

## Module 12.1

### Dynamic Risk Measures GBM-Based Binomial Models

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## Overview

- 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

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



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## Inputs Assumed

- Stock price = \$100
- Strike prices
  - XL = \$90
  - X = \$100
  - XH = \$110
- Interest rate = 5%
- Dividend yield = 0%
- Volatility = 30%
- Maturity = 1 year
- Steps = 250
- Style
  - European (Panel A)
  - American (Panel B)
- Type = Vanilla
- EMM probability = 50%



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## Simulation Inputs Assumed

- Horizon = 1 month
- Confidence level = 90%
- Simulations = 2,000
- Means
  - Stock = 5%
  - Rate = 0%
  - Volatility = 0%
- Standard deviations
  - Stock = 30%
  - Rate = 10%
  - Volatility = 40%
- Correlations
  - Stock, Rate = -0.3
  - Rate, Volatility = 0.0
  - Stock, Volatility = -0.5



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Table 12.1.1 Return VaR Based on GBM BOVM Stock Return and Volatility Correlation

Panel A: European-style

Strategy/Correlation	-0.75	-0.50	-0.25	0.00	0.25	0.50	0.75
LS	2.54	2.64	2.74	2.82	2.88	2.86	
LCXL	11.49	11.99	13.19	13.55	14.31	13.71	15.53
LCX	13.70	14.54	16.15	16.66	17.56	17.32	19.60
LCXH	16.08	17.44	19.58	20.48	21.64	21.21	24.01
LPXL	26.78	25.66	23.72	22.73	21.26	19.29	16.86
LPX	20.86	20.14	18.45	17.92	16.79	15.58	13.73
LPXH	16.41	16.05	14.77	14.31	13.48	12.56	11.31
LCCWXL	0.48	0.44	0.34	0.19	0.19	0.03	-0.12
LCCWX	0.84	0.79	0.70	0.51	0.53	0.31	0.20
LCCWXLH	1.20	1.12	1.05	0.83	0.90	0.63	0.59
LPPBXL	1.81	1.91	2.13	2.22	2.34	2.22	2.57
LPPBX	1.43	1.54	1.75	1.82	1.94	1.90	2.20
LPPBXH	1.05	1.16	1.35	1.41	1.52	1.49	1.73
LLCXL	4.00	4.16	4.46	4.43	4.65	4.40	4.91
LLCX	3.91	4.07	4.39	4.39	4.63	4.36	4.91
LLCXH	3.75	3.92	4.25	4.23	4.50	4.23	4.75
LLPXL	3.42	3.47	3.46	3.15	3.38	3.04	3.25
LLPX	3.99	4.04	4.02	3.65	3.90	3.51	3.74
LLPXH	4.68	4.75	4.71	4.33	4.62	4.17	4.45

Panel B: American-style

Strategy/Correlation	-0.75	-0.50	-0.25	0.00	0.25	0.50	0.75
LS	2.83	2.84	2.79	2.69	2.68	2.88	2.71
LCXL	12.26	12.60	13.17	13.24	13.61	15.29	14.81
LCX	14.46	14.97	16.33	16.48	17.17	19.12	18.67
LCXH	16.83	17.70	19.58	20.04	20.90	23.46	23.15
LPXL	27.23	26.24	24.54	23.87	20.91	19.12	17.83
LPX	21.42	20.48	19.32	19.07	16.78	15.48	14.80
LPXH	16.90	16.20	15.37	15.21	13.71	12.90	12.56
LCCWXL	0.62	0.50	0.39	0.23	0.15	0.06	-0.16
LCCWX	1.01	0.89	0.77	0.55	0.49	0.40	0.13
LCCWXLH	1.40	1.26	1.15	0.92	0.86	0.79	0.50
LPPBXL	1.94	2.00	2.12	2.13	2.23	2.51	2.44
LPPBX	1.50	1.56	1.73	1.76	1.85	2.07	2.04
LPPBXH	1.05	1.13	1.27	1.31	1.37	1.58	1.56
LLCXL	4.40	4.46	4.47	4.33	4.47	4.93	4.68
LLCX	4.26	4.37	4.39	4.29	4.41	4.88	4.67
LLCXH	4.09	4.19	4.24	4.16	4.27	4.74	4.55
LLPXL	3.90	3.81	3.66	3.40	3.24	3.41	3.07
LLPX	4.58	4.47	4.29	3.98	3.80	3.99	3.59
LLPXH	5.42	5.28	5.07	4.76	4.53	4.80	4.39

Key Insights: 1) Return VaR is slow to converge as illustrated with LS (correlation should have no influence). 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 12.1.2 Return VaR Based on GBM BOVM Stock Return and Interest Rate Correlation

Panel A: European-style

Strategy/Correlation	-0.75	-0.50	-0.25	0.00	0.25	0.50	0.75
LS	2.75	2.72	2.75	2.72	2.74	2.79	2.70
LCXL	12.28	12.32	12.37	12.35	12.44	12.81	12.40
LCX	14.64	14.67	14.96	14.96	14.92	15.31	14.90
LCXH	17.26	17.59	17.75	18.02	17.61	18.21	17.72
LPXL	25.31	25.53	26.16	26.23	25.87	25.63	25.20
LPX	19.61	20.01	20.40	20.44	20.25	20.15	19.80
LPXH	15.34	15.75	16.09	16.18	15.87	16.05	15.44
LCCWXL	0.48	0.43	0.44	0.39	0.49	0.45	0.42
LCCWX	0.87	0.81	0.82	0.77	0.86	0.83	0.81
LCCWXLH	1.25	1.14	1.16	1.12	1.21	1.21	1.15
LPPBXL	1.99	1.99	1.99	1.99	1.98	2.03	1.96
LPPBX	1.58	1.57	1.60	1.58	1.56	1.61	1.54
LPPBXH	1.16	1.18	1.18	1.18	1.15	1.18	1.14
LLCXL	4.33	4.32	4.32	4.25	4.32	4.47	4.28
LLCX	4.24	4.24	4.23	4.13	4.22	4.36	4.15
LLCXH	4.05	4.06	4.07	3.96	4.06	4.18	4.02
LLPXL	3.63	3.59	3.56	3.50	3.58	3.67	3.62
LLPX	4.25	4.17	4.15	4.07	4.17	4.27	4.20
LLPXH	4.94	4.89	4.87	4.79	4.91	5.01	4.95

Panel B: American-style

Strategy/Correlation	-0.75	-0.50	-0.25	0.00	0.25	0.50	0.75
LS	2.88	2.72	2.75	2.67	2.68	2.78	2.60
LCXL	12.77	12.54	12.52	12.19	12.32	12.57	12.29
LCX	15.52	14.84	14.91	14.54	14.87	14.96	14.57
LCXH	18.12	17.51	17.72	17.43	18.07	17.66	17.56
LPXL	25.43	26.26	25.44	25.67	26.69	26.08	26.32
LPX	20.14	20.70	20.05	20.24	21.14	20.46	20.87
LPXH	16.03	16.43	15.83	15.91	16.91	16.23	16.59
LCCWXL	0.51	0.46	0.50	0.39	0.43	0.45	0.37
LCCWX	0.92	0.83	0.88	0.74	0.80	0.84	0.75
LCCWXLH	1.28	1.17	1.28	1.08	1.16	1.20	1.11
LPPBXL	2.07	1.99	1.99	1.93	1.94	1.97	1.91
LPPBX	1.65	1.56	1.56	1.51	1.54	1.53	1.46
LPPBXH	1.17	1.12	1.12	1.10	1.14	1.09	1.07
LLCXL	4.48	4.32	4.36	4.20	4.27	4.38	4.21
LLCX	4.37	4.20	4.28	4.13	4.18	4.28	4.13
LLCXH	4.19	4.03	4.13	3.97	4.02	4.11	3.99
LLPXL	3.84	3.59	3.79	3.62	3.56	3.66	3.48
LLPX	4.51	4.22	4.44	4.24	4.17	4.30	4.08
LLPXH	5.29	4.98	5.27	4.99	4.94	5.10	4.84

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 12.1.3 Return VaR Based on GBM BOVM Volatility and Interest Rate Correlation

Panel A: European-style

Strategy/Correlation	-0.75	-0.50	-0.25	0.00	0.25	0.50	0.75
LS	2.75	2.77	2.73	2.82	2.76	2.77	2.59
LCXL	12.60	12.63	12.28	12.62	12.70	12.31	11.98
LCX	15.18	15.07	14.94	15.03	15.34	14.85	14.39
LCXH	18.20	17.90	17.91	17.76	18.20	17.91	17.26
LPXL	26.16	25.76	25.77	25.52	26.28	24.99	23.48
LPX	20.49	20.30	20.11	20.06	20.53	19.62	19.98
LPXH	16.15	16.13	16.06	15.85	16.21	15.36	15.63
LCCWXL	0.46	0.49	0.46	0.51	0.46	0.47	0.44
LCCWX	0.82	0.88	0.84	0.90	0.84	0.83	0.81
LCCWXLH	1.16	1.23	1.21	1.27	1.19	1.16	1.13
LPPBXL	2.04	2.03	1.98	2.02	2.04	1.97	1.92
LPPBX	1.64	1.61	1.60	1.60	1.64	1.57	1.52
LPPBXH	1.24	1.21	1.19	1.19	1.23	1.18	1.13
LLCXL	4.41	4.42	4.30	4.45	4.30	4.30	4.13
LLCX	4.26	4.31	4.20	4.36	4.24	4.22	4.05
LLCXH	4.11	4.14	4.04	4.18	4.09	4.06	3.90
LLPXL	3.59	3.66	3.61	3.69	3.62	3.60	3.45
LLPX	4.18	4.24	4.22	4.28	4.23	4.19	4.01
LLPXH	4.90	4.98	4.94	5.05	4.91	4.93	4.70

Panel B: American-style

Strategy/Correlation	-0.75	-0.50	-0.25	0.00	0.25	0.50	0.75
LS	2.72	2.80	2.82	2.88	2.77	2.79	2.76
LCXL	12.52	12.80	12.38	12.59	12.58	12.93	12.56
LCX	14.90	15.32	14.93	15.04	15.41	15.44	14.89
LCXH	17.66	18.31	17.78	17.99	18.52	18.11	18.08
LPXL	26.44	26.04	24.91	25.74	25.65	26.37	25.66
LPX	20.70	20.42	19.68	20.29	20.03	20.66	20.32
LPXH	16.40	16.19	15.57	16.04	15.92	16.53	16.14
LCCWXL	0.44	0.44	0.48	0.52	0.42	0.50	0.44
LCCWX	0.81	0.81	0.84	0.91	0.79	0.87	0.82
LCCWXLH	1.20	1.14	1.21	1.29	1.11	1.23	1.19
LPPBXL	2.00	2.05	1.98	2.00	2.01	2.08	1.99
LPPBX	1.55	1.61	1.55	1.57	1.61	1.62	1.55
LPPBXH	1.13	1.17	1.13	1.15	1.18	1.15	1.15
LLCXL	4.30	4.47	4.40	4.43	4.36	4.47	4.35
LLCX	4.18	4.36	4.33	4.32	4.26	4.40	4.25
LLCXH	4.04	4.19	4.14	4.16	4.12	4.21	4.09
LLPXL	3.66	3.67	3.67	3.81	3.67	3.73	3.70
LLPX	4.29	4.30	4.31	4.47	4.29	4.38	4.33
LLPXH	5.08	5.07	5.12	5.29	5.09	5.17	5.12

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 5.2 (Valuation)
  - Module 8.1 (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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## GBM-Based BOVM

### ■ GBM-based BOVM

$$\begin{aligned}
 O_0 &= PV_t[E_0(O_T)] \\
 &= PV_t\left[\sum_{j=0}^n \Pr(n, j) Payoff(t, n, j)\right] \\
 &= PV_t\left[\sum_{j=0}^n \left(\frac{n!}{j!(n-j)!}\right) \pi^j (1-\pi)^{n-j} \max\left[0, t(S_0 u^j d^{n-j} - X)\right]\right]
 \end{aligned}$$



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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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