

Module 12.5

Dynamic Risk Measures GBM-Based Compound Option Valuation Model

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Overview

- Follows Module 12.3 closely (GBMOVIM)
- Performance of 7 strategies, 3 variables simulated, and 3 different strike prices
- Focus, for illustration, on correlation effects
 - Stock returns and volatility
 - Stock returns and interest rates
 - Volatility and interest rates



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Central Finance Concepts

- Explore performance of seven strategies
- Monte Carlo simulate three input variables
- Evaluate three strike prices
- Goal
 - Illustrate power of simulation
 - Potentially identify outcomes not seen in history



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Seven Strategies UC - Underlying Call

1. Long underlying
2. Long call on call
3. Long put on call
4. Covered call writing (UC – 2.)
5. Protective put buying (UC + 3.)
6. Leveraged calls (UC + 2.)
7. Leveraged puts (UC – 3.)



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Simulation of Three Variables

- Stock price
- Volatility
- Interest rate
- Explore correlation effects typically absent in option-based strategy analysis



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Three Strike Prices

- Low strike price (call ITM, put OTM)
- At-the-money strike price
- High strike price (call OTM, put ITM)
- Enables exploration of influence of implied leverage influence on performance
- Return VaR-focused based on correlation
- Higher confidence interval because higher number of simulations



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Inputs Assumed

- Underlying price = \$100
- Strike prices
 - XL = \$90
 - X = \$100
 - XH = \$110
- Compound X = \$20.46
- Interest rate = 5%
- Underlying yield = 5%
- Volatility = 30%
- Maturity = 5 years
- CO Maturity = 1 year
- Style
 - European Only
- Type = Vanilla



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Simulation Inputs Assumed

- Horizon = 1 month
- Confidence level = 95%
- Simulations = 10,000
- Means
 - Underlying = 5%
 - Rate = 0%
 - Volatility = 0%
- Standard deviations
 - Underlying = 30%
 - Rate = 10%
 - Volatility = 40%
- Correlations
 - Underlying, Rate = -0.3
 - Rate, Volatility = 0.0
 - Stock, Volatility = -0.5



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Table 12.5.1 Return VaR Based on GBM COVM Stock Return and Volatility Correlation

Strategy/Correlation	-0.75	-0.50	-0.25	0.00	0.25	0.50	0.75
LS	5.59	7.48	8.90	10.20	11.14	12.29	13.04
LCXL	13.22	16.74	19.43	21.84	23.51	25.54	27.00
LCX	14.85	18.90	22.54	24.94	27.22	29.39	30.90
LCXH	16.69	21.32	25.53	28.10	30.89	33.16	34.86
LPXL	46.71	44.45	42.31	38.73	35.73	31.41	25.63
LPX	35.31	33.41	31.49	28.35	25.75	22.38	17.66
LPXH	26.44	25.05	23.34	20.79	18.82	16.13	12.45
LCCWXL	0.41	1.20	1.76	2.30	2.74	3.26	3.61
LCCWX	1.66	2.50	3.02	3.61	4.12	4.67	5.08
LCCWXH	2.56	3.48	4.05	4.74	5.32	5.92	6.38
LPPBXL	4.93	6.88	8.71	9.87	11.29	12.18	12.90
LPPBX	4.98	6.64	8.23	9.29	10.50	11.28	11.72
LPPBXH	5.30	6.45	7.47	8.24	9.23	9.70	10.02
LLCXL	7.78	10.14	11.91	13.57	14.68	16.11	17.05
LLCX	7.72	10.14	12.09	13.70	14.92	16.29	17.29
LLCXH	7.62	10.04	12.04	13.62	14.88	16.25	17.21
LLPXL	7.96	9.39	10.03	10.98	11.80	12.59	13.26
LLPX	11.48	12.72	12.83	13.52	14.26	14.73	15.26
LLPXH	18.21	19.15	18.85	19.77	20.16	20.43	20.74

Key Insights: 1) Return VaR reflects the optionality within the underlying call option (similar to long call in GBMOV case). 2) For LC, Return VaR increases with X and for LP, Return VaR decreases with X (implied leverage effect). 3) Option blend strategies have lower Return VaR. 4) Compared with LS, lower Return VaR for LCCW and LPPB due to deleveraging, whereas higher Return VaR for LLC and LLP due to leveraging. 5) Correlation between stock return and volatility has significant impact on Return VaR although theoretically no impact on model option values.



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Table 12.5.2 Return VaR Based on GBM COVM Stock Return and Interest Rate Correlation

Strategy/Correlation	-0.75	-0.50	-0.25	0.00	0.25	0.50	0.75
LS	7.28	7.63	7.53	7.77	7.83	7.89	8.15
LCXL	16.48	17.05	16.88	17.32	17.38	17.54	17.98
LCX	18.77	19.39	19.33	19.82	19.86	19.82	20.41
LCXH	21.39	21.76	21.87	22.22	22.36	22.32	22.90
LPXL	43.32	43.84	44.60	44.88	44.41	45.53	45.65
LPX	32.27	32.83	33.51	33.69	33.42	34.23	34.58
LPXH	23.90	24.48	25.07	25.35	25.07	25.92	26.01
LCCWXL	1.07	1.24	1.19	1.28	1.33	1.38	1.48
LCCWX	2.29	2.51	2.47	2.59	2.64	2.67	2.82
LCCWXH	3.23	3.48	3.45	3.56	3.61	3.68	3.83
LPPBXL	7.00	7.12	7.00	7.19	7.20	7.14	7.36
LPPBX	6.87	6.94	6.72	6.82	6.72	6.77	6.89
LPPBXH	6.45	6.61	6.48	6.49	6.47	6.37	6.63
LLCXL	9.94	10.34	10.24	10.51	10.58	10.66	11.00
LLCX	9.98	10.39	10.33	10.58	10.59	10.69	11.04
LLCXH	9.89	10.29	10.25	10.46	10.53	10.62	10.95
LLPXL	8.62	9.20	9.30	9.43	9.66	9.79	10.10
LLPX	11.61	12.25	12.76	12.99	13.14	13.37	13.78
LLPXH	17.77	18.69	19.63	19.89	20.19	20.42	21.20

Key Insights: 1) Patterns observed from prior table remain the same. 2) Correlation between stock returns and interest rates do not have a material influence on option strategy performance.



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Table 12.5.3 Return VaR Based on GBM COVM Volatility and Interest Rate Correlation

Strategy/Correlation	-0.75	-0.50	-0.25	0.00	0.25	0.50	0.75
LS	7.42	7.25	7.39	7.46	7.57	7.73	7.66
LCXL	16.64	16.39	16.61	16.75	16.94	17.25	17.09
LCX	18.79	18.56	18.93	19.04	19.35	19.60	19.33
LCXH	21.04	20.94	21.49	21.67	21.90	22.06	21.88
LPXL	45.64	45.10	44.72	44.50	43.62	43.55	42.79
LPX	34.32	33.85	33.56	33.35	32.57	32.60	31.74
LPXH	25.77	25.29	25.06	24.98	24.18	24.41	23.71
LCCWXL	1.14	1.07	1.12	1.15	1.18	1.27	1.24
LCCWX	2.42	2.34	2.37	2.44	2.41	2.52	2.50
LCCWXH	3.38	3.29	3.32	3.40	3.39	3.50	3.46
LPPBXL	6.88	6.82	7.02	7.05	7.11	7.13	7.02
LPPBX	6.73	6.69	6.74	6.79	6.89	6.83	6.70
LPPBXH	6.59	6.58	6.57	6.50	6.58	6.41	6.35
LLCXL	10.08	9.87	10.05	10.15	10.26	10.47	10.36
LLCX	10.07	9.98	10.05	10.18	10.34	10.52	10.40
LLCXH	9.98	9.85	9.97	10.09	10.23	10.44	10.29
LLPXL	9.03	8.96	9.14	9.05	9.12	9.27	9.24
LLPX	12.40	12.35	12.68	12.33	12.29	12.55	12.48
LLPXH	19.13	18.81	19.55	18.83	18.72	19.07	19.15

Key Insights: 1) Patterns observed from prior tables remain the same. 2) Correlation between volatility and interest rates do not have a material influence on option strategy performance.



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Quantitative Finance Materials

- Analysis presented here based on valuation models previously covered
 - Module 5.6 (Valuation)
 - Module 8.5 (Static Risk Measures)
- Large number of alternative strategies could be covered
 - Alternative option-based strategies
 - Portfolios of stocks rather than just one



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COVM

$$CO(S, t_1, T_1, T_2, t_U) = t_U S_t B_{t, T_2, \delta} B_{T_1, T_2, -\delta} N_2(t_U d_{11}, t_U d_{12}; t_U \rho) - t_U X_U B_{t, T_2, \delta} B_{T_1, T_2, -\delta} N_2(t_U d_{21}, t_U d_{22}; t_U \rho) - t_U X_C B_{t, T_1, \delta} N(t_U d_{21})$$

$$N_2(a, b; \rho) = \int_{-\infty}^a \int_{-\infty}^b \frac{\exp\left\{-\frac{z_1^2 - 2\rho z_1 z_2 + z_2^2}{2(1-\rho^2)}\right\}}{2\pi\sqrt{1-\rho^2}} dz_1 dz_2$$

$$d_{21} = \frac{\ln\left(\frac{S_t B_{t, T_1, -(\delta)}}{S_t^*}\right) - \frac{\sigma_{t, T_1}^2}{2}}{\sigma_{t, T_1}} \quad d_{11} = \frac{\ln\left(\frac{S_t B_{t, T_1, -(\delta)}}{S_t^*}\right) + \frac{\sigma_{t, T_1}^2}{2}}{\sigma_{t, T_1}} = d_{21} + \sigma_{t, T_1}$$



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COVM

$$d_{22} = \frac{\ln\left(\frac{S_t B_{t, T_2, -(\delta)}}{X_U}\right) - \frac{\sigma_{t, T_2}^2}{2}}{\sigma_{t, T_2}} \quad d_{12} = \frac{\ln\left(\frac{S_t B_{t, T_2, -(\delta)}}{X_U}\right) + \frac{\sigma_{t, T_2}^2}{2}}{\sigma_{t, T_2}} = d_{22} + \sigma_{t, T_2}$$

$$t_U S_t^* B_{t, T_2, \delta - \delta} N_1(t_U d_{1, T_2}^*) - t_U X_U B_{t, T_2, \delta - \delta} N_1(t_U d_{2, T_2}^*) - X_C = 0$$

$$d_{2, T_2}^* = \frac{\ln\left(\frac{S_t^* B_{t, T_2, -(\delta)}}{X_U}\right) - \frac{\sigma_{t, T_2}^2}{2}}{\sigma_{t, T_2}} \quad d_{1, T_2}^* = \frac{\ln\left(\frac{S_t^* B_{t, T_2, -(\delta)}}{X_U}\right) + \frac{\sigma_{t, T_2}^2}{2}}{\sigma_{t, T_2}} = d_{2, T_2}^* + \sigma_{t, T_2}$$



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Summary

- Performance of 7 strategies, 3 variables simulated, and 3 different strike prices
- Focus, for illustration, on correlation effects
 - Stock returns and volatility (high influence)
 - Stock returns and interest rates
 - Volatility and interest rates



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