

$$u = 1.1; d = 0.9$$

$\tilde{S}_n = S_n e^{-r_c n \Delta t}$	$\tilde{V}_n = V_0 + \sum_{k=1}^n \phi_k \Delta \tilde{S}_k$
$\phi_{n+1} = \frac{c(n+1, S_n u) - c(n+1, S_n d)}{S_n(u-d)}$	$\phi_{n+1}^0 = \tilde{V}_n - \phi_{n+1} S_n e^{-r_c n \Delta t}$

For $n = 0$:

$$\tilde{S}_0 = S_0 = 50$$

$$V_0 = e^{-r_c T} \mathbf{E}_{\mathbf{Q}}(S_N - K)_+ = c(0, 50) = 5.5939$$

$$\phi_1 = \frac{8.4036 - 1.8750}{50 \times (1.1 - 0.9)} = 0.65286$$

$$\phi_1^0 = 5.5939 - 0.65286 \times 50 = -27.0491$$

Observe that $\phi_1 S_0 + \phi_1^0 S_0^0 = 0.65286 \times 50 - 27.0491 = 5.5939 = c(0, 50)$.

$$u = 1.1; d = 0.9$$

$\tilde{S}_n = S_n e^{-r_c n \Delta t}$	$\tilde{V}_n = V_0 + \sum_{k=1}^n \phi_k \Delta \tilde{S}_k$
$\phi_{n+1} = \frac{c(n+1, S_n u) - c(n+1, S_n d)}{S_n(u-d)}$	$\phi_{n+1}^0 = \tilde{V}_n - \phi_{n+1} S_n e^{-r_c n \Delta t}$

For $n = 1$:

$$\tilde{S}_1 = 55 \times e^{-0.2 \times \frac{1}{12}} = 54.0909$$

$$\begin{aligned} \tilde{V}_1 &= V_0 + \phi_1 \Delta \tilde{S}_1 = 5.5939 + 0.65286 \times (54.0909 - 50) \\ &= 8.2647 \end{aligned}$$

$$\phi_2 = \frac{12.3057 - 3.2645}{55 \times (1.1 - 0.9)} = 0.82193$$

$$\phi_2^0 = 8.2647 - 0.82193 \times 54.0909 = -36.1943$$

Test:	Sell	$\phi_1 S_1 + \phi_1^0 e^{r_c \Delta t}$	=	$0.65286 \times 55 - 27.0491 e^{0.2 \frac{1}{12}}$	=	8.4036
	Buy	$\phi_2 S_1 + \phi_2^0 e^{r_c \Delta t}$	=	$0.82193 \times 55 - 36.1943 e^{0.2 \frac{1}{12}}$	=	8.4036

$$u = 1.1; d = 0.9$$

$\tilde{S}_n = S_n e^{-r_c n \Delta t}$	$\tilde{V}_n = V_0 + \sum_{k=1}^n \phi_k \Delta \tilde{S}_k$
$\phi_{n+1} = \frac{c(n+1, S_n u) - c(n+1, S_n d)}{S_n(u-d)}$	$\phi_{n+1}^0 = \tilde{V}_n - \phi_{n+1} S_n e^{-r_c n \Delta t}$

For $n = 2$:

$$\tilde{S}_2 = 49.5 \times e^{-0.2 \times \frac{2}{12}} = 47.8772$$

$$\begin{aligned} \tilde{V}_2 &= \tilde{V}_1 + \phi_2 \Delta \tilde{S}_2 = 8.2647 + 0.82193 \times (47.8772 - 54.0909) \\ &= 3.1575 \end{aligned}$$

$$\phi_3 = \frac{5.6835 - 0}{49.5 \times (1.1 - 0.9)} = 0.57409$$

$$\phi_3^0 = 3.1575 - 0.57409 \times 47.8772 = -24.3283$$

Test:	Sell	$\phi_2 S_2 + \phi_2^0 e^{r_c 2 \Delta t}$	=	$0.82193 \times 49.5 - 36.1943 e^{0.2 \frac{2}{12}}$	=	3.2645
	Buy	$\phi_3 S_2 + \phi_3^0 e^{r_c 2 \Delta t}$	=	$0.57409 \times 49.5 - 24.3283 e^{0.2 \frac{2}{12}}$	=	3.2645

$$u = 1.1; d = 0.9$$

$\tilde{S}_n = S_n e^{-r_c n \Delta t}$	$\tilde{V}_n = V_0 + \sum_{k=1}^n \phi_k \Delta \tilde{S}_k$
$\phi_{n+1} = \frac{c(n+1, S_n u) - c(n+1, S_n d)}{S_n(u-d)}$	$\phi_{n+1}^0 = \tilde{V}_n - \phi_{n+1} S_n e^{-r_c n \Delta t}$

For $n = 3$:

$$\tilde{S}_3 = 54.45 \times e^{-0.2 \times \frac{3}{12}} = 51.7944$$

$$\begin{aligned} \tilde{V}_3 &= \tilde{V}_2 + \phi_3 \Delta \tilde{S}_3 = 3.1575 + 0.57409 \times (51.7944 - 47.8772) \\ &= 5.4063 \end{aligned}$$

$$\phi_4 = \frac{9.895 - 0}{54.45 \times (1.1 - 0.9)} = 0.90863$$

$$\phi_4^0 = 5.4063 - 0.90863 \times 51.7944 = -41.6556$$

Test:	Sell	$\phi_3 S_3 + \phi_3^0 e^{r_c 3 \Delta t}$	=	$0.57409 \times 54.45 - 24.3283 e^{0.2 \frac{3}{12}}$	=	5.6835
	Buy	$\phi_4 S_3 + \phi_4^0 e^{r_c 3 \Delta t}$	=	$0.90863 \times 54.45 - 41.6556 e^{0.2 \frac{3}{12}}$	=	5.6835

$$u = 1.1; d = 0.9$$

$\tilde{S}_n = S_n e^{-r_c n \Delta t}$	$\tilde{V}_n = V_0 + \sum_{k=1}^n \phi_k \Delta \tilde{S}_k$
$\phi_{n+1} = \frac{c(n+1, S_n u) - c(n+1, S_n d)}{S_n (u - d)}$	$\phi_{n+1}^0 = \tilde{V}_n - \phi_{n+1} S_n e^{-r_c n \Delta t}$

For $n = 4$:

$$\tilde{S}_4 = 59.895 \times e^{-0.2 \times \frac{4}{12}} = 56.0322$$

$$\begin{aligned} \tilde{V}_4 &= \tilde{V}_3 + \phi_4 \Delta \tilde{S}_4 = 5.40631 + 0.90863 \times (56.0322 - 51.7944) \\ &= 9.2568 \end{aligned}$$

Test:	Sell	$\phi_4 S_4 + \phi_4^0 e^{r_c 4 \Delta t}$	=	$0.90863 \times 59.895 - 41.6556 e^{0.2 \frac{4}{12}}$	=	9.895
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$$u = 1.1; d = 0.9$$

$\tilde{S}_n = S_n e^{-r_c n \Delta t}$	$\tilde{V}_n = V_0 + \sum_{k=1}^n \phi_k \Delta \tilde{S}_k$
$\phi_{n+1} = \frac{c(n+1, S_n u) - c(n+1, S_n d)}{S_n(u-d)}$	$\phi_{n+1}^0 = \tilde{V}_n - \phi_{n+1} S_n e^{-r_c n \Delta t}$

For $n = 0$:

$$\tilde{S}_0 = S_0 = 50$$

$$V_0 = e^{-r_c T} \mathbf{E}_{\mathbf{Q}}(S_N - K)_+ = c(0, 50) = 5.5939$$

$$\phi_1 = \frac{8.4036 - 1.8750}{50 \times (1.1 - 0.9)} = 0.65286$$

$$\phi_1^0 = 5.5939 - 0.65286 \times 50 = -27.0491$$

Observe that $\phi_1 S_0 + \phi_1^0 S_0^0 = 0.65286 \times 50 - 27.0491 = 5.5939 = c(0, 50)$.

$$u = 1.1; d = 0.9$$

$\tilde{S}_n = S_n e^{-r_c n \Delta t}$	$\tilde{V}_n = V_0 + \sum_{k=1}^n \phi_k \Delta \tilde{S}_k$
$\phi_{n+1} = \frac{c(n+1, S_n u) - c(n+1, S_n d)}{S_n(u-d)}$	$\phi_{n+1}^0 = \tilde{V}_n - \phi_{n+1} S_n e^{-r_c n \Delta t}$

For $n = 1$:

$$\tilde{S}_1 = 45 \times e^{-0.2 \times \frac{1}{12}} = 44.2562$$

$$\begin{aligned} \tilde{V}_1 &= V_0 + \phi_1 \Delta \tilde{S}_1 = 5.5939 + 0.65286 \times (44.2562 - 50) \\ &= 1.844 \end{aligned}$$

$$\phi_2 = \frac{3.2645 - 0}{45 \times (1.1 - 0.9)} = 0.36272$$

$$\phi_2^0 = 1.8440 - 0.36272 \times 44.2562 = -14.2086$$

Test:	Sell	$\phi_1 S_1 + \phi_1^0 e^{r_c \Delta t}$	=	$0.65286 \times 45 - 27.0491 e^{0.2 \frac{1}{12}}$	=	1.875
	Buy	$\phi_2 S_1 + \phi_2^0 e^{r_c \Delta t}$	=	$0.36272 \times 45 - 14.2086 e^{0.2 \frac{1}{12}}$	=	1.875

$$u = 1.1; d = 0.9$$

$\tilde{S}_n = S_n e^{-r_c n \Delta t}$	$\tilde{V}_n = V_0 + \sum_{k=1}^n \phi_k \Delta \tilde{S}_k$
$\phi_{n+1} = \frac{c(n+1, S_n u) - c(n+1, S_n d)}{S_n(u-d)}$	$\phi_{n+1}^0 = \tilde{V}_n - \phi_{n+1} S_n e^{-r_c n \Delta t}$

For $n = 2$:

$$\tilde{S}_2 = 40.5 \times e^{-0.2 \times \frac{2}{12}} = 39.1723$$

$$\begin{aligned} \tilde{V}_2 &= \tilde{V}_1 + \phi_2 \Delta \tilde{S}_2 = 1.844 + 0.36272 \times (39.1723 - 44.2562) \\ &= 0 \end{aligned}$$

$$\phi_3 = 0$$

$$\phi_3^0 = 0$$

Test:	Sell	$\phi_2 S_2 + \phi_2^0 e^{r_c 2 \Delta t}$	=	$0.36272 \times 40.5 - 14.2086 e^{0.2 \frac{2}{12}}$	=	0
	Buy	$\phi_3 S_2 + \phi_3^0 e^{r_c 2 \Delta t}$	=	0	=	0

$$u = 1.1; d = 0.9$$

$\tilde{S}_n = S_n e^{-r_c n \Delta t}$	$\tilde{V}_n = V_0 + \sum_{k=1}^n \phi_k \Delta \tilde{S}_k$
$\phi_{n+1} = \frac{c(n+1, S_n u) - c(n+1, S_n d)}{S_n (u - d)}$	$\phi_{n+1}^0 = \tilde{V}_n - \phi_{n+1} S_n e^{-r_c n \Delta t}$

For $n = 3$:

$$\begin{aligned}\tilde{S}_3 &= 44.55 \times e^{-0.2 \times \frac{3}{12}} = 42.3773 \\ \tilde{V}_3 &= \tilde{V}_2 + \phi_3 \Delta \tilde{S}_3 = 0 \\ \phi_4 &= 0 \\ \phi_4^0 &= 0\end{aligned}$$

Test:	Sell	0
	Buy	0

For $n = 4$:

$$\begin{aligned}\tilde{S}_4 &= 40.095 \times e^{-0.2 \times \frac{4}{12}} = 37.5092 \\ \tilde{V}_3 &= \tilde{V}_3 + \phi_4 \Delta \tilde{S}_4 = 0\end{aligned}$$

Test:	Sell	$\phi_4 S_4 + \phi_4^0 e^{r_c 4 \Delta t}$	=	0
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