OPTIONS: HISTORICAL OVERVIEW, FUNDAMENTAL TERMINOLOGY AND VALUATION TECHNIQUES

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Abstract: Since options are an important segment of the financial markets and economy in general, it is important to get a better understanding of them. This study will offer a deeper insight into the history and development of options and will explain the fundamental theory such as classification of options based on exercise style and payoff calculation. Also, it will conceptually describe valuation techniques that are commonly used to price American and European options (Black-Scholes-Merton Model and The General Monte Carlo Simulation) and their advantages and disadvantages. I believe that this paper will serve as guide for all those individuals who are interested in learning more about option trading and that it will equip them with necessary knowledge and skills.

Keywords: financial derivatives, options, valuation techniques

JEL Classification Code: G12, G13 FIN

HISTORY OF OPTION TRADING

This section gives a brief overview of the historical development of option trading. It beings by examining the option trading in Greek civilization in 4th Century BC. It also describes Tulipmania, an option trading event in Netherlands that had caused many Dutch investors to lose their wealth and pushed the Dutch economy into the recession. For many years, investors have been skeptical about option trading since they realized the consequences of Tulipmania. Discovery of The Black Scholes Pricing Model, however, allowed investors to estimate theoretical option prices has raised investors' confidence. The increase in investors` confidence had triggered the expansion of option markets.

Options trading can be traced back to Greek civilization. Through the work *Politics*, the Greek philosopher Aristotle provided a reference about the successful speculation of the philosopher Thales. Although Aristotle`s short anecdote is lacking information related to the nature of the contract, it shows the existence of informal option contracts in the past (4th Century BC).

The interesting event that illustrates the use of options in the modern era was the Tulip Bulb Mania, also known as Tulipmania in the 17th Century. This event occurred in Holland where tulips had high popularity and have been a symbol of Dutch aristocracy. Tulipmania had its roots in the Ottoman Empire when Suleiman the Magnificent noticed the flower in the 15th Century (Holodny, 2014). Tulips popularity had spread across Europe and tulip demand increased significantly. The increase in demand for tulips caused the increase of their price, which served as an incentive for Dutch families to start investing in tulip contracts using their savings or borrowing against the assets that they possessed (ex. homes). In the article published in *The Economist* (October 2013 edition), historical data were used to show the irrational value of rare tulips:

At the beginning of 1637, some tulip contracts reached a level about 20 times the level of three months earlier. A particularly rare tulip, Semper Augustus, was priced at around 1,000 guilders in the 1620s. But just before the crash, it was valued at 5,500 guilders per bulb—roughly the cost of luxurious house in Amsterdam (Aievoli, 2016, p.9).

Tulip growers used to buy puts to protect their profit in case that the price of tulip bulbs decreased. Tulip wholesalers would buy calls to protect themselves of the risk caused by decreases in tulips` price. The price of tulips continued to rise and eventually it reached the point when the "bubble burst" and the obligations for that season`s bulbs became worthless (Goldgar, 2008). Since Dutch people had invested everything that they had in tulips, the crash of the tulip market made them lose their money and homes. Since the tulip option market was unregulated, it was impossible to make investors fulfil their obligations specified in their option contracts. In the book *Tulipmania: Money, Honor, and Knowledge in the Dutch Golden Age*, Anne Goldgar presents two important myths of Tulipmania. She argues that the drop-in prices wiped out the merchant class. Additionally, Goldgar claims that the Dutch economy went into a recession and options gained a negative reputation globally.

In the period between the 16th and 19th Century, options were banned in many countries since people had understanding of Tulipmania debacle. Options were banned across the world: from Europe, Japan, and some states in the US but the most notable ban was in London (England). In 1733, Sir John Barnard introduced the bill *An Act to prevent the infamous Practice of Stock-jobbing in the UK in order to prevent option trading*. It is interesting to add that the ban in London lasted over 100 years and was finally lifted during the late 19th Century.

Russell Sage, an American financier and politician, is a notable figure in the history of options trading. He created call and put options that were traded over the counter in the US in the late 19th Century ("Russell," 2016). Sage has made millions by trading those newly created options that were highly unregulated and illiquid. There was a market crash in 1884 that could be perceived as the foreshadow to the Great Depression (Sobel, 1968). The

market crash in 1884 was caused by the failure of Grant and Ward and Marine National Bank of New York (Sobel, 1968). The collapse of those two firms had caused many other firms to fail and created panic on the Wall Street. Russell Sage had lost his fortune and he quit trading, but the option market continued to operate without any regulations. Although in that time, the formal exchange market was not established – there is belief that Sage was the first one who created a relationship between the price of the option, the price of its underlying security, and the interest rates.

Option trading was not progressing a lot due to the investors` skepticism. There have been many debacles caused by inconsistent option pricing, so investors did not want to purchase or sell options. During the 1960s, the Chicago Board of Trade has noticed a significant decline in the trading at their exchange, so they had to focus on a new approach that would make business grow. In fact, they realized that only the creation of the formal option exchange would promote and attract option trading. In 1973, the Chicago Board of Options and Exchange (CBOE) had begun trading option and that was the first time in the US that options contracts were properly standardized on the marketplace and made option trading more regulated.

In the beginning, there were only a few option contracts listed on the CBOE since many investors have remained averse towards option trading. The first listed contracts were mostly call options because many put options were not standardized at that time. Discovery of the Black Scholes Pricing Model had a positive impact on investors, so they became more comfortable with option trading. In 1977, the put options were introduced on the CBOE and option trading started its expansion. According to Kiernan (2015), in 1982 more than 500,000 contracts were traded in a single day. Kiernan (2015) also writes that in 2014, 16.9 million contracts were traded on average per day. By comparing data from 1982 to 2014, it is possible to notice the expansion level in the options market.

OPTION TERMINOLOGY

The main aim of this section is to define basic terminology and characteristics of option contracts that are widely used in finance. It also describes the classification of options based on exercise style and payoff calculation. This section also shows the general use of the options in investment and the role of the option pricing.

An option is a common form of a derivative because an option derives its value from its underlying asset. In fact, most exchange-traded options have stocks as their underlying asset, but they could have any other type of security or commodity such as indexes, interest rates, bonds, currencies, swaps, baskets of assets or an economic goods such as real estate, water and electricity (McCafferty, 2011, p.3). Technically, it is possible to place an option on anything that can be purchased: coffee, cocoa, gold, silver, oil, gas, a plane, watch and so on.

People who buy options are called holders and people who sell options are called writers. Holding the option gives the buyer the right to do something with it, but it does not obligate the buyer (holder) to exercise the option. On the contrary, in forward and futures contracts the sellers and buyers have committed themselves to some action.

Unlike the stocks that investors can hold forever, the options have an expiration cycle defined in the binding contract. The buyer of the option has the right, but not the obligation to exercise the option at the expiration date. Every option is linked to the binding contract, which strictly defines terms and properties related to that option. Natenberg (2015) claims that "without the understanding of the terms of an option contract and the rights and responsibilities under that contract, a trader cannot hope to make the best use of options, not will be prepared for the very real risks of trading" (p.26).

Through the analysis of the contract specifications, all options are classified into two groups: call options and put options. A call option gives the buyer the right to purchase an asset at a certain price within a specific period. On the other hand, a put option gives the buyer the right to sell an asset at a certain price within a specific period. Simply, it is possible to notice that in option trading, all rights lie with the buyer and all obligations with the seller. A call option is a bullish instrument since the market participants expect that the price of the underlying entity (e.g. stock) will increase. On the contrary, a put option is a bearish instrument since the market participants expect the price decrease of the underlying asset.

There are four positions in option trading: Long Call, Long Put, Short Call, and Short Put. Option positions together with rights and obligations of buyers and sellers are summarized in **Table 1**. In fact, it is generally accepted that that option buyers have long position, and sellers have short position.

Table 1: Option Positions

	Call	**Put**
BUYER (Long)	Right to buy	Right to sell
SELLER (Short)	Obligation to sell	Obligation to buy

Source: TD AMERITRADE, p.39

From **Table 1**, it is possible to notice that while buying the call and/or put option does not carry any obligation, selling the call and/or put option obligates an investor to sell or buy a stock at the strike price, respectfully, if assigned by the option owner who exercised the option. Since holding options exposes investors to time decay, it is reasonable that investors want to have options with a longer expiration cycle, which could potentially enable the increase in the options` value (Cohen, 2005, p.3). More particularly, Cohen (2005) explains that in respect to four option strategies, investors will buy calls and puts that will have at least three months left to expiration date (p.3). Furthermore, the investors will sell (short) calls and

puts within a short time exercise cycle (preferably less than a month) which will bring investor short-term income.

The price of a particular option can be split into two components: the strike price and the intrinsic price. The strike price is fixed in the contract and specifies the price at which a specific derivative contract can be exercised. The intrinsic value is the difference between the underlying market price (spot price) and the strike price. For a call option, the option is "in-the-money" if the underlying price is higher than the strike price; then the intrinsic value is the underlying price minus the strike price. For a put option, the option is "in-the-money" if the strike price is higher than the underlying price; then the intrinsic value is the strike price minus the underlying price. It is possible to notice that if a call option is "in-the-money," a put option with the same exercise price and underlying contract must be "out-of-money "and vice versa (Natenberg, 2015). Depending on the relationship between an option`s exercise price and the price of the underlying contract, an option could also be "at-the-money" and "out-of-the-money." An option is "at-the-money" if the exercise price is the equal to the current price of the underlying contract. An option is "out-of-money" if it does not have intrinsic value or simply the strike price exceeds the current spot price of the underlying asset.

When an exchange-traded option is exercised, depending on the terms specified in the contract, it can settle into three cases: 1) the physical underlying; 2) a futures position and 3) cash.

Each option is part of the particular style or family that is usually defined by the dates on which the option may be exercised. Styles can also depend on option complexity and the payoff calculation. The majority of options could be classified as European or American because their payoff is calculated similarly. European and American options are known as vanilla options due to their level of complexity. On the other hand, there are exotic options that have specific characteristics, which can create challenges in the valuation and hedging process. Asian options, Bermudan options, Evergreen options, Russian options and Binary options are types of exotic options. From the exotic options listed, it is possible to notice that the name of the option is mostly correlated to a particular geographic region. It is wrong to think, however, that the name of option is related to the options in the specific geographic region. For example, Asian options are the most basic form of exotic options and their main characteristic is that their payoff is determined by the average underlying price over some time. In 1987 Mark Standish and David Spaughton, workers in London-based Bankers Trust fixed derivative department, were in Tokyo on business when they developed the first commercially used pricing formula for options linked to the average price of crude oil (Palmer, 2010). They named this exotic option as the Asian option because they were in Asia when they created it.

The Options Clearing Corporation (OCC) is a vital entity in option trading. The main role of the OCC is to standardize option contracts, to

guarantee the performance of option contracts, and to issue options (McCaffery, 2011, p.58). McCaffery also explains that standardization is the procedure that makes all option contracts interchangeable and liquid, so they can be traded between investors (p.59). For example, it would be very hard to buy 25.75 shares of Apple and hope to find someone who would be willing to buy that identical contract. In the case of the issuance of a new option request by an exchange member, the exchange has to present the request and get the approval from the Security and Exchange Commission. When the new product is approved, OCC creates its specifications and settle options on the market.

TRADING OPTIONS: EXCHANGE FLOOR, OTC OR HYBRID

Options trading can be floor-based, over-the-counter (OTC) or a hybrid of those two exchange types. The exchange type, however, should not have significant impact on the average trader at all. Although the exchange type should not necessarily have an impact on the trader, it is crucial to observe the functioning and volatility of the exchange in general (McCafferty, p.58). It is possible to trade options on the following exchanges in the US: Chicago Board Options Exchange (CBOE), Chicago Mercantile Exchange (CME), Chicago Climate Exchange, Chicago Board of Trade and New York Mercantile Exchange (merged and acquired and now are CME Group), Nadex, International Security Exchange (Eurex ISE), and many other (McCafferty, p.57).

Market Makers are considered important people in the process of the facilitating option trading. Their role is to quote a bid and offer (ask) price on the particular option. The bid represents the price at which Market Makers are willing to buy a particular option and offer (ask) is the price at which Market Makers are willing to sell a particular option. The main goal of market makers is to increase the liquidity of the option market by ensuring the constant purchasing/selling of options at some quoted price without any delays (Hull, p.203).

It is important to mention that some exchanges have established the position limits and exercise limits. The position limit and exercise limit are usually equal, and their main goal is to prevent the market from being excessively influenced by the activities of an investor or a group of them (Hull, p.203). The position limit refers to the maximum number of the option contracts that one investor can hold on the one side of the market (Hull, p.222). More precisely, long calls and short puts are on the same side of the market, and short calls and long puts are on the same side of the market too. The exercise limit is defined as the maximum number of the option contracts that can be exercised by an individual, or the group of them acting together, in any period of five consecutive business days. There is a general belief that the position limits and exercise limits are not necessary for the proper function of the exchanges which makes them very controversial. The US

exchanges are large and liquid, so they cannot be easily influenced by an individual or the group of them.

Derivative markets are considered liquid, so they attract many different types of traders. In fact, traders can be categorized as into three categories: hedgers, speculators and arbitrageurs. Hedgers use options to reduce the risk that can be caused by the potential future movements in prices. Hedging can simply be compared to taking out an insurance policy that offers the protection from high price volatility. Speculators use options to bet on the future direction of a market volatility and they enable investors to limited loss to the amount paid for the option (Hull, p.10). Arbitrageurs take offsetting positions in two or more instruments to lock in a profit (Hull, p.10).

METHODS FOR OPTIONS PRICING

Because the value of an option contract does not depend only on the value of the underlying asset, but also on many other variables such as market volatility and option exercise time, the option pricing procedure is more complex. The aim of this section is to conceptually investigate mathematical models that are used for pricing options. Many different valuation models have been developed, but not all of them can incorporate all variables that have impact on the option price. Commonly used models in options pricing are: 1) The Black-Scholes-Merton Option pricing; 2) The Monte Carlo Simulation; and 3) Lattice models: Binomial and Trinomial tree. Although there are many different valuation models used in option pricing, this study will only focus on two frequently used models in the literature: The Black-Scholes-Merton Model and The Monte Carlo Method.

Black-Scholes-Merton Option Pricing Model

The Black-Scholes Option Pricing Model had a crucial role in development of the option markets because it was the first mathematical model established with the purpose to valuate options. It is used for the development of many other pricing models. In 1970 Fischer Black, a mathematical physicist, and Myron Scholes, a professor of finance at Stanford University, wrote a paper titled *The Pricing of Options and Corporate Liabilities*. The authors tried to publish the paper, but various publishers rejected it. They managed to publish the paper in 1973 in Chicago University's Journal of Political Economy. Black and Scholes claimed that every option has a correct price, which could be determined by using their equation known as the Black-Scholes formula. In 1973, a subsequent paper, *Theory of Rational Option Pricing*, was written by Robert Merton with the aim to expand on the Black-Scholes option-pricing model. Black, Scholes and Merton have shown the application of differential equations to determine a fair value of European style calls and puts. Merton and Scholes were awarded the Nobel Prize in Economics in 1997 in honor of development of the model – two years after the death of Fischer Black.

The assumptions of the model are: 1. Options can be exercised only at expiration; 2. Risk-free rate and volatility are constant over the life of the option; 3. The underlying security does not pay dividends; 4. The underlying security will sometimes go up in price and sometimes go down and that the direction of the movement cannot be predicted; 5. There is no commission charged on the purchase or the sale of the option; 6. There is no arbitrage opportunity.

Natenberg (2015) claims that "Black-Scholes model, with its very simple arithmetic and limited number of inputs, most of which were easily observable, proved an ideal tool for traders in the newly opened U. S. option market" (p.62). In fact, in order to calculate an option`s theoretical value by using the Black-Scholes model, we need to know at least five identifiers of the option and its underlying contract. The five crucial variables of the Black-Scholes model are:

1. The option`s exercise price (strike price): the price is fixed, and it is defined in the binding contract.
2. The time remaining to expiration: it is fixed and cannot vary.
3. The current price of the underlying contract: the correct price of the underlying contract is not always obvious. There is a bid price and ask price (bid-ask spread) and it may not be clear whether a trader should use the bid price, ask price or some value in between. The current price of the underlying contract should be the price for which the trader believes that she/he can make the most favorable trade.
4. The applicable interest rate over the life of the option: since the option trader may end up with the cash credit or debit on his/her trading account –the interest generated by those cash flows should be considered. Usually, it is suggested to use the prime risk-free rate (the rate that applies to the most secure borrowers).
5. The volatility of the underlying contract – this is the most difficult variable to be understood. Volatility could be considered as the most important variable in actual trading. Any change of assumptions related to the volatility could have significant effect on the option`s value.

Limitation of the Black-Scholes Model

It is crucial to keep in mind that this model assumes that the risk-free rate and volatility are assumed to be constant over the option`s life-span. This assumption is very unlikely to be encountered in option trading. Furthermore, the other major assumption is that the option can only be exercised at the maturity, but not all options have the same maturity date. In fact, this model loses its magic when dealing with vanilla options: American options, since they can be exercised anytime during their lifetime. It is possible to valuate European option using the Black-Scholes-Merton model because European options can be exercised only at the end of their lives. In

contrast, the Black-Sholes-Merton model fails in the process of valuation American options because American options have a more flexible exercise rule and can be exercised at any time before the expiration date.

The Monte Carlo Simulation

The Monte Carlo Simulation is one of the most important and powerful algorithms in finance. Its application is very common in option pricing, risk management and financial modeling. The advantage of this algorithm is the ability to handle complex and high-dimension problems. There are many different types of the Monte Carlo Algorithm, but this paper will be only focused the General Monte Carlo.

The fundamental methods of the first modern Monte Carlo Simulation were established and used by John von Neumann and Stanislaw Ulam. In fact, Stan Ulam came up with the idea while he was recovering from illness and playing solitaire (card game). Ulam tried to calculate the likelihood of winning based on the initial layout of cards using combinatorial calculations (Eckhardt, 1987). Due to the calculation complexity, Ulam decided to focus more on a practical approach by trying many different layouts and observing the number of successful games (Eckhardt).

Ulam and Van Neumann had suggested the use of their simulation to investigate the properties of neutron traveling through radiation shielding. This simulation was part of the secret Manhattan Project during World War II when the US government had plans to develop nuclear weapons. Due to the fact that the chance and random outcomes are central to the Monte Carlo method, Ulm and Van Neumann have named The Monte Carlo Method in reference to popular gambling center Monte Carlo.

Since the Monte Carlo Simulation has gained popularity in many different disciplines ranging from the natural sciences to finance, its diverse application has caused adjustments of the method and the creation of many different versions of the Monte Carlo simulation. Hull (2012, p.470) summarize the five fundamental steps of The Monte Carlo Simulation used to estimate the value of particular derivative. The author assumes that the interest rate is constant in the economy.

Five-Step Monte Carlo Method:
1. To sample a random path for S in a risk-neutral world
2. To calculate derivative payoff using formula St = S_0exp((r - $\frac{1}{2}$ σ²)T + σ√Tz)
3. To keep repeating step 1 and step 2 in order to collect many sample values of the payoff from derivative in as risk-neutral environment
4. To calculate the average of the sample payoffs in order to get an estimate of the expected payoffs in a risk-neutral world
5. Discount the expected payoff at the risk-free rate using The Monte Carlo Estimator: $C_0 \approx e^{-rT} \frac{1}{I} \sum_I payoff$

Advantages and Disadvantage of The Monte Carlo Simulation

The Monte Carlo Simulation is more efficient than other models when there are more than three stochastic variables included in the calculation. In fact, the time needed to perform The Monte Carlo Simulation increases approximately linearly with the number of variables (other models usually have exponential time complexity). The Monte Carlo Simulation requires a lot of memory even for the simplest programs which implies that efficient implementation of it is crucial.

CONCLUSION

This paper began by explaining the historical roots and development of options as financial instruments. It showed that options can be traced back to the Ancient Greek civilization (4th Century BC). Furthermore, it explained the event of Tulipmania and pointed out that options were perceived as obscure and were banned until the discovery of the first formal mathematical valuation technique (Black-Scholes-Merton model).

Since the interest in option trading increased significantly in the past few decades, this paper also showed the most important terminology related to this area of finance. It explained important characteristics of option contracts, classification of options based on exercise style and payoff calculation, and the most important agents in derivative markets.

At the end, The Black-Scholes-Merton and The General Monte Carlo Simulation are conceptually presented since they are two most common methods used to valuate the options. Also, it included some historical facts related to development of those methods and presented their advantages and disadvantages.

OPCIJE: ISTORIJSKI PREGLED, TEMELJNE TERMINOLOGIJE I TEHNIKE VREDNOVANJA

MA Gorica Malešević

Apstrakt: S obzirom da su opcije važan segment finansijskih tržišta i ekonomije, važno je imati dobro razumijevanje istih. Ovaj rad će pružiti uvid u istoriju i razvoj opcija te će objasniti fundamentalnu teoriju kao što je klasifikacija opcija zasnovanih na stilu i obračunu isplate. Takođe, konceptualno će opisati tehnike vrednovanja koje se često koriste u procesu valuacije američkih i evropskih opcija (Black-Scholes-Merton model i General Monte Carlo Simulation) te njihove prednosti i mane. Vjerujem da će ovaj rad služiti kao vodič za sve one pojedince koji su zainteresovani da više saznaju o trgovini opcijama i da će ih opremiti potrebnim znanjem i vještinama.

Ključne riječi: *finansijski derivativi, opcije, tehnike valuacije*

BIBLIOGRAPHY

1. A Brief History of the Options Market. (2015, September 18). Retrieved April 17, 2017, from https://www.thealertinvestor.com/history-of-options-market/
2. Aievoli, P. (2016). Veal: The rise of generation interactive. Lincoln, Nebraska: Zea Books. Retrieved from http://digitalcommons.unl.edu/zeabook/47/
3. Black, F., & Scholes, M. (1973). The pricing of options and corporate liabilities. Journal of Political Economy, 81(3), 637-654. http://doi:org/10.1086/260062
4. CBOE. (n.d.). About CBOE: History. CBOE. Retrieved March 1, 2017 from http://www.cboe.com/aboutcboe/history
5. Cohen, G. (2005). The bible of options strategies: The definitive guide for practical trading strategies. Upper Saddle River, NJ: FT Press.
6. Eckhardt, A. (1987). Stan Ulm, John Van Neumann, and the Monte Carlo method. Los Almos Science, 15 (Special issue), 131-143. Retrieved from http://library.sciencemadness.org/lanl1_a/lib-www/pubs/00326867.pdf
7. Glasserman, P. (2003). Monte Carlo methods in financial engineering. Berlin: Springer.
8. Goldgar, A. (2008). Tulipmania: Money, honor, and knowledge in the Dutch golden age. Chicago, IL: University of Chicago Press.
9. Harrison, R. L. (2010). Introduction to Monte Carlo Simulation. AIP Conference Proceedings, 1204, 17–21. http://doi.org/10.1063/1.3295638
10. Hull, J. (2012). Options, futures, and other derivatives. Boston: Prentice Hall.
11. McCafferty, T. (2011). Options demystified. New York: McGraw-Hill.
12. Merton, R.C. (2005). Theory of rational option pricing. Theory of Valuation, 229-288. doi:10.1142/9789812701022_0008
13. Natenberg, S. (2015). Option volatility and pricing: advanced trading strategies and techniques. New York: McGraw-Hill Education
14. Poitras, G. (2011). Valuation of equity securities: history, theory and application. New Jersey: World Scientific.
15. Russell Sage. (2016). In Encyclopaedia Britannica Online. Retrieved from http://www.britannica.com
16. Sobel, R. (1968). Panic on Wall Street; a history of America`s financial disasters. New York: Macmillan.
17. TD Ameritrade. (2013). How to thinkorswim. Lund, K (Ed.). (n.p): T3 Custom.
18. The History of Options Trading. (n.d). Retrieved April 17, 2017, from http://www.optionstrading.org/histor
19. Weisenthal, J. (2012, March 04). The Story Of The First-Ever Options Trade In Recorded History. Retrieved April 17, 2017, from http://www.businessinsider.com/thestory-of-the-first-ever-options-trade-in-recorded-history-2012-3