

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

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April, 2012

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

input: rets.txt

output: sqrautocorr.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: qavecrr.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

output: 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 rrets / = [series] jj
```

```
display "index" j
```

```
display "price statistics"
```

```
statistics price
```

```
display "return statistics"
```

```
statistics rrets
```

```
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=rrets,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

* sqrautocorr.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 sqrautocorr c:\eurovol\output\sqrautocorr.txt

declare vector vautocorr(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 / sqrautocorr

do jj = 1,10

compute jjp1 = jj + 1

compute vautocorr(jj) = sqrautocorr(jjp1)

end do jj

write(unit=sqrautocorr,format='(10(f10.5))',noskip) vautocorr

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 sgvar / = 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 / = sgvar
```

* 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 sgvar / = 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 qavevar

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*qsigal)
```

```
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

* $d^2f/dx^2dy = \lim(1/(4*e1*e2))*[(f(x+e1,y+e2)-f(x+e1,y-e2))-(f(x-e1,y+e2)-f(x-e1,y-e2))]$

* 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
```

```
compute 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*qsigal)
```

```
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

* $d^2f/dx^2dy = \lim(1/(4*e1*e2))*[(f(x+e1,y+e2)-f(x+e1,y-e2)-(f(x-e1,y+e2)-f(x-e1,y-e2)))]$

* 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 $\epsilon_1 \epsilon_2$

```
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) **sqrautocorr.txt**
- 4) **garch11.txt**
- 5) **midasgarch.txt**
- 6) **midastheta.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 rrets / = [series] jj
```

```
(01.0172) display "index" j
```

```
(01.0200) display "price statistics"
```

```
(01.0219) statistics price
```

```
(01.0233) display "return statistics"
```

```
(01.0252) statistics rrets
```

```
(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=rrets,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
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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 sgvar / = 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 sgvar / = 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*lrsv)+ret2/(sgv*lrsv))
(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*lrsv)**.5)
(01.2212) set predvar 261 4788 = sgv*lrsv
(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)
(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
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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
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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
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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
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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
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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 Q SIGNAL

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 / = gavevar - %mean
```

```
* save the quarterly average correlations and average variance
```

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

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

```
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
DMRATIO	1.000000000	0.827814554	0.860812287	-0.301450815	0.159364669
LAGDMRATIO	0.151421402	0.431762313			
DMTREND			1.000000000	0.865982962	-0.098711769
DMCUMRET			0.182017357	0.360423983	0.235199352
DMSIGNAL					1.000000000

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 R² 0.8137229
 R-Bar² 0.8085485
 Uncentered R² 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 R² 0.8100984
 R-Bar² 0.8048234
 Uncentered R² 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 R² 0.7688847
 R-Bar² 0.7621857
 Uncentered R² 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 R² 0.6726303
 R-Bar² 0.6617180
 Uncentered R² 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 R² 0.8256182

R-Bar² 0.8152074

Uncentered R² 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 R² 0.7676571
R-Bar² 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 gavevar 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 Q SIGNAL

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 LAG Q SIGNAL

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	0.000000000
19. CORR0(6,1)	0.323939	0.010060	32.19917	0.000000000
20. CORR0(6,2)	0.336600	0.010397	32.37503	0.000000000
21. CORR0(6,3)	0.313112	0.010582	29.58893	0.000000000
22. CORR0(6,4)	0.328000	0.010725	30.58206	0.000000000
23. CORR0(6,5)	0.323553	0.010353	31.25182	0.000000000
24. CORR0(6,6)	1.000000	0.000000	0.00000	0.000000000
25. CORR0(7,1)	0.446263	0.008429	52.94367	0.000000000
26. CORR0(7,2)	0.503028	0.006231	80.73452	0.000000000
27. CORR0(7,3)	0.477296	0.007891	60.48313	0.000000000
28. CORR0(7,4)	0.521911	0.008297	62.90322	0.000000000
29. CORR0(7,5)	0.515677	0.007582	68.01523	0.000000000
30. CORR0(7,6)	0.301768	0.009706	31.09152	0.000000000
31. CORR0(7,7)	1.000000	0.000000	0.00000	0.000000000
32. CORR0(8,1)	0.470828	0.009268	50.80244	0.000000000
33. CORR0(8,2)	0.631283	0.006272	100.65414	0.000000000
34. CORR0(8,3)	0.560968	0.006745	83.16582	0.000000000
35. CORR0(8,4)	0.770139	0.003624	212.53109	0.000000000
36. CORR0(8,5)	0.717078	0.004555	157.42230	0.000000000
37. CORR0(8,6)	0.304106	0.010933	27.81527	0.000000000
38. CORR0(8,7)	0.468725	0.008713	53.79379	0.000000000
39. CORR0(8,8)	1.000000	0.000000	0.00000	0.000000000
40. CORR0(9,1)	0.534542	0.007863	67.98347	0.000000000
41. CORR0(9,2)	0.735635	0.003973	185.17974	0.000000000
42. CORR0(9,3)	0.650272	0.005289	122.93793	0.000000000
43. CORR0(9,4)	0.835423	0.002690	310.55996	0.000000000
44. CORR0(9,5)	0.801986	0.003256	246.29738	0.000000000

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*qsigal)

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 Q SIGNAL

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 LAGQ SIGNAL

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*qsigal)
```

* 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*qsigal)
```

```
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 Q SIGNAL

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 LAGQ SIGNAL

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	0.0000000
2. B2	0.022452	0.002023	11.10037	0.0000000
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	0.0000000
6. CORR0(1,1)	1.000000	0.000000	0.00000	0.0000000
7. CORR0(2,1)	0.502980	0.008251	60.95740	0.0000000
8. CORR0(2,2)	1.000000	0.000000	4.29497e+009	0.0000000
9. CORR0(3,1)	0.453383	0.009139	49.61133	0.0000000
10. CORR0(3,2)	0.540318	0.006952	77.71769	0.0000000
11. CORR0(3,3)	1.000000	0.000000	4.29497e+009	0.0000000
12. CORR0(4,1)	0.499485	0.009085	54.97707	0.0000000
13. CORR0(4,2)	0.705378	0.004868	144.90728	0.0000000
14. CORR0(4,3)	0.625304	0.005700	109.69301	0.0000000
15. CORR0(4,4)	1.000000	0.000000	0.00000	0.0000000
16. CORR0(5,1)	0.543682	0.007361	73.85832	0.0000000
17. CORR0(5,2)	0.679753	0.005311	127.98970	0.0000000
18. CORR0(5,3)	0.617726	0.005847	105.65105	0.0000000

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*lrvar)**.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*lrvar)**.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
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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
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Statistics on Series RV

Observations	4724		
Sample Mean	0.000283	Variance	0.000000
Standard Error	0.000235	of Sample Mean	0.000003
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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
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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
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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

* $d^2f/dx^2dy = \lim(1/(4*e1*e2))*[(f(x+e1,y+e2)-f(x+e1,y-e2))-(f(x-e1,y+e2)-f(x-e1,y-e2))]$

* 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*qsigal)
(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*qsigal)
(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

* $d^2f/dx^2dy = \lim(1/(4*e1*e2))*[(f(x+e1,y+e2)-f(x+e1,y-e2))-(f(x-e1,y+e2)-f(x-e1,y-e2))]$

* 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 Q SIGNAL

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
```