1 - 5"
diffs 1 - 5
display diff1
-2.09151e-004
display diff2
 6.74711e-005
display diff3
-4.14809e-004
```

```
display diff4

-2.86241e-004

display diff5

 2.35724e-005



* now model 7

rewind fsdrvsorgobs

open gmat7 c:\eurovol\output\gmat7.txt

open ssdrvs7 c:\eurovol\output\ssdrvs7.txt

open phi7 c:\eurovol\output\phi7.txt


* zadj = gmat*covtheta*scorevec

* this is the adjustment term in the computation of zeta



read(unit=gmat7) gmat


* do over observations treating each cross-section of observations as a vector


do i=261,4788

(01.0041)

(01.0041) read(unit=fsdrvsorgobs) scorevec

(01.0073)

(01.0073) compute zadj = gmat*ctheta*scorevec

(01.0102)

(01.0102) do j = 1,60
```

```
(02.0137) set [series] j i i = zadj(j)
(02.0192) end do j
(01.0194)
(01.0194) end do i
data(unit=ssdrvs7,format=free,org=obs) 261 4788 61 62 63 64 65 66 67 68 69 70 $
71 72 73 74 75 76 77 78 79 80 $
81 82 83 84 85 86 87 88 89 90 $
91 92 93 94 95 96 97 98 99 100 $
101 102 103 104 105 106 107 108 109 110 $
111 112 113 114 115 116 117 118 119 120
* uncorrected opg estimated covariance matrix
cmom 261 4788
# 61 62 63 64 65 66 67 68 69 70 $
71 72 73 74 75 76 77 78 79 80 $
81 82 83 84 85 86 87 88 89 90 $
91 92 93 94 95 96 97 98 99 100 $
101 102 103 104 105 106 107 108 109 110 $
111 112 113 114 115 116 117 118 119 120

compute covs = inv(%cmom)

read(unit=phi7) phi

display (covs(1,1))**.5
   0.02873
display (covs(2,2))**.5
   0.00175
```

```
display (covs(3,3))**.5
      0.00123
display (covs(4,4))**.5
      0.09504
display (covs(5,5))**.5
      0.03679
display phi(1)/(covs(1,1))**.5
      9.79773
display phi(2)/(covs(2,2))**.5
     12.89398
display phi(3)/(covs(3,3))**.5
      2.60313
display phi(4)/(covs(4,4))**.5
      5.00621
display phi(5)/(covs(5,5))**.5
     21.84619



* now engle-corrected estimated covariance matrix
do j = 1,60
(01.0041) compute jp60 = j + 60
(01.0064) compute jp120 = j + 120
(01.0087) set [series] jp120 = ([series] jp60) - ([series] j)
(01.0134)
(01.0134) end do j
```

```
cmom 261 4788
# 121 122 123 124 125 126 127 128 129 130 $
131 132 133 134 135 136 137 138 139 140 $
141 142 143 144 145 146 147 148 149 150 $
151 152 153 154 155 156 157 158 159 160 $
161 162 163 164 165 166 167 168 169 170 $
171 172 173 174 175 176 177 178 179 180
compute mmat = %cmom
compute covmat = covs*mmat*covs

* adjusted standard errors
write(format='(f20.10)') covmat(1,1)**.5
        0.0287462936
write(format='(f20.10)') covmat(2,2)**.5
        0.0017450879
write(format='(f20.10)') covmat(3,3)**.5
        0.0012269030
write(format='(f20.10)') covmat(4,4)**.5
        0.0950434836
write(format='(f20.10)') covmat(5,5)**.5
        0.0368121825

* unadjusted standard errors
write(format='(f20.10)') covs(1,1)**.5
        0.0287311451
write(format='(f20.10)') covs(2,2)**.5
        0.0017450006
```

```
write(format='(f20.10)') covs(3,3)**.5

        0.0012268330

write(format='(f20.10)') covs(4,4)**.5

        0.0950420027

write(format='(f20.10)') covs(5,5)**.5

        0.0367936078


* proportional difference in standard errors

compute diff1 = (covs(1,1)/covmat(1,1))**.5 -1

compute diff2 = (covs(2,2)/covmat(2,2))**.5 -1

compute diff3 = (covs(3,3)/covmat(3,3))**.5 -1

compute diff4 = (covs(4,4)/covmat(4,4))**.5 -1

compute diff5 = (covs(5,5)/covmat(5,5))**.5 -1


display "diffs 1 - 5"

diffs 1 - 5

display diff1

-5.26973e-004

display diff2

-5.00282e-005

display diff3

-5.70300e-005

display diff4

-1.55817e-005

display diff5

-5.04579e-004
```