Winter 12-15-2015

The Historical Role of the Use of Derivatives for Speculation

Charles Austin Boyd II

Winter 12-15-2015

THE HISTORICAL ROLE OF THE USE OF DERIVATIVES FOR SPECULATION

Charles Austin Boyd II

THE HISTORICAL ROLE OF THE USE OF DERIVATIVES FOR SPECULATION

By

Charles Austin Boyd II

Submitted in Partial Fulfillment
of the Requirements for
Graduation with Honors from the
South Carolina Honors College

December, 2015

Approved:

James Austin
Director of Thesis

Thomas M. Hughes
Second Reader

Steve Lynn, Dean
For South Carolina Honors College

Table of Contents

Thesis Summary

The creation of this thesis was a long and winding road indeed. I began to take interest in the subject of options trading in the Fall of 2014 when I took a class for my finance major: Derivative Securities. While it was not a total failure, I struggled heavily with the abstract nature of the subject matter, and was reminded of the importance of advanced mathematics in the financial world. Even the basic payout equations gave me trouble at first; the whole practice reminded me of the word problems that would be assigned in my linear algebra classes, and the collision of my math and business educations really piqued my interest. I began the project by studying every piece of literature I could get my hands on: my old textbook, technical manuals thick with mathematical proofs, less technical nonfiction books on the history of the trade, seminal academic papers, biographies of mathematicians, and much more. Two recurring themes began appearing in my research. First, for every credible or important source I would find online, there would be ten invitations to pay for someone's foolproof options trading strategy with the promise of huge returns and the creation of fortunes. Second, most of what has been written regarding speculation using derivatives has a decidedly negative tone, focusing on market crashes and instances of abuse that are in many cases too complex to pin the blame on a single factor. For this reason I decided to take a look at how the practice of speculation may have actually helped the creation of markets as we know them today, and the history of their usage. I found that the practice is as old as time, and certainly shaped modern financial markets.

Abstract

As long as humans have had a concept of possession of items and a means of trading for them, there have been speculative position in the form of derivative contracts. The first instance of a written code of laws contains protection for farmers leveraging their future crops. Aristotle writes of an instance of the equivalent of call options being used to secure a monopoly on olive presses. Many features of contemporary derivative markets were developed in Europe during Medieval trade fairs or Renaissance *bourse* marketplaces. The development of the first modern stock exchange brought with it further development in the speculation of not just commodities but the performance of a company's profits. The increased usage of derivative contracts known as options required that a sound mathematical model be developed to accurately price these instruments. That model would take three separate generations of academic and financial minds to develop. Centering on the idea of future stock price movements as a random variable, the Black-Scholes formula was ultimately discovered and allowed for the first regulated exchange markets for options that exist to this day.

Introduction

Derivative contracts have been a part of human history since the first humans settled into the cradle of civilization between the Tigris and Euphrates rivers. Mesopotamians had a wonderful habit of writing their contracts onto clay tablets, and because of their durability some early forward contracts for grain or other crops have survived as evidence of their trading practices. These contracts even enjoyed some legal protection, as the 48th law of Hammurabi's Code deals with protection against the risk of a catastrophic natural events on the wheat harvest for farmers who have borrowed money or rented land. It is certainly worth noting that the world's first written code of laws contains a section on speculative positions in agricultural commodities. It confirms the existence of leveraging practices have existed since the beginnings of commerce.

In Aristotle's Politics, he tells the story of Thales, a fellow philosopher who set out to prove that the profession of philosophy could indeed be profitable. Through his knowledge of astronomy, Thales predicted that there would be a large olive harvest in Greece. Based on this foresight he negotiated with the area's merchants for the right to rent all of the olive presses for the following harvest season, paying only a small deposit. The depository agreements that Thales paid to the owners of the olive presses essentially amount to a call option: the right, but not the obligation, to take possession of an asset during the course of an agreed upon amount of time. When the harvest came, Thales took possession of the presses and sold their services at whatever price he desired, turning a huge profit.

As international trade in Europe began to increase towards the end of the Middle Ages, centralized markets developed in order to match buyers and sellers. Medieval trade fairs facilitated this process by organizing gatherings where goods and services could be transferred between buyers and sellers. Major sites of these fairs included Genoa, Geneva, Lyons, and Champagne, but many others occurred throughout medieval Europe. The fairs standardized the trading practice and concentrated the time and location of trade between merchants located long distances from each other, making "international" trade more practical and profitable in a time where transportation was expensive, time consuming, and risky. In addition, they established a standardized clearing process, which fostered higher volumes of trades by transferring default risk away from both participants. As trade volume grew over time, stationary trading centers could be supported year round, rather than temporary fairs. The trading system that developed is known as the bourse system. The bourse system revolved around unofficial market locations in major European commerce centers. Antwerp became one of the most important of these cities. Techniques seen later in the development of derivative trading have their roots in the Antwerp markets. Trading on the future returns of an uncertain outcome began when merchants would basically gamble on whether or not a ship's cargo would arrive safely. The buying and selling of positions on an intangible asset, with gains or losses paid on a cash basis with no delivery of the underlying asset, would prove to be the basis for modern options trading.

Throughout the course of the development of modern financial markets, it will be seen that speculative ventures, such as derivative contracts, are necessary for efficient financial markets to exist because the speculative and hedging activity they promote increase trading volume in their underlying asset market. This volume is a necessary condition for sufficient liquidity in its market and estimation of its intrinsic value and thus accurate pricing. The search for a formula that can accurately price the value of such derivatives markets is a precondition for modern exchange traded derivative contracts.

The First Stock Options

Modern financial markets were born in the month of March, 1602, in Amsterdam and five other Dutch cities. This was the month in which the States General granted charter to the Dutch East India Company, abbreviated VOC and known colloquially as "the Company." The Company would be organized as a publicly available joint stock share, with all Dutch residents invited to subscribe to shares in the venture between April 1st and August 31st. The dates for the world's first IPO in a modern exchange were set. The corporate structure of the Company was made up of six semi-autonomous "chambers" located in Amsterdam, Enkhuizen, Hoorn, Delft and Rotterdam in the province of Holland and Middelburg in Zeeland. Each chamber had their own ship that would sail in fleet with the other five Company ships to the East Indies and back. Upon the voyage's completion, each ship would return to their respective port, where the responsibility of organizing an auction of the goods fell on each chamber. The proceeds would then be aggregated and redistributed among each chamber based on the percentages of shares held on each chamber's books. Each chamber issued its own shares during subscription; a share from one chamber was not equivalent to a share in another although both signified the same percentage claim to the Company's profits as a whole. The most important feature of the shares was that they were transferrable between individuals, all that was required was a request to the bookkeeper to change the name in the ledger from the seller to the buyer. This allowed for a secondary market for VOC shares to develop that would grow over the course of the 17th century to a full service modern stock exchange.

The Amsterdam chamber sold 1,147 shares during the subscription period which translates to about 57% of all offered shares. Following the subscription period, a secondary market for VOC shares began to emerge. By 1607, a secondary market for forward contracts began to appear. The market for options contracts was at least existent by the middle of the 17th century. During this time, the emergence of the first stock options began with long and short positions on “priviledges” on Dutch East India Companny shared being trading on the Amsterdam exchange, complete with standardized maturities. It’s hard to tell when options trading began to catch on, or the scope of the practice on the Amsterdam bourse; however, the Official Options Tariff was imposed in 1689, suggesting that it was prevalent enough to see as a profitable target for the government to tax.

Most scholars on the subject agree that the market for VOC shares did not turn speculative until the second half of the 17th century. The speculation surrounding the trade in the latter half of the century led to a more efficient market. For the first half of the century, the period immediately following the first offering of Company shares, the volume of transactions concentrates around a few weeks out of each year. This increased trading activity can be explained by new information arriving about the status of a particular voyage: the fleet leaves, first news of the endeavor’s status, or the ship physically returning to port. This trading pattern would indicate that the spot market is the prevalent tool for investment in those years. Volume began to pick up once concerns on the legality of the joint stock structure began to clear closer to the second half of the century. During the second half of the century, volume of transactions increased substantially. Importantly, the distribution of volume is evenly spread throughout the year, favoring the last week of each month when the process of settling margin accounts, *reconstre*, occured. This shift in volume pattern concentrated around the settlement of monthly margin calls suggests that the derivative market had become the preferred method of investment. The Amsterdam market had become decidedly speculative.

According to the first versions of the Efficient Market Hypothesis as put forward by economist Eugene Fama, a market can be efficient if it satisfies these three conditions: there are large number of participants, the participants behave rationally, and they compete to predict future market movements. The move to a more modern, speculative market in Amsterdam helps market efficiency as defined by Fama; the added volume fulfills the stipulation that a market be composed of numerous participants competing to predict future price. The added volume also helps in another of Fama's conditions: that participants behave rationally, which can be interpreted as, "they did not take on bad positions." Increased numbers of transactions help to flush out the instrument's real value by added to the sample size of what other people have paid for it. There is actually an example of the market processing unannounced information in 1688. Stadholder William III was secretly making plans to invade England. He had only consulted a small number of advisors, but starting at the end of August, an abnormally high volume of trades were taking place. Somehow the rumor of William's plans had circulated and were being borne out in the market. On September 22, the rumors proved true as the State of Holland approve the recruitment of troops. Had this same scenario played out eighty years earlier in the thin markets of the early 17th century, there would not have been enough liquidity to handle the situation.

The Shortcomings of Early Derivative Markets

Early derivative markets had their flaws. The true value of a contract was based largely on anecdote and "rules of thumb." Because of this an investor outside of the ranks of professional brokers was unlikely to know what a fair deal was and wasn't. This scenario was borne out time and time again throughout the following centuries. Options contracts began to gain some popularity in the United States in the years following the Civil War. Their popularity among retail class investors likely had to do with the advertising efforts of the brokers who were trying to sell them. They were likely popular among brokers because they turn out to be wildly advantageous to their side. Kairys and Valerio's 1997 paper, *The Market for Equity Options in the 1870s*, examines options quotes advertised weekly in the Saturday edition of The Commercial and Financial Chronicle during the period from January 1873 to June 1875. Kairys and Valerio note the advertisements that accompany the option quotations overstate the potential gains of entering an option contract, or outright distort the nature of an option class. The advertisements studied are for the primary market of a single broker, with no attempt at a secondary market. When two and a half years' worth of weekly ask quotations were compared to their theoretical fair value, 86% of calls were overpriced, 11% of calls were fairly priced, and 3% of calls were underpriced. For puts, 82% were overpriced, 16% were fairly priced, and 2% were underpriced. At the turn of the 20th century it's no wonder that trading on options had a bad image in the United States

A "fair bet" is any wager or position in which the expected value of the outcome is zero. In the previous example it's clear that the contract positions offered by the broker were examples of wildly unfair bets. A gambler is someone who is willing to take on a speculative position with an expected value less than zero. Options markets had gained the reputation of being inherently unfair, and in order to gain legitimacy beyond the Saturday morning advertisements, drastic changes in public opinion and marketplace practice would have to be made. Perhaps it is precisely that options were inherently bad bets that drew the great minds of the 20th century to solve them. A group of academics, gamblers, and investors (and all combinations of the three) were about to tackle the problem of unfair options markets. Perhaps all the options trade needed was some attention from academia.

The Road to a Fair Bet in the Options Market

At roughly the same time overpriced quotations for options on stocks listed in New York were appearing weekly in The Commercial and Financial Chronicle, a young man named Louis Bachelier was laying the foundation for an intellectual movement that would eventually bring In 1892, following a tour with the French army, Bachelier moved to Paris to pursue a degree from the University of Paris, and hopefully a career in academia. In order to support himself and his family, he spent his days trading at the Paris Bourse, while his nights were devoted to his studies in physics. After completing his undergraduate degree he stayed at the Sorbonne to begin his doctorate. His dissertation, published in 1900 and titled: A Theory of Speculation, would become a pillar of modern finance. In his thesis, Bachelier applied the theory of probability to understand the behavior of future movements of stock prices. Ironically, the field of probability theory was pioneered independently by a habitual Italian gambler, Gerolamo Cardano, and a pair of mathematicians, Blaise Pascal and Pierre de Fermat, who were working at the behest of a gambler.

Bachelier built off of an idea called Brownian motion, which describes the random movement of particles through a fluid. The phenomenon was first recorded by botanist Robert Brown in 1826 while observing the aimless wandering of pollen particles suspended in water. The idea of Brownian motion when applied to mathematic variables is referred to as a “random walk.” When variable follow a random walk, their next “step” may take them any distance from where they started, from no movement up to infinity in theory. The probability of a variables next value is modelled by a normal, or Gaussian, distribution function, which is shown graphically by a bell curve. If our variable is the future price of a given stock, most probable future values will be clumped around the current price, with future prices becoming increasingly less likely as they move further away. As the future value moves further away from the current value towards infinity, the probability of such an outcome approaches zero.

Previously, the idea of a fair bet, a wager in which both participants have an expected value of zero, was discussed in order to describe when something could be considered a gamble. Bachelier's pricing model is based on this principle. In his pricing model, Bachelier argues that the true fair price of an option is that which makes the position a fair bet. This does not, however, mean that if two investors entered into a fairly priced option contract they would necessarily come out in a dead tie; in fact, such a scenario would be inherently unlikely. A fair bet in this situation simply means that each participant has an equal chance of winning or losing in a given round.

Much of Bachelier's contributions seem almost second nature to a contemporary observer. They have percolated into market observers' collective worldview to the point where the idea that prices move based on some random pattern in the short term, or that the fair price of an asset means both sides of the transaction have an equal chance for success, are so second nature that it almost seems ridiculous to bear mention. Just over a century ago, however, these ideas were truly revolutionary, and the ideas of Bachelier were ultimately the first step towards the creation of the modern financial theory.

Bachelier's argument hangs on the assumption that the probability a stock price goes up equals the probability that the stock price goes down, that the price acts as a variable in a random walk. The lynchpin of Bachelier's argument is supported by a paper by Paul Samuelson, an MIT professor who was among the first few to rediscover the work of Bachelier. He makes a similar argument to Eugene Fama regarding the behavior of price movements in an efficient market. In his paper, Proof That Properly Anticipated Prices Fluctuate Randomly, he proves through backwards induction that if all players in a market are privy to all information, at any point in time the market will set the price to the fair expected rate of return, and speculative prices that appear around this price will form a distribution known as a martingale. In a martingale, best described by Robert Thompkins' example in his book, Options Analysis, data points behave like pellets leaving the barrel of a shotgun. While they are condensed tightly at distances close to the end of the barrel, as they move further away from their starting point they begin to spread out more widely. It is important to note that a martingale differs from a normal distribution in that the former deals with the potential , while the latter with the probability distribution of the position of a single point on its next step.

A defining property of a normal probability distribution is that any future value, however unlikely, is technically possible. Applied to the case of stock prices, this means that over a sufficient number of trials, the future price will yield a negative value. As it is impossible for a stock price to go lower than zero, this means that Bachelier's argument that price movements follow a normal distribution must be false. This was the insight of (among others including Paul Samuelson) Maury Osborne, a Virginia native trained not in finance, but rather statistics and astrophysics. Brilliantly curious and intellectually flexible, Osborne's scope of work ranged from financial modeling to the efficiency of salmon migration. He finished high school at age 15, studied astrophysics at the University of Virginia and pursued a graduate degree in the field from Berkley. The flaw in Bachelier's assumption of normal distribution: the possibility of a negative stock price. Osborne's solution was to apply the lognormal distribution function to the stock prices, with which he was familiar through his background in physics and its application to the movement of molecules. The lognormal distribution is produced by taking the natural log of the normal distribution, and is useful in that it yields results that are nonnegative and can go theoretically go up to positive infinity, conveniently in line with the properties of stock prices. The normal distribution and random walk hypothesis do have a place in Osborne's model, however. He theorizes that the rate of return, rather than the stock price itself, is the variable that undergoes a random walk. The probability that a stock price goes up one percent still equals the probability that it goes down by one percent, but the movement of the price itself is influence by their nonnegative property. Ultimately, an investor cares less about the dollar amount a stock price moves, but rather the percentage the price changes relative to the total value of the share.

Ultimately, that Bachelier's model needed revision is no slight on the man's talents or insight. Such is the scientific process, insights build upon each other and with each additional layer the true nature of the problem becomes clearer. With the revisions made by Osborne, the puzzle pieces were in place for the discovery of the holy grail of price modelling: a formula for the calculation of the fair value of an option.

The long sought-after solution to the true price of an option finally began to be realized in 1965 when Fisher Black joined the Boston-based consulting group Arthur D. Little and met a member of the firm named Jack Treynor. Treynor had been a part of the development of a model for the pricing of securities called the Capital Asset Pricing Model, which still holds as a useful analytical tool and pillar of business education fifty years later. The CAPM states that the expected return on a security or portfolio is equal to the market premium times the risk of the security relative to the overall market, plus the return on a risk free investment (as measured by a Treasury Bond). Black was immediately drawn to the formula's ability to assign price to risk, an intuitive reality that had finally been given an eloquent mathematical description. Jack Treynor left Arthur D. Little barely a year after Fisher Black had arrived, but not before Black began thinking about the applications of the CAPM to a wide range of other assets, including options.

Fisher Black met newly appointed MIT assistant professor Myron Scholes when the former first arrived in Massachusetts in 1968. The two formed a friendship and intellectual partnership. Late in 1969 when Scholes mentioned that he had a graduate student that was interested in options pricing, Fisher Black pulled out the CAPM applications he had been working on but lacked the mathematical wherewithal to solve. He had already worked out the CAPM options pricing problem to a differential equation which related the asset price, the option price, and the option price's rate of change with respect to time. Unlike previous attempts at an option pricing formula which ran into a dead end when a value for a stock's expected return was needed, but after a time they realized that *any* expected return could be used so long as it was consistent, and they settled on the riskless rate. Black and Scholes then treated the expected value of the option in the same way as they had the stock's: simply replace it with the risk-free rate. Exactly seventy years after Bachelier's A Theory of Speculation was published, a formula for the price of an option was solved; three years later *The Pricing of Options and Corporate Liabilities* appeared in the May-June 1973 edition of the Journal of Political Economy.

Fisher Black and Myron Scholes were not the only people attempting to solve the option pricing puzzle in the late 1960s. While Black and Scholes were attempting to solve the option pricing problem using the CAPM, a colleague of Scholes at MIT, Robert Merton, a graduate assistant of the Efficient Market Hypothesis pioneer Paul Samuelson. Merton was working on the problem from a completely different angle. He approached the problem with the use of a technique known as stochastic calculus (also known as Ito calculus for the Japanese mathematician who perfected it), which allows a mathematical framework for continuous random fluctuations. Merton applied this mathematical framework to the movement of stock and option prices and derived the same differential equation that Black and Scholes had solved. It's worth noting that in Black and Scholes' published paper, the Merton derivation is actually shown first, followed by their CAPM-based approach. With the more powerful mathematical framework, Merton built on the application of the Black-Scholes model to include more general conditions.

There was yet another player in the arms race to an option formula, and one that comes full circle as a reminder of the intertwined between investors, academics, and gamblers; Edward Thorp has been wildly successful as all three. Thorp is as interesting and brilliant a person as one could find, and coincidentally, he also probably solved the option pricing problem before Fisher Black and Myron Scholes. Thorp earned a doctorate in mathematics from UCLA and was offered the C.L.E. instructorship at MIT upon graduation, a seat once held by legendary game theorist John Nash. It was here that he formulated a strategy to beat the house in blackjack, and invented the practice of card counting. Thorp published a book detailing a mathematical formula on how to turn the odds in a game of blackjack in your favor by counting the number of each type of card left in a deck. His book was titled *Beat the Dealer* and was based on a published paper he titled: *Fortune's Formula: A Winning Strategy for Blackjack*. Thorp was famously bankrolled by a flashy businessman Manny Kimmel to test out his strategy on Vegas and Reno casinos, and he made out with a handsome profit. He would go on to found the first quantitative hedge funds, and it was probably during this time that he began working on the options pricing formula. He describes undertaking a strategy in 1967-68 that shows he was capable of applying dynamic hedging, and thus possessed the tools needed to solve the problem of option pricing. Thorp noticed that same thing that Black, Scholes, and Merton did: that accounting for the expected returns was as simple as replacing it with the risk-free rate, although he never proofed it and simply put it into a trial by fire test in the marketplace. The formula worked, but rather than publish it, in classic fashion Thorp admitted in a telephone interview with Boyle & Boyle that he planned on setting up a hedge fund with the new tool and that it would provide a "competitive edge."

Conclusion

The advances in pricing theory by the series of academics involved in the journey that eventually lead to the Black-Scholes equation helped the market for such instruments in two separate ways. First, they added credibility to a practice that had been looked down on as only a notch better than casino gambling for its entire four hundred years of existence. Second, accurate pricing of options contracts allows market participants to make more rational and profit maximizing decisions, thus making for a more efficient market. From the forward contracts of ancient Babylonia, to the trade fairs of Medieval Europe, to the eventual formulation of the Black-Scholes equation and the establishment of today's options exchanges, the spirit of speculation played a major role.

Bibliography

Boyle, Feidhlim, and Phylim P. Boyle. *Derivatives: The Tools That Changed Finance*. London: Risk, 2001. Print.

Fama, Eugene F. "Random Walks in Stock Market Prices." *Financial Analysts Journal* 51.1 (1995): 75-80. *JSTOR*. Web. 6 Jan. 2016

Hull, John C. *Fundamentals of Futures and Options Markets*. 8th ed. Upper Saddle River: Pearson, 2014. Print.

Kairys, Joseph P., Jr., and Nicholas Valerio, III. "The Market for Equity Options in the 1870s." *The Journal of Finance* LII.4 (1997): 1707-22. Print.

Kummer, Steve, and Christian Pauletto. "The History of Derivatives: A Few Milestones." EFTA Seminar on Regulation of Derivatives Markets. Zurich. 2 May 2012. Print.

Niederhoffer, Victor. "The Life of Matthew Fontaine Maury Osborne." *Daily Speculations*. N.p., 28 May 2013. Web. 6 Jan. 2016. <http://www.dailyspeculations.com/wordpress/?p=8410>.

Osborne, M. F. M. "Brownian Motion in the Stock Market." *Operations Research* 7.2 (1959): 145-73. *JSTOR*. Web. 6 Jan. 2016.

Petram, Lodewijk O. "The World's First Stock Exchange: How the Amsterdam Market for Dutch East India Company Shares Became a Modern Securities Market." Diss. U of Amsterdam, 2011. Print.

Poitras, Geoffrey. "From Antwerp to Chicago: The History of Exchange Traded Derivative Security Contracts." 15 Mar. 2009. TS.

Poitras, Geoffrey. "The Early History of Option Contracts." 30 Sept. 2008. TS.

Samuelson, Paul A. "Proof That Properly Anticipated Particles Fluctuate Randomly." *Industrial Management Review* 6.2 (1965): n. pag. Print.

Thompkins, Robert G. *Options Analysis*. London: Macmillan, 1994. Print.

Weatherall, James Owen. *The Physics of Wall Street: A Brief History of Predicting the Unpredictable*.
New York: Houghton, 2013. Print.

Weber, Ernst Juerg. "A Short History of Derivative Security Markets." Aug. 2008. TS.