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A study on parameters of option pricing: The Greeks

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Abstract
An option's price can be prejudiced by various factors like underlying price, interest rates, volatility etc. The underlying price and strike price of the option determines the intrinsic value. The time till expiration and instability determines the probability of a profitable move. The interest rates determines the cost of money. Dividends can cause an adjustment to share price. These factors influence the traders, depending on the type of options positions they have established. In order to become an efficacious option trader, it is necessary to understand the factors that influence the price of an option.
This study is conducted to provide some knowledge and application about the Greeks. Each Greek separates a variable that can drive option's price movement, giving insight on how the option's premium will vary if that variable changes.

Keywords: underlying price, interest rates, volatility, Greeks

1. Introduction
The world financial market has undergone many qualitative changes in last four decades due to phenomenal growth of derivatives. An increasingly large number of organizations now consider derivatives to play a significant role in implementing their financial strategies. With the world embracing the derivatives trading, the Indian market obviously cannot aloof, especially after liberalization has been set in motion. It is believed that derivatives, being highly leveraged instruments, can be explosive and hence derivative trading is held back in India. Future and option exchanges, over-the-counter derivative markets are integral parts of virtually all the economies which have reached an advanced state of economic development. While trading in options and futures in a crude and unregulated manner has reportedly been prevalent in some parts India, the concepts and details related to derivative options and futures are indeed new.
A derivative is a security whose price is dependent upon or is derived from one or more underlying assets. The derivative is a contract between two or more parties based upon asset or assets. The values of derivative are determined by fluctuations in underlying assets. Derivatives are specialized contract employed for a numerous purposes including reduction of funding costs by borrowers, enhancing the yield on assets, modifying the payment structure of assets in relation to investors market view, etc. The most important use of derivatives is in transferring market risk, called hedging, which is, a shield against the losses resulting from the unforeseen price or volatility changes. Thus, derivatives are significant tool of risk management. The markets for derivatives have increases derivatives due to awareness in people about derivatives as a risk management tool. Various types of derivatives being traded today are Futures, Options, Interest rate swaps, and Mortgage derivatives.

An option's price can be prejudiced by various factors. In order to become an efficacious option trader, it is necessary to understand the factors that influence the price of an option. Understanding these factors requires the knowledge about the GREEKS. GREEEKS are a set of risk measures that indicates how exposed an option is to time value decay, implied volatility and the changes in the underlying price of the commodity. The Greeks are the collection of statistical values that gauges the risk associated with an options contract in relation to certain underlying variables. Greeks are dimensions of risk involved in taking a position in an option. Each risk variable is the outcome of an imperfect assumption or relationship of the option with another underlying variable. Each Greek separates a variable that can drive option's price movement, giving in sight on how the option's premium will vary if that variable changes. Popular Greeks include Delta, Vega, Gamma and Theta.
DELTA: Delta, Δ, measures the rate of change of the option value (theoretical) with respect to changes in the underlying asset's price. Delta is the first derivative of the option value with respect to the underlying security's price. Delta is often used as the "hedge ratio".
GAMMA: Gamma, Γ, measures the rate of change in the Delta with respect to changes in underlying price.
The change in the Delta with respect to a one point movement of the underlying asset price is expressed as Gamma and it is generally expressed in percentage.
THETA: Theta, Θ, measures the sensitivity of the derivative value to the passage of time, also known as the "time decay." The option's Theta is a measurement of the option's time decay. The options value can be analyzed into two parts i.e. the intrinsic value and the time value.
VEGA: Vega, ν, measures the sensitivity of the derivative of the value of the option with respect to the implied volatility of the underlying asset. The option's Vega measures the impact on the option price due to changes in the underlying volatility. RHO: Rho, ρ, measures

sensitivity to the interest rate and thus it is the derivative of the value of the option with respect to the risk free interest rate.

In the following tables the major influences on a long and a short call option price as well on put option price have been shown. These influences have been explained in the description of the Greeks.

Call options	Increase in the underlying	Decrease in the underlying	Increase in the time to expiration	Decrease in the time to expiration	Increase in the volatility	Decrease in the volatility	Increase in the interest rates	Decrease in the interest rates
Long	+	-	+	-	+	-	+	-
Short	-	+	-	+	-	+	-	+

Major influences on a short and long call option's price.

Put options	Increase in the underlying	Decrease in the underlying	Increase in the time to expiration	Decrease in the time to expiration	Increase in the volatility	Decrease in the volatility	Increase in the interest rates	Decrease in the interest rates
Long	-	+	+	-	+	-	-	+
Short	+	-	+	+	-	+	+	-

Major influences on a short and long put option's price.

Review of Literature

Research Journal by Xisheng Yu and Xiaoke Xie (On Derivations of Black-Scholes Greek Letters, Research Journal of Finance and Accounting, ISSN 2222-1697 (Paper) ISSN 2222-2847 (Online) Vol.4, No.6, 2013): In this research journal, definitions and procedure of deriving the Greek letters of Delta, Theta, Gamma, Vega and Rho has been discussed. It also informs about the relationship between Delta, Theta, and Gamma that it satisfies Black-Scholes partial differential equation.

Research Journal by C. Rajanikanth and Dr. E. Lokanadha Reddy (Analysis of Price Using Black Scholes and Greek Letters in Derivative European Option Market, International Journal of Research in Management, science and Technology, Vol. 3, ISSUE No. 1, 2015): In this research journal, there is application of Greek letters on five different companies belonging to different industries and suggestions are provided and in result helping investors eliminate risk. The estimation of hazard in the market is a critical work and it can't be utilized to signify for future desires.

Research Journal by Sanjana Juneja (Understanding the Greeks and their use to measures risk, VOLUMENO. 3(2013), ISSUENO. 10(OCTOBER)): A brief description about all the basic option terminologies, Greek letters and its significance is given. Exchanging choices without a comprehension of the Greeks - the basic hazard measures and benefit/misfortune guideposts in choices procedures - is synonymous to flying alpine without the capacity to peruse instruments

The book by Hull C. John., (Options, Futures and Other Derivatives (2009) [1], 7th edition. New Jersey: Pearson Education, Inc.) : It describes about the five most used Greek letters in detail and also its applications in ascertaining option price**.** It also describes about how time, volatility and other pricing factors drives profits. It begins from the basic concepts of the Greek letters to a broader concept involving using Greek letters as trading strategies.

Research Journal by Jelena Paunović (Options, Greeks, and Risk management, SJAS 2014, 11 (1): 74-83): It describes the risk characteristics of plain vanilla European stock options contracts using the Greeks. There is also construction of portfolios to eliminate risk of a trader. Choices are budgetary subsidiaries speaking to an agreement which gives the ideal to the holder, however not the commitment, to purchase or off era hidden resource at a pre-characterized strike cost amid a specific timeframe.

Statement of Problem

An option's price can be prejudiced by various factors like underlying price, interest rates, volatility etc. The underlying price and strike price of the option determines the intrinsic value. The time till expiration and instability determines the probability of a profitable move. The interest rates determines the cost of money. Dividends can cause an adjustment to share price. These factors influence the traders, depending on the type of options positions they have established. In order to become an efficacious option trader, it is necessary to understand the factors that influence the price of an option.

This study is conducted to provide some knowledge and application about the Greeks. Each Greek separates a variable that can drive option's price movement, giving insight on how the option's premium will vary if that variable changes.

Objectives of the Study

- Measure the likelihood that an option we are considering will expire in the money (Delta).
- Estimate how much the Delta will change when the stock price changes(Gamma)
- How much value an option might lose each day as it approaches expiration(Theta)
- How sensitive an option is to large price fluctuations in the underlying stock(Vega)
- Measure the effect of interest rate changes on an option(Rho)
- Analyze the effect of Greeks in relation with options.

Research Methodology

Options have been obtained from the following sector

- Finance
- Fast Moving Consumable Goods(FMCG)
- Power generation and distribution

A Top performing company from the above industry have been shortlisted for Greek calculation.

All the calculations are done using VBA, various functions and add-Ins from Microsoft Excel.
The stock and European option data of each company is taken for a period of one month i.e. Jan 2017.

91 days treasury bills rate 6.19% p.a. has been used as risk free rate of return for calculation.
Annualized volatility has been used for calculation.

Formulae for calculating Greek

	Calls	Puts
value	$Se^{-qT}\Phi(d_1) - e^{-rT}K\Phi(d_2)$	$e^{-rT}K\Phi(-d_2) - Se^{-qT}\Phi(-d_1)$
delta	$e^{-qT}\Phi(d_1)$	$-e^{-qT}\Phi(-d_1)$
vega	$Se^{-qT}\phi(d_1)\sqrt{\tau} = Ke^{-rT}\phi(d_2)\sqrt{\tau}$	
theta	$-e^{-qT}\frac{S\phi(d_1)\sigma}{2\sqrt{\tau}} - rKe^{-rT}\Phi(d_2) + qSe^{-qT}\Phi(d_1)$	$-e^{-qT}\frac{S\phi(d_1)\sigma}{2\sqrt{\tau}} + rKe^{-rT}\Phi(-d_2) - qSe^{-qT}\Phi(-d_1)$
rho	$K\tau e^{-rT}\Phi(d_2)$	$-K\tau e^{-rT}\Phi(-d_2)$
gamma	$e^{-qT}\frac{\phi(d_1)}{S\sigma\sqrt{\tau}} = Ke^{-rT}\frac{\phi(d_2)}{S^2\sigma\sqrt{\tau}}$	

Fig 1

Limitation of Study

- The data collected for the study is for a month.
- The study doesn't cover all the Greek letters.
- Volatility is annualized.

Result Analysis

Collected data is analyzed using the above mentioned models and results drawn are tabulated as follows.

ITC	
today	02/01/2017
maturity	25/01/2017
strike price	265
stock price	240.95
dividend	0
int rate	0.0619
volatility	0.2090
calendar	17
years	0.06746
shares	100

Fig 2

						CALL					PUT				
TODAY	MATURITY	NO OF DAYS LEFT	t= days left/252	STRIKE PRICE	CLOSING STOCK PRICE	DELTA	GAMMA	VEGA	THETA	RHO	DELTA	GAMMA	VEGA	THETA	RHO
24-Jan-17	25-Jan-17	1	0.0040	265.0000	259.85	0.1363	0.0398	0.0223	-0.2285	0.0007	-0.8637	0.0398	0.0223	-0.0659	-0.0098
23-Jan-17	25-Jan-17	2	0.0079	265.0000	259.65	0.2275	0.0471	0.0526	-0.2658	0.0030	-0.7725	0.0471	0.0526	-0.1223	-0.0181
20-Jan-17	25-Jan-17	3	0.0119	265.0000	255.4	0.1155	0.0198	0.0322	-0.1085	0.0017	-0.8845	0.0198	0.0322	-0.0651	-0.0298
19-Jan-17	25-Jan-17	4	0.0159	265.0000	254.15	0.1224	0.0183	0.0392	-0.0985	0.0025	-0.8776	0.0183	0.0392	-0.0652	-0.0395
18-Jan-17	25-Jan-17	5	0.0198	265.0000	250.85	0.0778	0.0105	0.0275	-0.0553	0.0017	-0.9222	0.0105	0.0275	-0.0650	-0.0508
17-Jan-17	25-Jan-17	6	0.0238	265.0000	251.95	0.1287	0.0158	0.0500	-0.0831	0.0039	-0.8713	0.0158	0.0500	-0.0657	-0.0591
16-Jan-17	25-Jan-17	7	0.0278	265.0000	248.8	0.0871	0.0101	0.0361	-0.0515	0.0028	-0.9129	0.0101	0.0361	-0.0651	-0.0707
13-Jan-17	25-Jan-17	8	0.0317	265.0000	249.65	0.1235	0.0133	0.0549	-0.0680	0.0049	-0.8765	0.0133	0.0549	-0.0663	-0.0791
12-Jan-17	25-Jan-17	9	0.0357	265.0000	244.65	0.0599	0.0062	0.0277	-0.0306	0.0022	-0.9401	0.0062	0.0277	-0.0650	-0.0922
11-Jan-17	25-Jan-17	10	0.0397	265.0000	247.55	0.1188	0.0115	0.0586	-0.0576	0.0058	-0.8812	0.0115	0.0586	-0.0670	-0.0991

10-Jan-17	25-Jan-17	11	0.0437	265.0000	248.95	0.1610	0.0148	0.0837	-0.0742	0.0095	-0.8390	0.0148	0.0837	-0.0738	-0.1059
09-Jan-17	25-Jan-17	12	0.0476	265.0000	245.85	0.1186	0.0106	0.0636	-0.0519	0.0069	-0.8814	0.0106	0.0636	-0.0681	-0.1190
06-Jan-17	25-Jan-17	13	0.0516	265.0000	242.7	0.0846	0.0073	0.0466	-0.0352	0.0048	-0.9154	0.0073	0.0466	-0.0660	-0.1315
05-Jan-17	25-Jan-17	14	0.0556	265.0000	246.75	0.1595	0.0131	0.0927	-0.0640	0.0118	-0.8405	0.0131	0.0927	-0.0769	-0.1349
04-Jan-17	25-Jan-17	15	0.0595	265.0000	245.45	0.1486	0.0119	0.0890	-0.0573	0.0114	-0.8514	0.0119	0.0890	-0.0754	-0.1457
03-Jan-17	25-Jan-17	16	0.0635	265.0000	243.35	0.1261	0.0098	0.0773	-0.0467	0.0097	-0.8739	0.0098	0.0773	-0.0719	-0.1578
02-Jan-17	25-Jan-17	17	0.0675	265.0000	240.95	0.1025	0.0078	0.0641	-0.0365	0.0079	-0.8975	0.0078	0.0641	-0.0692	-0.1701

Fig 3

HDFC	
today	02/01/2017
maturity	25/01/2017
strike price	1300
stock price	1217.1
dividend	0
int rate	0.0619
volatility	0.2161
calendar	17
years	0.06746
shares	100

Fig 4

						CALL					PUT				
TODAY	MATURITY	NO OF DAYS LEFT	t= days left/252	STRIKE PRICE	CLOSING STOCK PRICE	DELTA	GAMMA	VEGA	THETA	RHO	DELTA	GAMMA	VEGA	THETA	RHO
24-Jan-17	25-Jan-17	1	0.0040	1300.0000	1280.7500	0.2249	0.0129	0.3266	-1.9162	0.0072	-0.7751	0.0129	0.1814	-2.7179	-0.0444
23-Jan-17	25-Jan-17	2	0.0079	1300.0000	1259.7500	0.1112	0.0046	0.4617	-0.6577	0.0055	-0.8888	0.0046	0.1248	-0.3193	-0.0977
20-Jan-17	25-Jan-17	3	0.0119	1300.0000	1237.3000	0.0485	0.0017	0.5653	-0.2298	0.0029	-0.9515	0.0017	0.0655	-0.3192	-0.1517
19-Jan-17	25-Jan-17	4	0.0159	1300.0000	1242.4000	0.1084	0.0032	0.6526	-0.4422	0.0104	-0.8916	0.0032	0.1696	-0.3193	-0.1958
18-Jan-17	25-Jan-17	5	0.0198	1300.0000	1249.0500	0.1809	0.0048	0.7294	-0.6564	0.0255	-0.8191	0.0048	0.3183	-0.3425	-0.2322
17-Jan-17	25-Jan-17	6	0.0238	1300.0000	1245.8000	0.1905	0.0046	0.7988	-0.6257	0.0327	-0.8095	0.0046	0.3661	-0.3608	-0.2764
16-Jan-17	25-Jan-17	7	0.0278	1300.0000	1256.9000	0.2732	0.0060	0.8625	-0.8254	0.0658	-0.7268	0.0060	0.5723	-0.6782	-0.2947
13-Jan-17	25-Jan-17	8	0.0317	1300.0000	1247.5000	0.2419	0.0050	0.9218	-0.6788	0.0616	-0.7581	0.0050	0.5378	-0.5146	-0.3503
12-Jan-17	25-Jan-17	9	0.0357	1300.0000	1221.1000	0.1378	0.0028	0.9774	-0.3604	0.0310	-0.8622	0.0028	0.3179	-0.3322	-0.4323
11-Jan-17	25-Jan-17	10	0.0397	1300.0000	1230.0500	0.1928	0.0036	1.0299	-0.4768	0.0545	-0.8072	0.0036	0.4724	-0.3966	-0.4601
10-Jan-17	25-Jan-17	11	0.0437	1300.0000	1217.2500	0.1552	0.0028	1.0799	-0.3630	0.0441	-0.8448	0.0028	0.3948	-0.3536	-0.5218
09-Jan-17	25-Jan-17	12	0.0476	1300.0000	1223.5500	0.1944	0.0034	1.1275	-0.4337	0.0657	-0.8056	0.0034	0.5192	-0.4144	-0.5516
06-Jan-17	25-Jan-17	13	0.0516	1300.0000	1222.3500	0.2024	0.0034	1.1732	-0.4314	0.0751	-0.7976	0.0034	0.5619	-0.4367	-0.5934
05-Jan-17	25-Jan-17	14	0.0556	1300.0000	1217.2000	0.1945	0.0031	1.2171	-0.3970	0.0761	-0.8055	0.0031	0.5579	-0.4274	-0.6437
04-Jan-17	25-Jan-17	15	0.0595	1300.0000	1212.1000	0.1869	0.0029	1.2595	-0.3666	0.0768	-0.8131	0.0029	0.5528	-0.4198	-0.6942
03-Jan-17	25-Jan-17	16	0.0635	1300.0000	1214.0000	0.2042	0.0031	1.3004	-0.3860	0.0927	-0.7958	0.0031	0.6247	-0.4574	-0.7294
02-Jan-17	25-Jan-17	17	0.0675	1300.0000	1217.1000	0.2248	0.0033	1.3400	-0.4104	0.1133	-0.7752	0.0033	0.7105	-0.5063	-0.7600

Fig 5

RELINFRA	
today	02/01/2017
maturity	25/01/2017
strike price	500
stock price	478.7
dividend	0
int rate	0.0619
volatility	0.1971
calendar	17
years	0.06746
shares	100

Fig 6

						CALL					PUT				
TODAY	MATURITY	NO OF DAYS LEFT	t= days left/252	STRIKE PRICE	CLOSING STOCK PRICE	DELTA	GAMMA	VEGA	THETA	RHO	DELTA	GAMMA	VEGA	THETA	RHO
24-Jan-17	25-Jan-17	1	0.0040	500.0000	515.2	0.0204	0.0032	0.1256	0.0566	0.0197	-0.9796	0.0032	0.0066	0.0000	-0.0002
23-Jan-17	25-Jan-17	2	0.0079	500.0000	515.25	0.0866	0.0096	0.1776	-0.0782	0.0380	-0.9134	0.0096	0.0397	0.0000	-0.0017
20-Jan-17	25-Jan-17	3	0.0119	500.0000	505.4	0.3440	0.0316	0.2174	-0.5371	0.0416	-0.6560	0.0316	0.1897	-0.0001	-0.0179
19-Jan-17	25-Jan-17	4	0.0159	500.0000	520.25	0.1021	0.0079	0.2510	-0.0485	0.0752	-0.8979	0.0079	0.0669	0.0000	-0.0041
18-Jan-17	25-Jan-17	5	0.0198	500.0000	510.4	0.2898	0.0205	0.2805	-0.3149	0.0773	-0.7102	0.0205	0.2083	-0.0006	-0.0218
17-Jan-17	25-Jan-17	6	0.0238	500.0000	512.55	0.2711	0.0174	0.3072	-0.2538	0.0953	-0.7289	0.0174	0.2144	-0.0011	-0.0235
16-Jan-17	25-Jan-17	7	0.0278	500.0000	510.3	0.3145	0.0188	0.3317	-0.2853	0.1032	-0.6855	0.0188	0.2675	-0.0148	-0.0355
13-Jan-17	25-Jan-17	8	0.0317	500.0000	505.65	0.3692	0.0208	0.3544	-0.3313	0.1014	-0.6308	0.0208	0.3326	-0.1157	-0.0570
12-Jan-17	25-Jan-17	9	0.0357	500.0000	509.9	0.3323	0.0175	0.3758	-0.2630	0.1273	-0.6677	0.0175	0.3202	-0.0582	-0.0508
11-Jan-17	25-Jan-17	10	0.0397	500.0000	506.05	0.3699	0.0186	0.3960	-0.2895	0.1260	-0.6301	0.0186	0.3729	-0.1625	-0.0719
10-Jan-17	25-Jan-17	11	0.0437	500.0000	501.3	0.3945	0.0191	0.4152	-0.3036	0.1182	-0.6055	0.0191	0.4132	-0.3052	-0.0995
09-Jan-17	25-Jan-17	12	0.0476	500.0000	492.7	0.3865	0.0182	0.4335	-0.2942	0.0912	-0.6135	0.0182	0.4155	-0.4177	-0.1462
06-Jan-17	25-Jan-17	13	0.0516	500.0000	492.7	0.3881	0.0176	0.4511	-0.2815	0.1002	-0.6119	0.0176	0.4343	-0.4039	-0.1569
05-Jan-17	25-Jan-17	14	0.0556	500.0000	490.7	0.3806	0.0167	0.4679	-0.2655	0.1002	-0.6194	0.0167	0.4402	-0.3891	-0.1766
04-Jan-17	25-Jan-17	15	0.0595	500.0000	483	0.3294	0.0142	0.4842	-0.2241	0.0749	-0.6706	0.0142	0.3882	-0.3167	-0.2217
03-Jan-17	25-Jan-17	16	0.0635	500.0000	478.4	0.2931	0.0123	0.4999	-0.1929	0.0638	-0.7069	0.0123	0.3533	-0.2653	-0.2524
02-Jan-17	25-Jan-17	17	0.0675	500.0000	478.7	0.3027	0.0124	0.5151	-0.1920	0.0717	-0.6973	0.0124	0.3763	-0.2736	-0.2642

Fig 7

Financial Derivatives could be sensitive to factors such as changes in the price of underlying asset and many other factors and events that take place in stock market. Each character denotes the sensitivity of an option price to change in some attribute of the underlying asset. These attributes imposes greater risk on investor and in order to maintain their portfolio and earn returns he/she has to manage the risk. Greek characters help investors in managing risk of their portfolio as they are easy to calculate and shows investors sensitivity of their investments based on which investor may take decision to buy and sell options.

We have calculated the parameters for three companies namely HDFC (Finance), ITC (FMCG) and RELINFRA (Power and Distribution). From the analysis of result we found out that Reliance infrastructure has in the money that is the stock price of reliance infrastructure is more than the strike price. This makes reliance infrastructure options less risky and thus attracts more investors to buy. Investors who are risk conscious can buy this option rather than options of HDFC or ITC which are out the money i.e. the stock price is less than strike price. Out the money options are less expensive at the same time they bare high risk associated with them in turn resulting in making portfolio highly risky.

Suggestions

Based on the above Calculation following are the suggestion for option trading:

1. Investor should wait for the time to increase in the value of underlying asset in case of HDFC and ITC to make Profit.
2. Investors can generate in the money in case of Reliance Infrastructure.
3. Investors should calculate sensitivity of the option before making any option trading decisions.
4. Financial tools like Greeks should be used by investors to manage their portfolio risk and derive expected returns on their investments.

Conclusion

The main objective of this study was to analyze the fluctuation in the options prices of the company and also to find out the factors affecting this options price. This study helps investor as to how to behave in the options market. Greek letters represents how sensitive a financial derivative's prices are to change in parameter. Below are the conclusions which can be drawn based on calculation

Option Delta is one of the most vital measurement method of all as it can investigate the level of sensitivity that an option price will move if there is change in the value of underlying asset.

Option Gamma measures the change in delta that is sensitivity to the movement in the stock prices. Positive gamma means that as stock rises the option prices will be more sensitive to further stock changes and negative gamma means rise in stock prices will result in less sensitive of stock. Gamma tends to rise as an option moves closer to expiration. Hence in the last week of option's life small change will result in large fluctuations in option pricing.

Option Vega is a measure of options sensitivity to change in implied Volatility. Implied Volatility is the market's estimate of the volatility which is calculated by standard deviation. Any change in such implied Volatility will affect the prices of stock. Vega measure the net effect of volatility on options pricing i.e. higher the absolute value of Vega the more sensitive the options are to implied Volatility.

Option Theta is the measure of decay in the value of option as it near expiry. Options are decaying asset and the prices keeps on reducing as it near the expiry date hence the options should be sold at the right time by the investor to earn the expected profit out of their investment. Theta value increases as options expiration nears.

Option Rho is the measure of the sensitivity of the option price with respect to change in interest rate prevailing in the market. Interest rates are likely to remain same

throughout the period hence the use of rho in option trading is less. However the use of rho for long term option is very important as interests rate remain constant for short period of time but in long run even interest rate play an important role in option pricing.

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