# VALUING TECHNOLOGY:

# PROBLEMS WITH TRADITIONAL TECHNIQUES AND AN EXPLORATION OF A REAL OPTIONS ALTERNATIVE

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In recent years, Internet company valuations have grown at unprecedented rates, transforming start-ups into multibillion dollar companies. However, there is a significant gap between the valuations provided by traditional cash flow methods and those observed in the market. Clearly, money managers and Wall Street analysts find value in these companies beyond their future expected cash flows. This thesis begins with an examination of some of the fundamental problems with traditional techniques, and looks to option valuation techniques as a potential solution. The author then applies real options techniques on two technology companies, and concludes with an analysis of the results.

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# CHAPTER I: INTRODUCTION, MOTIVATION FOR STUDY & BACKGROUND

Anyone who has followed the stock market over the past few years can bear witness to the huge growth in the valuation of Internet and other technology companies. Companies like Amazon.com, America Online, and Ebay quickly transformed from small start-ups into companies worth tens of billions of dollars. According to *The Wall Street Journal*, more than one-third of 1999's top-performing stocks were technology companies that had not been traded three years earlier. The market for offerings of Internet companies' stock has also flourished, reaching nearly $9 billion in 1998 (Picker 1999). However, these huge valuations have been controversial and stock prices have been highly volatile. Some experts hypothesize that much of this uncertainty has occurred because traditional valuation methods, which depend on cash flow forecasts or accounting measures are ineffective when analyzing technology companies.

Furthermore, there has been a growing gap between valuations provided by traditional academic methods and those observed in the market (Mauboussin & Hiler 1999). Many professionals now rely less (or not at all) on cash flow valuation techniques to value technology companies and have begun to look elsewhere for valuation metrics. These critics of traditional techniques believe that cash flow valuation methods contain fundamental flaws that understate the value of the investments made by technology companies. Overall, their primary criticism is that the methods ignore the strategic value of technology companies' investments (we will examine the specific criticisms later in this paper). In examining this subject, this thesis will begin by first examining the challenges that these new economy companies present, then will look at some fundamental problems with traditional valuation techniques, and will conclude with an examination of how less traditional valuation techniques can be applied.

Before looking at specific valuation methods, it is important to have a basic grasp of the Internet and the electronic-commerce industry as a whole. In the last five years, the Internet has been transformed from an isolated network used primarily by the government and researchers, into a mainstream global network of more than 100 million interconnected computers (*S&P Industry Surveys* 1999). During this transformation, the Internet has evolved into an extraordinarily fast growing global marketplace where businesses and consumers meet for the exchange of goods and services. Industry experts[1] agree that the market for selling goods on-line will continue to grow tremendously, and will provide even greater opportunities for revenue growth in the future. Increasing numbers of worldwide Internet users as well as an increased percentage of both individuals and businesses purchasing goods on-line will drive this growth.

Current Internet companies defy any single industry classification. They are spread across numerous industries including financial services, travel sales, computers, software, clothing, and books. Companies compete for users in order to generate advertising revenue, gain commission from auctions, sell goods, or simply to establish themselves as a destination for web surfers.

Even though these Internet companies experience huge valuations and have access to large customer bases, most are not producing the accounting earnings or positive cash flows that traditionally drive business value. These companies have poured millions of dollars into advertising and product development, and will continue to face sizable cash outflows for the foreseeable future. Analysts understand that these gigantic investments should create future value, but have a very difficult time placing a value on them using traditional techniques. The difficulties result because of the inherent uncertainty and contingency of decisions the companies face, which makes forecasts of highly variable outcomes many years in the future almost impossible. Some experts claim that more than 70% of the market value in technology companies will come from future businesses that do not exist yet (Jagle 1999). Clearly, producing forecasts for businesses that do not even exist is very difficult. Exhibit 1.1 breaks down company value into current operations and growth opportunities for several technology industries.

First, we will examine some specific strategies that technology companies have implemented which make them unique, and will see how these strategies create problems for traditional valuation methods. Just about every Internet company has joined the frenzy to attract as many customers as possible in the shortest amount of time, regardless of short-term costs. For example, software companies like Netscape and Microsoft invested millions in developing Internet browsers, but both companies ended up giving their software away as a means to attract loyal customers and set an industry standard. Companies like Buy.com and Egghead.com sell their products at prices below cost to attract customers, establish a dominant presence and garner advertising revenue. These strategies are based on the idea that once the companies have generated a critical mass of customers, they will be able to gain a return on their initial investment.

Credit Suisse First Boston (CSFB) analyst Michael Mauboussin compares technology strategies to the creation of traditional barriers to entry, and identifies several key barriers including the network effect and switching costs. Mauboussin defines the network effect (also known as network externality) as the concept that the value of a network grows exponentially as the number of members grows arithmetically. Ebay, an online auction site is an example of a company with a strong network effect—the company's user base has rapidly grown into the millions because customers value being where everyone else is. Ebay also demonstrates the idea of positive feedback, which means that the more people who use a network, the more valuable it becomes, which attracts even more users. It is important to note that these types of demand-side driven economies of scale differ from those experienced by old economy companies, which are supply-side driven. Traditional manufacturing driven companies counted on manufacturing efficiencies and other discounts from their sheer size, but economists generally recognize that these advantages disappear as companies become bureaucratic and spread out among too many products and industries.

However, new economy companies theoretically become increasingly valuable as they increase their scale, because the more people that use their service, the more valuable the service becomes to other potential customers. If fact, Mauboussin contends that the positive feedback strengthens as technology companies reach market dominance. America Online provides another example of these scale effects; its services such as ICQ, chat rooms, and e-mail become more valuable to users as more people sign up for the service. AOL has clearly benefited from the network effect as we can see in the table below (adapted from Mauboussin 1999).

| Number of Members | Date | Days to add 1 million members |
|---|---|---|
| 12 million | 4/16/98 | |
| 13 million | 8/27/98 | 133 |
| 14 million | 11/12/98 | 77 |
| 15 million | 12/30/98 | 48 |
| 16 million | 2/09/99 | 41 |

Once companies like AOL gain their dominant market share, they theoretically should enter a stage of high profitability. The company is in what economists call "increasing-returns-to-scale" industry that has high initial costs: writing programs, buying servers, and developing web sites (Business Week 2000). But once the initial investment is in place, the costs of serving additional customers should be relatively low.

Another significant barrier to entry for technology, and specifically Internet companies are switching costs, which are the costs users bear when they switch from one system to another. Switching costs refer to how much companies must pay to lure a customer away from another business, and show the degree of customer loyalty. Experts argue over whether Internet company switching costs are higher or lower than for old economy industries. Some believe that customers have almost nonexistent switching costs because they are given greater access to information, and almost anyone can build a web site with a relatively small investment (Harrington 2000). However, others argue that customers generally have higher switching costs, especially for companies that have gained market dominance. For example, the switching cost for departing AOL customers are potentially high because they have to change e-mail addresses, learn a new browser and seek out new sources of web content.

We have now seen that technology companies' investments can position these companies to take advantage of fundamental differences that their business models provide. We will now step back to examine traditional valuation techniques and see how they fail to fully recognize the value that investments in technology can provide.

# CHAPTER II: TRADITIONAL VALUATION BACKGROUND & PROBLEMS

Traditional finance theory states that a security is simply worth the sum of all future payments to its owner discounted to arrive at a present value of cash flows (Wiese 1930). In the case of common stock, shareholders receive cash flows in the form of dividend payments. Therefore, the value of the company is the sum of the dividend stream for the life of the business.[2] The theory is modified slightly to account for the valuation of companies that forego dividends, and reinvest all or a portion of their earnings in order to foster growth in the company, which will eventually lead to increased future payments to shareholders.

One widely accepted method for valuing a company is the Free Cash Flow[3] (FCF) method, which accounts for reinvestment, and provides a calculation for the amount of cash that is available to be distributed to shareholders and creditors. Experts differ on their implementation of FCF analysis, but all of the methods project FCF available for distribution and then discount the cash flows at an appropriate risk adjusted rate. In practice, the FCF method is often difficult to implement for high growth companies or companies that have fluctuating cash flows (Higgins 1992). The difficulty occurs because the analysis often relies on predictions of sales revenue and profitability figures, which are often nonexistent or highly variable for new or high growth companies.

Next, we will examine a very brief example of a FCF valuation for a traditional business, Ford Motor Company, which manufactures automobiles. The purpose is not to produce a precise valuation, but instead will show how the FCF method typically might work to price a company's equity.

The FCF method, like most valuation methods, predicts a company's performance in the future. An analyst generally begins by analyzing the industry and scrutinizing management's forward looking statements, which predict the direction the company will take in terms of product offerings and plans for expansion. For well-established businesses, most analysts closely examine financial statements filed with the Securities and Exchange Commission. For our purposes, we begin by compiling relevant data from the financial statements to look for historical trends. A typical analysis examines the company's historical margins and ratios to measure profitability, liquidity, and leverage, and compares these measures to the rest of the industry. Exhibit 2.1 provides data on Ford's historical sales growth, gross and operating margins, while illustrating how the company's working capital[4] and capital expenditures have trended.

The next step is to predict Ford's performance over a specified time frame such as five years, the length of which is determined by our confidence in our forecasting ability. We take a percent of sales approach in this model, which means that we predict sales for the company, and then base the remainder of our value drivers on the sales figures. For example, we predict a sales growth rate of 6% for the next five years, and then assume that gross margins will remain near historical levels at 22% of sales. After making our assumptions, we calculate the FCF[5] for the company over the five-year time frame, and discount the cash flows back to present day dollars. Also, we generally assume that the company's life will extend many years beyond the five-year forecast period, and our valuation must reflect this fact. A commonly used method to value the cash flows beyond a forecast period is to calculate a 'terminal value' based on some growth assumptions. In our example, we assume Ford's cash flows will grow in perpetuity at

3%, which allows us to calculate its terminal value that we then discount to present day figures.

Next, because we are valuing the company's equity, we subtract out any debt and other long-term obligations from the value, and finally divide the equity value by the number of shares outstanding to arrive at a per share price. As Exhibit 2.1 shows, our assumptions provide a price of $42, which is near the company's current trading range. Generally, analysts test their assumptions by performing sensitivity analysis on key value drivers such as sales growth and capital expenditures. For example, if we vary our sales growth rate from 3-10%, we can generate a price range of $35-50 a share. Obviously, a professional analyst would present a much more in-depth analysis of the company and the industry, but this example shows how a rough FCF valuation works.

Although sensitivity analysis provides for a number of possible outcomes, the FCF method ignores the flexibility and contingent decisions a company's investments provide. Because the FCF method collapses a distribution of possible outcomes into an expected value, the model typically ignores the flexibility present in almost any investment project. Long-term investments rarely follow a set plan, and managers often have the opportunity to increase investment if a positive outcome occurs, or alter their strategies if things do not go as planned. Still, the FCF method fails to capture this value because it assumes that managers will stick to a strategy regardless of unexpected circumstances.

For example, a more detailed valuation of Ford might predict that the company will soon begin developing an electric car. Our analysis would reflect the investments required to develop the electric vehicle, but ignores the flexibility that the investment would provide. The investment in electric engine research might lead to something entirely unexpected, such as the creation of technology for a hybrid gas and electric car. Another scenario is that Ford management learns that it cannot profitably produce the electric car, and sells its electric division to another company that is better able to take advantage of the technology. The bottom line is that the company will not have the option to enter the new industry without making these initial investments. Later on in this thesis, we will see how important contingency is for technology companies.

Now that we have seen how a cash flow analysis works in practice, we can look at how the application works for an Internet company. We begin by examining another example, this time Amazon.com, one of the most prominent Internet retailers. Amazon began doing business as an online bookseller, went public in 1995 and the market now values the company at more than $20 billion. Amazon branched out into selling videos, music, and recently began to collect advertising revenues. However, like most Internet retailers, the company is not yet profitable, and has made huge investments in information technology and distribution networks. As a result of continued investment, the company's management does not believe the company will begin producing positive cash flows or earnings for at least two more years.

Amazon presents several valuation challenges. First, the company's short history provides little financial data to work with in predicting margins and future investments in working capital and capital expenditures. Second, sales growth has been explosive; for the most recent year sales grew 164% to about $1.6 billion. Clearly, sales cannot continue to grow this rapidly for long, and the company is in such an early stage that sales are extremely difficult to forecast. H.M. Blodget, an analyst for Merrill Lynch explains what makes predictions so difficult: "The company is also evolving so quickly, we don't really know what its (Amazon's) business model will look like in three years." Still, the company has been able to become a dominate player in Internet retailing with over 17 million customers, and should begin to take advantage of the economies of scale such as the network effect and potentially high switching costs we discussed earlier.

On the other hand, the FCF method fails to properly value the opportunities that huge investment in warehouses and information technology can potentially generate in Amazon's future. These investments allow the company's managers to be extremely flexible, and because the company operates in cyberspace, it can change its offerings more quickly than traditional businesses. For example, if Amazon's plan to sell home improvement goods online fails, its managers can quickly disinvest and move into a more promising venture. The FCF model, which is based on expected values, does not consider the managers' ability to change strategy during the investment period.

As a result, my application of the FCF method yields a much lower result for Amazon relative to the market, even when the analysis includes highly optimistic margins and much lower working capital and capital expenditure requirements than the company has experienced in the past. The valuation results in a per share price of about $21, which compares to the current market value of about $60 per share. A summary of my assumptions and valuation can be seen in Exhibit 2.2. As in the Ford example, sales growth is a key value driver— we can create per share ranges of $4-$70 when we vary sales from 50%-100% for the next six years. Blodget recognizes the huge variation that can be created by simply changing one assumption and states that he has been able to create a range of $1-200 per share with the slight twist of a dial on his valuation model.

Some experts take sensitivity analysis a step farther by conducting computer simulations called Monte Carlo analysis that consider thousands of iterations for each of their valuation inputs. Over the past several years, Monte Carlo simulation has become easier to use as software makers have developed simulation programs that work with common spreadsheet models. Using a package called @Risk, we can quickly conduct a simulation for our Amazon valuation model.

The first step requires us to set our inputs and their distributions. In the FCF model we set out several key inputs: sales growth, gross profit margins, operating expense as a percentage of sales, net working capital requirements, and capital expenditures. Next, we must determine the distribution type for our inputs; @Risk allows us to choose from a variety of distributions such as normal, triangular and lognormal. Analysts generally study the past behavior of the inputs for the company and the industry, and then choose the most appropriate. For example, an analyst might find that the gross profit margin for a company and industry falls between 15-40%, and roughly approximates a normal distribution with a mean of 25%. Before making the assumption, the analyst must also make sure that the distributions mirror reality; in the case of gross profit margins, a lognormal distribution may be more appropriate because it very rare for a retail company to experience negative gross profits. It is also important to note that the mean inputs of the distributions should represent our best estimate for the input. In addition, some simulation packages allow for the correlation of inputs to provide for more accurate representations. For example, it is important to recognize that a company's sales growth is related to working capital requirements, because increased inventory and receivables are generally necessary for a company to expand its sales.

Exhibit 2.3 provides a list of the assumptions we used in our Amazon simulation model, along with a graph of the resulting distributions. As the table shows, we believe that future sales growth figures are best represented by a normal distribution with the same mean used in our FCF calculations, and a standard deviation of 20%. We arrived at these numbers by looking at the company's future growth prospects and simply estimating a range of likely future outcomes. The remainder of the input variables are represented by lognormal distributions because they should be positive.

We repeated our simulation for 1000 iterations, which provided a mean share price of about $23 a share—with a minimum share price of -$48 and a maximum of $171. This is a wide range, but if we assume the results are normally distributed (which seems reasonable given the graph in Exhibit 2.3), we know that about 70% of the time our results will fall within one standard deviation on either side of the mean, or between $0-48 per share. Clearly, this is still a wide variation and is well below the current trading range for Amazon. Also, the extremely negative share prices provide additional insight into the problems with FCF methods. Our model assumes that managers would continue to invest in the company under the worst possible values for our inputs. Instead, an improved model would recognize that managers can make decisions in reaction to these unexpected events.

However, the potential for highly variable outcomes is not the primary criticism of traditional cash flow methods. Amram & Kulatilaka (*Taking an Option on IT* 1999) claim that traditional valuation methods fall short when investments in information technology play a strategic role in uncertain markets. Their main argument is that traditional tools fail to account for the valuable flexibility that the investments in information technology provide. Amram & Kulatilaka believe that traditional methods incorrectly penalize risky investments with longer decision.[6] They suggest an options approach (which we will discuss in the next chapter) because they believe added time and risk can add value for businesses. In Amazon's case, Amram and Kulatilaka's approach would suggest that the company's creation of a highly sophisticated information technology and distribution network, along with a strong customer base, should be valuable because they could potentially allow the company to enter or even create new markets.

Experts also criticize cash flow valuation methods because they ignore the contingency many decisions provide. For example, a company may invest in a project with a negative net present value (NPV) in order to establish a foothold in an attractive market. At the time the decision is made the company may not fully understand the potential of the market or possible product offerings, but the initial investment provides the opportunity to enter the market in the future. For example, Amazon initially invested huge amounts of capital in hardware and warehouses in order to sell books online. The investment has now given the company the opportunity and flexibility to begin selling other products online and even enter the online auction market.

Before we move on, we should note that in practice many professional security analysts supplement FCF analysis with proxy measures of valuation (Gurley 1998). These measures, such as price-to-earnings or price-to-book are used to approximate cash flow, and compare company valuations to each other. They are typically used on high growth companies and start ups because of the lack of financial history that we discussed earlier. Simply stated, the technique involves comparing what the market pays for $1 of a measure for one company with that of another similar company. In Amazon's case, investors might find that online retailers currently trade at 15 times sales, so they would reason that Amazon should trade in a similar range.

However, traditional ratios do not work with many Internet companies that have negative earnings or low book values.[7] As a result, analysts valuing e-commerce companies rely on less common ratios such as price-to-sales, price-to-customer, and even price-to-page view in order to measure a company's potential. This type of valuation is problematic because it ignores all profitability or cash flow issues. It also rewards companies for acquiring customers and sales at any cost. Critics of these methods use the example of an on-line retailer who sells dollars for $.80. This business would quickly gain customers and sales, which would favorably impact its price-to-sales and price-to-customer ratios. However, it is clear that this company would not remain in business for very long. A final problem with the technique is that many businesses are unique, so that finding a comparable company may be difficult or impossible (Luehrman 1999).

# CHAPTER: III REAL OPTIONS

Earlier in this thesis we alluded to the fact that some professionals and academics have begun searching elsewhere to solve some of the problems with traditional valuation techniques. Many have concluded that the solution lies in adapting an option way of thinking, and believe that an options approach is especially appropriate for the valuation of technology driven investments. Before elaborating on how options can be applied to the valuation of technology companies, we need to first understand how option models work and are valued.

An option is the right, but not the obligation to take an action in the future. Most of the literature on options concerns financial options, and the valuation techniques we will discuss were developed specifically for the financial variety. Financial options are contracts that allow their owners to buy (call option) or sell (put option) an asset in the future at a pre-specified price. Initially options were created with individualized contracts, but now financial options are standardized and widely traded on financial exchanges. The explosion of option trading is largely due to improved valuation techniques. Two methods of valuation that we will explore later in this thesis include the binomial pricing model and the Black-Scholes model.

It is important to understand how options differ from their underlying assets. Call options are unique because they give their owner the right (but not obligation) to take an action in the future, which results in asymmetric returns. If an advantageous outcome occurs, then the owner can choose to exercise the option. However, if the outcome is poor, then the owner can choose to let the option expire, and only loses the amount paid for the option. This limits the owner's downside potential. Exhibit 3.1 provides a visual representation for the payoff to the owner of a call option, and clearly shows the asymmetry of the returns. Now we will briefly look at several of the factors that drive financial option value.

The key value drivers in option valuation include: underlying security price, exercise price, volatility, time to expiration, interest rate, and dividend payout. Obviously, the price of the underlying asset affects the value of the option, and in the case of a call option an increase in the security price increases the option value. The exercise price is the amount the owner must pay to exercise or trigger the option, and a decrease in the exercise price increases the value of the option. Volatility is also a key factor in option valuation because of the asymmetric returns involved. Call option value increases with volatility because of increased probability of the call being 'in the money.'[8] The same line of reasoning can be used to explain the relationship between time to expiration and option value. When the option has a longer time to expiration, the probability of the security price moving into the money is increased. Option value also increases with the risk free interest rate, because the owner of the option can gain a return on the funds that will be used to exercise the option. Finally, any dividend payments from the underlying asset decrease its value, and the option's value as well. The chart below summarizes these relationships for a call option.

| If this increases... | The value of a call option |
|---|---|
| Security price | Increases |
| Exercise Price | Decreases |
| Volatility | Increases |

| | |
|---|---|
| Time to expiration | Increases |
| Interest rate | Increases |
| Dividend payout | Decreases |

Adapted from Bodie, Kane, Marcus (1999)

It is also important to note that option valuation techniques rely on a risk-neutral valuation assumption, which means that cash flows are discounted at a risk-free, rather than risk-adjusted rate. The assumption is justified by the idea that an option can theoretically be created in the market with a portfolio of the underlying securities, and therefore zero arbitrage opportunities should exist. Since profitable arbitrage is not possible, earning only the risk-free rate of interest is justified.

We will now move on to a brief review of the literature concerning real options to better understand why experts began studying them, and how they apply to our problem. Stewart Myers is credited with introducing the term 'real option' in an attempt to bridge the gap between strategic analysis and cash flow calculations (Kester 1984). Over the past two decades numerous scholars have explored the real option approach as an alternative to traditional methods. Authors like Lenos Trigeorgis (1995) criticize cash flow valuation techniques because they make explicit assumptions about the operating strategy of an investment, which can lead its undervaluation. Trigeorgis claims that the true value of capital investments should reflect both the NPV of the project's cash flow plus any option value. Still, some scholars respond that the problem is not with cash flow techniques, but is in their application.

Proponents of real options believe that the approach provides the user with the opportunity to value the uncertainty, flexibility, and contingency of an investment.

Numerous types of real options have been identified and some commonly referenced instances can be seen in the table below (Trigeorgis).

| Category | Description | Important in: |
|---|---|---|
| Option to Defer | Management has opportunity to wait to invest, and can see if markets warrant further investment. | Natural resources extraction, real estate, farming, technology. |
| Staged Investment | Staging investment creates the option to reevaluate and/or abandon at each stage. | R&D intensive industries, energy generation, start-up ventures. |
| Option to alter operating scale | If market conditions change, the firm can expand/contract or temporarily shut down. | Natural resources, fashion, real estate, consumer goods. |
| Option to abandon | If market conditions decline, management sells off assets | Capital-intensive industries, new product introductions in uncertain markets. |
| Option to switch | If prices or demand change, management can change product mix (product flexibility) or switch inputs (process flexibility) | Companies in volatile markets with shifting preferences, energy companies |
| Growth options | An early investment opens up future growth opportunities in the form of new products or processes, access to markets, or strengthening of core capabilities—like interproject compound options | High tech; industries with multiple product generations (drug companies, computers, strategic acquisitions). |
| Multiple Interacting Options | Projects involve a collection of various options—both put and call types. Values can differ from the sum of separate option values because they interact. | Many of the industries discussed above |

Most of the available literature on real options concerns investment decisions, instead of our problem of business valuation. A substantial amount has been written about real options in terms of investments in manufacturing, natural resource and pharmaceutical industries, but very few application models are available discussing technology companies. The only exceptions are the writings by Amram & Kulatilaka and professional analyst reports published by Mauboussin & Hiler (See Exhibit 3.2 for the authors' visual representation of Amazon.com's option value). Still, even these authors have not yet published any real-world numerical examples showing how a real options model could be used to value entire technology companies.

There are several fundamental differences between cash flow and real option methods. First, options have contingency and flexibility built into their model; the investor pays for the right take an action or actions, but is not forced to follow through with the action unless conditions are favorable. Conversely, FCF calculations collapse a distribution of possible outcomes into an expected value. Also, uncertainty affects the value of investments differently for FCF and real options. Uncertainty decreases the value of an investment using FCF, but increases its value when using a real option model (just like financial options). This occurs because FCF methods discount riskier cash flows at an increased rate because investors demand compensation for bearing the extra risk. However, option holders have limited downside risk, therefore increased volatility increases the chances for a huge payoff. Amram & Kulatilaka argue that uncertainty can indeed be valuable, especially for technology companies, because increased uncertainty creates valuable opportunities.

Now that we have a general understanding of what real options are, and where they might come from, we will look at how the model applies to technology and other companies that do business in uncertain markets. In the first chapter, we demonstrated that the Internet is a high growth market with an uncertain future; no one really knows where it will take businesses in the next several years. Still, investors have placed huge valuations on a number of companies that operate in the market. Empirical analysis has shown that these valuations are priced well beyond the value provided by FCF methods (Kester 1984 and Jagle 1999).[9] One explanation for these huge valuations amidst uncertain conditions is that investors recognize the real option value of the companies. We have already seen that uncertainty increases option value, and it is likely that investors recognize this value.

Scholars have also identified numerous growth options within technology companies in the form of the barriers to entry we discussed earlier. Giving away free Internet browsers is a concrete example of purchasing a growth option to establish a foothold in the market. The investment in software development creates a real option that can be exercised if and when the browser becomes a success, but can be abandoned if it is a failure. Traditional FCF analysis would not properly identify the value from this option because the outcome is highly uncertain and contingent on other unpredictable factors. Because FCF methods use expected values based on a probability of future outcomes, the analysis would fail to recognize that managers could choose to abandon the investment if the market proved unattractive, or could defer investment until conditions improved. Numerous Internet companies are feverishly investing large amounts of capital because they understand the huge option value that exists from gaining customers early on.

Still another real option that results from doing business in cyberspace is the value from increased flexibility. Internet companies are theoretically much more flexible than traditional businesses because they do not need to build a physical presence in order to enter new markets or switch products. This increased flexibility should allow technology companies to move much more quickly and with lower investments than traditional businesses. Clearly this increased flexibility is valuable, and we should be able to measure the value with real option methods.

Since real option valuation is a new way of thinking about investment analysis, it requires a different framework and valuation method. The most complete and easy to follow framework available has been constructed by Amram & Kulatilaka (condensed):

- Step 1: Frame the application
  - ⇒ What are possible decisions?
  - ⇒ Identify uncertainty
  - ⇒ Look to financial markets
  - ⇒ Review for transparency and simplicity

- Step 2: Implement the valuation model
  - ⇒ Establish the Inputs
    - o Identify sources for leakage in value
    - o Look at market priced risk
    - o Look at private risk
    - o Establish risk free rate

  - ⇒ Value option with "calculator"
    - o Partial differential equations
    - o Dynamic programming
    - o Simulation approach

- Step 3: Review the results
- Step 4: Redesign

Following this framework, after we determine the types of options appropriate to our valuation, we next must establish the inputs for our model. This involves translating available data into the six value drivers that we discussed for financial options. A major portion of this analysis will be dedicated to determining the source of the uncertainty for the option. Uncertainty will exist as market and company specific risk, both types of which must be reflected in our model. Amram & Kulatilaka suggest that one method to measure risk would be to select a group of publicly traded companies that are similar to the company under consideration. For our purposes, we could choose an Internet stock index such as ISDEX to measure the variability of the companies' assets. Other inputs such as the probability for success and uncertainty can be determined by looking at industry data. For example, if we examine an option for a software application, we might look at past success rates for the company or industry. This is a common practice for drug-development companies, where success rates for each stage of drug development are well documented. It is also important for any real option model to account for the leakage in value before the option decision date such as dividend payments or other cash outflows.

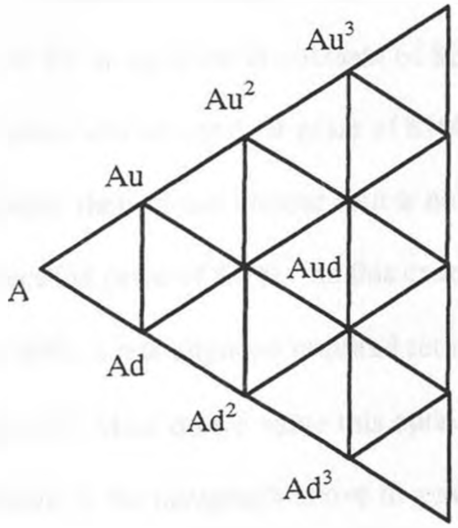
Amram & Kulatilaka have constructed several "options calculators" presented along with their framework. These calculators break down into three categories: solutions to partial differential equations (Black-Scholes), the dynamic programming approach (binomial model), and the simulation approach that identifies and averages thousands of outcomes. The inputs are almost identical for each method and are very similar to those used in financial options. I have also accessed several examples of calculators (embedded in spreadsheets) using both the Black-Scholes method and binomial model. Timothy Luehrman has also established other, less complex methods. The first technique (Harvard Business Review Sept-Oct 1998) categorizes real options into physical space by the likelihood of them being exercised from "never" to "now." Luehrman also applies the Black-Scholes model to real options by using an option-pricing chart (Harvard Business Review July-August 1998).

The binomial model appears to be the most promising method for our study. It offers the best chance to preserve transparency because it allows us to visually map out contingent decisions, and requires no knowledge of advanced calculus. The major problem with the binomial model is that it can quickly get very complex because the branches grow exponentially as we add decision points.

Now that we have seen how a real options approach can prove valuable for investments in uncertain markets where flexibility and contingency are important, we will begin to explore the application of these techniques on several technology companies in the next chapter.

# CHAPTER III APPENDIX: APPLICATION OF BINOMIAL OPTION PRICING

This appendix takes readers who are unfamiliar with option pricing through a binomial pricing example. Binomial option pricing relies on some relatively simple representations of an asset's value given the six value drivers we discussed in Chapter III. The simplest form of a binomial model assumes that an asset (A) has two possible outcomes over a time period, an up movement (Au) or a down movement (Ad). The model can be represented visually in a tree form as seen below on the left, or in a spreadsheet as seen on the right. Each new asset value represents a decision point for the option holder. As decision nodes are added, the distribution of outcomes becomes more detailed and the possible outcomes can be approximated by a smooth distribution.




| | | |
|---|---|---|
| A | Au | $Au^2$ |
| | Ad | Aud |
| | | $Ad^2$ |

Our goal in option pricing is to determine the value of the right to buy or sell an asset at some future point in time at a prespecified price. The visual representations above help us to estimate the value of the underlying asset by determining the price of the asset at some future date. As stated earlier, binomial pricing relies on a risk-neutral assumption, which means that the expected return on the underlying asset is equal to the risk free rate of interest, denoted as r. Because we know the expected return (risk free rate), we can calculate the risk-neutral probability of an upward (u) or downward (d) movement where $u=e^{\sigma}$ and $d=e^{-\sigma}$. We can also use established methods to calculate the probability (p) for each upward outcome, which equals $(e^{r}-d)/(u-d)$. Since there are only two possible outcomes at each node, the probability of a downward movement is 1-p. For financial options we can obtain a standard deviation ($\sigma$) by observing the volatility of the underlying stock price, or some other asset that is highly correlated with the asset we are studying. We will now see how this approach can be used in a spreadsheet form to predict a hypothetical asset's value in the future.

Consider an option that allows its owner to acquire an asset with a current value of $100 for an up front investment of $20, a fixed payment of $5 for each of the next three years and an exercise price of $100 in four years. If the holder makes all of the payments, then he can choose (but is not obligated) to purchase the asset for the prespecified price of $100. In this example we assume that the asset's standard deviation ($\sigma$) is 40%, a risk adjusted required return on the project is 10%, and the risk free rate equals 6%. How do we value this option? A first step is to use the use the formulas presented in the paragraph above to generate a distribution of asset values ranging from year zero to four. At the end of the fourth year the asset value ranges from $20 to $495. The table below illustrates the distribution of asset valuations provided using annual decision points. If desired, we could generate a more thorough distribution by splitting the years into smaller segments and increasing the number of decision points.

| Yearly Asset Value Tree | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| | 100.0 | 149.2 | 222.6 | 332.0 | 495.3 |
| | | 67.0 | 100.0 | 149.2 | 222.6 |
| | | | 44.9 | 67.0 | 100.0 |
| | | | | 30.1 | 44.9 |
| | | | | | 20.2 |

Now that we have some idea of the asset's potential value, we can begin to consider the specifics of the investment under examination. Our first step is to determine the value of the option given our predicted asset values for year four. These values are found by subtracting the asset price with the exercise price of $100. For example, to calculate $Au^4$ we subtract 100 from 495.3, which simply gives us the payoff to the option holder at the exercise of the option. It is important to note that if the asset value is less than the exercise price, the option holder will not choose to exercise the option but instead would let it expire worthless, which appears as a zero in the table. The final step in the option valuation is to 'roll back' the option value by multiplying each outcome by its risk neutral probability (p), then discounting the value at the risk free rate, and subtracting out the investment for the year. This gives us the option value for each possible outcome; the final rolled back value at the far left is the value of the option at time zero. For example, we reach the value in $Au^3$ by taking the following steps (see table below):

- Subtract out the exercise price in year 4 (100) to get the payoff at $Au^4$ (395.3)
- Multiply $Au^4$ times p (0.47658), then add $Au^3d$ times 1-p (0.52342)
- Subtract out the investment needed in year three to continue option (5)
- Discount the value from above to year three values by multiplying by $e^{-.06}$
- Take the maximum of calculated value (233.1) and zero.

| Option Value Tree | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| | 9.8 | 60.1 | 124.7 | 233.1 | 395.30 |
| | | 3.3 | 17.9 | 50.3 | 122.55 |
| | | | 0.0 | 0.0 | 0.0 |
| | | | | 0.0 | 0.0 |
| | | | | | 0.0 |

As the above table shows, we place a value of $9.76 for the investment opportunity that the option provides, which compares to a FCF value of -$.74. We can calculate the FCF value by subtracting the present value of future outflows discounted at 10% (-100.74) from the present value of the asset (100). The difference in the two values results from the flexibility that the option provides; if the outcome is poor then our options analysis recognizes that the holder can walk away from further investment. A spreadsheet combining all of the elements used in this valuation can be seen in Exhibit 3.3. Throughout the remainder of the paper, we will follow the format of Exhibit 3.3 to represent option value.

# CHAPTER IV: TECHNIQUES IN PRACTICE

As mentioned previously, Amram & Kulatilaka have worked to develop a business valuation model using a real options approach, which they integrated into a spreadsheet and compared to FCF methods. For example, they valued an imaginary start-up brewery that possesses an option to expand in the future (growth option) if it experiences preliminary success. The framework uses the same type of cash flow forecasts as typical FCF valuations, except the model adapts the forecasts to an options approach.

One possible approach to option valuation for a technology company like Amazon is to follow the authors' approach and think of the company as one giant growth option. However, translating Amazon's diverse business model into a single option contract proves very difficult, because the company possesses numerous growth options that are all interdependent. The first step in Amram & Kulatilaka's real options framework is to frame the application by outlining possible decisions. It does not seem beneficial or even possible to frame all of Amazon's growth opportunities into a single framework. Instead, we will attempt to identify and value one of Amazon's key projects, and will begin with the company's expansion into the auction market.

Internet auctioning was pioneered several years ago by Ebay, producing revenues of more than $220 million in 1999, taking the company to a market capitalization of more than $20 billion. The company offers auction services to more than 10 million registered users who shop for a wide variety of products including antiques, collectibles, electronics, and cars. Last May, Amazon entered the auction market by purchasing

LiveBid and its live auction software for $40 million dollars. Amazon's management is betting that it can use its 17 million established customers and technology infrastructure to enter the market, and we will now see how the company's market opportunity translates into an option. Before moving on, we should note that our analysis, like the analysis of investors, will rely on a fair measure of speculation because the online auction market is so new. Therefore, generating solid forecasts is almost impossible, and we will be forced to rely on broad industry information to generate our forecasts for Amazon's auction venture.

We begin by outlining a framework for the company's decision to enter the auction market in order to understand how options thinking can be applied. By spending $40 million for LiveBid's software, the company created a call option. Amazon's managers now have the opportunity to make additional investments in the future if the company's entry is successful or the auction market expands. Making these additional investments essentially exercises the option and will serve to produce a well-established Internet auction business. We will assume that Amazon's investment will mirror those of other online auction houses, and the full investment will take place over a period of four years.

Our first step in the calculation (see the appendix at the end of Chapter III for a thorough hypothetical example) is to identify an appropriate asset value and determine a reasonable level of volatility for the asset. In our example, the asset under question is a well-established Internet auction site, so we must first identify the present value of Amazon's potential auction site. This is probably the most difficult portion of the analysis because we have very few reference points to start with. We really do not know how much cash flow, or even revenue Amazon will be able to generate through this portion of the business. One starting point is that Standard & Poors estimates that the market for online auctions will generate over $2 billion in sales by 2003. We can make some very broad assumptions about Amazon's ability to leverage its existing customers into the market, and assume that by 2003 the company could take 25% of the market share if things go as planned. This would give the company about $500 million in revenues per year from auctions alone. How much are these $500 million in revenues worth today? We can also use proxy measures like price-to-sales that we discussed in Chapter II to estimate the current market value for a company with similar revenues, but we have to be careful. As mentioned earlier, experts like Jagle and Kester believe that most of the current market valuations for Internet companies incorporate the option value of future growth opportunities. For this reason, we want to compare our revenue figures to a more traditional auction company like Sotheby's, which historically trades at one to two times trailing revenue figures. This assumes that Sotheby's has little option value, which seems reasonable given the company's stable and relatively predictable performance.

Although our analysis is based on a considerable amount of speculation, it provides a future asset value of about $750 million ($500 million in revenues x 1.5 price-to-sales ratio). This value can be discounted back to a current asset price of about $307 million using a risk-adjusted rate of 25%. We calculated this rate using observed volatility in the stock market for two online auction companies, Ebay and Priceline.com.[10] The next step is to determine the volatility for our options operation; we will again look to the market for the volatility of online auction companies. Using last year's data, we can calculate an annualized standard deviation for Ebay and Priceline.com of 99% and 115% respectively. Although this is not a large sample, it gives us an estimate of the volatility for online auction companies. The table below shows how the asset value evolves over time with an annual standard deviation of 110%. Given our assumptions, at the end of four years the value of an established online auction business will range from $4 million to $25 billion. This is clearly a highly uncertain business.

| **Yearly Value Tree** | **0** | **1** | **2** | **3** | **4** |
|---|---|---|---|---|---|
| | 307 | 923 | 2,772 | 8,329 | 25,022 |
| | | 102 | 307 | 923 | 2,772 |
| | | | 34 | 102 | 307 |
| | | | | 11 | 34 |
| | | | | | 4 |

Next we must identify the investments that Amazon will be required to make in order to exercise the option. We will start with the projected cash outflows that the company will face for the investment. These cash flows are difficult to predict because the industry is so new, and Amazon's position within the industry is unique. Clearly, the company will have to make additional investments in employees, marketing, and administration. The only reference point we have to predict these cash flows are other online auction companies like Priceline.com and Ebay. For example, Ebay experienced free cash outflows of $4 million in its first year, $10 million the second, $22 million the third, $60 million the fourth, and $170 million in its most recent year. Priceline.com had similar outflows of $2 million the first year, $48 million the second, and $130 in the third. Although it is dangerous to base our assumptions on such a small sample, these companies provide our best guess for the cost of setting up auction operations and we will assume that Amazon will face similar types of expenditures. We know that the option cost the company $40 million for technology, and we will assume that the company will have to make additional investments of $50 million in the first year, $80 million in the second, and $100 million in the third. In the fourth year, managers will be able to evaluate their success to see if they want to spend an additional $200 million to truly establish the auction business. These numbers are based on the outflows experienced by Priceline and Ebay, which are the only grounds we have to forecast the cost of setting up an action operation.

After including the outflows discussed above into our option valuation model, we 'roll back' the values just like we did in the appendix on binomial pricing. We can see that our approach has yielded a much different result from traditional FCF methods (See Exhibit 4.1). Our option valuation produced a value of about $126 million for the value of the auction project, while discounted cash flows provides in a negative net NPV of $3.2 million. We calculate the NPV by subtracting the present value of investment from the asset value in year zero. The difference between the two models results from the huge volatility of the auction market and its asymmetric returns. This makes sense in relation to this project because Amazon's managers can take a wait-and-see approach. If the auction market proves to be unsuccessful, they can simply shut down the auction portion of the company web site and discontinue operations. However, given the market volatility, a huge success is also possible and our option model acknowledges the value of this potential.

Further analysis of our auction valuation provides some valuable insight into the differences between option and *expected* cash flow valuation. The high volatility of the online auction business creates much of the difference between the results. If we reduce the annualized standard deviation of our decision points to 50%, the gap between FCF methods decreases to roughly $20 million. If we further reduce the standard deviation to 20%, the difference is only $3 million. Clearly, real options analysis proves especially relevant in highly volatile industries like this one.

We will now apply our real option techniques to a biotechnology company, which is another relevant industry that is highly volatile and faces significant uncertainty. There are many parallels between biotechnology and Internet companies such as the highly negative early free cash flows and the heavy reliance on investments in new technology. However, biotechnology companies have existed for much longer than Internet companies, so we should be able to make more informed forecasts than we saw in the previous example. We will value a company called Aviron that is currently completing Phase III clinical trials for its primary product, an inhaled flu vaccine called FluMist. We begin our analysis by quickly examining the drug approval process.

Every drug sold in the United States must pass through a lengthy and rigorous process monitored by the Food and Drug Administration (FDA). This process has been well documented, and experts have determined that the average drug development takes 14 years, the probability of success is below 10%, and the development costs average between $200-$350 million (Heil & Peck, 1999). Phase III testing represents the final step before approval, and it is made up of several stages of rigorous and complex tests.

The consensus among Wall Street analysts who cover Aviron is that the company will complete its FDA trials in late 2001 or early 2002 (Lind, 1999). Until then, the company will continue to invest in activity related to the approval process, and the development of its portfolio of drugs that draw on the same technology as FluMist. If and when approval is granted, the company will be able to organize a full-scale product launch, and will begin selling to the public in mass quantities. Morgan Stanley Dean Witter (MSDW) analyst D. Lind forecasts the following sales figures and operating margins for the company:

| | 2001 | 2002 |
|---|---|---|
| **Unit Sales** | 13 million | 27 million |
| **Dollar Amount** | $155 million | $234 million |
| **Operating Margin** | $8 million | $57 million |

We can now begin to place a value on Aviron as an established company selling flu vaccines in 2002. We will again look to the marketplace for guidance. There are currently several companies with a flu vaccine on the market, but Biochem Pharma is clearly the most successful and dominant, and produced roughly $200 million in sales for 1999. The company currently trades at about 10 times trailing sales, and 25 times its operating margin. These numbers are reasonably close to the drug industry average of 16 times sales and 30 times operating margin. Although this analysis only includes one comparable company, these ratios provide some indication of the value of an established flu vaccine selling company.

Using MSDW's forecasts for sales and operating margin, we can forecast a value of between $1.4 and $2.3 billion for Aviron in 2002. We will split the difference between these numbers and assume that the value of an established flu vaccine company in 2002 equals $2 billion. The upper left-hand corner of Exhibit 4.2 shows these calculations, and the reader should note that these estimates are in 2002 dollar figures.[11] This value is then discounted to $1.556 billion with a risk-adjusted rate of 15% for our FCF and real options analysis.[12] The next step in our analysis is to forecast how this asset value will change throughout time. We will construct a decision tree with quarterly steps beginning in the first quarter of 2000 and ending in the first quarter of 2002, when we believe the company will begin selling large quantities of vaccine. In order to calculate the projected asset values we need to determine an appropriate annualized standard deviation. Looking to the market, we can observe that the annualized standard deviation for the Nasdaq biotech index is roughly 50%, which gives us some idea of the market risk for biotechnology companies. However Aviron's venture is obviously much riskier because it lacks diversification, and relies on the approval of a single type of drug. One way to measure the market's judgement of this risk is to observe the company's stock price volatility, which for the most recent year was about 90%. We will use this value as our estimate, and can produce the asset value tree seen below (note that the σ is annualized, and is adjusted to a quarterly rate by multiplying it by √.25).

| Quarterly Asset Value | Q1 2000 | Q2 2000 | Q3 2000 | Q4 2000 | Q1 2001 | Q2 2001 | Q3 2001 | Q4 2001 |
|---|---|---|---|---|---|---|---|---|
| | 1,566 | 2,456 | 3,852 | 6,041 | 9,474 | 14,858 | 23,303 | 36,546 |
| | | 999 | 1,566 | 2,456 | 3,852 | 6,041 | 9,474 | 14,858 |
| | | | 637 | 999 | 1,566 | 2,456 | 3,852 | 6,041 |
| | | | | 406 | 637 | 999 | 1,566 | 2,456 |
| | | | | | 259 | 406 | 637 | 999 |
| | | | | | | 165 | 259 | 406 |
| | | | | | | | 105 | 165 |
| | | | | | | | | 67 |

Now that we know what potential asset values look like, we must better frame our investment decision. Our model is built on the idea that Aviron will make a series of investments in drug development costs that will result in the company's transformation into a well-established drug company. We must now try to estimate the scale of investment that it will take for Aviron to make this transformation. First, we look at how Aviron's expenditures in research have developed over time, and we can see that they have grown at an average annualized rate of about 45% over the last three years. If we use this rate to forecast, we can generate expenditures of about $150 million in 2000 and $230 million for 2001 (which we break into quarterly amounts). These forecasts roughly correspond to Lind's estimates for the company.

We now have a complete framework to value Aviron using both FCF and options valuation (see Exhibit 4.2 for a detailed representation). For the FCF method we simply subtract the projected discounted outflows from the present value of the asset, which yields a value of about $1.052 billion dollars. Options analysis produces a value of $1.213 billion, which is about 15% higher. These values provide a reasonable estimate of the company's market value, which has fluctuated the last several months between $500 million and $1.1 billion. We can also perform additional sensitivity analysis by varying the standard deviation in our option analysis. For example, if we decrease the value to 50%, the difference between the FCF and options valuation is only about $2 million.

Now that we have seen how an options approach can be applied to real life technology companies, in the next chapter we will critically examine our results to determine if they add value, and we will also explore what we learned from the analysis.

# CHAPTER V: ANALYSIS OF RESULTS, POSSIBLE EXTENSIONS, CONCLUSION

In the first two chapters of this thesis, we saw how Internet companies' business models and strategies create difficulties for the application of traditional valuation techniques. When expected discounted cash flow models are applied, they produce results that are well below those observed in the marketplace. Evidently, Wall Street analysts and money managers find value in these companies beyond the *expected* value of their future cash flows. Many experts believe that the companies' investments in technology make them flexible and able to take advantage of future opportunities in the highly uncertain Internet marketplace. We saw how companies' investments in technology can potentially create efficiencies, flexibility, and barriers to entry that translate into valuable options that must be recognized in a valuation model.

Chapters Three and Four demonstrated how options valuation techniques can recognize the value of the flexibility and contingency that is especially important in the uncertain markets where Internet companies conduct business. We examined the inputs needed for an options based model, and translated one hypothetical and two real life investments into our binomial pricing framework. Our application met with some success, while also presenting some challenges.

The binomial pricing model provides analysts with a transparent and relatively simple format to map out an investment decision. Required inputs are no more difficult to estimate than for DCF models and can generally be estimated or observed in the marketplace. However, addressing our initial problem of business valuation is problematic for companies like Amazon that hold numerous interacting options. Simple binomial pricing models cannot price these compound options because their values are interdependent on multiple investment decisions and outcomes.

We also encountered difficulty mapping out the investment decision in the online auctions example, because even industry experts are not sure of the timeline and scope of the investment required. Like other valuation techniques, the real options approach requires us to make predictions about a company's performance in the future. This is extremely difficult to accomplish when we are not even sure what online auctions services will look like in the three years and have very little information about what the level of investment will be. Overall, options models will not solve the issue Blodget raises of not knowing what the company's business model will look like in three years.

It should also be noted that I attempted several other applications of option valuation techniques for Amazon and on other Internet companies and faced similar problems. Taking the first step of determining an asset value requires a great deal of speculation that could not be backed up with any substantial data or information.

Still, our application of real options techniques has produced some success. The online auction example demonstrates that an option model can recognize value where expected cash flow methods do not. Clearly, Amazon's management finds some value in the project or they would not have undertaken the project, and our option model helps to quantify that value. Also, the Aviron example shows that option pricing can provide more precise results when used in an uncertain environment that has a longer operating history. In Aviron's model, we are able to map out investment decisions, determine a future asset value based on gross profit and sales, and estimate the uncertainty of the project. In this case, the real options approach appears to provide better results than the

FCF method, because the analysis recognizes management's ability to abandon investment if the drug is not approved.

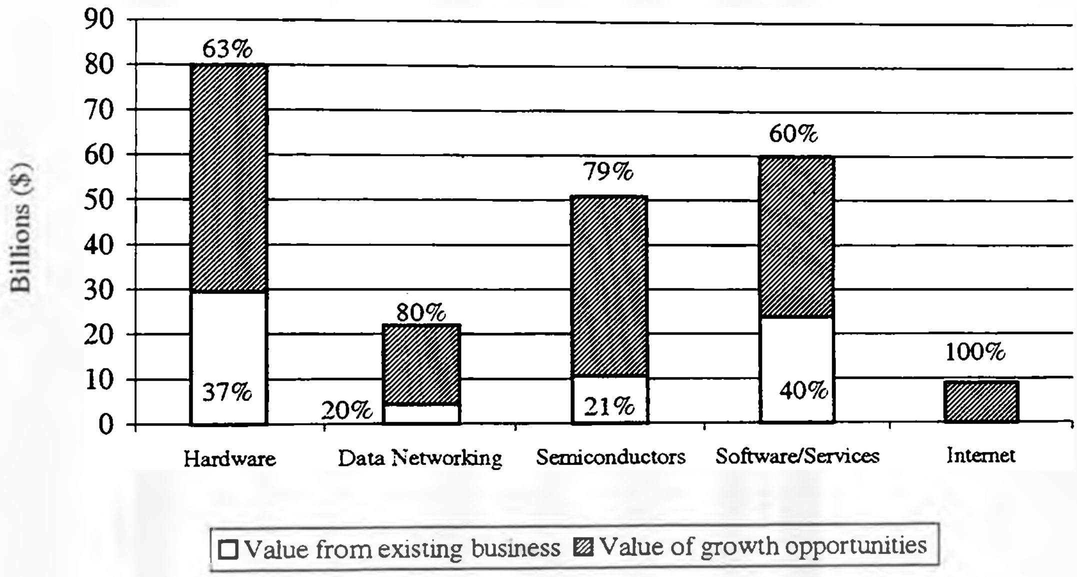
Clearly, it will take more refined models and detailed applications before real options valuations become widely accepted. As mentioned previously, binomial option pricing can only handle the valuation of a single investment decision. Since many projects and most businesses gain their value from multiple interacting decisions, further development of compound option pricing models will be necessary. Trigeorgis (1999) and others have made significant progress in developing detailed option pricing models using advanced calculus and further development of these models is necessary.

Even though it is currently difficult to price real options, it is important that we do not simply ignore a company's option value. Luehrman's visual representation of real options provides a nice framework with which to analyze options and judge their relative worth. If current numerical pricing models cannot handle the option, it is still useful to apply his models to better understand the option's relevance and potential value.

This thesis began with an examination of how the flexibility and uncertainty that technology companies face exacerbates some fundamental limitations in expected cash flow techniques. We then saw how option based models can compensate for some of these limitations, and attempted to apply these techniques to real life technology companies. Although the application of option models presents its own difficulties, there is great room for further study and application of real option models.

EXHIBIT 1.1

Adapted from Jagle 1999



# EXHIBIT 2.1

Figures in millions (except percentages)

| | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | Assumptions | 2000E | 2001E | 2002E | 2003E | 2004E |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Revenue | 100,132 | 108,448 | 128,439 | 137,137 | 146,991 | 153,627 | 144,416 | 162,558 | | 172,311 | 182,650 | 193,609 | 205,226 | 217,539 |
| Revenue growth rate | 13.4% | 8.3% | 18.4% | 6.8% | 7.2% | 4.5% | -6.0% | 12.6% | 6.0% | | | | | |
| Cost of Goods Sold | 86,256 | 90,220 | 103,031 | 109,313 | 117,936 | 119,630 | 112,125 | 123,699 | | | | | | |
| Gross Profit | 13,877 | 18,228 | 25,408 | 27,824 | 29,055 | 33,997 | 32,291 | 38,859 | | 37,909 | 40,183 | 42,594 | 45,150 | 47,859 |
| % Revenue | 13.9% | 16.8% | 19.8% | 20.3% | 19.8% | 22.1% | 22.4% | 23.9% | 22.0% | | | | | |
| EBIT | 7,121 | 10,760 | 16,072 | 16,105 | 16,264 | 20,414 | 17,962 | 15,193 | | 18,954 | 20,092 | 21,297 | 22,575 | 23,929 |
| % Revenue | 7.1% | 9.9% | 12.5% | 11.7% | 11.1% | 13.3% | 12.4% | 9.3% | 11.0% | | | | | |
| Tax Rate | -232.6% | 33.7% | 37.9% | 35.5% | 31.9% | 34.2% | 12.5% | 33.3% | 35.0% | | | | | |
| Taxes | 295 | 1,350 | 3,329 | 2,379 | 2,166 | 3,741 | 3,176 | 3,670 | | 6,634 | 7,032 | 7,454 | 7,901 | 8,375 |
| EBIT(1-t) | 6,826 | 9,410 | 12,743 | 13,726 | 14,098 | 16,673 | 14,786 | 11,523 | | 12,320 | 13,059 | 13,843 | 14,674 | 15,554 |
| Depreciation | 6,756 | 7,468 | 9,336 | 11,719 | 12,791 | 13,583 | 14,329 | 9,254 | | 13,785 | 14,612 | 15,489 | 16,418 | 17,403 |
| % Revenues | 6.7% | 6.9% | 7.3% | 8.5% | 8.7% | 8.8% | 9.9% | 5.7% | 8.0% | | | | | |
| CF from Operations | 13,582 | 16,878 | 22,079 | 25,445 | 26,889 | 30,256 | 29,115 | 20,777 | | 26,105 | 27,672 | 29,332 | 31,092 | 32,957 |
| Net Working Capital | 46,674 | 53,430 | 65,517 | 72,355 | 80,833 | 90,178 | 67,261 | 75,818 | | | | | | |
| Change in NWC | 1,051 | 6,756 | 12,087 | 6,838 | 8,478 | 9,345 | (22,917) | 8,557 | | 8,616 | 9,133 | 9,680 | 10,261 | 10,877 |
| % Revenues | 1.0% | 6.2% | 9.4% | 5.0% | 5.8% | 6.1% | -15.9% | 5.3% | 5.0% | | | | | |
| Capital Expenditures | 5,790 | 6,814 | 9,470 | 10,456 | 10,410 | 9,675 | 10,407 | 8,535 | | 12,062 | 12,786 | 13,553 | 14,366 | 15,228 |
| % Revenues | 5.8% | 6.3% | 7.4% | 7.6% | 7.1% | 6.3% | 7.2% | 5.3% | 7.0% | | | | | |
| Free Cash Flow | 6,742 | 3,308 | 522 | 8,151 | 8,001 | 11,236 | 41,625 | 3,685 | | 5,428 | 5,753 | 6,099 | 6,465 | 6,852 |
| Present Value | | | | | | | | | | 4,825 | 4,546 | 4,283 | 3,587 | 3,803 |
| Pv of Terminal Value | | | | | | | | | | | | | | 36,648 |

| | |
|---|---|
| Discount Rate | 12.5% |
| Total PV of Future CF | 57,692 |
| Long-term Debt | 10,542 |
| PV of Equity | 47,150 |
| Shares outstanding | 1,120 |
| Implied per share value | $ 42.10 |
| Recent Share Price | $ 45.00 |

# EXHIBIT 2.2

**Example FCF for Amazon.com (AMZN)**
*Figures in thousands (except percentages)*

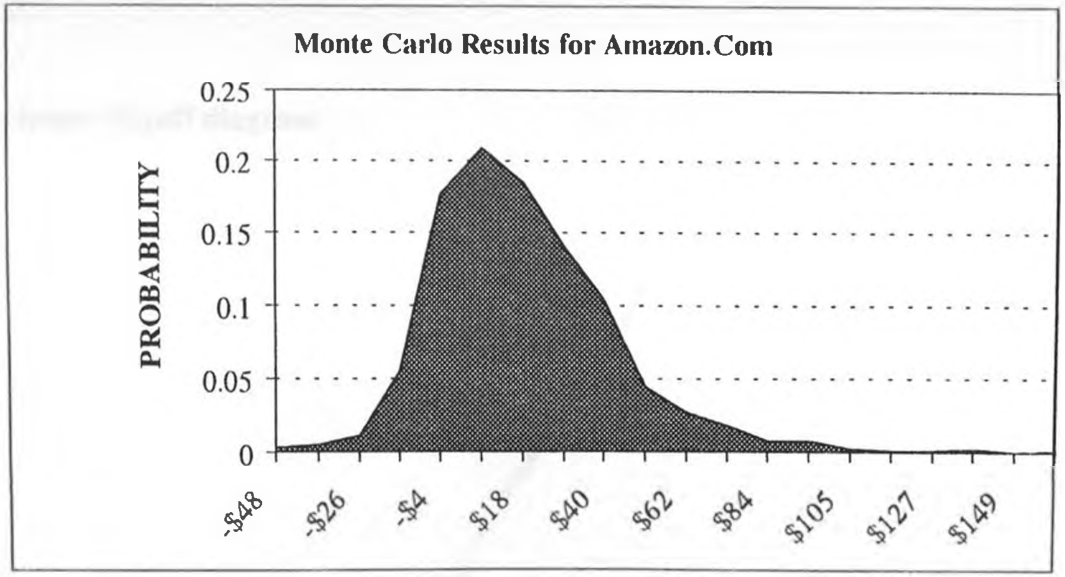
| | 1995 | 1996 | 1997 | 1998 | 1999 | Asmp. | 2000E | 2001E | 2002E | Asmp. | 2003E | 2004E | 2005E | Asmp. | 2006E | 2007E | 2008E |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Revenue | 511 | 15,746 | 147,787 | 609,996 | 1,639,839 | | 3,279,678 | 6,559,356 | 13,118,712 | | 19,678,068 | 29,517,102 | 44,275,653 | | 55,344,566 | 69,180,708 | 86,475,885 |
| Revenue growth rate | | 2981% | 839% | 313% | 169% | ***100%*** | | | | ***50%*** | | | | ***25%*** | | | |
| Cost of Sales | 409 | 12,287 | 118,969 | 476,155 | 1,349,194 | | | | | | | | | | | | |
| GrossProfit | 102 | 3,459 | 28,818 | 133,841 | 290,645 | | 655,936 | 1,311,871 | 2,623,742 | | 5,903,420 | 8,855,131 | 13,282,696 | | 16,603,370 | 20,754,212 | 25,942,765 |
| % sales | 19.96% | 22% | 19% | 22% | 18% | ***20%*** | | | | ***30%*** | | | | ***30%*** | | | |
| Operating Expenses | 406 | 9,902 | 61,413 | 245,801 | 896,400 | | 1,311,871 | 2,623,742 | 5,247,485 | | 3,935,614 | 5,903,420 | 8,855,131 | | 11,068,913 | 13,836,142 | 17,295,177 |
| % sales | 79.45% | 62.89% | 41.56% | 40.30% | 54.66% | ***40%*** | | | | ***20%*** | | | | ***20%*** | | | |
| EBITDA | -304 | -6,443 | -32,595 | -111,960 | -605,755 | | -655,936 | -1,311,871 | -2,623,742 | | 1,967,807 | 2,951,710 | 4,427,565 | | 5,534,437 | 6,918,071 | 8,647,588 |
| Depreciation | | 296 | 3442 | 9692 | ***20892*** | | 65,594 | 131,187 | 262,374 | | 393,561 | 590,342 | 885,513 | | 1,106,891 | 1,383,614 | 1,729,518 |
| % sales | | 2% | 2% | 2% | 1% | ***2%*** | | | | ***2%*** | | | | ***2%*** | | | |
| Net Interest Expense | | 3 | 1,575 | 12,586 | 37,444 | ***2%*** | 65,594 | 131,187 | 262,374 | ***2%*** | 393,561 | 590,342 | 885,513 | ***2%*** | 1,106,891 | 1,383,614 | 1,729,518 |
| Earnings before taxes | | -6,742 | -37,612 | -134,228 | -664,091 | | -787,123 | -1,374,245 | -3,148,491 | | 1,180,684 | 1,771,026 | 2,656,539 | | 3,320,674 | 4,150,842 | 5,188,653 |
| Less Taxes | | | | | | | | | | | | | | | 830,168 | 1,037,711 | 1,297,138 |
| Plus Depreciation | | 296 | 3,442 | 9,692 | 20,892 | | 65,594 | 131,187 | 262,374 | | 393,561 | 590,342 | 885,513 | | 1,106,891 | 1,383,614 | 1,729,518 |
| Net Working Capital | 920 | 1,698 | 93,158 | 262,679 | 273,243 | | 491,952 | 983,903 | 1,967,807 | | 2,558,149 | 3,837,223 | 5,755,835 | | 5,534,457 | 6,918,071 | 8,647,588 |
| % sales | | 85% | 5386% | 182% | 4% | ***15%*** | | | | ***13%*** | | | | ***10%*** | | | |
| Change in NWC | | 778 | 91,460 | 169,521 | 10,564 | | 218,709 | 491,952 | 983,903 | | 590,342 | 1,279,074 | 1,918,612 | | 221,378 | 1,383,614 | 1,729,518 |
| Capital Expenditures | | 1,335 | 7,603 | 47,352 | 643,000 | | 327,968 | 655,936 | 1,311,871 | | [illegible] | 2,066,197 | 3,099,296 | | 1,660,337 | 2,075,421 | 2,594,277 |
| % sales | | 8% | 5% | 8% | 39% | ***10%*** | | | | ***7%*** | | | | ***3%*** | | | |
| Free Cash Flow | | -8,569 | -133,233 | -241,419 | -1,296,763 | | -1,137,019 | [illegible] | -4,657,143 | | 393,561 | 196,781 | 295,171 | | 4,372,221 | 3,804,939 | 4,756,174 |
| PV of CFs | | | | | | | -990,434 | -1,766,875 | -3,078,179 | | 226,592 | 98,690 | 128,950 | | 1,663,830 | 1,261,283 | 1,373,348 |
| Terminal Value | | | | | | | | | | | | | | | | | 41,515,753 |
| PV of Terminal | | | | | | | | | | | | | | | | | 10,442,249 |

| | |
|---|---|
| Discount Rate | 15% |
| Total PV of Future CF | 9,359,454 |
| Long-term Debt | 1,533,852 |
| PV of Equity | 7,825,602 |
| Shares outstanding | 349,000 |
| Implied per share value | $22 |
| Recent Share Price | $60 |

| Discount Rate Calculations | |
|---|---|
| Risk Free rate | 6% |
| Market risk Premium | 8% |
| Beta | 2.5 |
| CAPM | 26% |
| Required debt return | 10% |
| Percent Debt | 70% |
| WACC | 14.8% |

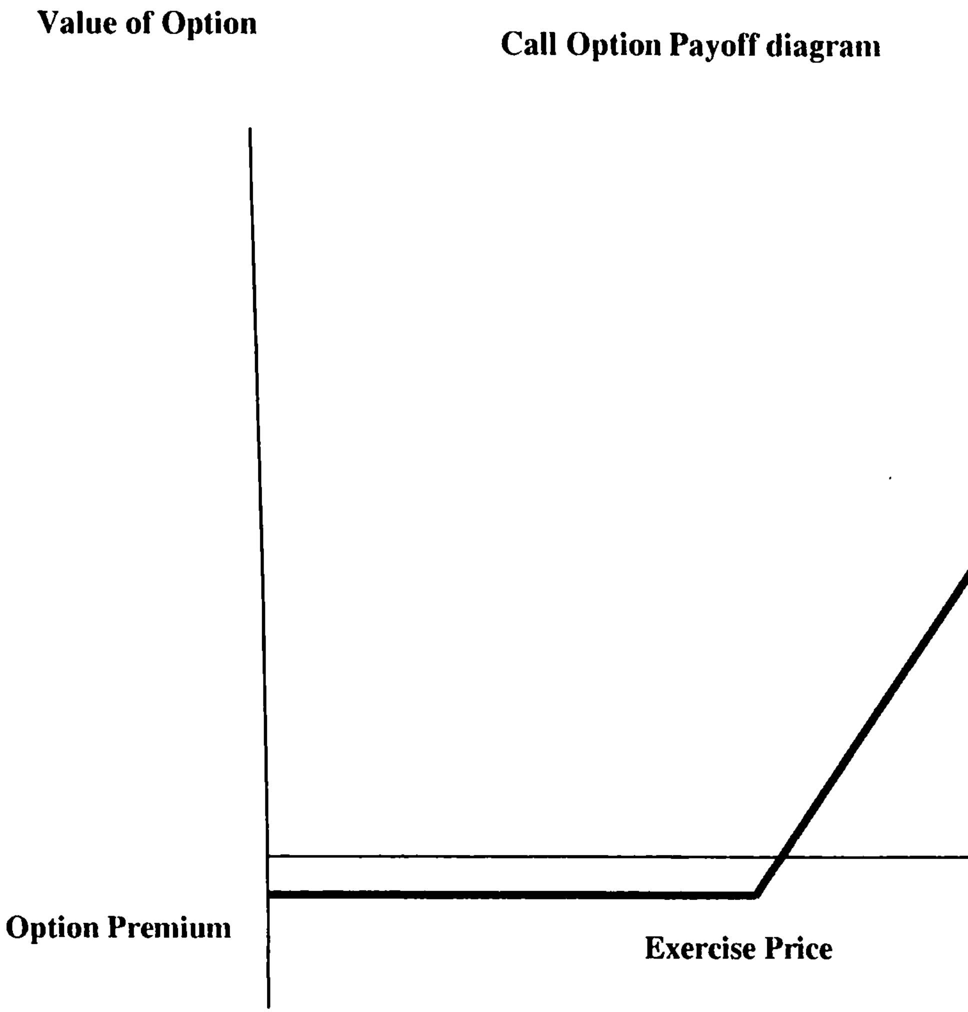
EXHIBIT 2.3

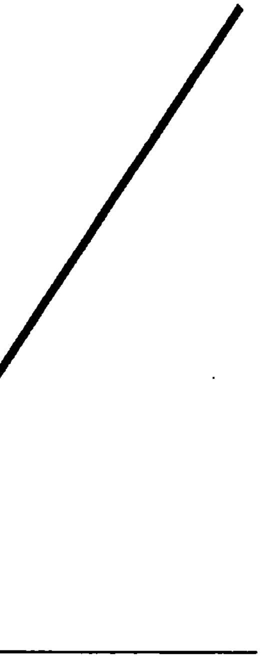
| Probability Distribution | |
|---|---|
| -$47.94 | 0.30% |
| -$36.99 | 0.50% |
| -$26.03 | 1.20% |
| -$15.08 | 5.50% |
| -$4.12 | 17.60% |
| $6.83 | 20.80% |
| $17.79 | 18.40% |
| $28.74 | 14.00% |
| $39.70 | 10.40% |
| $50.65 | 4.50% |
| $61.61 | 2.70% |
| $72.56 | 1.80% |
| $83.52 | 0.80% |
| $94.47 | 0.80% |
| $105.43 | 0.20% |
| $116.38 | 0.10% |
| $127.34 | 0.10% |
| $138.29 | 0.20% |
| $149.25 | 0.00% |
| $160.20 | 0.10% |
| $171.16 | 0.00% |




| Input Variable | Years | Distribution--type(mean, st. dev) |
|---|---|---|
| Sales Growth | 00-'03 | Normal(1,0.2) |
| Sales Growth | 03-'06 | Normal(0.5,0.15) |
| Sales Growth | 06-'09 | Normal(0.25,0.1) |
| Gross Profit Margin | 00-'03 | Lognorm(0.2,0.025) |
| Gross Profit Margin | 03-'06 | Lognorm(0.3,0.025) |
| Gross Profit Margin | 06-'09 | Lognorm(0.35,0.025) |
| Operating Expenses | 00-'03 | Lognorm(0.4,0.025) |
| Operating Expenses | 03-'06 | Lognorm(0.2,0.025) |
| Operating Expenses | 06-'09 | Lognorm(0.2,0.025) |
| NWC | 00-'03 | Lognorm(0.15,0.025) |
| NWC | 03-'06 | Lognorm(0.13,0.025) |
| NWC | 06-'09 | Lognorm(0.1,0.025) |
| Cap Exp. | 00-'03 | Lognorm(0.05,0.025) |
| Cap Exp. | 03-'06 | Lognorm(0.05,0.025) |
| Cap Exp. | 06-'09 | Lognorm(0.02,0.025) |

**Exhibit 3.1**


Value of Option
Call Option Payoff diagram
Option Premium
Exercise Price



**Stock Price**

**Exhibit 3.2** (Adapted from Mauboussin, not drawn to scale)

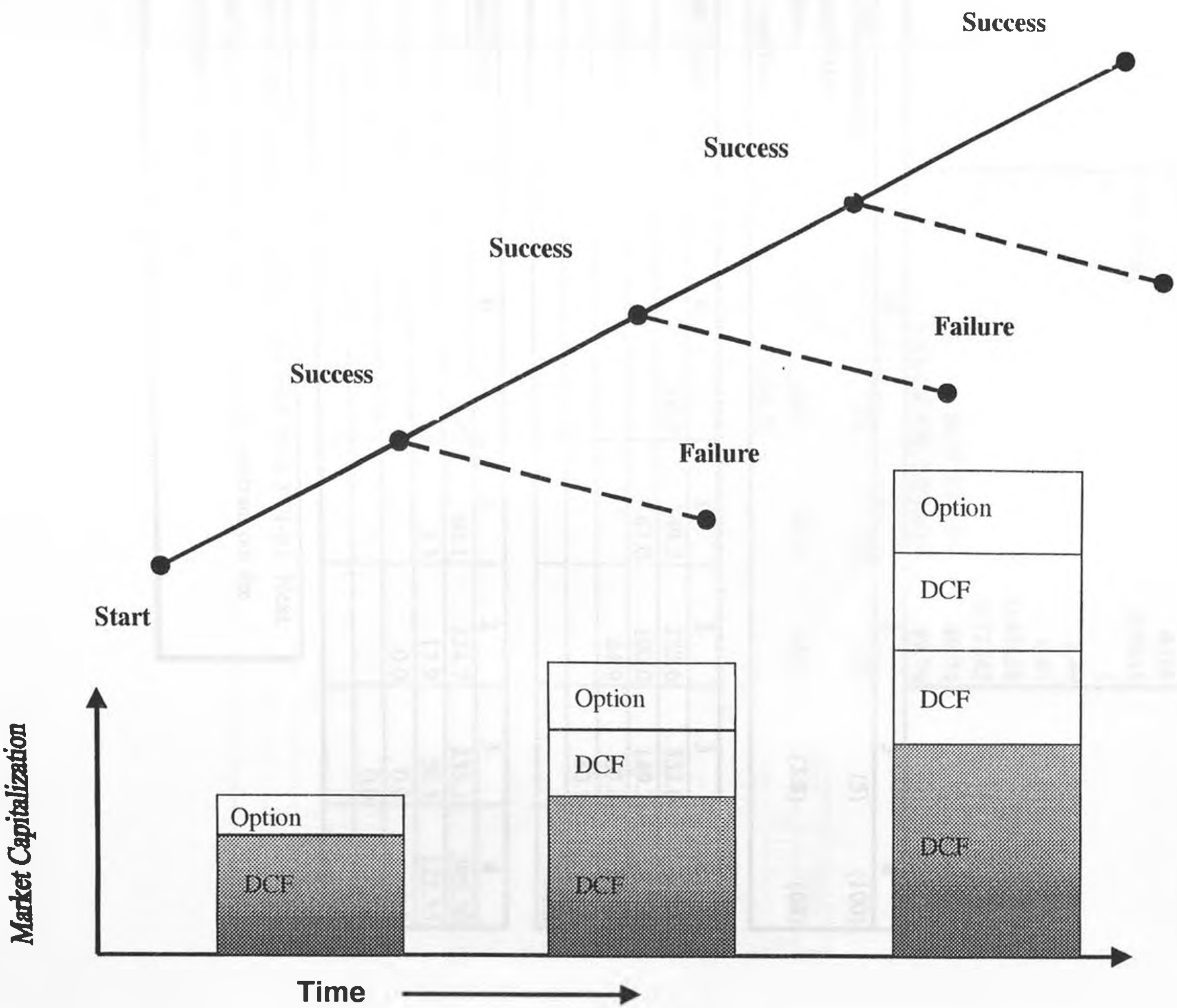


**Exhibit 3.3**

**Binomial Example**

| **Inputs and Preliminary Calculations** | |
|---|---|
| A (at time 0) | $100 |
| sigma | 40% |
| r | 6.0% |
| exp(-r*dt) | 0.9418 |
| dt | 1 |
| u | 1.49 |
| d | 0.67 |
| p | 0.47658 |
| 1-p | 0.52342 |
| **DCF VALUE** | **-$0.74** |
| **VALUE OF OPTION** | **$9.76** |

| **Year** | **0** | **1** | **2** | **3** | **4** |
|---|---|---|---|---|---|
| **Schedule of Investment** | (20) | (5) | (5) | (5) | (100) |
| **Ending Asset Value** | | | | | |
| **PV of outflows** | (20.0) | (4.5) | (4.1) | (3.8) | (68) |
| **Sum of PV outflows** | (100.7) | | | | |

| **Yearly Asset Value Tree** | **0** | **1** | **2** | **3** | **4** |
|---|---|---|---|---|---|
| | 100.0 | 149.2 | 222.6 | 332.0 | 495.3 |
| | | 67.0 | 100.0 | 149.2 | 222.6 |
| | | | 44.9 | 67.0 | 100.0 |
| | | | | 30.1 | 44.9 |
| | | | | | 20.2 |

| **Option Value Tree** | **0** | **1** | **2** | **3** | **4** |
|---|---|---|---|---|---|
| | 9.8 | 60.1 | 124.7 | 233.1 | 395.30 |
| | | 3.3 | 17.9 | 50.3 | 122.55 |
| | | | 0.0 | 0.0 | 0.0 |
| | | | | 0.0 | 0.0 |
| | | | | | 0.0 |

To calculate the year zero option value, take 60.1*p+3.3*(1-p). Next, discount the value by multiplying it by $e^{-.6}$. Finally, subtract out the investment needed in year zero.

**Exhibit 4.1**

**Amazon.Com**

**Option value from auction business (figures in millions)**

| **Inputs and Preliminary Calculations** | | |
|---|---|---|
| A (at time 0) | | 307.2 |
| sigma | | 110% |
| r | | 6% |
| exp(-r*dt) | | 0.9418 |
| dt | | 1 |
| u | | 3.004 |
| d | | 0.333 |
| p | | 0.273 |
| 1-p | | 0.727 |
| **DCF VALUE** | $ | (3.20) |
| **VALUE OF OPTION** | $ | 126.50 |

| | **2000** | **2001** | **2002** | **2003** | **2004** |
|---|---|---|---|---|---|
| **Year** | **0** | **1** | **2** | **3** | **4** |
| **Schedule of Investment** | (40) | (50) | (80) | (100) | (200) |
| **PV of investment @ 25%** | (40) | (40) | (64) | (64) | (102) |
| **PV of ending Asset** | | | | | 307 |

| **Yearly Value Tree** | **0** | **1** | **2** | **3** | **4** |
|---|---|---|---|---|---|
| | 307 | 923 | 2,772 | 8,329 | 25,022 |
| | | 102 | 307 | 923 | 2,772 |
| | | | 34 | 102 | 307 |
| | | | | 11 | 34 |
| | | | | | 4 |

| **Option Value Tree** | **0** | **1** | **2** | **3** | **4** |
|---|---|---|---|---|---|
| | 126 | 639 | 2,431 | 8,046 | 24.822 |
| | | 0 | 89 | 640 | 2,572 |
| | | | 0 | 0 | 107 |
| | | | | 0 | 0 |
| | | | | | 0 |

# Exhibit 4.2

Aviron

Value from Flu Vaccine (figures in millions)

| Inputs and Preliminary Calculations | |
|---|---|
| A (at time 0) | 1566.06 |
| sigma | 90% |
| r | 6% |
| exp(-r*dt) | 0.9851 |
| dt | 0.25 |
| u | 1.568 |
| d | 0.638 |
| p | 0.406 |
| 1-p | 0.594 |
| DCF VALUE | $ 1,052.0 |
| VALUE OF OPTION | $ 1,213.5 |

| Ratio Comparisons | Estimated Ratios | 2002 Estimates | Implied 2002 Value (ratios*estimates) |
|---|---|---|---|
| Price to Sales | 10 | 237 | 2,370 |
| Price to Op. Margin | 25 | 57 | 1,425 |

| | Q1 2000 | Q2 2000 | Q3 2000 | Q4 2000 | Q1 2001 | Q2 2001 | Q3 2001 | Q4 2001 |
|---|---|---|---|---|---|---|---|---|
| Schedule of Investment | (30) | (35) | (40) | (45) | (50) | (55) | (60) | (65) |
| PV of investment @ 15% | (30) | (34) | (37) | (40) | (43) | (46) | (48) | (50) |
| PV of ending Asset | 1566 | | | | | | | |

| Quarterly Asset Value | Q1 2000 | Q2 2000 | Q3 2000 | Q4 2000 | Q1 2001 | Q2 2001 | Q3 2001 | Q4 2001 |
|---|---|---|---|---|---|---|---|---|
| | 1,566 | 2,456 | 3,852 | 6,041 | 9,474 | 14,858 | 23,303 | 36,546 |
| | | 999 | 1,566 | 2,456 | 3,852 | 6,041 | 9,474 | 14,858 |
| | | | 637 | 999 | 1,566 | 2,456 | 3,852 | 6,041 |
| | | | | 406 | 637 | 999 | 1,566 | 2,456 |
| | | | | | 259 | 406 | 637 | 999 |
| | | | | | | 165 | 259 | 406 |
| | | | | | | | 105 | 165 |
| | | | | | | | | 67 |

| Option Value Tree | Q1 2000 | Q2 2000 | Q3 2000 | Q4 2000 | Q1 2001 | Q2 2001 | Q3 2001 | Q4 2001 |
|---|---|---|---|---|---|---|---|---|
| | **1,213** | **2,127** | **3,553** | **5,778** | **9,252** | **14,683** | **23,179** | **36,481** |
| | | 671 | 1,267 | 2,193 | 3,630 | 5,865 | 9,351 | 14,793 |
| | | | 340 | 735 | 1,344 | 2,281 | 3,729 | 5,976 |
| | | | | 146 | 415 | 823 | 1,443 | 2,391 |
| | | | | | 43 | 230 | 514 | 934 |
| | | | | | | 0 | 136 | 341 |
| | | | | | | | 0 | 100 |
| | | | | | | | | 2 |

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[1] A few examples of Industry resources are International Data Corp, Forrester Research, and Jupiter Communications. These sources provide industry data and predictions for PC sales, WWW users, and dollars spent on the Internet.

[2] We should note that there is also a liquidation value of a business, which is the cash generated by shutting down a business and selling off its assets individually. In most cases the going-concern value is well above the liquidation value.

[3] Also known as discounted cash flow method or net present value.

[4] Working capital is defined as current assets minus current liabilities, and gives a measure of the capital needs for a business's day-to-day operations. Investment in working capital typically includes inventory and payables.

[5] Free Cash flows can be calculated a number of ways, but a common method is to begin with earnings before interest, subtract taxes, add back depreciation, and subtract investment in working capital and capital expenditures. This translates accounting numbers from the financial statements into cash flows for a company.

[6] As we saw in the Ford and Amazon examples, finance theory dictates that we discount future cash flows at an appropriate risk adjusted rate. The discount rate increases with risk and time, which therefore decreases any future cash flows.

[7] The book value of a company comes from a company's accounting statements. Although these statements use historical data, they give a reasonable measure of a company's assets, liabilities, and stockholder's equity.

[8] An option is "in the money" when the underlying asset's price is above the exercise price. At and above this point, the owner would consider exercising the option.

[9] This research capitalized the earnings stream of technology companies, and then subtracted the value from their market capitalizations to get an implied value of the growth options.

[10] We use the Capital Asset Pricing model to calculate this risk adjusted rate. The calculations rely on a risk measure called beta to compare a company or project's risk to the market as a whole. The calculations for the discount rate are as follows assuming a calculated beta of 2.5, a risk free rate of 6%, and a market risk premium of 8%: .06+2.5*.08=roughly 25%

[11] Because a dollar today is worth more than a dollar in the future, finance theory dictates that we discount future cash flows at an appropriate risk adjusted rate. The discount rate increases with risk and time, which therefore decreases any future cash flows.

[12] The calculations for the discount rate are as follows assuming a calculated beta of 1.06 for Aviron, a risk free rate of 6%, and a market risk premium of 8%: .06+1.06*.08=14.4% or roughly 15%