Option Model Handbook, Part III: European Option Pricing With QuantLib Python

May 08, 2015 by Gouthaman Balaraman (http://gouthamanbalaraman.com/author/gouthaman-balaraman.html)

Demonstrates how to price European options using QuantLib Python. Methods using Black-Scholes-Merton formula and binomial tree will be discussed.

Visit here for other QuantLib Python examples (http://gouthamanbalaraman.com/blog/quantlib-python-tutorials-with-examples.html). If you found these posts useful, please take a minute by providing some feedback. (https://docs.google.com/forms/d/e/1FAIpQLSdFdJ768HKmIyJmaVRHBUJNY5NyQl6vr0GZvSkx-bUfIloNZA/viewform)

I have written about option pricing earlier. The introduction to option pricing (http://gouthamanbalaraman.com/blog/option-model-handbook-part-I-introduction-to-option-models.html) gave an overview of the theory behind option pricing. The post on introduction to binomial trees (http://gouthamanbalaraman.com/blog/option-model-handbook-part-II-introduction-to-binomial-trees.html) outlined the binomial tree method to price options.

In this post, we will use QuantLib and the Python extension to illustrate a very simple example. Here we are going to price a European option using the Black-Scholes-Merton formula. We will price them again using the Binomial tree and understand the agreement between the two.

```
import QuantLib as ql # version 1.5
import matplotlib.pyplot as plt
%matplotlib inline
```

Let us consider a European call option for AAPL with a strike price of \$130 maturing on 15th Jan, 2016. Let the spot price be \$127.62. The volatility of the underlying stock is know to be 20%, and has a dividend yield of 1.63%. Lets value this option as of 8th May, 2015.

```
# option data
maturity_date = ql.Date(15, 1, 2016)
spot_price = 127.62
strike_price = 130
volatility = 0.20 # the historical vols for a year
dividend_rate =  0.0163
option_type = ql.Option.Call

risk_free_rate = 0.001
day_count = ql.Actual365Fixed()
calendar = ql.UnitedStates()

calculation_date = ql.Date(8, 5, 2015)
ql.Settings.instance().evaluationDate = calculation_date
```

We construct the European option here.

```
# construct the European Option
payoff = ql.PlainVanillaPayoff(option_type, strike_price)
exercise = ql.EuropeanExercise(maturity_date)
european_option = ql.VanillaOption(payoff, exercise)
```

The Black-Scholes-Merto process is constructed here.

```
spot_handle = ql.QuoteHandle(
    ql.SimpleQuote(spot_price)
)
flat_ts = ql.YieldTermStructureHandle(
    ql.FlatForward(calculation_date, risk_free_rate, day_count)
)
dividend_yield = ql.YieldTermStructureHandle(
    ql.FlatForward(calculation_date, dividend_rate, day_count)
)
flat_vol_ts = ql.BlackVolTermStructureHandle(
    ql.BlackConstantVol(calculation_date, calendar, volatility, day_count)
)
bsm_process = ql.BlackScholesMertonProcess(spot_handle,
                                           dividend_yield,
                                           flat_ts,
                                           flat_vol_ts)
```

Lets compute the theoretical price using the `AnalyticEuropeanEngine`.

```
european_option.setPricingEngine(ql.AnalyticEuropeanEngine(bsm_process))
bs_price = european_option.NPV()
print "The theoretical price is ", bs_price
```

```
The theoretical price is  6.74927181246
```

Lets compute the price using the binomial-tree approach.

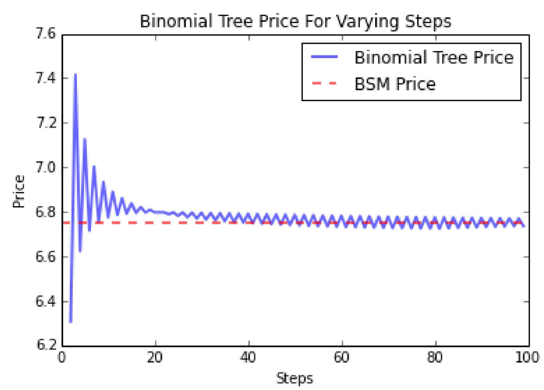
```
def binomial_price(bsm_process, steps):
    binomial_engine = ql.BinomialVanillaEngine(bsm_process, "crr", steps)
    european_option.setPricingEngine(binomial_engine)
    return european_option.NPV()

steps = range(2, 100, 1)
prices = [binomial_price(bsm_process, step) for step in steps]
```

In the plot below, we show the convergence of binomial-tree approach by comparing its price with the BSM price.

```
plt.plot(steps, prices, label="Binomial Tree Price", lw=2, alpha=0.6)
plt.plot([0,100],[bs_price, bs_price], "r--", label="BSM Price", lw=2, alpha=0.6)
plt.xlabel("Steps")
plt.ylabel("Price")
plt.title("Binomial Tree Price For Varying Steps")
plt.legend()
```

```
<matplotlib.legend.Legend at 0x7f0b85fa7510>
```



Conclusion

This post shows how to price European Options using the theoretical and binomial-tree methods in QuantLib Python. You can download the ipython notebook on European option pricing with QuantLib (/extra/notebooks/european-option-models.ipynb).

quantlib (http://gouthamanbalaraman.com/tag/quantlib.html) python (http://gouthamanbalaraman.com/tag/python.html) finance (http://gouthamanbalaraman.com/tag/finance.html) option models (http://gouthamanbalaraman.com/tag/option-models.html)

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I am Goutham Balaraman, and I explore topics in quantitative finance, programming, and data science. You can follow me @gsbalaraman (https://twitter.com/gsbalaraman).

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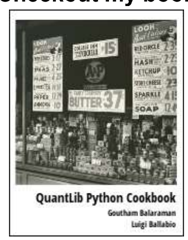

(https://leanpub.com/quantlibpythoncookbook)

Updated posts from this blog and transcripts of Luigi's screencasts on YouTube is compiled into QuantLib Python Cookbook (https://leanpub.com/quantlibpythoncookbook).

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