MFE 405 HW 4
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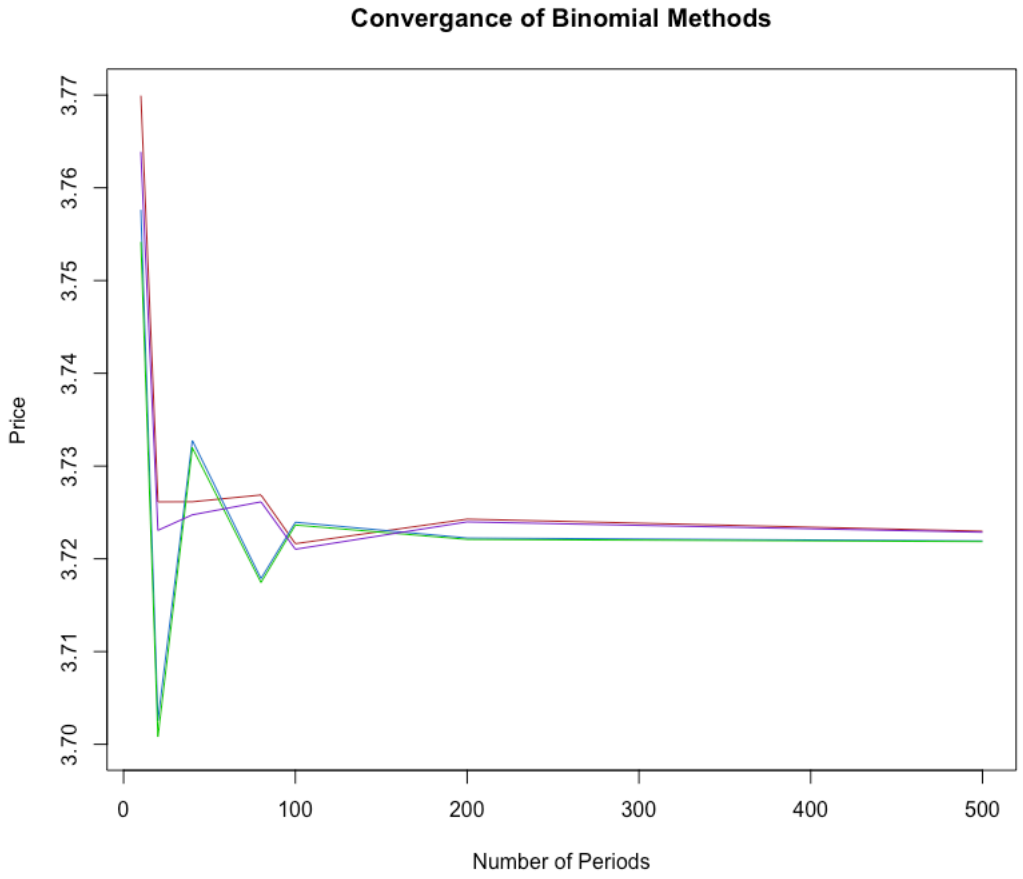
1. Convergence of Different Binomial Methods

The convergence of each of the 4 different binomial methods are showcased in the plot below:



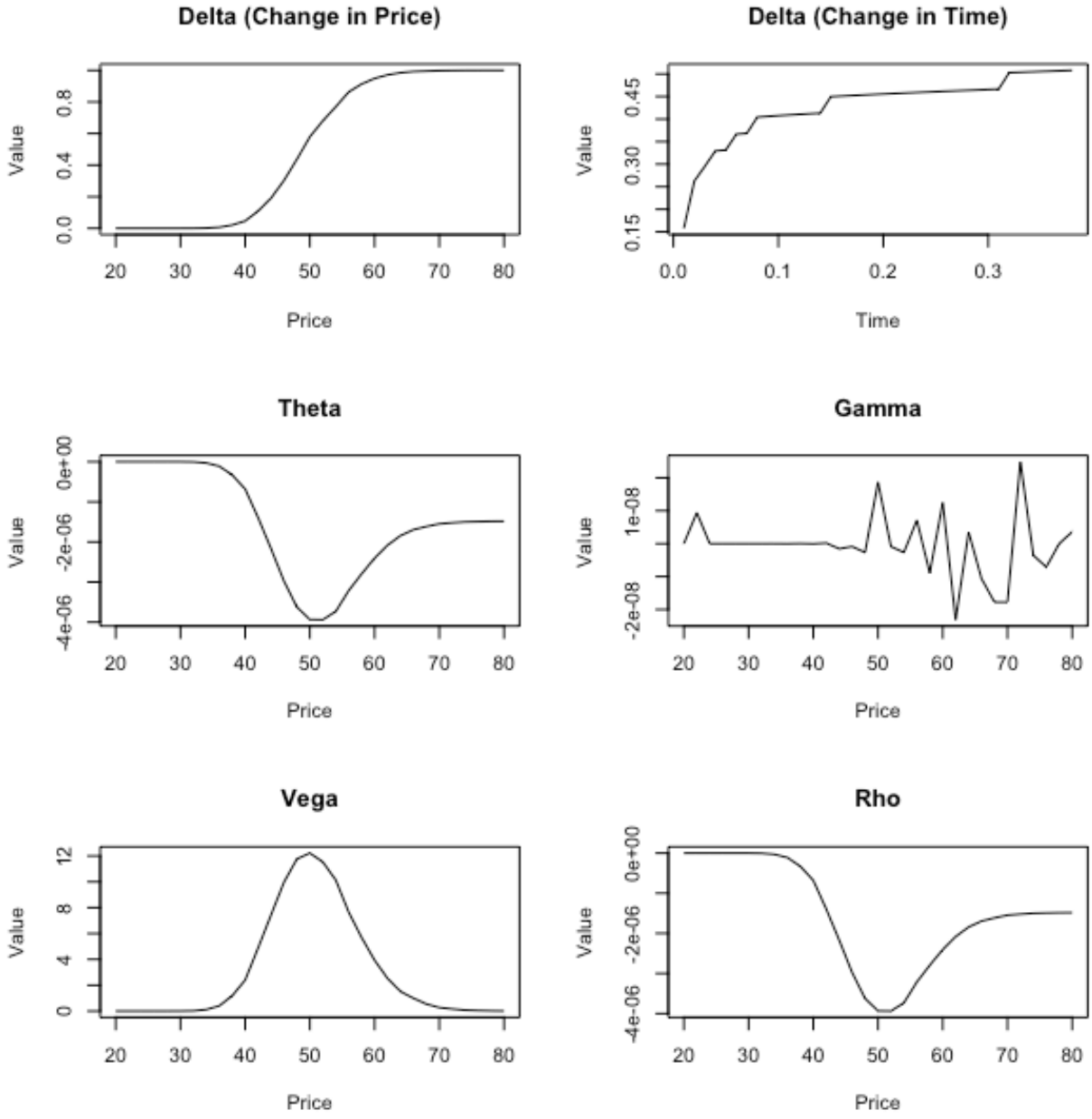
In this plot, the red line is method (a), the blue line is method (b), the green line is the Jarrow-Rudd (JW) model, and the purple line is the Cox-Ross-Rubinstein (CRR) model. We can clearly see that both the JW and the CRR models converge very quickly, but all 4 methods converge well and quite quickly to the "true" value.

2. Binomial Pricing of GOOG Call Option

The closing price for GOOG on Feb.6, 2019 is $1,115.23. Using the historical prices of GOOG from the past 60 months and find the volatility of returns, we find the volatility to be around 23.47%. Using this price, this volatility, and assuming an annual risk-free rate of 2%, we calculate the price of a call option on GOOG with a strike price of $1,220 to be **$67.39**. This value is actually very close to the actual last price of the corresponding option on the market, which was noted as **$68.50**. The small difference in value could be due to not using a more precise risk-free rate or estimating a slightly different volatility than the market. To have the same call price, the volatility should instead be around **23.75%**.

3. Binomial Estimation of Greeks

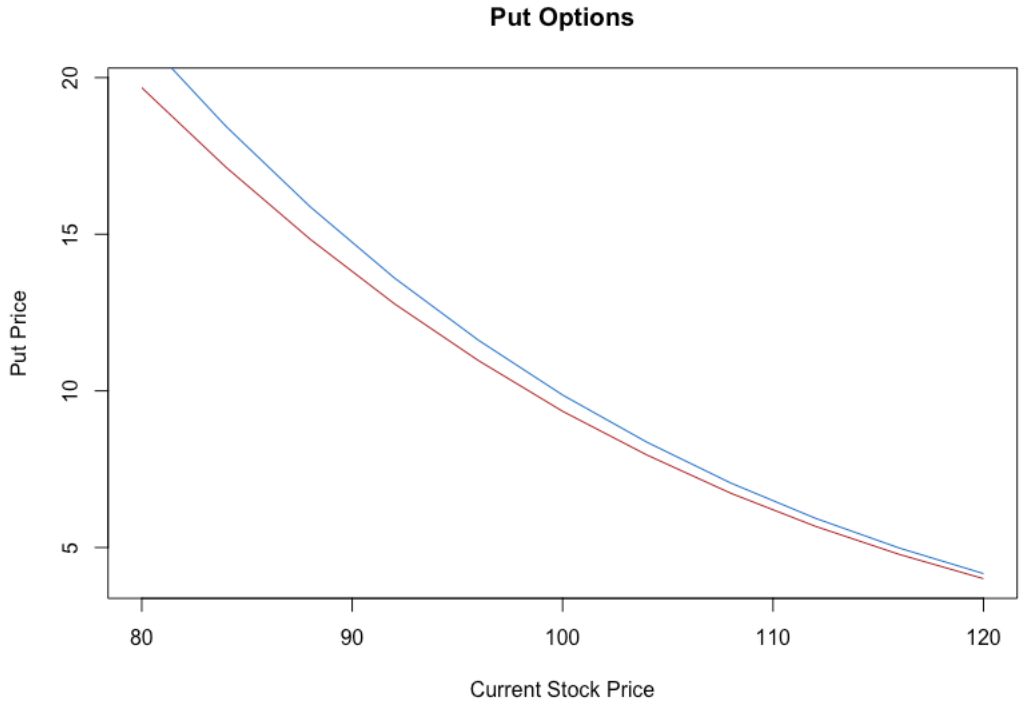
Using the CRR Binomial model, we estimate all the Greeks of the indicated stock, as well as how Delta varies with time T. The plots are as below:



4. Binomial Method to Price European and American Put Options

The difference between pricing European and American put options is that while for European put options, I only need to continuously find the continuing values (as early exercise is not possible), for pricing American put options I would need to compare the continuing values with the exercise values in each period and choose the higher value.

The computational results are showcased in the plot below:

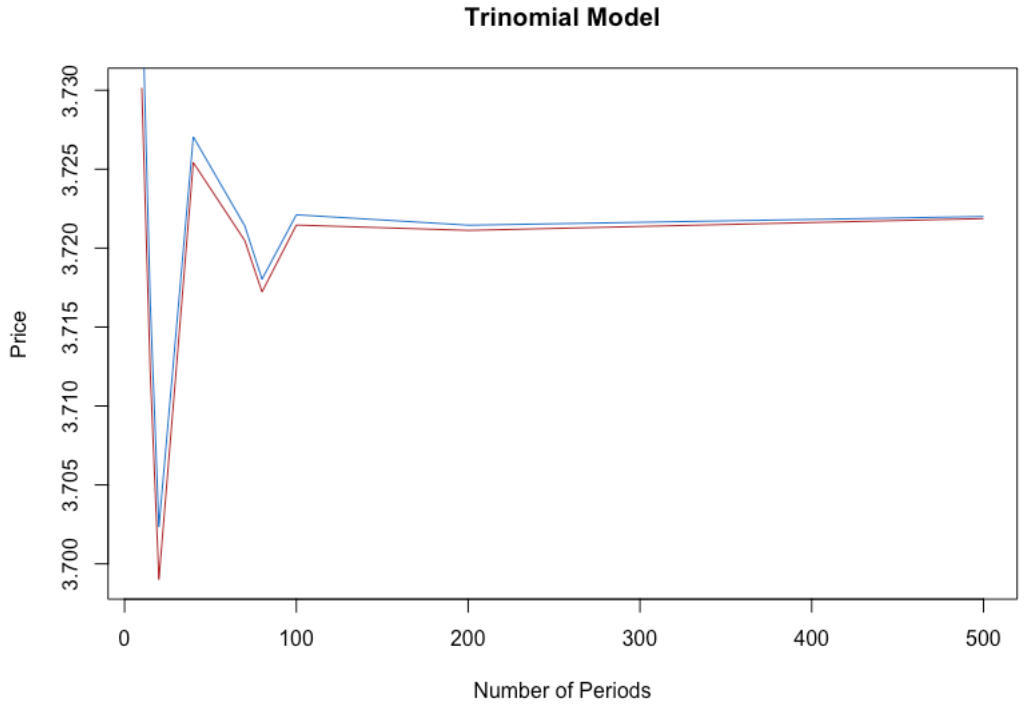


As we can see, the American put option is consistently priced higher than the European put option, which intuitively makes sense as well.

5. Trinomial Method to Price European Call

The Trinomial method is similar to the Binomial methods. However, instead of having *n* ending values for *n* periods, the Trinomial tree has *n* x 2 + 1 amount of values. First, we try the Trinomial method with the usual stock price process, and then we try the Trinomial method assuming a log stock price process.

The computed prices, corresponding with the number of periods in the Trinomial tree, is shown in the plot below:



We see that both methods converge very well and very quickly.

6. Using Halton Sequence Generated Random Normal Variables to Simulate European Call Prices

In this case, instead of using uniformly distributed random numbers in the Box-Muller method to generate normal numbers, we use numbers from two Halton sequences. To test this method, I set the initial stock price as $50, the strike price as $55, time to expiration as 2 years, risk free rate of 2%, and volatility of 20%. I use base 2 and base 7 Halton sequences in my simulations, and after 1,000 simulations, I compute a call price of **$4.46**.