Hedging and Risk Aversion on Russian Stock Market: Strategies Based on MGARCH and MSV Models

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Introduction I

- Constant hedging coefficient (HC): full hedging, OLS hedging

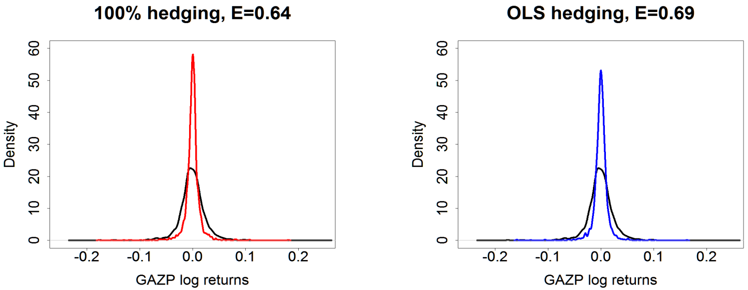

Figure: Constant HC

Introduction II

- Dynamic optimal hedging
- The question: how to estimate covariance matrix of returns to build hedging strategy?
  - We'll compare two options: stochastic volatility (MSV) and conditional heteroskedasticity (MGARCH)

Previous studies

- Dynamic HC: CCC and DCC (Chang et al., 2011), VARMA-AGARCH (Chang et al., 2013), ADCC (Kolokolov, 2002; Asaturov, Teplova, 2014), DCC with realized volatility (Hung, 2015); MSV and MGARCH (Lien, Wilson, 2002)
- Different specifications of MSV: (Harvey, 1994), LDL MSV (Tsay, 2002), SV-LSE (Asai, McAleer, 2006), factor MSV (Chib et al., 2006), DCC MSV (Yu, Meyer, 2006), threshold MSV (So, 2008), MSV with jumps (Laurini et al., 2016), regime switching MSV (Gribisch, 2016)

Hedge ratio

- Calculation of hedged position returns

$$r_t = r_{S,t} - hr_t \cdot r_{F,t} \tag{1}$$

- Obtaining the optimal hedge ratio from maximization of the investor's expected utility

$$\mathrm{E}\, U(r_t) = \mathrm{E}(r_t) - \tau \frac{\mathrm{V}(r_t)}{2}, \tag{2}$$

$$hr_t^* = \frac{\mathrm{cov}(r_{S,t}, r_{F,t})}{\mathrm{V}(r_{F,t})} - \frac{\mathrm{E}(r_{F,t})}{2\tau\, \mathrm{V}(r_{F,t})}, \tag{3}$$

- Calculation of hedging efficiency and comparison

Multivariate Volatility, MSV

$$x_t = \mathbb{E}(x_t|\mathcal{F}_{t-1}) + y_t,\ t = 1, \dots, T,\ x_t - (n \times 1)\text{-vector} \tag{4}$$

$$y_t|\Sigma_t \sim N(0, \Sigma_t) \tag{5}$$

$$\Sigma_t \sim IW(\nu, H_t) \tag{6}$$

$$y_t \sim t(\nu, 0, H_t), \tag{7}$$

where

$$t(\nu, 0, H_t) \propto \left[1 + y_t^{\intercal}(TH_t^{-1})y_t\right]^{-(\nu+n)/2}. \tag{8}$$

See Ando, Kaufman (1965). The estimation is carried out via Hamiltonian Monte Carlo (Duane, Kennedy, Pendleton, Rowet, 1987; Neal, 2011; Betancourt, Girolami, 2013).

Multivariate Volatility, GARCH

$$y_t = \Sigma_t^{1/2}\zeta_t, \zeta_t \sim f(0, \Sigma_\zeta; \theta), \tag{9}$$

$$\begin{aligned} \Sigma_t^{GO-GARCH} &= XV_tX^\intercal,\ V_t = \mathrm{diag}(v_t), \\ v_t &= \mathbb{C} + A(y_t \odot y_t) + Bv_{t-1} \end{aligned} \tag{10}$$

$$\Sigma_t^{ADCC} = D_t R_t D_t, \tag{11a}$$

$$D_t = \mathrm{diag}(d_t),\ d_t \odot d_t = v_t \tag{11b}$$

$$R_t = \mathrm{diag}\left(q_{11,t}^{-1/2} \dots q_{nn,t}^{-1/2}\right) Q_t\, \mathrm{diag}\left(q_{11,t}^{-1/2} \dots q_{nn,t}^{-1/2}\right), \tag{11c}$$

$$Q_t = (1-\alpha-\beta)\bar{Q} + \alpha y_{t-1}y_{t-1}^\intercal + \beta Q_{t-1} + \gamma \widetilde{y}_{t-1}\widetilde{y}_{t-1}^\intercal, \tag{11d}$$

Data description

- 17 Russian stocks, listed both on RTS and RTS FORTS

Ticker	Company name	Ticker	Company name
CHMF	Severstal	ROSN	Rosneft Oil Company
FEES	Federal Grid Company	RTKM	Rostelecom
GAZP	Gazprom	SBER	Sberbank of Russia
GMKN	Norilsk Nickel	SNGS	Surgutneftegas
HYDR	RusHydro	TATN	Tatneft
LKOH	Lukoil	TRNF	Transneft
MGNT	Magnit	URKA	Uralkali
NLMK	Novolipetsk Steel	VTBR	Bank VTB
NVTK	Novatek		

Descriptive statistics

		Stocks				Futures			
Ticker	N	Mean	St.dev.	Skew.	Kurt.	Mean	St.dev.	Skew.	Kurt.
CHMF	1395	0.040	2.215	-0.366	6.237	0.040	2.402	-0.592	10.494
FEES	1318	-0.050	2.941	-0.324	9.748	-0.048	3.184	0.189	8.993
GAZP	2730	-0.013	2.458	-0.084	19.300	-0.013	2.591	0.213	24.388
GMKN	3041	0.058	2.747	-1.001	20.524	0.058	2.907	-1.112	26.078
HYDR	1404	-0.032	2.172	0.199	6.239	-0.031	2.273	-0.092	6.818
LKOH	3586	0.055	2.317	-0.055	16.122	0.055	2.393	-0.335	25.889
MGNT	587	0.036	2.027	-0.089	5.140	0.040	2.202	-0.042	5.573
NLMK	231	0.244	2.030	0.229	3.906	0.242	2.879	0.936	12.178
NVTK	1973	0.084	2.925	-1.362	31.895	0.084	3.712	-0.530	14.097
ROSN	2547	0.025	2.610	0.929	36.043	0.025	2.770	0.536	47.209
RTKM	3020	0.030	2.284	0.293	12.500	0.030	3.031	-0.676	26.798
SBER	2753	0.068	2.995	0.129	17.146	0.068	3.122	0.210	17.946
SNGS	3583	0.031	2.692	0.963	24.704	0.031	2.799	2.272	54.004
TATN	1402	0.065	2.170	-0.020	4.212	0.067	2.145	-0.407	7.613
TRNF	2367	0.065	3.082	0.023	18.438	0.066	3.150	0.039	9.705
URKA	1383	-0.028	2.136	-1.621	23.653	-0.024	2.537	-0.649	13.852
VTBR	2357	-0.026	2.919	0.576	45.755	-0.027	3.286	2.680	80.832

Research design

- In-sample period includes the first 80% of the series.
- Conditional mean of returns is modeled using ARMA.
- According to BIC, ARMA(1,0) for mean and GARCH(1,1) for all volatility models give the best fit.
- Estimation of MSV is conducted via Hamiltonian Monte Carlo algorithm.
- The convergence of Markov chains is checked by Geweke Z-test.
- The risk aversion parameter τ varies from 0 to 10.
- Hedging strategies are compared via three measures of hedging efficiency — maximum risk reduction, financial result and investor's utility. The comparison is conducted for the out-of-sample period.

Geweke Z-test convergence

Ticker	$\text{cov}(r_{S,t}, r_{F,t})$	$V(r_{F,t})$	$E(r_{F,t})$
CHMF	0.612	0.554	0.505
FEES	0.832	0.829	0.937
GAZP	0.844	0.929	0.557
GMKN	0.896	0.897	0.562
HYDR	0.630	0.545	0.790
LKOH	0.914	0.944	0.759
MGNT	0.834	0.545	0.984
NLMK	0.709	0.548	0.822
NVTK	0.534	0.644	0.803
ROSN	0.931	0.887	0.666
RTKM	0.664	0.598	0.611
SBER	0.876	0.849	0.551
SNGS	0.933	0.933	0.674
TATN	0.610	0.569	0.898
TRNF	0.885	0.913	0.580
URKA	0.591	0.690	0.969
VTBR	0.872	0.821	0.637

Measures of hedging efficiency

- Maximum risk reduction

$$E = 1 - \frac{var(r)}{var(r_S)}. \tag{12}$$

- Financial result is calculated as the sum of the logarithmic returns of the portfolio for the forecast period.
- Investor's utility

$$\mathrm{E}\,U\,(r_t) = \mathrm{E}(r_t) - \tau \frac{\mathrm{V}(r_t)}{2}. \tag{13}$$

Summary of hedging efficiency

	ADCC			GO-GARCH			cop-GARCH			MSV		
ra	mrr	profit	util	mrr	profit	util	mrr	profit	util	mrr	profit	util
0.00	4	0	1	4	2	2	7	6	8	2	9	6
1.11	10	0	13	7	2	3	0	3	1	0	12	0
2.22	10	2	10	7	1	6	0	5	1	0	9	0
3.33	10	2	10	7	1	6	0	6	1	0	8	0
4.44	10	2	10	6	5	6	1	5	1	0	5	0
5.56	10	2	10	6	5	6	1	5	1	0	5	0
6.67	10	2	10	6	5	6	1	5	1	0	5	0
7.78	10	2	10	6	6	6	1	5	1	0	4	0
8.89	10	2	10	6	6	6	1	5	1	0	4	0
10.00	10	2	10	6	6	6	1	5	1	0	4	0

Conclusion

- Four hedging strategies based on ADCC, GO-GARCH, copula-GARCH with the Student's copula and MSV were built.
- Optimal dynamic hedge ratios with risk aversion were calculated for 17 portfolios.
- The efficiency of hedging strategies is assessed by maximum risk reduction, financial result of hedged position and investor's utility.
- The most stable performance of hedging strategies demonstrates ADCC model, which provides the highest maximum risk reduction and utility for about 60% portfolios.
- MSV maximizes profit of the hedged position for small values of risk aversion in 70% cases.

Thank you for your attention!

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