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Comparative Analysis of Options Pricing Models

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Abstract

Global futures and options trading hit 28.9 billion contracts in the first half of 2021, up 32.1% from the same period in 2020. Open interest, which gauges the number of outstanding contracts at a certain period in time, increased this year as well, though not as quickly as last year. At the end of June, total open interest was 1.08 billion contracts, up 11.6 percent from June 2020. Fisher Black and Scholes (1973) revolutionized the world of options by proposing the widely used FSM valuation model for American options, which was improved upon by Robert Jarrow and Andrew Judd (1982) for European options valuation using arbitrary stochastic processes, and further, numerical techniques based on Binomial trees have been developed. There is currently no literature that details the accuracy of these pricing models across a variety of market conditions - bear, bull, and stable markets, which are a marker of the COVID-19 impact on global markets, and options markets by extension - due to the various types of options pricing methods available.

Keywords:
Derivatives, options, Black Scholes Merton, open interest, trading

1. Introduction

Options are specialized derivative contracts, which allows the seller the option to buy or sell an underlying security but not the obligation to do so. The sale price is defined as the strike price, which is specified in the contract along with the tick size, underlying security and maturity. The counterparty must deliver if the seller chooses to exercise the option. There are 2 kinds of options based on whether the exercise is to sell an underlying security (put option) or buy an underlying security (call option). The premise of options in derivatives markets is to hedge against some risk accounted for in another financial action or to speculate for trading purposes on standardized exchanges (Diao et.al,2020). To profit from options trading, many combinations of long and short bets can be used. These combinations in relation to profit are largely driven by the pricing method of the options. Options can either be American or European Style. An American option holder can exercise their right at any time before the expiration date, whereas a European option holder can only do so on the expiration day (Pagano and Roell, 1990). The response to the Black Scholes Partial Differential Equation is the Black Scholes Pricing Equation, which describes the value of a European call or put option as a function of the stock price S, the risk-free rater, stock volatility, and time to expiration (Petzel,1996; Sharma & Rastogi, 2020). The paper "The Pricing of Options and Corporate Liabilities" from 1973 was the first to publish them.

Barone-Adesi and Whaley offer a commodities option valuation technique in their 1987 publication, "Efficient Analytic Approximation of American Option Values". They propose a Quadratic Approximation for the value of both American calls and puts, specifically taking into consideration the prevalent early exercise feature that defines American options. According to

Barone and Whaley, if the Black-Scholes PDE applies to American options, it must alsoapply to the early exercise premium of American options. The next logical step is the Bjerksund-Stensland Method approximation method of interest. Using the work from their1993 study as a starting point, "Approximation of American in closed form alternatives", the Bjerksund-Stensland approach approximates American calls and puts by a factor of seven, putting a lower limit on the option's value. Bjerksund and Stensland (1993) provide a class of general exercise regimens, as well as the benefits of each value for the appropriate option. There is a constant trigger price X in eachexercise technique, which denotes the cost of exercising the option ahead of expiry (Renault, 1997; Bates,2003).

From binomial trees to finite difference approaches, numerical methods are used in option pricing in a variety of ways. Binomial trees are graphs, specifically trees, with a finite number of possible outcomes at each time step. By virtue of back testing, one can get a rough estimate of a European or American option's current real value. Finite Difference Methods use Taylor Series expansions of thevariables in the root problem to determine the answer to a differential equation (Anwar& Andallah, 2019; Bendob and Bentouir, 2019).

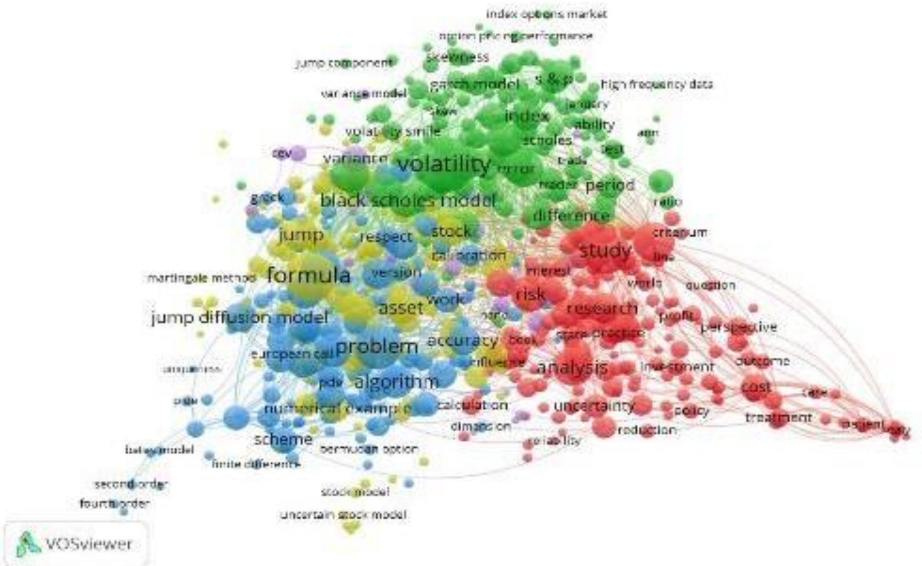
2. Literature Review

There is immense literature about futures and options in context of their pricing and valuation as it relates to profitability. There are also research reports by leading investment banks that delve into the subject. Owing to the volume of F&O trading as it occurs in global markets worldwide, there is a substantial increase in the quality and volume of data that can be utilized in order tounderstand key parameters as they relate to option pricing methodologies (Roll et al, 2010). This current study provides a systematic literature review over option pricing methodologies as they currently exist in theory and in practice. The authors reviewed over 75 research papers and scientific articles from35 journals in financial engineering and valuation. Of 75 papers, nearly 47 are generalized while the remaining speak to the application of pricing methods in different financial contexts. 2 key questions are addressed through this literature review:

1) What are the existing trends in terms of optionpricing in academia?
2) What are the main themes that emerge in thesearticles and how do they associate with one another?

The analyzed articles were retrieved from a variety of sources like Dimensions database, Research gate and byusing their DOI IDs. In January 2022, a keyword-basedliterature search was undertaken online. Journals, conferenceproceedings, and title years have all been searched for specific material. After indexing, about 30 articles were taken. The articles' citation was downloaded in RIS format to be processed using VOSViewer to visualize and analyse trends in bibliometric form. VOSViewer is a network-based software that can construct publication maps, country maps, and journal maps, as well as a keyword map based on sharednetworks and large-scale maps. Depending on their importance, the number of terms might be raised or lowered.VOSViewer was used to do text mining, modeling, andclustering on these articles.

Figure 1:



From figure 1, it can be seen that the dominant keywords here are Volatility, Black Scholes Model, Formula, Study and Risk. This means that topics in the period from 1980- 2021 were most discussed by researchers. This denotes that risk and volatility were critical underlying themes for the research surrounding options pricing. The more concentrated colours indicate higher research interest in the area.

Figure 2: Overlay visualization

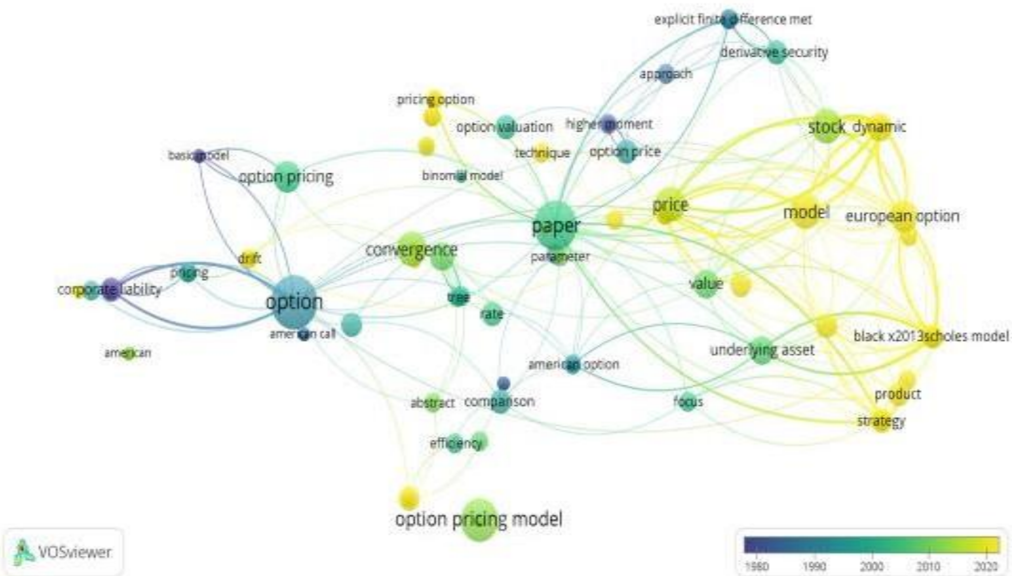


Figure 2 depicts that from 1980-2021 articles relating to convergence, European options, Black Scholes Merton and American options are most frequently discussed by researchers.

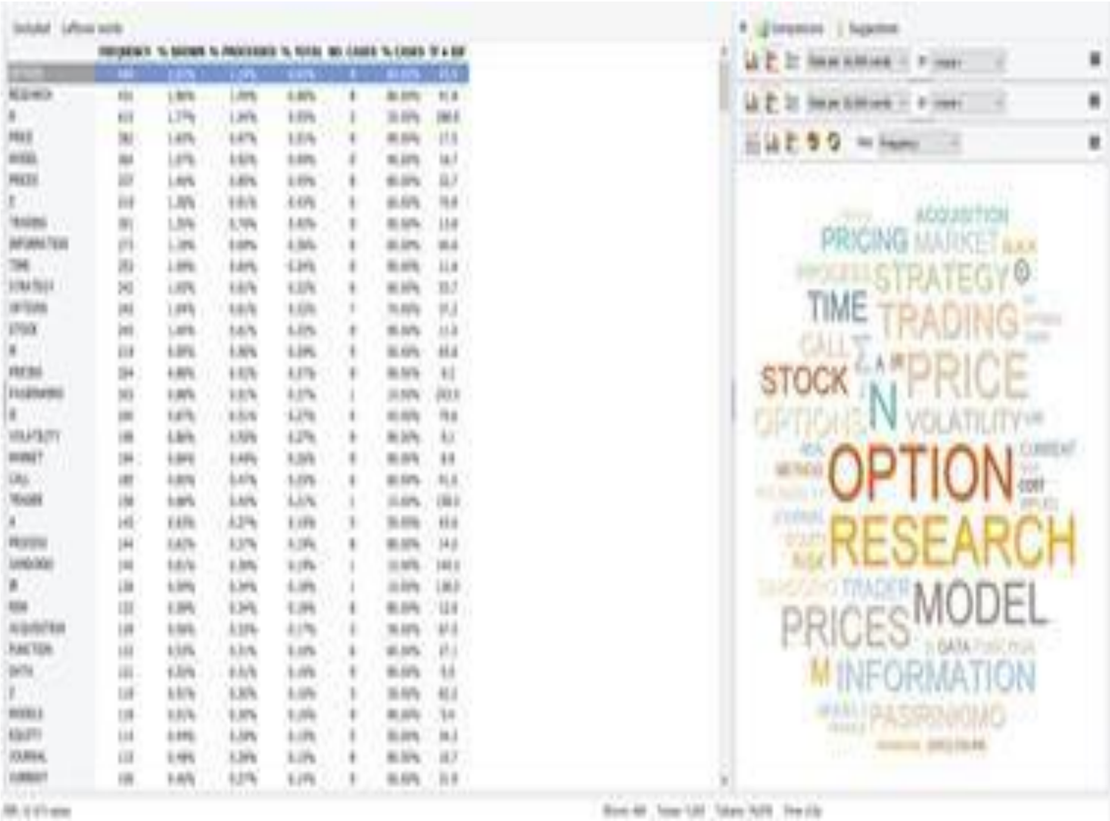


Figure 3: Word Cloud

With reference to figure 3 output executed on WordStat, we can see that the most frequently occurring words are option, research, model, prices, trading, volatility and information. Research occurs a total number of 431 times indicating that it has a high use case in the collated research papers, price refers to options prices and model indicates the different kinds of models that are used to evaluate options price which occurs over 337 times.

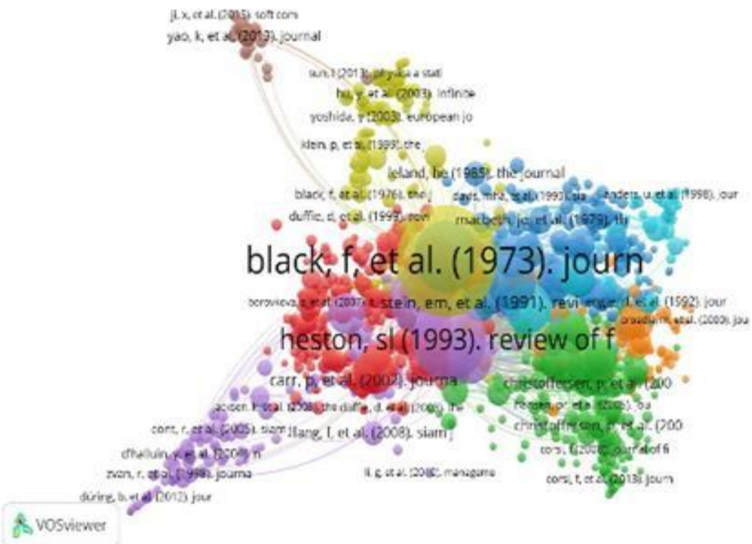


Figure 4: Co Citation Analysis

The co-citation analysis revealed that the 1973 paper that established the Black Scholes model was the one that was most referred to in improving research contexts. In a close second was the Heston model that was proposed in 1993 in a paper titled “A Closed-Form Solution for Options

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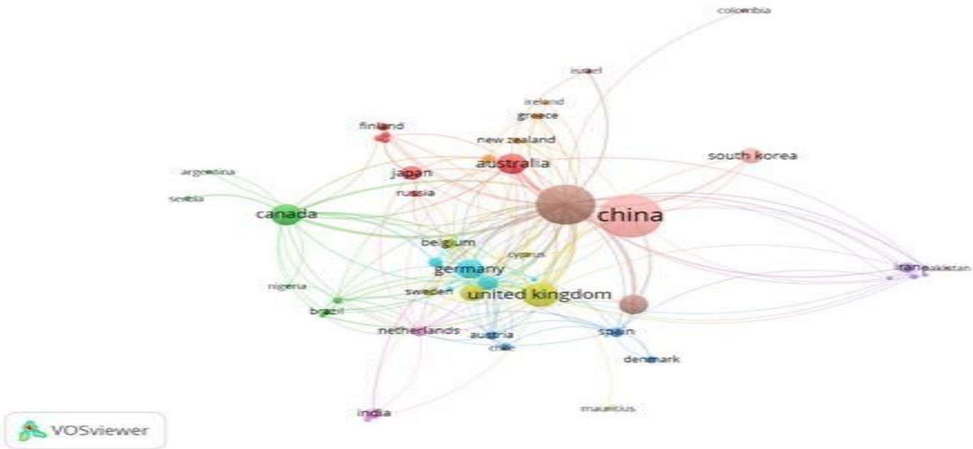
with Stochastic Volatility with Applications to Bond and Currency Options.
The derivation of this solution was arrived at by establishing a relationship between asset returns and corresponding volatility. The Heston model is significant in that it proposes arbitrary volatility which is at odds with the Black Scholes model, which claims that volatility is constant.



A country analysis of the authors pertinent to option pricing methods revealed that most of the research was concentrated in North America i.e., USA and Canada which is in line with the premise that F&O trading volumes have historically been the highest in the region. China and the United Kingdom closely second it. US research papers on the subject have been widely linked to research in South America as well as European countries like Belgium and Netherlands.

3. Options Pricing Methods

The basic premise for this research is to evaluate most frequently used pricing methods for American and European style options. Despite the fact that the most often used pricing models are listed, the list is by no means complete. The formulas range from those used in theory, such as Analytical approximations (*Barone-Adesi and Whaley, 1987*), to those utilised in practice, such as the Binomial Tree approach (*Jarrow & Rud, 2020*). A number of pricing methods are theoretical in nature while some are utilized practically by investment banks and fund managers worldwide.

A. *Analytical Formulas*

Analytical Formulas are the first type of option pricing method we'll look at. Based on a set of input factors, these approaches provide an explicit formula for the true value of a European or American choice. For example, the Black- Scholes Pricing Formulas will be explored. Fischer Black and Myron Scholes' Black Scholes Partial Differential Equation inspired the Black Scholes Pricing Formulas, which was first published in 1973 in the publication *"The Pricing of Options and Corporate Liabilities"*. The PDE expresses the price of a European call or put option, As shown below, V is a function of the stock price *S*, the risk-free rate *r*, stock volatility *v*, and the time to expiration *t.*

(1)
$$\frac{\partial V}{\partial t} + \frac{1}{2}\sigma^2 S^2 \frac{\partial^2 V}{\partial S^2} + rS\frac{\partial V}{\partial S} + \frac{\partial V}{\partial t} - rV = 0$$

The Black-Scholes Formulas, which can be used to determine the estimated value of a European option, are as follows when the partial differential equation is solved with European option boundary conditions. We should point out that the expected value of a European call option is not the same as the expected value of a call option in the United States (Wu and Wang, 2021). The call option value, *C(S, t)*, is:

C(S, t) = SN(d1)-Ke r(t)N(d2), where

(2)

S stands for the spot price, r for the risk free rate, sigma for the underlying asset's volatility, and

$$d_1 = \frac{\ln\frac{S}{K} + (r + \frac{\sigma^2}{2})(t)}{\sigma\sqrt{t}}$$

$$d_2 = \frac{\ln\frac{S}{K} + (r - \frac{\sigma^2}{2})(t)}{\sigma\sqrt{t}}$$

t for the time to expiration, with K standing for the strike price at which the option is exercised. N is the CDF of the normal distribution. In the same breath, European puts can be found for their expected value through:

P(S, t) = -SN(-d1)+Ke r(t)N(-d2) (3)

B. Analytical Approximations

Another kind of option pricing strategy to be assessed is analytic approximation methods. These methods provide an assessment for the real value of an American option based on an estimate of the Black- Scholes PDE. While the Black-Scholes PDE offers analytic solutions with European option boundary conditions, this is not the case with American option boundary conditions, therefore the approximation. We shall, however, analyze two of these methods: The Barone-Adesi-Whaley Method and the Bjerksund- Stensland Method.

For quantitative assessments, the Barone-Adesi- Whaley Method is the basic foundation. Barone-Adesi and Whaley proposed a commodities option specific technique in their 1987 work, "Efficient Analytic Approximation of American Option Values." They offered a Quadratic Approximation for the value of both American calls and puts, according to the newspaper, taking into account the common early exercise feature that identifies American options.

Again, a formal derivation will not be proposed, but rather a summary of the method's essential ideas and formulas. According to Barone and Whaley, if the Black-Scholes PDE applies to American options, it should also extend to the premature exercise premium of American options. The initial exercise premium partial differential equation is turned into a second-order ordinary differential equation by approximating the results:

S2Fss+NSFs-M/KF = 0 (4)

This equation can have 2 possible solutions, namely roots q1 and q2. On applying the boundary conditions, the derived value for an American call option C(S,T) is:

spot price should not exceed the trigger so as to not incite early exercise and this makes sense intuitively. Hereon, there exist 2 strategies that result in a range of trigger prices X of the exercise option. The defined exercise price for a certain contract BT and their trigger price as Xt

$$\begin{cases} C(S,T) = c(S,T) + A_2(\frac{S}{S^*})^{q_2} & S < S^* \\ C(S,T) = S - X & S \geq S^* \end{cases}$$

The formula denotes the approximation that is A2(s/s*) ^q2 where

A2 = $\frac{S^*}{q_2}(1 - e^{(b-r)T}N[d_1(S^*)])$ (6)

and c(S, T) S is the spot price, S is the vital spot price, S is the short term interest rate, r is the cost of carrying, b is the cost of carrying, T is the period until expiration, and S-X is the exercisable proceeds, where S is the spot price, S is for the critical spot price, S stands for the short term interest rate, r stands for the cost of carrying, b stands for the cost of carrying, T stands for the time until expiration, and S-X stands for the exercisable proceeds. Furthermore, the Black- Scholes cumulative distribution function of the regular normal distribution is the same as that of N. (d1). The value of an American put option is determined in the same way as the BSM model:

$$\begin{cases} P(S,T) = p(S,T) + A_1\left(\frac{S}{S^{**}}\right)^{q_1} & S > S^{**} \\ P(S,T) = X - S & S \leq S^{**} \end{cases} \tag{7}$$

(8) $A_1 = -\frac{S^{**}}{q_1}\left(1 - e^{(b-r)T} N\left[-d_1(S^{**})\right]\right.$

S** is the spot price and concurrent variables as exist in the American call option evaluation.
The next pricing model of interest as in (Bjerskund & Stensland, 1993) is the Bjerksund-Stensland method. By establishing a lower constraint to the option value, the Bjerksund-Stensland technique approximates American calls and puts.
Bjerksund and Stensland begin by presenting a set of generic exercise tactics, as well as the option values that go with them. There is a constant trigger price X in each exercise strategy that defines the price at which the holder will exercise the contract early. For any execution strategy that fits these parameters, the valuation of an American call option is

(9) $c = \alpha(X)S^{\beta} - \alpha(X)\phi(S,T|\beta,X,X) + \phi(S,T|1,X,X) - \phi(S,T|1,K,X) - K\phi(S,T|0,X,X) + K\phi(S,T|0,K,X)$

where S is t expiration, K is the strike price, X the trigger price, sigma denotes volatility, b is the cost to carry and r is the risk free interest rate. Sigma is found by

(10) $\alpha(X) := (X - K)X^{-\beta}$ and $\beta := \left(\frac{1}{2} - \frac{b}{\sigma^2}\right) + \sqrt{\left(\frac{b}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2r}{\sigma^2}}$

In addition, our function ϕ(S, Tj;H;X) calculates the payment at time T, provided that the spot is available. The

(11) $X_T = B_0 + (B_\infty - B_0)(1 - e^{h}(T))$

The trigger price, XT, can be thought of as a time- weighted average of the ideal exercise price between an infinitely long B∞ and an infinitely short B0 American option. The Bjerksund-Stensland Approximation for American call options is obtained by including this trigger in our approximation.
As anticipated, likewise technique can be used to prove that the adjusted price of the American put option is the same as the approximate value of the American call option with the following alteration:

(12)

$$\beta := \left(\frac{1}{2} + \frac{b}{\sigma^2}\right) + \sqrt{\left(-\frac{b}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2r - b}{\sigma^2}}$$

C. Pricing Method Scripts

Having evaluated common pricing methods in the academic context, this module will comprise of Python scripts necessary for comparison of the pricing methods in line with real time data collated from Robin hood. For programming these scripts, we use the QuantLib engine for modelling option methods. This is coupled with pandas and numpy for data processing and implementing the scripts.

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```
options=[]
for x in rs.get_open_option_positions():
    response=requests.get(x['option'])
    expiration=response.json()['expiration_date']
    strike=response.json()['strike_price']
    symbol=response.json()['chain_symbol']
    right=response.json()['type']
    quantity=x['quantity']
    options.append((symbol,expiration,strike,right,quantity))

return options
```

Figure 6: Extracting stock data

To interact with the Robinhood API, we used the RobinStocks library. With rs.get_open_option(), we wereable to extract our current option positions after authenticating with my Robinhood account (). This was usedto record the underlying, strike, expiration, and right in a listthat was utilized later by filtering the JSON response to the attributes of each contract.

```
('AAPL', '2022-04-14', '150.0000', 'call')
```

Figure 7: Command Line Output

It is important to note at this stage that American optionsare pricing with the 2 approximation formulas namely Barone-Adesi-Whaley and Bjerksun-Stensland. BSM can only be applied on European options since they're exercised only at maturity and is included for the purpose of comparison. The pricing script passes the requisite variables to pass the current market price of the contract. The underlyingasset, price, strike price, expiration date, and right are all variables. There is a settlement parameter that is utilized for the former 2 methods. Since the risk free rate and dividend on the underlying stock equally affect the return on option atexercise price, the pricing script accommodates the same. Specifically, this dividend rate is drawn using a yield function from the RobinStocks library.

```
#Divdend rate
if rs.get_fundamentals(symbol)[0]['dividend_yield'] is None:
  dividend_rate=0
else:
  dividend_rate =  float(rs.get_fundamentals(symbol)[0]['dividend_yield'])/100
```

Figure 8: Dividend Fetch

The pricing script passes the requisite variables to pass the current market price of the contract. The underlyingasset, price, strike price, expiration date, and right are all variables. There is a settlement parameter that is utilized for the former 2 methods. Since the risk free rate and dividend rate on the underlying asset affect the return on expiration, itis critical to account for it in the pricing. The dividend rate isfetched using a yield function.

```
 # Option Type
 if optionType =='call':
   option_type = ql.Option.Call
 else:
   option_type = ql.Option.Put
#Monthly Daily Realized Volatility
 volatility=get_vol(symbol)
```

Figure 9: Volatility of call

By computing the standard deviation of log returns from close to close, the above-mentioned function calculates the previous month's volatility. The underlying assets' requisite closure prices are the far-fetched.

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```python
def get_vol(symbol):
  '''
    Input:
      symbol:str of underlying

    Output:
      vol: float, monthly daily volatility computed from close to clsoe
  '''
  close=[float(x['close_price']) for x in rs.get_stock_historicals('AAPL', interval='day', span='month')]
  vol=np.log(close).std()*np.sqrt(30)
  return vol
```

Figure 10: Close price for underlying

The European option is required for the Black-Scholes engine, whereas the American option is required for theBinomial Pricing Model engines, which is why they are bothdefined.

```python
#Initiate option payoff and exercise styles
payoff = ql.PlainVanillaPayoff(option_type, strike)
europeanexercise=ql.EuropeanExercise(maturity_date)
americanexercise = ql.AmericanExercise(calculation_date,maturity_date)
european_option=ql.VanillaOption(payoff, europeanexercise)
american_option = ql.VanillaOption(payoff, americanexercise)

#Initiate Black Scholes Metron Process
spot_handle = ql.QuoteHandle(
  ql.SimpleQuote(float(underlying_open))
```

Figure 11: Option payoffs

The pricing engine is set at the corresponding input variables of the user, post which the option's Net Present Value is calculated and supplied to the Main function.

```python
#Black-Scholes Analytical Solution, Approximation to American options
if model =='BS':
  european_option.setPricingEngine(ql.AnalyticEuropeanEngine(bsm_process))
  val=european_option.NPV()

#Barone Adesi-Whaley Quadratic Approximation
elif model=='BAW':
  american_option.setPricingEngine(ql.BaroneAdesiWhaleyApproximationEngine(bsm_process))
  val=american_option.NPV()

#Bjerksund-Stensland Approximation
elif model=='BJST':
  american_option.setPricingEngine(ql.BjerksundStenslandApproximationEngine(bsm_process))
  val=american_option.NPV()
```

Figure 12: CMP per model

```python
#compute desired theoretical price
theor=[]
for i in range (0, int(df.shape[0])):
  theor.append(pricer.calculate_theor(df['chain_symbol'][i],float(df['strike_price'][i]),df['
df['Theoretical']= theor

#Sort by strike price for ease of use
df['strike_price']=pd.to_numeric(df['strike_price'].values)
df=df.sort_values(by='strike_price')
new_sorteddf1=pd.DataFrame(df,columns=['chain_symbol','expiration_date','strike_price','type',
```

Figure 13: main() function

```
BS
  chain_symbol expiration_date  strike_price  type last_trade_price  \
0         AAPL      2022-04-14          85.0  call        83.620000
1         AAPL      2022-04-14          95.0  call        68.850000
3         AAPL      2022-04-14         115.0  call        55.660000
2         AAPL      2022-04-14         150.0  call        25.100000
4         AAPL      2022-04-14         240.0  call         0.620000

  mark_price  Theoretical     delta     gamma     theta       rho      vega
0  84.900000    84.629799  0.985403  0.000635 -0.009716  0.258756  0.035197
1  75.025000    74.674443  0.978246  0.000986 -0.012293  0.285987  0.049461
3  55.650000    54.767718  0.947382  0.002430 -0.021080  0.330553  0.102184
2  24.650000    21.549085  0.765269  0.009221 -0.044915  0.330991  0.292189
4   0.610000     0.021080  0.047463  0.002972 -0.014353  0.023422  0.094121

  implied_volatility  volume
0           0.612692      10
1           0.554155       0
3           0.464645       1
2           0.350068      42
4           0.349898     189
```

Figure 14: Black Scholes model output

The above result demonstrates how the Black Scholes model was used to estimate the value of AAPL call options. It is interesting to note that theoretical and current market prices have a huge spread between them, indicating that the BSM model isn’t extremely accurate. Coming to the Binomial pricing model, the input variables include parameters such as ‘p’ and ‘q’ which denote the probabilities of pricing going up or down, summating to 1. ‘u’ and ‘d’ refer to the volatility on either side as the prices oscillate above a certain mean. These four parameters make up the option tree and runs with the assumption that the equity prices underlying said option follows random walk (Abdullazade, Z., 2019).

```
## define Cox_Ross_Rubinstein binomial model
def Cox_Ross_Rubinstein_Tree (S,K,T,r,sigma,N, Option_type):

    # Underlying price (per share): S;
    # Strike price of the option (per share): K;
    # Time to maturity (years): T;
    # Continuously compounding risk-free interest rate: r;
    # Volatility: sigma;
    # Number of binomial steps: N;

        # The factor by which the price rises (assuming it rises) = u ;
        # The factor by which the price falls (assuming it falls) = d ;
        # The probability of a price rise = pu ;
        # The probability of a price fall = pd ;
        # discount rate = disc ;

    u=math.exp(sigma*math.sqrt(T/N));
    d=math.exp(-sigma*math.sqrt(T/N));
    pu=((math.exp(r*T/N))-d)/(u-d);
    pd=1-pu;
    disc=math.exp(-r*T/N);

    St = [0] * (N+1)
    C = [0] * (N+1)

    St[0]=S*d**N;

    for j in range(1, N+1):
        St[j] = St[j-1] * u/d;
```

Figure 15: Cox Ross Rubenstein tree code

```
u=math.exp((r-(sigma**2/2))*T/N+sigma*math.sqrt(T/N));
d=math.exp((r-(sigma**2/2))*T/N-sigma*math.sqrt(T/N));
pu=0.5;
pd=1-pu;
disc=math.exp(-r*T/N);

St = [0] * (N+1)
C = [0] * (N+1)

St[0]=S*d**N;

for j in range(1, N+1):
    St[j] = St[j-1] * u/d;

for j in range(1, N+1):
    if Option_type == 'P':
        C[j] = max(K-St[j],0);
    elif Option_type == 'C':
        C[j] = max(St[j]-K,0);

for i in range(N, 0, -1):
    for j in range(0, i):
        C[j] = disc*(pu*C[j+1]+pd*C[j]);

return C[0]
```

Figure 16: Jarrow Rudd Tree code

Since both the pricing models have similar underlying assumptions, it is imperative to understand the difference between the both of them. The Jarrow-Rudd model is widelyreferred to as the equal probability model for the reason that there is a comparable likelihood of upward movement as there is for downward movement of asset values. A drawback of this model is that it is not risk-neutral and is consequently improved upon by the founders through an alternative Jarrow-Rudd risk neutral model (Bondi et.al,2020; Sutradhar & Hossain 2020).

The Cox-Ross-Rubenstein model works on the premise that upward and downward movement are inversely related and solves for four parameters using the risk free rate, expirytime for the option and standard deviation of the option price.Consequently, over a short period of time the binomial model functions well in a risk-free world however in case, there are multiple steps involved in the model, the underlyingasset ends up functioning symmetrically around the spot price S (Coelho & Reddy, 2018)

Type of Option	Formula
American Call	$V_n = \max(S_n - X, e^{-r\Delta t}(pV_u + (1-p)V_d))$
American Put	$V_n = \max(X - S_n, e^{-r\Delta t}(pV_u + (1-p)V_d))$
European options	$V_n = e^{-r\Delta t}(pV_u + (1-p)V_d)$

	Symbol	Input
Underlying price	S	100.000000
Strike price	K	110.000000
Time to maturity	T	2.221918
Risk-free interest rate	r	5.000000
Volatility	sigma	30.000000

Figure 17: Input variables for binomial model

	Option	Price
Cox-Ross-Rubinstein	Call	18.350952
Cox-Ross-Rubinstein	Put	16.784775
Jarrow-Rudd	Call	18.343573
Jarrow-Rudd	Put	16.777730

Figure 18: CRR and JR output for binomial pricing model

CMP	Theoretical	Spread	Model
84.9	84.629	0.271	Black Scholes
75.03	74.67	0.36	Black Scholes
55.65	54.76	0.89	Black Scholes
24.65	21.55	3.1	Black Scholes
0.61	0.021	0.589	Black Scholes
18.365	18.351	0.014	Binomial
16.8	16.784	0.016	Binomial
18.45	18.34	0.11	Binomial
16.85	16.777	0.073	Binomial

Figure 19: Comparison of Spread

The spreads between the Black Scholes and Binomial Pricing models are evaluated in Figure 19. By a large margin, the binomial pricing model outperforms the BSM. Its accuracy is very well denoted in the fact that the spread isextremely small.

4. Conclusion

The keyword and citation analysis depict the dominant themes of options research which were identified to be risk and volatility, which are implied in the Black Scholes, Binomial and Finite Difference models. Most referred papers were the 1973 one about the BSM, which was improved upon throughout the years and was foundational to option pricing research contexts, with the Heston model in a close second as a pricing model applied to bond & currency options.The primary aim of this analysis is to discuss two distinct pricing techniques: the Binomial Pricing Model and the Black-Scholes Merton Model. Risk Management is a key factor as to the exercising of these models since the underlying stock volatility is directly related to the accuracy of these models – highly volatile stocks such as small caps might adversely affect the accuracy. The option type has an impact on the price and accuracy because European options can only be exercised at the time of expiry, but American option writers have more temporal flexibility (Popescu and Wu, 2007).

Although it is a well-known fact in the trading world thata portfolio is always exposed to price risk, which can occur at any time during the trading period, the overall risk can be mitigated to a certain extent if a trader employs appropriate risk mitigation strategies prior to entering the market (Biais & Hillion,1994). Options are one of the most essential derivative vehicles for offsetting and risk mitigation. Many businesses throughout the world adopt the Black & Scholes options pricing model and the binomial options pricing model. As a result, the primary goal of conducting research on this topic is to compare the two models by implementing said models in Python and then evaluating the spreads on both of them, comparing them to pinpoint the model that prompts a lower spread. Because it denotes the difference between the theoretical price and the existing market price at that point intime, a lower spread suggests more accuracy. Whencomparing the Black Scholes and Binomial Pricing models, the Binomial Pricing model surpasses the Black Scholesmodel with a lower spread outlay across call and put options. However, it's vital to keep in mind that accuracy is affected by a variety of factors, including the use case, underlying stock volatility, and the moneyness of the option (Ryu and Yu, 2021; Kaul et al.,2004; Hsu, 2016).

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