

# An Analysis of Dynamic Applications of Black-Scholes

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For decades people have invested in the stock market in with stocks, options, and bonds. One of the earliest is Black-Scholes. Developed by Fischer Black and Merton Scholes in 1973, it remains one of the most prevalent tools used by European investors today. The major focus of study will be comparing call and put values generated by the Black-Scholes model to historical call and put values.

Figure 2: Main formulas of Black-Scholes

$$C(S, t) = SN(d_1) - Ke^{-r(T-t)}N(d_2)$$

$$d_1 = \frac{\ln\left(\frac{S}{K}\right) + \left(r + \frac{\sigma^2}{2}\right)(T-t)}{\sigma\sqrt{T-t}}$$

$$d_2 = d_1 - \sigma\sqrt{T-t}$$

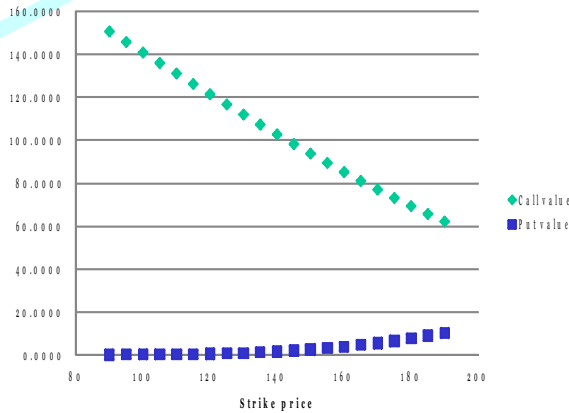
$$P(S, t) = Ke^{-r(T-t)} - S + (SN(d_1) - Ke^{-r(T-t)}N(d_2)) = Ke^{-r(T-t)} - S + C(S, t)$$

	B	C	D	E	F	G	H	I	J
1	Stock price	Strike Price	Time to Maturity	Risk free rate	Volatility	Equation d1	Equation d2	Call value	Put value
2	196.07	196.07	0.06	0.35%	40.0%	0.0501	-0.0459	7.5555	7.5555
4	196.29	196.29	0.05	0.35%	40.0%	0.0499	-0.0448	7.3455	7.3455
5	196.48	196.48	0.05	0.35%	40.0%	0.0496	-0.0438	7.1483	7.1483
6	193.32	193.32	0.05	0.35%	40.0%	0.0484	-0.0425	6.9646	6.9646
7	188.05	188.05	0.05	0.35%	40.0%	0.0461	-0.0413	6.8201	6.8201
8	189.87	189.87	0.04	0.35%	40.0%	0.0457	-0.0405	6.7555	6.7555
9	197.8	197.8	0.04	0.35%	40.0%	0.0423	-0.0388	6.4108	6.3923
10	196.43	196.43	0.04	0.35%	40.0%	0.0409	-0.0375	6.3502	6.3288
11	194.67	194.67	0.04	0.35%	40.0%	0.0394	-0.0361	5.8730	5.8488
12	196.98	196.98	0.03	0.35%	40.0%	0.0379	-0.0347	5.7093	5.6865
13	194.17	194.17	0.03	0.35%	40.0%	0.0362	-0.0332	5.3874	5.3674
14	195.03	195.03	0.03	0.35%	40.0%	0.0346	-0.0317	5.1596	5.1409
15	191.95	191.95	0.02	0.35%	40.0%	0.0328	-0.0300	4.8148	4.7983
16	195.43	195.43	0.02	0.35%	40.0%	0.0309	-0.0283	4.5236	4.5087
17	198.29	198.29	0.02	0.35%	40.0%	0.0289	-0.0265	4.2886	4.2733
18	200.36	200.36	0.02	0.35%	40.0%	0.0268	-0.0246	4.1035	4.0930
19	202.1	202.1	0.01	0.35%	40.0%	0.0244	-0.0224	3.7760	3.7654
20	209.04	209.04	0.01	0.35%	40.0%	0.0219	-0.0200	3.4958	3.4877
21	211.61	211.61	0.01	0.35%	40.0%	0.0190	-0.0173	3.0642	3.0581
22	209.1	209.1	0.01	0.35%	40.0%	0.0165	-0.0142	2.4715	2.4679
23	211.64	211.64	0.00	0.35%	40.0%	0.0109	-0.0100	1.7487	1.7467

Figure 1: The Black-Scholes Spreadsheet

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The Black-Scholes involves several main variables: stock price, strike price, volatility, time until maturity, and the risk-free interest rate. We assume that the valuation of options follows a Geometric Brownian motion and the return is normally distributed with no limits on shorting, no arbitrage, no dividends, and no transaction costs or taxes. The volatility is calculated through a logarithmic function from historical data; the risk free rate is estimated by the U.S. T-bond rate. The generated values are then compared with actual values.



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Although in the future many more companies will be analyzed, Apple (NASDAQ: AAPL) was used as a preliminary subject for analysis. At a given time t, the stock price for AAPL was \$239.94. APPL options used are ranged from \$90.00 to \$190.00 in increasing increments of \$5.00. All options were calculated with three days until maturity, volatility of 20%, and a risk free rate of 0.35%.

