

Supplementary Appendix

A Additional Tables

Table A1: Symbol Names

Symbol	Name	Start Date	Obs.(T)
.AEX	AEX	January 03, 2000	5473
.AORD	All Ordinaries	January 04, 2000	5422
.BFX	Bell 20	January 03, 2000	5471
.BSESN	S&P BSE Sensex	January 03, 2000	5322
.BVLG	PSI All-Share	October 15, 2012	2207
.BVSP	BVSP BOVESPA	January 03, 2000	5282
.DJI	Dow Jones Industrials	January 03, 2000	5380
.FCHI	CAC 40	January 03, 2000	5475
.FTMIB	FTSE MIB	June 01, 2009	3056
.FTSE	FTSE 100	January 04, 2000	5414
.GDAXI	DAX	January 03, 2000	5440
.GSPTSE	S&P/TSX Composite	May 02, 2002	4786
.HSI	HANG SENG	January 03, 2000	5258
.IBEX	IBEX 35	January 03, 2000	5440
.IXIC	Nasdaq 100	January 03, 2000	5384
.KS11	Korea Composite	January 04, 2000	5283
.KSE	Karachi SE 100	January 03, 2000	5229
.MXX	IPC Mexico	January 03, 2000	5384
.N225	Nikkei 225	February 02, 2000	5219
.NSEI	NIFTY 50	January 03, 2000	5313
.OMXC20	OMX Copenhagen 20	October 03, 2005	3902
.OMXHPI	OMX Helsinki All Share	October 03, 2005	3943
.OMXSPI	OMX Stockholm All Share	October 03, 2005	3943
.OSEAX	Oslo Exchange All-share	September 03, 2001	4931
.RUT	Russel 2000	January 03, 2000	5381
.SMSI	Madrid General	July 04, 2005	4069
.SPX	S&P 500	January 03, 2000	5383
.SSEC	Shanghai Composite	January 04, 2000	5184
.SSMI	Swiss Stock Market	January 04, 2000	5377
.STI	Straits Times	January 03, 2000	3439
.STOXX50E	EURO STOXX 50	January 03, 2000	5472

This table provides descriptive statistics for the dataset of 31 assets. The sample ending date is June 24, 2021. Column 2 show the asset names. Column 3 show the sample starting date. Column 4 is in the number of observations (or the sample size T) of the asset.

Table A2: EHEAVY models Estimated parameters: Open-to-Close Return

Symbol	EHEAVY-r					EHEAVY-RM					
	w	α_{RR}	β_R	γ_{Rr}	LL	w	α_{RR}	β_R	γ_{Rr}	ρ	LL
AEX	-0.287	0.378	0.971	-0.120	-18627	-0.310	0.412	0.967	-0.120	0.833	-18636
AORD	-0.187	0.275	0.970	-0.104	-16490	-0.208	0.301	0.968	-0.110	0.890	-16233
BFX	-0.323	0.432	0.964	-0.107	-18377	-0.337	0.445	0.964	-0.101	0.837	-17974
BSESN	-0.422	0.588	0.952	-0.064	-20360	-0.504	0.696	0.941	-0.059	0.841	-19099
BVLG	-0.407	0.497	0.970	-0.064	-6636	-0.424	0.519	0.967	-0.064	0.845	-6511
BVSP	-0.236	0.384	0.962	-0.071	-22071	-0.294	0.473	0.953	-0.080	0.864	-21470
DJI	-0.328	0.463	0.957	-0.146	-18132	-0.329	0.462	0.956	-0.137	0.833	-17603
FCHI	-0.245	0.352	0.967	-0.115	-19767	-0.248	0.360	0.966	-0.112	0.838	-19774
FTMIB	-0.358	0.516	0.951	-0.115	-11535	-0.354	0.501	0.952	-0.111	0.818	-11081
FTSE	-0.300	0.405	0.969	-0.093	-19310	-0.341	0.456	0.966	-0.081	0.836	-19093
GDAXI	-0.234	0.326	0.972	-0.109	-20444	-0.252	0.346	0.971	-0.114	0.828	-20174
GSPTSE	-0.260	0.337	0.975	-0.096	-14759	-0.264	0.344	0.972	-0.108	0.859	-13711
HSI	-0.244	0.338	0.971	-0.023	-18324	-0.299	0.420	0.961	-0.025	0.846	-17965
IBEX	-0.312	0.411	0.971	-0.088	-20435	-0.339	0.448	0.969	-0.083	0.831	-20496
IXIC	-0.327	0.447	0.965	-0.109	-20077	-0.362	0.488	0.962	-0.110	0.836	-19240
KS11	-0.326	0.393	0.983	-0.047	-18679	-0.341	0.412	0.981	-0.049	0.846	-18044
KSE	-0.158	0.424	0.921	-0.066	-20175	-0.212	0.560	0.887	-0.063	0.866	-18901
MXX	-0.252	0.410	0.955	-0.078	-20552	-0.327	0.512	0.942	-0.077	0.837	-19042
N225	-0.269	0.401	0.963	-0.057	-18818	-0.293	0.436	0.958	-0.070	0.863	-18157
NSEI	-0.432	0.551	0.966	-0.073	-19105	-0.464	0.598	0.959	-0.070	0.834	-18192
OMXC20	-0.262	0.437	0.948	-0.076	-14503	-0.355	0.565	0.935	-0.079	0.846	-13957
OMXHPI	-0.231	0.335	0.970	-0.100	-14382	-0.282	0.408	0.962	-0.112	0.863	-13890
OMXSPI	-0.273	0.376	0.972	-0.135	-13966	-0.293	0.402	0.968	-0.149	0.864	-13343
OSEAX	-0.237	0.364	0.966	-0.093	-19049	-0.274	0.407	0.962	-0.100	0.857	-17775
RUT	-0.192	0.345	0.954	-0.116	-20173	-0.204	0.344	0.955	-0.120	0.855	-18928
SMSI	-0.321	0.431	0.971	-0.092	-15299	-0.349	0.465	0.968	-0.093	0.855	-15042
SPX	-0.282	0.406	0.960	-0.150	-18218	-0.283	0.404	0.959	-0.146	0.840	-17358
SSEC	-0.387	0.511	0.972	-0.040	-21147	-0.466	0.612	0.964	-0.043	0.836	-20196
SSMI	-0.422	0.559	0.950	-0.087	-17316	-0.441	0.565	0.954	-0.072	0.825	-16734
STI	-0.406	0.513	0.962	-0.047	-10360	-0.438	0.550	0.958	-0.043	0.846	-9884
EURO50	-0.207	0.320	0.967	-0.138	-20799	-0.223	0.344	0.964	-0.133	0.847	-20619

This table provides QML estimates of EHEAVY model for the dataset of 31 assets. All parameters are statistically significant at 5% level.

Table A3: EHEAVY models Estimated parameters: Close-to-Close Return

Symbol	EHEAVY-r					EHEAVY-RM					
	w	α_{RR}	β_R	γ_{Rr}	LL	w	α_{RR}	β_R	γ_{Rr}	ρ	LL
AEX	-0.235	0.341	0.970	-0.154	-20928	-0.259	0.356	0.969	-0.137	0.807	-18617
AORD	-0.181	0.278	0.970	-0.107	-17547	-0.200	0.298	0.966	-0.113	0.886	-16222
BFX	-0.338	0.450	0.970	-0.121	-20266	-0.337	0.430	0.972	-0.105	0.815	-17962
BSESN	-0.362	0.536	0.955	-0.075	-21524	-0.451	0.643	0.943	-0.064	0.804	-19085
BVLG	-0.366	0.526	0.954	-0.106	-8136	-0.388	0.517	0.952	-0.099	0.809	-6501
BVSP	-0.130	0.296	0.961	-0.091	-24674	-0.268	0.439	0.955	-0.080	0.815	-21449
DJI	-0.343	0.478	0.959	-0.132	-18813	-0.312	0.428	0.963	-0.133	0.824	-17586
FCHI	-0.268	0.394	0.967	-0.141	-21842	-0.290	0.401	0.968	-0.113	0.811	-19761
FTMIB	-0.389	0.626	0.938	-0.140	-13167	-0.416	0.599	0.942	-0.109	0.779	-11070
FTSE	-0.278	0.371	0.973	-0.103	-19409	-0.332	0.436	0.969	-0.091	0.835	-19079
GDAXI	-0.240	0.335	0.975	-0.129	-22124	-0.272	0.354	0.977	-0.118	0.810	-20152
GSPTSE	-0.214	0.307	0.970	-0.124	-15426	-0.223	0.305	0.970	-0.113	0.850	-13693
HSI	-0.189	0.295	0.972	-0.074	-21655	-0.222	0.319	0.969	-0.057	0.785	-17947
IBEX	-0.317	0.458	0.963	-0.108	-22331	-0.368	0.500	0.962	-0.086	0.806	-20478
IXIC	-0.299	0.427	0.967	-0.128	-21883	-0.305	0.418	0.967	-0.123	0.797	-19215
KS11	-0.308	0.412	0.975	-0.082	-21169	-0.326	0.420	0.973	-0.064	0.787	-18026
KSE	-0.104	0.277	0.954	-0.056	-21268	-0.186	0.445	0.919	-0.068	0.841	-18884
MXX	-0.231	0.383	0.958	-0.081	-20975	-0.323	0.506	0.943	-0.070	0.831	-19037
N225	-0.124	0.362	0.937	-0.104	-22153	-0.228	0.420	0.939	-0.098	0.824	-18140
NSEI	-0.271	0.327	0.990	-0.078	-22000	-0.422	0.483	0.989	-0.063	0.773	-18200
OMXC20	-0.230	0.459	0.935	-0.093	-15350	-0.289	0.495	0.936	-0.092	0.834	-13948
OMXHPI	-0.177	0.302	0.967	-0.115	-15525	-0.268	0.404	0.961	-0.109	0.838	-13882
OMXSPI	-0.260	0.395	0.965	-0.151	-15115	-0.338	0.472	0.962	-0.146	0.835	-13334
OSEAX	-0.244	0.360	0.971	-0.087	-19406	-0.276	0.397	0.966	-0.098	0.853	-17771
RUT	-0.172	0.295	0.968	-0.119	-22618	-0.190	0.308	0.962	-0.128	0.810	-18899
SMSI	-0.335	0.454	0.972	-0.118	-16590	-0.401	0.519	0.970	-0.107	0.815	-15026
SPX	-0.284	0.422	0.959	-0.141	-19172	-0.257	0.373	0.961	-0.145	0.830	-17342
SSEC	-0.410	0.571	0.962	-0.052	-22109	-0.478	0.651	0.955	-0.054	0.813	-20200
SSMI	-0.375	0.539	0.947	-0.140	-19147	-0.408	0.536	0.952	-0.111	0.812	-16706
STI	-0.478	0.675	0.940	-0.071	-12173	-0.523	0.685	0.938	-0.033	0.792	-9890
EURO50	-0.192	0.301	0.970	-0.147	-21887	-0.224	0.337	0.967	-0.136	0.841	-20602

This table provides QML estimates of EHEAVY model for the dataset of 31 assets. All parameters are statistically significant at 5% level.

B Other Models

In this appendix, we present the specification of asymmetric HEAVY of Shepard and Sheperd (2010) and realized EGARCH Hansen and Huang (2016) model.

The AHEAVY model of Shepard and Sheperd (2010) is

$$h_t = \omega_r + (\alpha_{rR} + \gamma_{rR}s_{t-1})RM_{t-1} + \beta_r h_{t-1}, \quad (18)$$

$$m_t = \omega_R + (\alpha_{RR} + \gamma_{RR}s_{t-1})RM_{t-1} + \beta_R m_{t-1}.$$

where $s_t = 0.5[1 - \text{sign}(r_t)]$, that is, $s_t = 1$ if $r_t < 0$ and 0 otherwise; γ_{ii} , γ_{ij} ($i \neq j$) are the own and cross leverage parameters, respectively⁹; positive γ_{ii} , γ_{ij} means a larger contribution of negative ‘shocks’ in the volatility process.

⁹This type of asymmetry was introduced by Glosten et. al., (1993).

The realized EGARCH model of Hansen and Huang (2016) is

$$\begin{aligned}\log h_t &= \omega_r + \beta_r \log h_{t-1} + \alpha_{rr} e_{rt-1}^2 + \gamma_{rr} e_{rt-1} + \alpha_{rR} u_{Rt-1}, \\ \log RM_t &= \omega_R + \beta_R \log h_t + \alpha_{Rr} e_{rt-1}^2 + \gamma_{Rr} e_{Rt-1} + u_{Rt}.\end{aligned}\tag{19}$$

where $u_{Rt} \sim N(0, \sigma_u)$. The first equation is referred to GARCH equation, and the second one is referred to measurement equation. It can be seen that the GARCH equation is close to our EHEAVY-r equation, where the measurement equation has a different specification as EHEAVY-RM equation.