In [1]:
```
from QuantLib import *
import numpy as np
import math
import scipy as scp
import scipy.stats as ss
import matplotlib.pyplot as plt
import pandas as pd
```

In [2]:
```
# Barrier Option: Up-and-Out Call
# Strike 100, Barrier 150, Rebate 50, Exercise date 4 years
#Set up the global evaluation date to today

def Option_Pricing(Option_Type, Barrier_Type, Spot_Price, Strike_Price

    #Example:
    #Option_Type = Option.Put
    #Barrier_Type = Barrier.UpOut
    #Spot_Price = 24363.0
    #Strike_Price = 24990.0
    #Barrier_Price = 24890.0
    #Volatility = 0.80
    #Risk_Free_Rate = 0.019
    #Dividend_Rate = 0.0414
    #Rebate = 100.0
    #today = Date(18,June,2020)  # or today = Date().todaysDate()
    #Maturity = Date(30, December, 2020)

    Option_Type = Option_Type
    Barrier_Type = Barrier_Type
    Spot_Price = Spot_Price
    Strike_Price = Strike_Price
    Barrier_Price = Barrier_Price
    Volatility = Volatility
    Risk_Free_Rate = Risk_Free_Rate
    Dividend_Rate = Dividend_Rate
    Rebate = Rebate
    today = today  # or today = Date().todaysDate()
    Maturity = Maturity


    Settings.instance().evaluationDate = today

    # Specify option
    option = BarrierOption(Barrier_Type, Barrier_Price, Rebate, PlainV

    #initialValue, riskFreeTS, dividendTS and volatility
    initialValue = QuoteHandle(SimpleQuote(Spot_Price))
    riskFreeTS = YieldTermStructureHandle(FlatForward(today, Risk_Free
    dividendTS = YieldTermStructureHandle(FlatForward(today, Dividend_
    volTS = BlackVolTermStructureHandle(BlackConstantVol(today, NullCa
    process = BlackScholesMertonProcess(initialValue, dividendTS, risk


    # Build the engine (based on an analytic formula) and set it to th
    option.setPricingEngine(AnalyticBarrierEngine(process))
```

```
    # Market Data Changes
    # Change the market data to get new option pricing.

    # Set initial value and define h
    h=0.00000001


    # Bump up the price by h
    P_plus = BarrierOption(Barrier_Type, Barrier_Price, Rebate, PlainV

    initialValue_plus = QuoteHandle(SimpleQuote(Spot_Price+h))
    process = BlackScholesMertonProcess(initialValue_plus, dividendTS,
    P_plus.setPricingEngine(AnalyticBarrierEngine(process))


    # Bump down the price by h
    P_minus = BarrierOption(Barrier_Type, Barrier_Price, Rebate, Plain

    initialValue_minus = QuoteHandle(SimpleQuote(Spot_Price-h))
    process = BlackScholesMertonProcess(initialValue_minus, dividendTS
    P_minus.setPricingEngine(AnalyticBarrierEngine(process))


    # Calculate Greeks: Delta, Gamma, Vega, Theta, Rho
    delta = (P_plus.NPV() - P_minus.NPV())/(2*h)




    return option.NPV(), delta
```

In [3]:

```
def Spot_Spot_slide(Option_Type, Barrier_Type, Spot_Price, Strike_Pric



    S0 = np.linspace(Spot_Price - Step_Size*Min,Spot_Price + Step_

    price = np.array([])
    for S in S0:
        price = np.append(price, Option_Pricing(Option_Type = Opti

    plt.figure(figsize=(14, 7))
    plt.plot(S0, price, label = "Black_Scholes Pricing")
    plt.title("Option Price & Spot Price")
    plt.xlabel("Spot price (S0)")
    plt.ylabel("Option_Price")
    plt.legend()


    Offset = Adj_Option_Price - Option_Pricing(Option_Type = Optic

    pd.options.display.max_rows, pd.options.display.max_columns =
```

```
        data = {'Spot_Price': S0, 'Option_Price': np.around(price/1000
        df = pd.DataFrame(data=data)

        plt.figure(figsize=(14, 7))
        plt.plot(S0, price + Offset, label = "Black_Scholes Pricing")
        plt.title("Adjusted Option Price & Spot Price")
        plt.xlabel("Spot price (S0)")
        plt.ylabel("Adj_Option_Price")
        plt.legend()




        return df
```

In [4]:

```
def Spot_Option_Slide(Option_Type, Barrier_Type, Spot_Price, Strike_Pr


        S0 = np.linspace(Spot_Price - 10/delta * Min,Spot_Price +  10/

        price = np.array([])
        for S in S0:
            price = np.append(price, Option_Pricing(Option_Type = Opti

        plt.figure(figsize=(14, 7))
        plt.plot(S0, price, label = "Black_Scholes Pricing")
        plt.title("Option Price & Spot Price")
        plt.xlabel("Spot price (S0)")
        plt.ylabel("Option_Price")
        plt.legend()


        Offset = Adj_Option_Price - Option_Pricing(Option_Type = Optic

        pd.options.display.max_rows, pd.options.display.max_columns =
        data = {'Spot_Price': S0, 'Option_Price': price/10000, 'Offset
        df = pd.DataFrame(data=data)

        plt.figure(figsize=(14, 7))
        plt.plot(S0, price + Offset, label = "Black_Scholes Pricing")
        plt.title("Adjusted Option Price & Spot Price")
        plt.xlabel("Spot price (S0)")
        plt.ylabel("Adj_Option_Price")
        plt.legend()




        return df
```

In [177…

```
def Spot_Adj_Option_Slide(Option_Type, Barrier_Type, Spot_Price, Strik


        Offset = Adj_Option_Price - Option_Pricing(Option_Type = Optic
```

```
        Adj_Dividend_Rate = Dividend_Search(Adj_Option_Price, Option_T


        # Adj_Spot_Price = Spot_Price + 1/delta * Offset


        adj_delta = Option_Pricing(Option_Type = Option_Type, Barrier_

        S0 = np.linspace(Spot_Price - Precision/adj_delta * Min, Spot_


        Adj_price = np.array([])
        for S in S0:
            Adj_price = np.append(Adj_price, Option_Pricing(Option_Typ

        price = np.array([])
        for S in S0:
            price = np.append(price, Option_Pricing(Option_Type = Opti


        pd.options.display.max_rows, pd.options.display.max_columns =
        data = {'Spot_Price': np.around(S0,0),  'Adj_Option_Price': np
        df = pd.DataFrame(data=data)


        return df
```

In [173…

```
def Spot_Adj_Option_Slide_Auto(Option_Type, Barrier_Type, Spot_Price,


        Offset = Adj_Option_Price - Option_Pricing(Option_Type = Optic



        Adj_Dividend_Rate = Dividend_Search(Adj_Option_Price, Option_T


        # Adj_Spot_Price = Spot_Price + 1/delta * Offset


        adj_delta = Option_Pricing(Option_Type = Option_Type, Barrier_

        S0 = np.linspace(Spot_Price - 1/adj_delta * Min, Spot_Price +


        Adj_price = np.array([])
        for S in S0:
            Adj_price = np.append(Adj_price, Option_Pricing(Option_Typ

        price = np.array([])
        for S in S0:
            price = np.append(price, Option_Pricing(Option_Type = Opti


        pd.options.display.max_rows, pd.options.display.max_columns =
        data = {'Spot_Price': np.around(S0,0),  'Adj_Option_Price': np
        df = pd.DataFrame(data=data)
```

```
count = 0
differ = 0

while differ == 0:
    count += 1
    differ = df.loc[df.index[Min-count],'Adj_Option_Price'] -


True_Option_Price = df.loc[df.index[Min-count],'Adj_Option_Pri
True_Spot_Price = df.loc[df.index[Min-count],'Spot_Price']


Offset = True_Option_Price - Option_Pricing(Option_Type = Opti


print(True_Option_Price, True_Spot_Price)


Adj_Dividend_Rate = Dividend_Search(True_Option_Price*10000, C


# Adj_Spot_Price = Spot_Price + 1/delta * Offset


adj_delta = Option_Pricing(Option_Type = Option_Type, Barrier_

S0 = np.linspace(True_Spot_Price - 10/adj_delta * Min, True_Sp


Adj_price = np.array([])
for S in S0:
    Adj_price = np.append(Adj_price, Option_Pricing(Option_Typ

price = np.array([])
for S in S0:
    price = np.append(price, Option_Pricing(Option_Type = Opti



data = {'Spot_Price': np.around(S0,S0_Round), 'Adj_Option_Pric
df = pd.DataFrame(data=data)


plt.figure(figsize=(14, 7))
plt.plot(S0, price, label = "Black_Scholes Pricing")
plt.title("Option Price & Spot Price")
plt.xlabel("Spot price (S0)")
plt.ylabel("Option_Price")
plt.legend()


plt.figure(figsize=(14, 7))
plt.plot(S0, Adj_price, label = "Black_Scholes Pricing")
plt.title("Adjusted Option Price & Spot Price")
plt.xlabel("Spot price (S0)")
plt.ylabel("Adj_Option_Price")
plt.legend()
```

```
        return df
```

In [151…

```
def Dividend_Search(option_price, Option_Type, Barrier_Type, Spot_Pric
    # apply bisection method to get the implied volatility by solving
    precision = 0.00001
    upper_spot = 1.0
    lower_spot = 0.0
    iteration = 0


    while 1:
        iteration +=1
        mid_spot = (upper_spot + lower_spot)/2.0
        price = Option_Pricing(Option_Type = Option_Type, Barrier_Type

        if Option_Type == Option.Put:
            lower_price = Option_Pricing(Option_Type = Option_Type, Ba
            if (lower_price - option_price) * (price - option_price) >
                lower_spot = mid_spot
            else:
                upper_spot = mid_spot
            if abs(price - option_price) < precision: break
            if iteration > 10000: raise ValueError("Computational erro

        elif Option_Type == Option.Call:
            upper_price = Option_Pricing(Option_Type = Option_Type, Ba
            if (upper_price - option_price) * (price - option_price) >
                upper_spot = mid_spot
            else:
                lower_spot = mid_spot
            if abs(price - option_price) < precision: break
            if iteration > 10000: raise ValueError("Computational erro

        else:
            raise NameError('delta = 0 !!!!')

    return mid_spot
```

In [152…

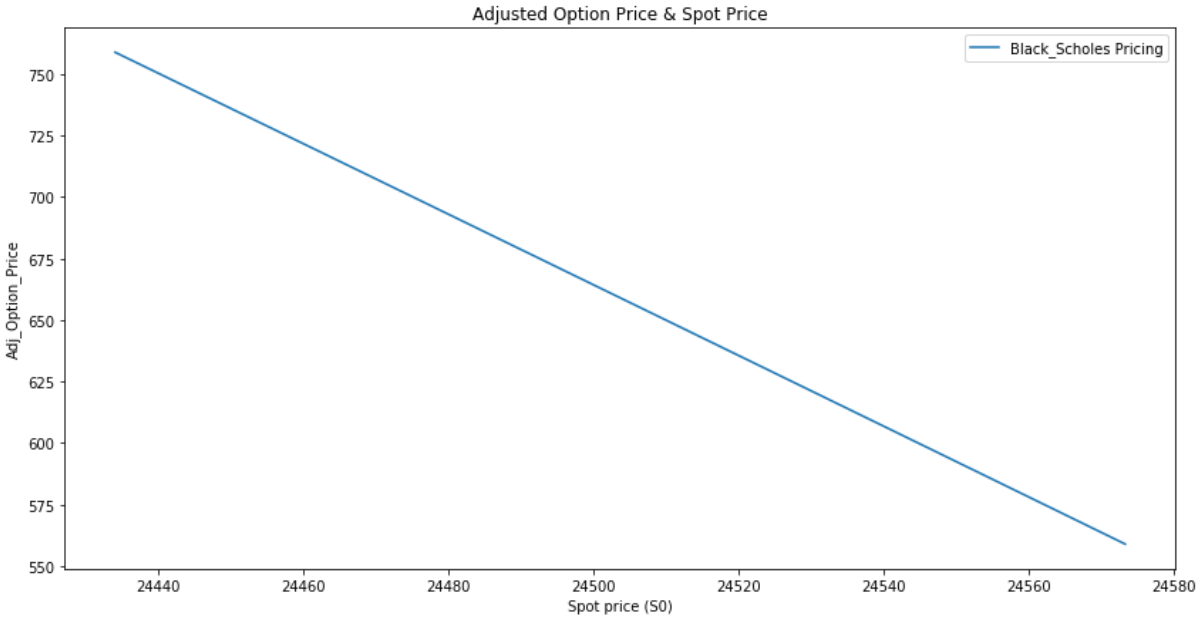
```
Spot_Adj_Option_Slide_Auto(Option_Type = Option.Put, Barrier_Type = Ba
```

```
0.0659 24503.696952096714
```

Out[152…

| | Spot_Price | Adj_Option_Price | Option_Price | Offset |
|---|---|---|---|---|
| **0** | 24573.0 | 0.056 | 0.051 | 0.004489 |
| **1** | 24566.0 | 0.057 | 0.052 | 0.004585 |
| **2** | 24559.0 | 0.058 | 0.053 | 0.004681 |
| **3** | 24552.0 | 0.059 | 0.054 | 0.004778 |
| **4** | 24546.0 | 0.060 | 0.055 | 0.004874 |
| **5** | 24539.0 | 0.061 | 0.056 | 0.004969 |
| **6** | 24532.0 | 0.062 | 0.057 | 0.005065 |

| | Spot_Price | Adj_Option_Price | Option_Price | Offset |
|---|---|---|---|---|
| **7** | 24525.0 | 0.063 | 0.058 | 0.005161 |
| **8** | 24518.0 | 0.064 | 0.059 | 0.005256 |
| **9** | 24511.0 | 0.065 | 0.060 | 0.005352 |
| **10** | 24504.0 | 0.066 | 0.060 | 0.005447 |
| **11** | 24497.0 | 0.067 | 0.061 | 0.005542 |
| **12** | 24490.0 | 0.068 | 0.062 | 0.005638 |
| **13** | 24483.0 | 0.069 | 0.063 | 0.005733 |
| **14** | 24476.0 | 0.070 | 0.064 | 0.005828 |
| **15** | 24469.0 | 0.071 | 0.065 | 0.005922 |
| **16** | 24462.0 | 0.072 | 0.066 | 0.006017 |
| **17** | 24455.0 | 0.073 | 0.067 | 0.006112 |
| **18** | 24448.0 | 0.074 | 0.068 | 0.006206 |
| **19** | 24441.0 | 0.075 | 0.069 | 0.006301 |
| **20** | 24434.0 | 0.076 | 0.069 | 0.006395 |




In [153…
```
Option_Pricing(Option_Type = Option.Put, Barrier_Type = Barrier.UpOut,
```

Out[153… -1.01542809716193

In [ ]:

In [ ]:

In [ ]:

In [ ]:

In [154…
```
Dividend_Search(option_price = 800, Option_Type = Option.Put, Barrier_
```

Out[154… 0.3172212541103363

In [155…
```
d = Option_Pricing(Option_Type = Option.Put, Barrier_Type = Barrier.Up
d
```

Out[155… -1.2914654234918999

In [156…
```
Option_Pricing(Option_Type = Option.Put, Barrier_Type = Barrier.UpOut,
```

Out[156… 773.0259945254356

In [157…
```
Option_Pricing(Option_Type = Option.Put, Barrier_Type = Barrier.UpOut,
```

Out[157… 799.9999971819666

In [ ]:

In [ ]:

In [ ]:

In [ ]:

In [ ]:

In [158…
```
Dividend_Search(option_price = 600, Option_Type = Option.Put, Barrier_
```

Out[158…
```
0.43114587664604187
```

In [159…
```
Option_Pricing(Option_Type = Option.Put, Barrier_Type = Barrier.UpOut,
```

Out[159…
```
599.9999971471614
```

In [160…
```
d = Option_Pricing(Option_Type = Option.Put, Barrier_Type = Barrier.Up
d
```

Out[160…
```
-1.5167643141467124
```

In [ ]:

In [ ]:

In [ ]:

In [161…
```
Option_Pricing(Option_Type = Option.Put, Barrier_Type = Barrier.UpOut,
```

Out[161…
```
815.1116565656555
```

In [162…
```
d = Dividend_Search(option_price = 850, Option_Type = Option.Put, Barr
d
```

Out[162…
```
0.3252650499343872
```

In [163…
```
Option_Pricing(Option_Type = Option.Put, Barrier_Type = Barrier.UpOut,
```

Out[163… 849.9999952086728

In [164…
```
Option_Pricing(Option_Type = Option.Put, Barrier_Type = Barrier.UpOut,
```

Out[164… -1.349718559140456

In [ ]:

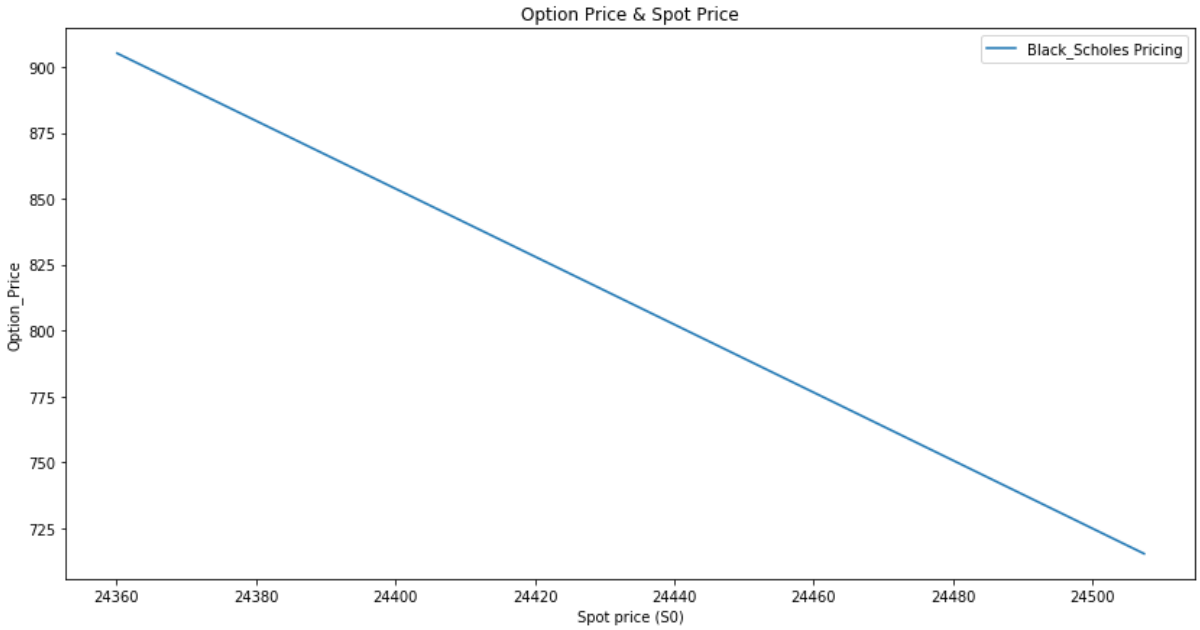
In [ ]:

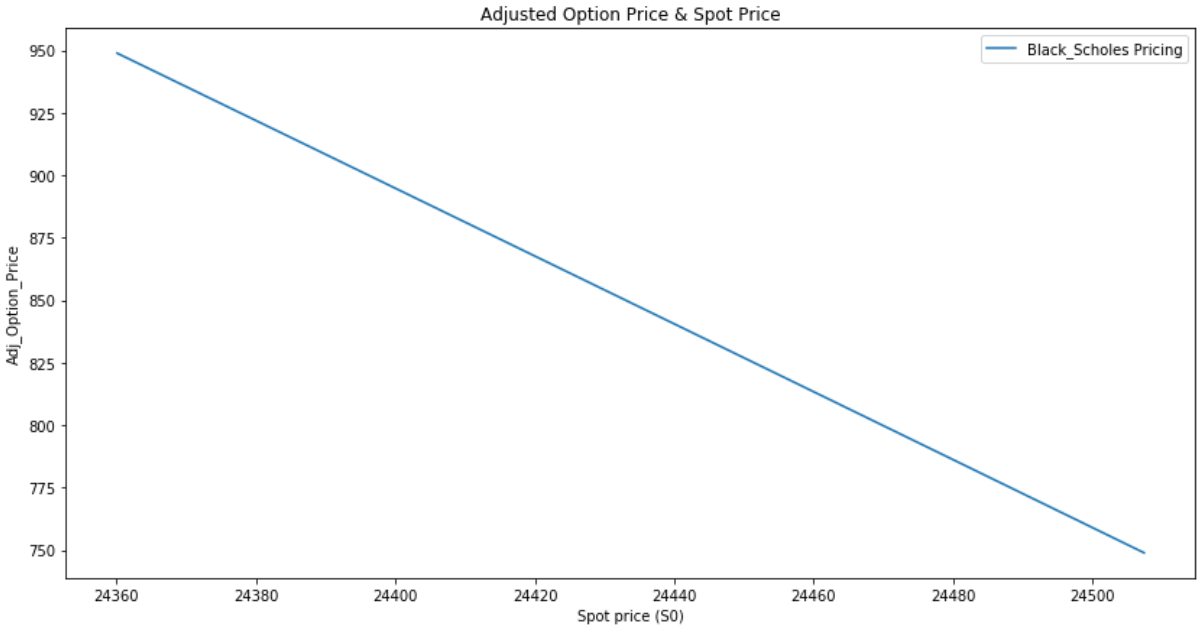
In [165…
```
Spot_Adj_Option_Slide_Auto(Option_Type = Option.Put, Barrier_Type = Ba
```

```
0.0849 24433.736941175375
```

Out[165…

| | Spot_Price | Adj_Option_Price | Option_Price | Offset |
|---|---|---|---|---|
| **0** | 24507.0 | 0.075 | 0.072 | 0.003367 |
| **1** | 24500.0 | 0.076 | 0.072 | 0.003418 |
| **2** | 24493.0 | 0.077 | 0.073 | 0.003469 |
| **3** | 24485.0 | 0.078 | 0.074 | 0.003519 |
| **4** | 24478.0 | 0.079 | 0.075 | 0.003569 |
| **5** | 24471.0 | 0.080 | 0.076 | 0.003620 |
| **6** | 24463.0 | 0.081 | 0.077 | 0.003670 |
| **7** | 24456.0 | 0.082 | 0.078 | 0.003720 |
| **8** | 24448.0 | 0.083 | 0.079 | 0.003770 |
| **9** | 24441.0 | 0.084 | 0.080 | 0.003821 |
| **10** | 24434.0 | 0.085 | 0.081 | 0.003871 |
| **11** | 24426.0 | 0.086 | 0.082 | 0.003921 |
| **12** | 24419.0 | 0.087 | 0.083 | 0.003970 |
| **13** | 24412.0 | 0.088 | 0.084 | 0.004020 |
| **14** | 24404.0 | 0.089 | 0.085 | 0.004070 |
| **15** | 24397.0 | 0.090 | 0.086 | 0.004120 |
| **16** | 24390.0 | 0.091 | 0.087 | 0.004170 |
| **17** | 24382.0 | 0.092 | 0.088 | 0.004219 |
| **18** | 24375.0 | 0.093 | 0.089 | 0.004269 |
| **19** | 24367.0 | 0.094 | 0.090 | 0.004318 |
| **20** | 24360.0 | 0.095 | 0.091 | 0.004368 |




In [166…
```
Option_Pricing(Option_Type = Option.Put, Barrier_Type = Barrier.UpOut,
```

Out[166…
```
(845.9503610084604, -1.3498151929525193)
```

In [167…
```
Option_Pricing(Option_Type = Option.Put, Barrier_Type = Barrier.UpOut,
```

Out[167…
```
(771.6272419975169, -1.3527028386306483)
```

In [ ]:

In [ ]:

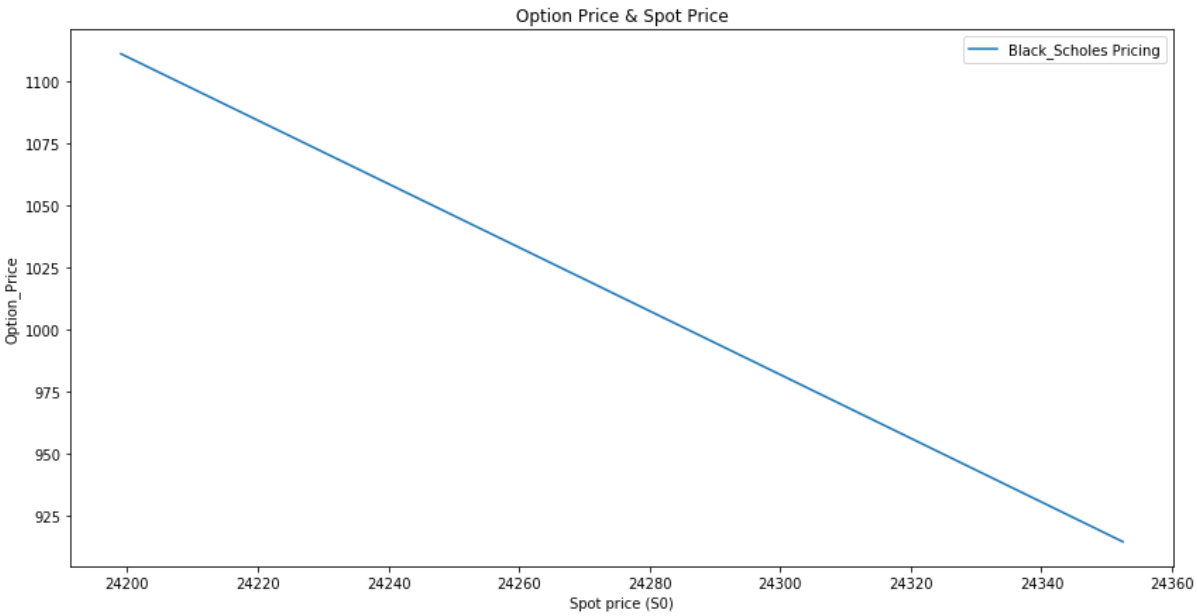
In [ ]:

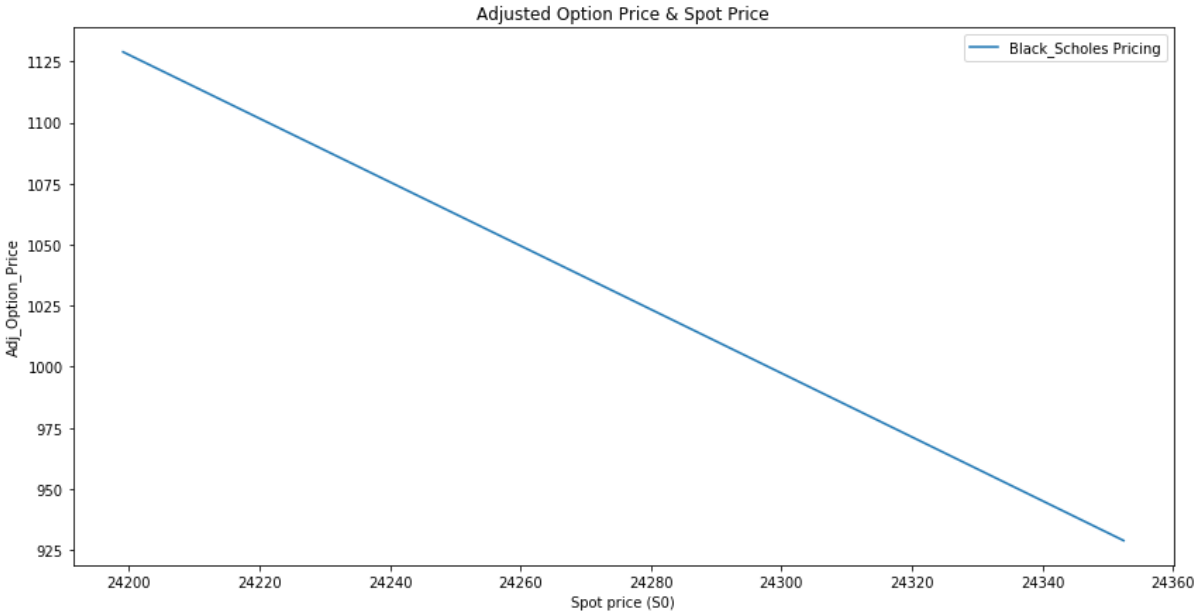
In [168…
```
Spot_Adj_Option_Slide_Auto(Option_Type = Option.Put, Barrier_Type = Ba
```

```
0.1029 24275.76672445998
```

Out[168…

| | Spot_Price | Adj_Option_Price | Option_Price | Offset |
|---|---|---|---|---|
| **0** | 24352.0 | 0.093 | 0.091 | 0.001435 |
| **1** | 24345.0 | 0.094 | 0.092 | 0.001451 |
| **2** | 24337.0 | 0.095 | 0.093 | 0.001468 |
| **3** | 24329.0 | 0.096 | 0.094 | 0.001485 |
| **4** | 24322.0 | 0.097 | 0.095 | 0.001501 |
| **5** | 24314.0 | 0.098 | 0.096 | 0.001518 |
| **6** | 24306.0 | 0.099 | 0.097 | 0.001534 |
| **7** | 24299.0 | 0.100 | 0.098 | 0.001551 |
| **8** | 24291.0 | 0.101 | 0.099 | 0.001568 |
| **9** | 24283.0 | 0.102 | 0.100 | 0.001584 |
| **10** | 24276.0 | 0.103 | 0.101 | 0.001601 |
| **11** | 24268.0 | 0.104 | 0.102 | 0.001617 |
| **12** | 24260.0 | 0.105 | 0.103 | 0.001634 |
| **13** | 24253.0 | 0.106 | 0.104 | 0.001650 |
| **14** | 24245.0 | 0.107 | 0.105 | 0.001666 |
| **15** | 24237.0 | 0.108 | 0.106 | 0.001683 |
| **16** | 24230.0 | 0.109 | 0.107 | 0.001699 |
| **17** | 24222.0 | 0.110 | 0.108 | 0.001716 |
| **18** | 24214.0 | 0.111 | 0.109 | 0.001732 |
| **19** | 24207.0 | 0.112 | 0.110 | 0.001748 |
| **20** | 24199.0 | 0.113 | 0.111 | 0.001765 |






In [169…
```
np.around(0.1155,3)
```

Out[169… 0.116

In [ ]:

In [ ]:

In [ ]:

In [ ]:

In [ ]:

In [ ]:

In [ ]:

In [ ]:

In [ ]:

In [ ]:

In [ ]:

# Put

In [179…
```
Spot_Adj_Option_Slide(Option_Type = Option.Put, Barrier_Type = Barrier
```

Out[179…

| | Spot_Price | Adj_Option_Price | Option_Price | Offset |
|---|---|---|---|---|
| **0** | 24944.0 | 0.086 | 0.0922 | -0.006205 |
| **1** | 24936.0 | 0.087 | 0.0933 | -0.006285 |
| **2** | 24929.0 | 0.088 | 0.0944 | -0.006365 |
| **3** | 24922.0 | 0.089 | 0.0954 | -0.006445 |
| **4** | 24914.0 | 0.090 | 0.0965 | -0.006525 |
| **5** | 24907.0 | 0.091 | 0.0976 | -0.006605 |
| **6** | 24900.0 | 0.092 | 0.0987 | -0.006685 |
| **7** | 24892.0 | 0.093 | 0.0998 | -0.006764 |
| **8** | 24885.0 | 0.094 | 0.1008 | -0.006844 |
| **9** | 24877.0 | 0.095 | 0.1019 | -0.006923 |
| **10** | 24870.0 | 0.096 | 0.1030 | -0.007003 |
| **11** | 24863.0 | 0.097 | 0.1041 | -0.007082 |
| **12** | 24855.0 | 0.098 | 0.1052 | -0.007162 |
| **13** | 24848.0 | 0.099 | 0.1062 | -0.007241 |
| **14** | 24840.0 | 0.100 | 0.1073 | -0.007320 |
| **15** | 24833.0 | 0.101 | 0.1084 | -0.007399 |
| **16** | 24826.0 | 0.102 | 0.1095 | -0.007479 |
| **17** | 24818.0 | 0.103 | 0.1106 | -0.007558 |
| **18** | 24811.0 | 0.104 | 0.1116 | -0.007637 |
| **19** | 24804.0 | 0.105 | 0.1127 | -0.007716 |
| **20** | 24796.0 | 0.106 | 0.1138 | -0.007794 |

In [ ]:

In [ ]:

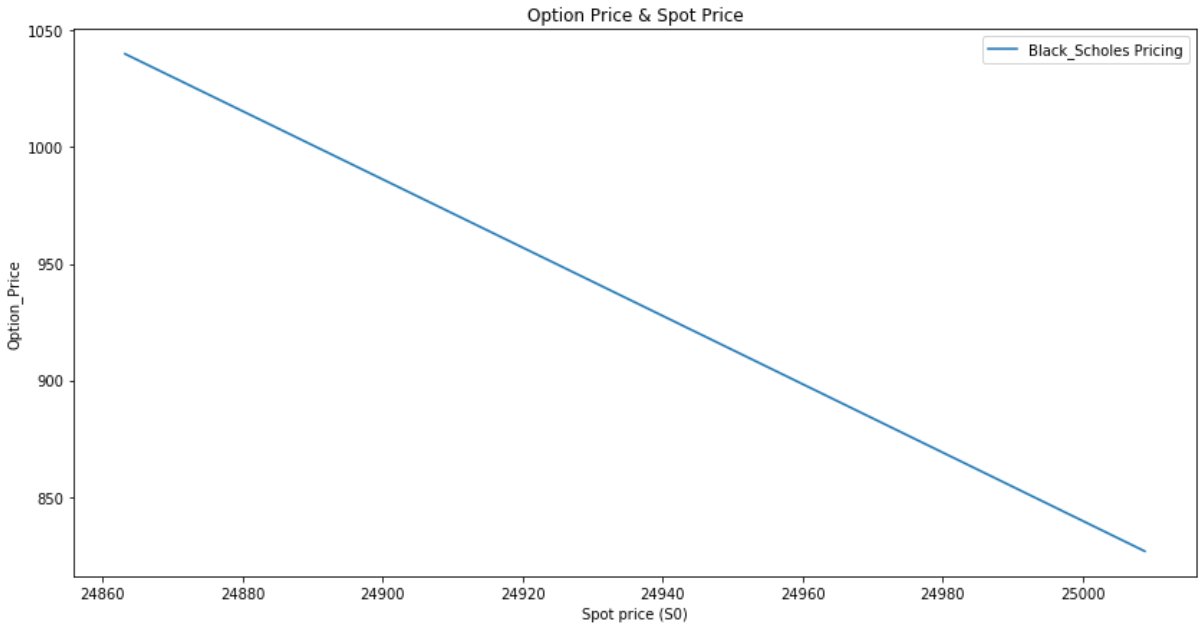
In [ ]:

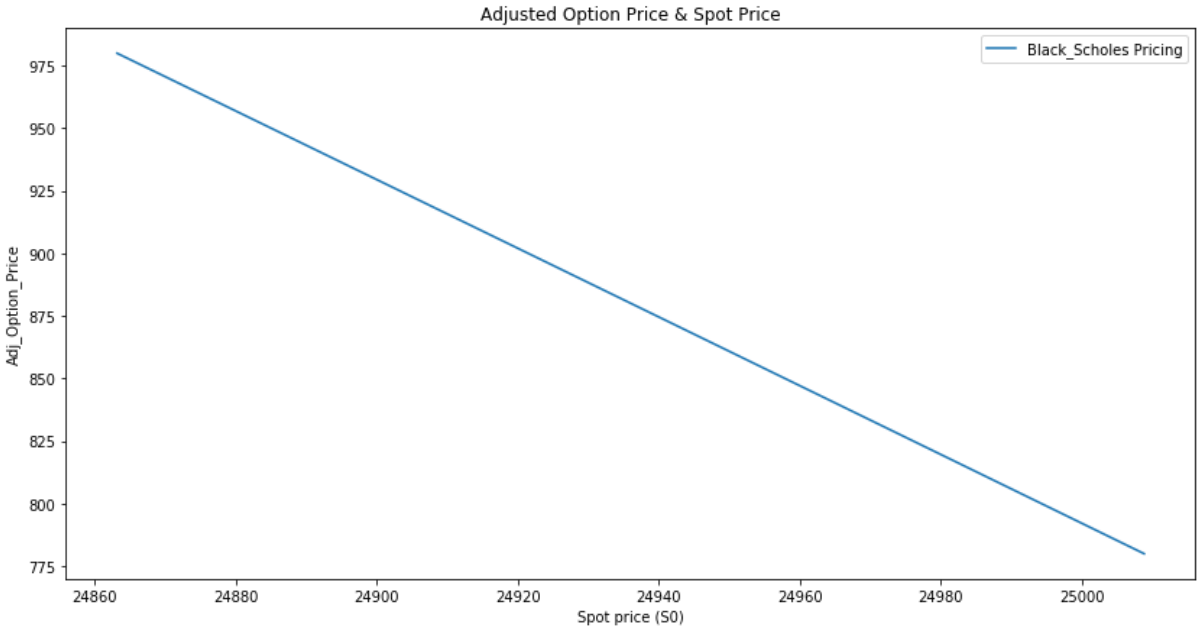
In [176…
```
Spot_Adj_Option_Slide_Auto(Option_Type = Option.Put, Barrier_Type = Ba
```

```
0.088 24936.0
```

Out[176…

| | Spot_Price | Adj_Option_Price | Option_Price | Offset |
|---|---|---|---|---|
| **0** | 25009.0 | 0.078 | 0.083 | -0.004672 |
| **1** | 25002.0 | 0.079 | 0.084 | -0.004739 |
| **2** | 24994.0 | 0.080 | 0.085 | -0.004807 |
| **3** | 24987.0 | 0.081 | 0.086 | -0.004874 |
| **4** | 24980.0 | 0.082 | 0.087 | -0.004942 |
| **5** | 24972.0 | 0.083 | 0.088 | -0.005009 |
| **6** | 24965.0 | 0.084 | 0.089 | -0.005076 |
| **7** | 24958.0 | 0.085 | 0.090 | -0.005143 |
| **8** | 24951.0 | 0.086 | 0.091 | -0.005211 |
| **9** | 24943.0 | 0.087 | 0.092 | -0.005278 |
| **10** | 24936.0 | 0.088 | 0.093 | -0.005345 |
| **11** | 24929.0 | 0.089 | 0.094 | -0.005412 |
| **12** | 24921.0 | 0.090 | 0.095 | -0.005479 |
| **13** | 24914.0 | 0.091 | 0.097 | -0.005546 |
| **14** | 24907.0 | 0.092 | 0.098 | -0.005613 |
| **15** | 24900.0 | 0.093 | 0.099 | -0.005679 |
| **16** | 24892.0 | 0.094 | 0.100 | -0.005746 |
| **17** | 24885.0 | 0.095 | 0.101 | -0.005813 |
| **18** | 24878.0 | 0.096 | 0.102 | -0.005880 |
| **19** | 24870.0 | 0.097 | 0.103 | -0.005946 |
| **20** | 24863.0 | 0.098 | 0.104 | -0.006013 |






In [ ]:

# Call

In [172…

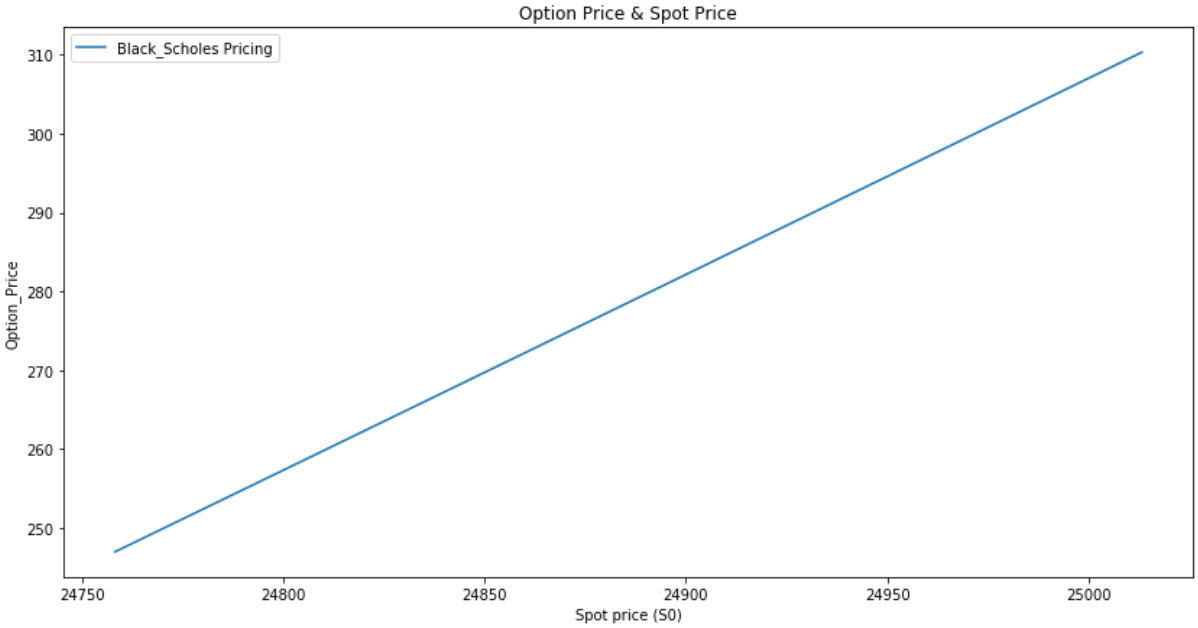
```
Spot_Adj_Option_Slide_Auto(Option_Type = Option.Call, Barrier_Type = B
```

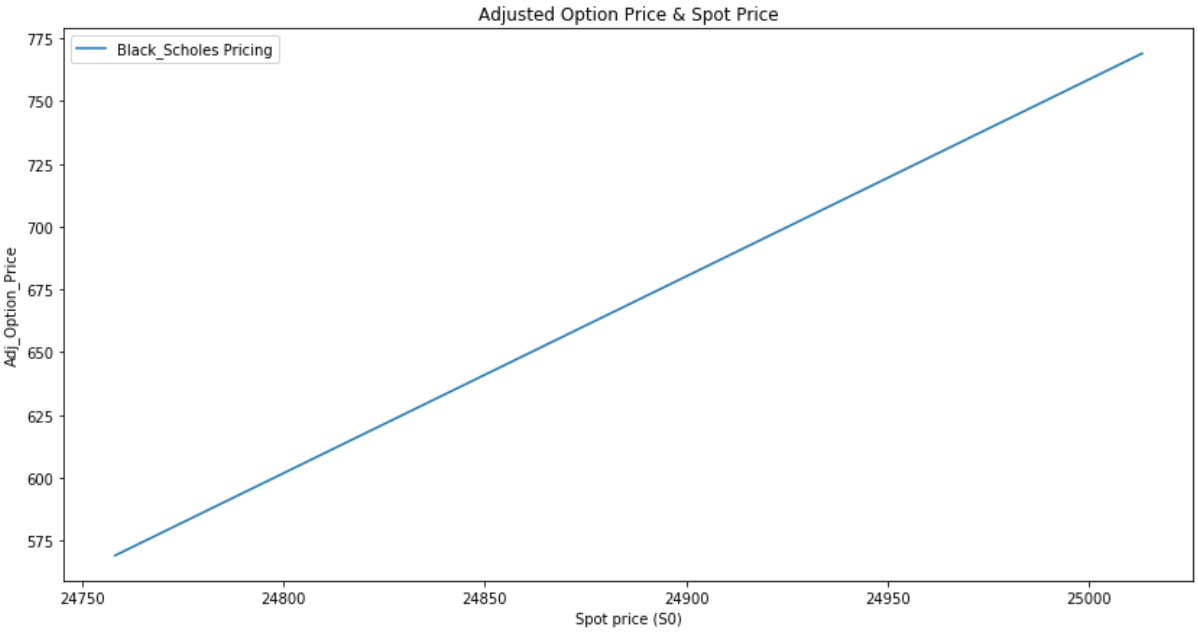
```
0.0669 24885.724769592223
```

Out[172…

| | Spot_Price | Adj_Option_Price | Option_Price | Offset |
|---|---|---|---|---|
| **0** | 24758.0 | 0.057 | 0.025 | 0.032208 |
| **1** | 24771.0 | 0.058 | 0.025 | 0.032892 |
| **2** | 24784.0 | 0.059 | 0.025 | 0.033576 |
| **3** | 24796.0 | 0.060 | 0.026 | 0.034259 |
| **4** | 24809.0 | 0.061 | 0.026 | 0.034943 |
| **5** | 24822.0 | 0.062 | 0.026 | 0.035626 |
| **6** | 24835.0 | 0.063 | 0.027 | 0.036310 |
| **7** | 24847.0 | 0.064 | 0.027 | 0.036993 |
| **8** | 24860.0 | 0.065 | 0.027 | 0.037676 |
| **9** | 24873.0 | 0.066 | 0.028 | 0.038360 |
| **10** | 24886.0 | 0.067 | 0.028 | 0.039043 |
| **11** | 24898.0 | 0.068 | 0.028 | 0.039726 |
| **12** | 24911.0 | 0.069 | 0.028 | 0.040409 |
| **13** | 24924.0 | 0.070 | 0.029 | 0.041092 |
| **14** | 24937.0 | 0.071 | 0.029 | 0.041774 |
| **15** | 24949.0 | 0.072 | 0.029 | 0.042457 |

| | Spot_Price | Adj_Option_Price | Option_Price | Offset |
|---|---|---|---|---|
| **16** | 24962.0 | 0.073 | 0.030 | 0.043140 |
| **17** | 24975.0 | 0.074 | 0.030 | 0.043822 |
| **18** | 24988.0 | 0.075 | 0.030 | 0.044505 |
| **19** | 25001.0 | 0.076 | 0.031 | 0.045187 |
| **20** | 25013.0 | 0.077 | 0.031 | 0.045870 |




In [ ]:

In [ ]:

In [ ]:

In [ ]: