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FINANCE

Yara Inc is listed on the NYSE with a stock price of $40 - the Company is not known to pay dividends. We need to price a call option with a strike of $45 maturing in 4 months. The continuously - compounded risk-free rate is 3%/year, the mean return on the stock is 7%/year, and the standard deviation of the stock return is 40%/year. What is the Black-Scholes Call price?

Solution

KEY TAKEAWAY

* The standard Black-Scholes model is only used to price EUROPEAN options and does not take into account that U.S options could be excercised before the expiration date.

But nevertheless, we would go on with the calculation.

☺

$$V_c = P_0 N_{d_1} - P_1 N_{d_2}$$

V_c - Value of the Call price
P_0 - Stock Price
N_{d_1} - The position of d_1 on standard distribution table
P_1 - Present price

Note; $P_1 = \dfrac{X_1}{e^{K_{RF} t}}$

where

X_1 - Exercise price / strike price
K_{RF} - Risk free rate
t - time (in years)

N_{d_2} - The position of d_2 on the distribution table

$$d_1 = \frac{\left[\ln\left(\frac{P_0}{X}\right) + (K_{RF} + .5\,\sigma^2)\,t \right]}{\sigma\sqrt{t}}$$

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

Where σ is volatility / standard deviation

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$P_0 = \$40$

$X_1 = \$45$

$t = 4 \text{ months} = 4/12 \text{ years} = 1/3 \text{ years}$

$k_{RF} = 3\% = 0.03$

$\sigma = 40\% = 0.4$

$\therefore$

$$d_1 = \frac{\left[\ln\left(\frac{40}{45}\right) + \left(0.03 + 0.5(0.4)^2\right) \cdot 1/3\right]}{0.4 \times \sqrt{1/3}}$$

$$d_1 = \frac{-0.11778 + (0.03 + 0.08)1/3}{0.4 \times 0.57735}$$

$$d_1 = \frac{-0.11778 + 0.036667}{0.23094}$$

$$d_1 = \frac{-0.081113}{0.23094} \approx -0.35123$$

$$d_2 = -0.35123 - 0.4 \times \sqrt{1/3}$$

$$= -0.35123 - 0.23094$$

$$\approx -0.58217$$

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From the distribution table attached

for d_1

$N(-0.35) - 0.3632$

$N(-0.35123) - x$

$N(-0.36) - 0.3594$

Finding x using Interpolation

$$\frac{x - 0.3594}{0.3632 - 0.3594} = \frac{-0.35123 + 0.36}{-0.35 + 0.36}$$

$$0.01x - 3.594\times10^{-3} = 3.3326\times10^{-5}$$

$$0.01x = 3.3326\times10^{-5} + 3.594\times10^{-3}$$

$$x = 0.3627$$

$\therefore N(d_1) = 0.3627$

for d_2

$N(-0.59) - 0.2776$

$N(-0.58217) - x$

$N(-0.58) - 0.2810$

Cumulative Area Under the Standard Normal Distribut

D	N(d)	D	N(d)	D	N(d)	D
-3.00	0.0013	-0.99	0.1611	-0.28	0.3897	0.
-2.95	0.0016	-0.98	0.1635	-0.27	0.3936	0.
-2.90	0.0019	-0.97	0.1660	-0.26	0.3974	0.
-2.85	0.0022	-0.96	0.1685	-0.25	0.4013	0.
-2.80	0.0026	-0.95	0.1711	-0.24	0.4052	0.
-2.75	0.0030	-0.94	0.1736	-0.23	0.4090	0.
-2.70	0.0035	-0.93	0.1762	-0.22	0.4129	0.
-2.65	0.0040	-0.92	0.1788	-0.21	0.4168	0.
-2.60	0.0047	-0.91	0.1814	-0.20	0.4207	0.
-2.55	0.0054	-0.90	0.1841	-0.19	0.4247	0.
-2.50	0.0062	-0.89	0.1867	-0.18	0.4286	0.
-2.45	0.0071	-0.88	0.1894	-0.17	0.4325	0.
-2.40	0.0082	-0.87	0.1922	-0.16	0.4364	0.
-2.35	0.0094	-0.86	0.1949	-0.15	0.4404	0.
-2.30	0.0107	-0.85	0.1977	-0.14	0.4443	0.
-2.25	0.0122	-0.84	0.2005	-0.13	0.4483	0.
-2.20	0.0139	-0.83	0.2033	-0.12	0.4522	0.
-2.15	0.0158	-0.82	0.2061	-0.11	0.4562	0.
-2.10	0.0179	-0.81	0.2090	-0.10	0.4602	0.
-2.05	0.0202	-0.80	0.2119	-0.09	0.4641	0.
-2.00	0.0228	-0.79	0.2148	-0.08	0.4681	0.
-1.98	0.0239	-0.78	0.2177	-0.07	0.4721	0.
-1.96	0.0250	-0.77	0.2206	-0.06	0.4761	0.
-1.94	0.0262	-0.76	0.2236	-0.05	0.4801	0.
-1.92	0.0274	-0.75	0.2266	-0.04	0.4840	0.
-1.90	0.0287	-0.74	0.2296	-0.03	0.4880	0.
-1.88	0.0301	-0.73	0.2327	-0.02	0.4920	0.
-1.86	0.0314	-0.72	0.2358	-0.01	0.4960	0.
-1.84	0.0329	-0.71	0.2389	0.00	0.5000	0.
-1.82	0.0344	-0.70	0.2420	0.01	0.5040	0.
-1.80	0.0359	-0.69	0.2451	0.02	0.5080	0.
-1.78	0.0375	-0.68	0.2483	0.03	0.5120	0.
-1.76	0.0392	-0.67	0.2514	0.04	0.5160	0.
-1.74	0.0409	-0.66	0.2546	0.05	0.5199	0.
-1.72	0.0427	-0.65	0.2578	0.06	0.5239	0.
-1.70	0.0446	-0.64	0.2611	0.07	0.5279	0.
-1.68	0.0465	-0.63	0.2643	0.08	0.5319	0.
-1.66	0.0485	-0.62	0.2676	0.09	0.5359	0.
-1.64	0.0505	-0.61	0.2709	0.10	0.5398	0.
-1.62	0.0526	-0.60	0.2743	0.11	0.5438	0.
-1.60	0.0548	-0.59	0.2776	0.12	0.5478	0.
-1.58	0.0571	-0.58	0.2810	0.13	0.5517	0.
-1.56	0.0594	-0.57	0.2843	0.14	0.5557	0.
-1.54	0.0618	-0.56	0.2877	0.15	0.5596	0.
-1.52	0.0643	-0.55	0.2912	0.16	0.5636	0.
-1.50	0.0668	-0.54	0.2946	0.17	0.5675	0.
-1.48	0.0694	-0.53	0.2981	0.18	0.5714	0.
-1.46	0.0721	-0.52	0.3015	0.19	0.5753	0.
-1.44	0.0749	-0.51	0.3050	0.20	0.5793	0.
-1.42	0.0778	-0.50	0.3085	0.21	0.5832	0.
-1.40	0.0808	-0.49	0.3121	0.22	0.5871	0.
-1.38	0.0838	-0.48	0.3156	0.23	0.5910	0.
-1.36	0.0869	-0.47	0.3192	0.24	0.5948	0.
-1.34	0.0901	-0.46	0.3228	0.25	0.5987	0.
-1.32	0.0934	-0.45	0.3264	0.26	0.6026	0.
-1.30	0.0968	-0.44	0.3300	0.27	0.6064	0.
-1.28	0.1003	-0.43	0.3336	0.28	0.6103	0.
-1.26	0.1038	-0.42	0.3372	0.29	0.6141	1.
-1.24	0.1075	-0.41	0.3409	0.30	0.6179	1.
-1.22	0.1112	-0.40	0.3446	0.31	0.6217	1.
-1.20	0.1151	-0.39	0.3483	0.32	0.6255	1.
-1.18	0.1190	-0.38	0.3520	0.33	0.6293	1.
-1.16	0.1230	-0.37	0.3557	0.34	0.6331	1.
-1.14	0.1271	-0.36	0.3594	0.35	0.6368	1.
-1.12	0.1314	-0.35	0.3632	0.36	0.6406	1.
-1.10	0.1357	-0.34	0.3669	0.37	0.6443	1.
-1.08	0.1401	-0.33	0.3707	0.38	0.6480	1.

$$\frac{x - 0.2776}{0.2810 - 0.2776} = \frac{-0.58217 + 0.59}{-0.58 + 0.59}$$

$$\frac{x - 0.2776}{3.4\times10^{-3}} = \frac{7.83\times10^{-3}}{0.01}$$

$$0.01x - 2.776\times10^{-3} = 2.6622\times10^{-5}$$

$$0.01x = 2.802622\times10^{-3}$$

$$x = 0.28026$$

$$N(d_2) = 0.28026$$

$$V_c = 40\times0.3627 - \left[\frac{45}{e^{0.03\times1/3}}\right]\times0.28026$$

$$\approx 14.508 - (44.5522)\times0.28026$$

$$\approx 14.508 - 12.4862$$

$$\approx \$2.0218$$