Table 4.1 – VaR Backtests

	p = 1%				p = 5%			
Model	%Viol.	LR_{uc}	LR_{ind}	LR_{cc}	%Viol.	LR_{uc}	LR_{ind}	LR_{cc}
Univariate:								
GARCH	2.547	0.000	0.886	0.000	6.565	0.004	0.282	0.009
EWMA	2.830	0.000	0.705	0.000	7.131	0.000	0.718	0.001
t GJR	1.811	0.002	0.277	0.005	6.848	0.001	0.622	0.003
Skewed-t GJR	1.132	0.585	0.498	0.685	6.169	0.029	0.459	0.071
Skewed-t NGARCH	1.528	0.038	0.360	0.077	6.282	0.017	0.403	0.041
MixN(2) GARCH	2.151	0.000	0.196	0.000	6.112	0.038	0.489	0.091
MixN(3) GARCH	1.585	0.023	0.342	0.048	6.565	0.004	0.375	0.010
MN-DCC GARCH	3.339	0.000	0.983	0.000	6.904	0.000	0.873	0.002
Fortin et al.:								
Normal cop. NGARCH	0.509	0.022	0.761	0.070	4.131	0.084	0.573	0.193
Normal cop. GARCH	1.075	0.753	0.520	0.774	4.414	0.249	0.409	0.366
t cop. NGARCH	0.509	0.022	0.761	0.070	4.131	0.084	0.273	0.124
t cop. GARCH	0.962	0.872	0.565	0.837	4.414	0.249	0.409	0.366
Skewed-t cop. GARCH	0.962	0.872	0.565	0.837	4.471	0.299	0.799	0.565
COMFORT:								
MVG-CCC GJR	0.736	0.241	0.661	0.457	4.924	0.883	0.409	0.703
MVG-CCC GARCH	0.736	0.241	0.661	0.457	4.980	0.970	0.762	0.954

This table presents the percentage of violations and the p-values of the likelihood ratio tests for unconditional coverage, independence and conditional coverage by Christoffersen (1998) for the 1% and 5% one-day-ahead VaR. Cells for which the corresponding null hypothesis could not be rejected on the 5% significance level are highlighted in gray. The forecasts were made using a rolling window of size 1000 and cover the time period from December 28, 2004 to December 30, 2011 (1767 forecasts).

Table 4.2 – VaR Exceedances over Time

	p = 1% (Expected: 17 Exceedances)									p = 5% (Expected: 88 Exceedances)								
Model	Total	2004	2005	2006	2007	2008	2009	2010	2011	Total	2004	2005	2006	2007	2008	2009	2010	2011
Univariate:																		
GARCH	45	0	2	4	9	13	4	7	6	116	0	14	8	22	26	15	13	18
EWMA	50	0	7	5	10	10	4	6	8	126	0	18	10	23	23	11	19	22
t GJR	32	0	2	3	7	8	3	6	3	121	0	15	9	20	26	18	17	16
Skewed-t GJR	**20**	0	2	2	5	4	2	3	2	109	0	14	9	19	19	16	16	16
Skewed-t NGARCH	27	0	2	4	6	6	1	5	3	111	0	14	8	19	25	13	17	15
MixN(2) GARCH	38	0	2	4	6	10	3	7	6	108	0	14	8	18	26	15	13	14
MixN(3) GARCH	28	0	1	3	3	9	2	6	4	116	0	12	8	17	39	14	11	15
MN-DCC GARCH	59	0	8	8	19	12	2	5	5	122	0	21	12	31	26	6	12	14
Fortin et al.:																		
Normal cop. NGARCH	9	0	2	1	3	1	0	0	2	73	0	11	7	15	14	5	11	10
Normal cop. GARCH	**19**	0	2	1	6	5	0	2	3	78	0	13	7	17	16	5	10	10
t cop. NGARCH	9	0	2	1	3	1	0	0	2	73	0	12	6	15	14	5	11	10
t cop. GARCH	**17**	0	2	1	6	5	0	1	2	78	0	13	7	17	16	5	10	10
Skewed-t cop. GARCH	**17**	0	2	1	6	5	0	1	2	**79**	0	12	7	17	16	7	10	10
COMFORT:																		
MVG-CCC GJR	13	0	0	0	2	6	0	3	2	**87**	0	1	4	15	29	13	12	13
MVG-CCC GARCH	13	0	0	0	1	7	1	2	2	**88**	0	1	4	15	30	14	11	13

VaR exceedances observed in every year for the 1% and the 5% VaR level for all the models. For each VaR level the three closest numbers to the expected exceedences are in bold. The forecasts were made using a rolling window of size 1000 and cover the time period from December 28, 2004 to December 30, 2011 (1767 one-day-ahead VaR forecasts).

Table 4.3 – Average VaR Tick Loss Ranking

p = 1%		p = 5%	
Model	Mean Loss	Model	Mean Loss
Skewed-t GJR	0.03632	Skewed-t GJR	0.13456
t GJR	0.03691	t GJR	0.13662
Normal cop. GARCH	0.03692	Skewed-t NGARCH	0.13706
Skewed-t cop. GARCH	0.03702	MixN(2) GARCH	0.13716
t cop. GARCH	0.03716	Skewed-t cop. GARCH	0.13731
Skewed-t NGARCH	0.03819	t cop. GARCH	0.13749
Normal cop. NGARCH	0.03868	Normal cop. GARCH	0.13756
t cop. NGARCH	0.03898	t cop. NGARCH	0.13781
MixN(2) GARCH	0.04018	Normal cop. NGARCH	0.13791
MVG-CCC GJR	0.04106	GARCH	0.13869
MVG-CCC GARCH	0.04143	EWMA	0.13937
GARCH	0.04152	MVG-CCC GJR	0.14438
EWMA	0.04238	MVG-CCC sGARCH	0.14468
MixN(3) GARCH	0.04307	MixN(3) GARCH	0.16518
MN-DCC GARCH	0.05215	MN-DCC GARCH	0.16950

Ranking of the average VaR tick loss (see section 3.3) of the models in ascending order for the VaR level 1% and 5%. Models starting with "MVG" refer to the COMFORT model class, models including "cop." refer to the Copula-DCC-(N)GARCH models as specified in Fortin et al. (2022).

Table 4.4 – CPA Test P-Values for 1% VaR Loss

	EWMA	t GJR	Skewed-t GJR	Skewed-t NGARCH	MixN(2) GARCH	MixN(3) GARCH	MN-DCC GARCH	Normal cop. NGARCH	Normal cop. GARCH	t cop. NGARCH	t cop. GARCH	Skewed-t cop. GARCH	MVG-CCC GJR	MVG-CCC GARCH
GARCH	0.000←	0.010 ↑	0.015 ↑	0.077 ↑	0.019 ↑	0.267←	0.000←	0.346 ↑	0.127 ↑	0.387 ↑	0.158 ↑	0.140 ↑	0.780 ↑	0.857 ↑
	EWMA	0.010 ↑	0.011 ↑	0.054 ↑	0.104 ↑	0.517←	0.000←	0.161 ↑	0.063 ↑	0.181 ↑	0.078 ↑	0.067 ↑	0.604 ↑	0.742 ↑
		t GJR	0.024 ↑	0.446←	0.029←	0.074←	0.000←	0.363←	0.827←	0.298←	0.799←	0.851←	0.076←	0.070←
			Skewed-t GJR	0.088←	0.023←	0.060←	0.000←	0.141←	0.834←	0.084←	0.778←	0.841←	0.083←	0.071←
				Skewed-t NGARCH	0.304←	0.143←	0.000←	0.260←	0.528 ↑	0.221←	0.680 ↑	0.595 ↑	0.174←	0.129←
					MixN(2) GARCH	0.066←	0.000←	0.182 ↑	0.171 ↑	0.182 ↑	0.189 ↑	0.168 ↑	0.015←	0.015←
						MixN(3) GARCH	0.002←	0.296 ↑	0.193 ↑	0.315 ↑	0.216 ↑	0.200 ↑	0.555 ↑	0.685 ↑
							MN-DCC GARCH	0.000 ↑	0.000 ↑	0.000 ↑	0.000 ↑	0.000 ↑	0.004 ↑	0.009 ↑
								Normal cop. NGARCH	0.001 ↑	0.000←	0.004 ↑	0.000 ↑	0.182←	0.154←
									Normal cop. GARCH	0.000←	0.011←	0.153←	0.111←	0.113←
										t cop. NGARCH	0.001 ↑	0.000 ↑	0.183←	0.154←
											t cop. GARCH	0.268 ↑	0.121←	0.123←
												Skewed-t cop. GARCH	0.116←	0.117←
													MVG-CCC GJR	0.492←

This table displays the p-values of the CPA test of Giacomini and White (2006) for the 1% VaR tick loss. A left (up) error signifies that the row (column) outperforms the column (row). A gray cell color indicates that we reject the null hypothesis of equal predictive ability on the 5% significance level. Models starting with "MVG" refer to the COMFORT model class, models including "cop." refer to the Copula-DCC-(N)GARCH models as specified in Fortin et al. (2022).

Table 4.5 – CPA Test P-Values for 5% VaR Loss

	EWMA	t GJR	Skewed-t GJR	Skewed-t NGARCH	MixN(2) GARCH	MixN(3) GARCH	MN-DCC GARCH	Normal cop. NGARCH	Normal cop. GARCH	t cop. NGARCH	t cop. GARCH	Skewed-t cop. GARCH	MVG-CCC GJR	MVG-CCC GARCH
GARCH	0.012←	0.129 ↑	0.006 ↑	0.236 ↑	0.093 ↑	0.000←	0.000←	0.109 ↑	0.141 ↑	0.106 ↑	0.140 ↑	0.179 ↑	0.142←	0.122←
	EWMA	0.015 ↑	0.002 ↑	0.097 ↑	0.155 ↑	0.000←	0.000←	0.038 ↑	0.063 ↑	0.038 ↑	0.065 ↑	0.073 ↑	0.228←	0.194←
		t GJR	0.010 ↑	0.174←	0.314←	0.000←	0.000←	0.082←	0.252←	0.083←	0.268←	0.328←	0.021←	0.018←
			Skewed-t GJR	0.004←	0.021←	0.000←	0.000←	0.167←	0.352←	0.173←	0.371←	0.395←	0.006←	0.005←
				Skewed-t NGARCH	0.774←	0.000←	0.000←	0.095←	0.434←	0.093←	0.453←	0.548←	0.066←	0.056←
					MixN(2) GARCH	0.000←	0.000←	0.031←	0.049←	0.029←	0.050←	0.065←	0.028←	0.017←
						MixN(3) GARCH	0.497←	0.001 ↑	0.001 ↑	0.001 ↑	0.001 ↑	0.000 ↑	0.005 ↑	0.006 ↑
							MN-DCC GARCH	0.000 ↑	0.000 ↑	0.000 ↑	0.000 ↑	0.000 ↑	0.000 ↑	0.000 ↑
								Normal cop. NGARCH	0.738 ↑	0.038 ↑	0.722 ↑	0.406 ↑	0.060←	0.056←
									Normal cop. GARCH	0.750←	0.140 ↑	0.016 ↑	0.069←	0.061←
										t cop. NGARCH	0.766 ↑	0.488 ↑	0.058←	0.054←
											t cop. GARCH	0.077 ↑	0.067←	0.060←
												Skewed-t cop. GARCH	0.066←	0.058←
													MVG-CCC GJR	0.877←

This table displays the p-values of the CPA test of Giacomini and White (2006) for the 5% VaR tick loss. A left (up) error signifies that the row (column) outperforms the column (row). A gray cell color indicates that we reject the null hypothesis of equal predictive ability on the 5% significance level. Models starting with "MVG" refer to the COMFORT model class, models including "cop." refer to the Copula-DCC-(N)GARCH models as specified in Fortin et al. (2022).