

Valuation Techniques and the Economics of Software as a Service

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Abstract

A significant amount of literature favors the notion that a real-options approach to capital budgeting is superior to the conventional discounted cash flow technique when uncertainty is present in the investment opportunity. Unlike traditional licensed-based software, SaaS¹ inherently provides the buyer with the flexibility to change the course of the investment as uncertainty related to the product or service is resolved. In this respect, SaaS changes the game with regard to the economic benefits provided by the product or service. The SaaS model builds management flexibility into the investment decision and that same flexibility may be valuable when uncertainty is present. With that said, the question at hand is whether or not conventional valuation techniques such as DCF² can be counted on to make accurate SaaS capital budgeting decisions. And if such methods cannot be counted on, do OPM³ techniques such as binomial lattices or modified Black Scholes models provide a more accurate picture of their value? The final and perhaps more important question seeks to understand which of the two methods is most likely to be used by finance professionals when making SaaS capital budgeting decisions. This paper will show that a considerable gap exists between those that *intend* to use conventional DCF models versus more sophisticated OPM techniques when making capital investment decisions that involve SaaS. This gap should be a concern for those that buy or sell products and services delivered via SaaS for the value of flexibility may go unrecognized.

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This paper, "Valuation Techniques and the Economics of Software as a Service", is a *revised edition* of Grabski (2008) "Do option pricing models outperform conventional DCF valuation techniques for capital budgeting decisions that involve SaaS? Which of the two models is most likely to be used going forward? University of Liverpool, pp.1-102.

¹ SaaS is a widely known acronym for *Software as a Service*.

² DCF is the acronym for *Discounted Cash Flows*, a valuation technique that accounts for time-value of money.

³ OPM represents the acronym for *Option Pricing Model*, a valuation technique following financial option pricing theory.

CERTIFICATION STATEMENT

I pledge that this paper represents my own work entirely and that where the language of others is used, proper credit is extended with the use of quotation marks. And where the use of ideas and previous work is used, credit has been noted without exception. Errors, omissions or mistakes are mine and mine alone.

Signed,

A handwritten signature in black ink, appearing to read "John R. Grabski". The signature is written in a cursive style with a large initial "J" and "G".

John R. Grabski

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CHAPTER I

Introduction

A major technological shift is underway that changes the manner in which many products and services are purchased. Corporate Performance Management systems and other knowledge-based assets for example are increasingly delivered via SaaS rather than as licensed software. This rise in popularity is due in part to the competitive advantage that SaaS creates by making products and services available to customers at lower upfront costs and with increased payment flexibility when compared to more traditional delivery methods (SIIA, 2006). In contrast to the conventional license, a subscription based model changes the complexion of the transaction including the timing, size of payments and the ability to unsubscribe or walk away from the investment. Since SaaS impacts the economic benefits provided by the product or service, the point of this research is to ascertain whether or not conventional valuation techniques such as DCF methods can be counted on to capture SaaS value in the capital budgeting environment. And if such methods cannot be counted on to value products or services that are delivered via SaaS: Do OPM techniques such as binomial lattices or Black Scholes option pricing models provide a more accurate picture of value?

According to Siegel (1985), Higgins (1998), Benninga (2000) and others, traditional DCF methods have been the most popular method of valuation for the past four decades. At the same time, traditional valuation methods including the DCF method have been widely criticized as ill equipped to capture value when the investment opportunity contains elements of flexibility. If this is so, it underscores the importance of understanding the degree of flexibility that SaaS brings to the environment. Perhaps more importantly, it becomes critical to know what that same flexibility is worth.

Valuation methods are also evolving (Trigeorgis, 1996). In fact, much debate exists in the literature that argues for and against the merit of traditional valuation methods. Noted valuation authorities including Damodaran (2001) Trigeorgis (1996) and Benninga (2000) argue that traditional techniques such as the discounted cash flow method fail to capture the complex nature of many assets and instead advocate the use of option pricing models as a superior alternative. As Pindyck (1991) makes clear, the net-present value rule that has dominated investment decisions, business schools and the capital budgeting process for decades may be incorrect for investment decisions that can be delayed, deferred or abandoned. This position is examined in detail since the research thesis argues that products and services delivered via SaaS inherently contain the option to abandon and that same option may be valuable.

Research objectives

The research sets out to uncover whether or not a CPM⁴ application delivered via SaaS is more accurately valued using a conventional DCF technique compared to a more contemporary OPM methodology. The second objective seeks to understand which of the two methods that finance professionals are most likely to use when making capital budgeting decisions that involve SaaS. The reason for this is clear. Any valuation method that fails to capture the full value of the product or service puts the seller of that same product or service at a distinct disadvantage when the buyer compares the product or service to a competitive alternative. For this reason alone, understanding the valuation model that is most likely to be used may be critical for it may impact the successful adoption of the product under consideration. The choice of techniques may be equally important on the buy-side of the transaction. Clearly, if finance professionals choose valuation methods that ignore the value of flexibility, they may unknowingly direct scarce resources toward competing investment opportunities that only *appear* to offer superior returns.

The aim of the research

The research aims to demonstrate that products and services delivered via SaaS contain embedded options in the form of managerial flexibility and that same flexibility has value. To succeed in this endeavor, the research examines the value of one real-life application delivered via SaaS using a traditional DCF model and two OPMs, including a binomial option pricing model and a modified Black-Scholes model in order to examine the differences between each method. Finally, to gain insight into the practical use of the valuation methods, a survey was conducted to understand which of the two methods, DCF or OPM, is most likely to be used by finance managers when purchasing products or services delivered via SaaS. The results prompt the question as to whether finance professionals put too much faith in DCF models when making capital budgeting decisions that involve complex assets and services such as those delivered via SaaS. The research is important since the failure to recognize the value of management flexibility provided by SaaS applications may lead to sub-optimal decision-making on both sides of the SaaS transaction. Further, such a condition may create a sales barrier for vendors that depend upon SaaS to deliver products and services. For example, if potential customers perceive the value of economic benefits provided by SaaS to be lower than true value, competitive alternatives can only appear more appealing by default. In addition, the research represents the opportunity to fill a gap in the current state of the literature. While a vast amount of academic literature exists in the *Journal of Finance*, the *Journal of Intellectual Capital* and the *Journal of Management Decision* among other important academic journals pertaining to DCF and OPM, the same cannot be said when it comes to the availability of literature that links optimal valuation methods to *specific* asset types or services. Indeed, complexity of assets vary considerably and despite widespread interest in real options and the abundance of literature on the topic Philippe (2005:1) points out that “empirical tests of real option models are scarce” and argues that case studies are needed in order to improve the general understanding of management behavior with respect to

⁴ CPM is the acronym for *Corporate Performance Management* system.

the valuation of products or services that include managerial flexibility. Such a condition opens the door for case studies that help transform theory into actionable knowledge.

Orientation of the research

The research approaches the problem from both a qualitative and quantitative perspective. Specifically, a qualitative approach is followed to uncover the attributes and limitations of DCF and OPM valuation methods, and a quantitative approach is followed to model the performance of each method in the context of the SaaS environment. Additionally, a quantitative approach is followed to learn the extent to which method is most likely to be utilized when financial managers make capital budgeting decisions that involve products and services delivered via SaaS.

Both sides of the buy-sell transaction are examined in a real life setting. The *seller* provides a CPM system delivered via SaaS to the *buyer*, in this case a growing electronics manufacturer that desires to improve cash flow by implementing the CPM system. The CPM under study in this case, ClearFinancials[®] is a Corporate Performance Management system developed by ClearMomentum, Inc. located in Rochester, New York, USA. The company's target market consists of North American mid-sized companies that range between one hundred million and one billion dollars in annual revenue. The ClearFinancials[®] CPM application is delivered via SaaS. The system is sold as a subscription based upon the company's size, number of divisions and the amount of ongoing support required. The customer may elect to cancel the subscription with a fee applied to the unused portion of the subscription. The system is positioned as a knowledge-asset⁵ designed to improve the execution of corporate strategy.

The customer of the CPM in this case, Badger Technologies, Inc., is headquartered in Farmington, New York, and provides a wide range of high technology manufacturing services to clientele that compete in the defense, medical instrumentation and telecommunications markets. The company was incorporated in 1989, employs approximately three hundred people and enjoys a reputation as the dominant electronics contract manufacturer in the region. In July 2007, the executive management team made the decision to procure the CPM application with the goal to improve execution of corporate strategy. According to Cirincione (2007), the management team concluded that the success or failure of the CPM application would be measured as a function of its ability to increase the company's free cash flow. Accordingly, the value of the CPM system was seen by the management team to be a function of the degree to which the CPM improves the performance of the underlying drivers of free cash flow such as material costs, SG&A expenses and inventory turnover.

⁵ A *knowledge asset* is analogous to intellectual property that is used to create or provide value to customers (Chang, Hung and Feng-Tse, 2005)

Introduction summary

Following a rigorous review of the literature, a valuation simulation followed by a statistically significant survey, the research aims to learn whether OPM techniques outperform conventional DCF methods when making capital budgeting decisions involving SaaS. In addition, the research seeks the answer to which of the two models, DCF or OPM, that is most likely to be used by finance managers in this setting. Answering both questions helps shed light on whether or not the *adoption* of emerging valuation techniques is keeping pace with the evolution of complex products and service delivery methods such as SaaS.

CHAPTER II

Literature Review

Introduction

The literature review seeks to provide an overview of the current state of the academic literature with respect to the strengths and weaknesses of DCF and OPM valuation methods and how they have evolved over the past four decades. The research examines past and current thinking as it relates to valuation methods used for the purpose of capital budgeting and resource allocation. In particular, the literature review seeks to uncover specific strengths and weaknesses of valuation methods in the context of the SaaS environment. Finally, the chapter examines the functional attributes of each method and considers the position and perspectives of a host of academics and two practitioners.

Background of valuation methods used for capital budgeting

For decades, corporate financial professionals have been tasked with the responsibility of making day to day investment decisions that make the most economic sense for their firm. Phelan (1997:163) points out, "The goal of sophisticated capital budgeting is to direct the firm's resources to those activities which provide the highest economic value for the owners of the firm". And since investment capital is normally finite and limited, this process involves understanding the cost versus the benefit of one or more competing investment opportunities and their relative expected cash flows (Kingston, 2001). While valuation may appear straightforward on the surface, the process can be confounded by costs and benefits that occur sporadically over the life of the project (Block and Hirt, 1987). And since value is a function of timing and uncertainty of the relevant future free cash flows generated by the product or service, it can be difficult to compare one against the other given the differences that exist with respect to both timing and the frequency of the benefits (Higgins, 1998). To address these and other valuation challenges, the discounted cash flows method according to Siegel (1985) was first developed by Williams (1938) and later refined in the context of corporate finance by Gordon (1962). The DCF method of valuation popularized by Gordon (1962) has remained the single most popular method of valuation among finance professionals for the past four decades (Siegel 1985; Higgins 1998). DCF is a simple and widely known method of discounting the value of expected future cash flows back to present value as a function of the time value of money and risk reflected in the discount rate. Essentially, the DCF equation answers the question: What is the value of future cash flows expressed in terms of today's present value? Evaluating two or more assets after adjusting each for the impact of both time and risk enables the decision maker to compare the assets on equal grounds in terms of present value and was widely considered to be one of the most important contributions to modern finance throughout history. Still to this day, various DCF techniques are considered to be an integral component of modern day finance evidenced by Higgins (1998:232) stating that "Indeed, it is not an exaggeration to say that discounted cash flow analysis is the

backbone of modern finance and even modern business". This position would appear to be shared by academics throughout the literature.

Following the work of Gordon (1962), a host of modifications to the traditional DCF model evolved. To illustrate, Fernandez (2002) compiled a list of ten versions of cash flow discounting models that can be used to value investments including, free cash flow, equity cash flow, capital cash flow, adjusted present value, risk adjusted cash flow, risk-free adjusted, economic profit and economic value added. Applying each model to one specific company for the purpose of valuation, Fernandez (2002) demonstrates that each model performs similarly since each method analyzes the same basic reality under the same circumstances with the only difference being the starting point of the cash flows. Along the same line of thinking, Higgins (1998) points out that the present value of an investment's EVA⁶ stream is precisely equal to the investment's NPV⁷ indicating that the popular metric, EVA is grounded by the same basic principle of NPV. Steffens and Douglas (2007) demonstrate other variations of the DCF model specifically designed for high risk technological investments used in venture capital financing and Trigeorgis (1996) illustrates modifications that adjust for uncertainty. Perhaps hundreds of modifications to DCF models exist in the literature. And as suggested by Fernandez (2002) each ultimately reduce to the reality of the present value of future flows of cash after adjusting for the effects of the time value of money and risk. Indeed, since both cost and time are central to value, most changes to DCF models take form as an adjustment to the discount rate (Dixit and Pindyck, 1995). For decades and perhaps still today, the DCF methodology was widely held as the gold standard of capital budgeting valuation techniques. For example, 1995 composite studies in the U.S., UK and Australia show that over eighty percent of the companies surveyed used a net present value of DCF when making capital budgeting decisions (Phelan, 1997).

In the past several decades however, and especially the most recent decade, academics have challenged the merit of the DCF method uncovering limitations and weaknesses of the model (Damodaran, 2001; Trigeorgis, 1996; Dixit and Pindyck, 1995). For example (Trigeorgis, 1996:1) states, "It is now widely recognized that traditional discounted cash flow (DCF) approaches to the appraisal of capital investment projects, such as the standard net present value (NPV) rule cannot properly capture management's flexibility to adapt and revise later decisions in response to unexpected market developments". In addition to the inability to capture the value of flexibility, DCF models are widely criticized for their inherent inability to capture synergy-value often created by two or more complimentary assets and for the model's dependence upon fixed discount rates that may be prone to error as risk changes over time (Phelan, 1997). Moreover, Dixit and Pindyck (1995) suggest that the traditional NPV models contain a host of weaknesses including the assumption that investment decisions are made in the present moment and at a single fixed point in time. Dixit and Pindyck (1995) suggest further that widespread use of inaccurate discount rates, the model's inability to recognize the value of options as well as assuming that the

⁶ EVA is the acronym for Economic Value Added and is a registered trademark of Stern, Stewart, Co.

⁷ NPV is the acronym for Net Present Value

investment is not reversible or cannot be delayed are but a sample of the many limitations and weaknesses of the DCF model.

Perhaps one of the most regularly cited weaknesses of conventional models is the failure to recognize the value of management flexibility. Many assets for example inherently provide the prospective buyer with the right to cancel, reschedule or make future payments as uncertainty related to economic performance is brought to light (Damodoran, 2000). To address the weaknesses of conventional DCF methods, academics and researchers continue to explore new valuation methods that seek to capture the economic value of flexibility as well as the option to optimize and change the investment strategy as uncertainty is resolved with the passage of time (Trigeorgis, 1996). For example, methods previously used to value financial assets such as call and put options proved to represent a viable technique to value real assets. Black and Scholes (1973) for example introduce an option pricing model that measures the value of financial assets that inherently contain the right but not the obligation to purchase the underlying asset. Variations of the model were used to make capital budgeting decisions however Trigeorgis (1998) and Damodoran (2000) point out that the model makes several unreasonable assumptions addressed later in this paper. Other option pricing models soon followed Black and Scholes (1973) including a binomial option pricing methodology introduced by Cox, Ross and Rubenstein (1979) that promised a more efficient and practical means to ascertain option value. Trigeorgis (1996) and others suggest that option pricing models may prove more accurate than DCF models when valuing certain types of assets that contain embedded options. Indeed, as increased competition forced companies to build additional flexibility and complexity into their products, more sophisticated valuation models were researched and tested with the aim to develop techniques that more accurately capture the value of complex assets.

Review of the valuation techniques

This section will examine the valuation methods in order to illustrate how the models work. A review of the mathematics is vital in this case in order to grasp the strengths and limitations of each method. The traditional DCF method, the Binomial Lattice and Black Scholes valuation methods will be examined within the context of the literature and most current thinking in order to understand the three models' ability to capture the value of products and services delivered in SaaS environment.

To begin, most *traditional* cash flow discounting techniques follow the equations illustrated in Figure 2.0 and 2.01 respectively (Benninga, 2000) and Trigeorgis (1996).

Figure 2.0

$$NPV = cf_0 + \sum_{t=1}^n \frac{cf_t}{(1+r)^t}$$

Where *cf* represents the cash flows and *r* represents the discount rate. As expressed by the equation in Figure 2.0, NPV is equal to the initial cash flow investment plus the sum of the periodic cash flows where each is divided by one plus the discount rate raised to the corresponding time period. It should be noted that *cf*₀ is most often a negative number and represents the initial cash outlay. The equation in Figure 2.0 is arguably the most basic and straightforward method of ascertaining the present value of a future cash flow stream and makes it easy to compare two competing investments in terms of present day value. Figure 2.0 essentially expresses the future value of expected cash flows in present day terms, discounted for the time value of money and risk.

Trigeorgis (1996) provides a more intuitive example that illustrates the process of subtracting the present value of cash outflows should the investment, or in this case cash outflows occur in different periods. As opposed to adding the negative cash flow at *t*-0 as indicated in Figure 2.0, Trigeorgis (1996) suggests subtracting the investment outlay denoted as *I* in Figure 2.01. The letter *C* in this case represents cash flow inflows. The equation to solve for *I* is presented in Figure 2.02.

Figure 2.01

$$NPV = \sum_{t=1}^T \frac{C_t}{(1+r)^t} - I$$

Figure 2.02 represents the net present value of cash outflows represented as the letter *I* and the letter *O* represents cash outflows for the specific period *t*.

Figure 2.02

$$I \equiv \sum_{t=0}^T \frac{O_t}{(1+r)^t}$$

To make this clear, Figure 2.02 represents the method to obtain the present value of the capital outflow denoted as, *I*, that will be subtracted from the present value of the cash inflows in Figure 2.01. In other words, the net present value is equal to the present value of the cash outflows subtracted from the present value of the cash inflows. Equations 2.0, 2.01 and 2.02 each make

the assumption that the discount rate remains constant, the investment is made on the first day of the period and that the investment is irreversible.

The discount rate used in the equations presented in Figure 2.0, 2.01 and 2.02 represent a source of contention among academics and practitioners. Implicit weaknesses of discount rates and the problems that they create are very well known. Nearly a half century ago, academics Robichek and Myers (1966) cautioned against the use of the discount rate. Indeed, each of the equations represented in Figures 2.0, 2.01 and 2.02 show that future cash flows are discounted back to present value using *one* specific and *constant* rate. While mathematically sound, the equations reveal that it is the discount rate that ultimately impacts the *degree* to which the cash flows are reduced over time. According to Robichek and Myers (1966), the discount rate is comprised of the time value of money and a corresponding adjustment to risk that is associated with the expected cash flows. Phelan (1997) in essence defines the discount rate as the opportunity cost of capital expressed as the expected rate of return on securities with a level of risk that is equivalent to the investment under consideration and Steffens and Douglas (2007) describe the discount rate as equivalent to a market return for a security of equivalent risk. While the discount rate as defined by Phelan (1997) and Steffens and Douglas (2007) might adequately describe opportunity cost with respect to a comparable investment, the statement implies that it is possible to measure and compare idiosyncratic risk⁸. Using the opportunity cost of capital as the discount rate in this sense seeks to compensate the investor for both the time value of money in addition to a premium for added risk. It is widely known throughout the literature that consolidating both risk and the time value of money in one constant rate implicitly assumes that risk can be accurately quantified and that it remains constant. Moreover, in order for the equations represented in Figures 2.0, 2.01 and 2.02 to deliver accurate values, one must assume that both the time value of money *and* the degree of risk expressed as the discount rate is both accurate and that both remain unchanged for the life of the investment.

The act of bundling both risk and the time value of money into one composite number clearly obscures both measures⁹. And since it is well known that both risk and the time value of money do in fact change over time, Robichek and Myers (1966) provide a straightforward and arguably important equation that explains the relationship between certain and uncertain cash flows and the discount rate. Robichek and Myers (1966) show that adding one plus the risk free rate divided by one plus the risk adjusted rate returns the certainty equivalent coefficient as illustrated in Figure 2.03.

⁸ Idiosyncratic risk is widely used as a term that refers to risk specific to the firm and unrelated to the overall market.

⁹ This statement is widely known throughout the literature and industry and can be observed with the equation in Figure 2.0 since it is difficult to know the degree to which risk and the time value of money impact NPV when both are included in the discount rate.

Figure 2.03

$$\alpha_t = \frac{(1+i)^t}{(1+k)^t}$$

The equation represented in Figure 2.03 is important since adjusting cash flows by α_t and discounting with the risk free rate i will produce the identical value as when discounting by the risk adjusted discount rate k without adjusting cash flows by the certainty equivalent coefficient. Observing α_t as unity between certain and uncertain cash flows and the risk free rate and the risk adjusted discount rate, Robichek and Myers (1966) show that the equation in Figure 2.03 will not hold if risk changes overtime, producing erroneous valuations as a result. From a practical standpoint, discount rates are likely to be unreliable if arbitrarily assigned according to the perceived risk level of the individual analyst. (Phelan, 1997:104) makes this point perfectly clear when he asserts that using a constant discount rate assumes that the analyst possesses “perfect knowledge about all future states of the world”. Clearly, such knowledge cannot exist in one person.

In summary, the literature shows that traditional DCF equations such as those illustrated in Figures 2.0, 2.01 and 2.02 shift the uncertainty of cash flows in the numerator to the discount rate in the denominator and further assumes that uncertainty will remain constant over time. The use of a single composite discount rate created by commingling arbitrary risk factors with the time value of money is a major source of frustration and debate among academics and practitioners throughout the literature¹⁰. Accordingly, many efforts to overcome the shortfalls of the discount rate have been undertaken.

Critics of DCF techniques such as Dixit and Pindyck (1995) and Phelan (1997) point out weaknesses of the basic DCF model stating in essence that risk and corresponding discount rates may change substantially over time. Supporting this position, Gallagher and Zumwalt (1991) show that even very small and seemingly insignificant changes to the discount rate greatly impact the outcome due to the effects of compounding. To correct for this problem, Trigeorgis (1996) presents a straightforward method to help overcome discount rates that change from period to period as a function of risk illustrated in Figure 2.04.

¹⁰ This view is well known throughout the literature as well as industry.

In this case, the cash inflow from each period, denoted by the letter C is divided by one plus the appropriate risk-adjusted discount rate for each period represented by k raised to the specific period. The sum minus the present value of cash outflows denoted by the letter I represent the net present value of the future flows of cash.

Figure 2.04

$$NPV = \sum_{t=1}^T \frac{C_t}{(1+k)^t \dots (1+k^t)} - I$$

The methodology put forth by Trigeorgis (1996) presented in Figure 2.04 would appear to accommodate the need to recognize periodic changes to risk that may occur over time. However, Phelan (1997) maintains that credible evidence suggest that nearly one half of companies surveyed do not take variable risk into consideration by adjusting discount rates.

While the method suggested by Trigeorgis (1996) that adjusts periodic discount rates appears sound, Kingston (2001) points to the importance of choosing the correct periodic discount rate, “If the chosen rate is too low, distant benefits are underweighted relative to near-term costs; and the analyst could end up recommending an unworthy project. If the chosen rate is too high, distant benefits are discounted too heavily; the analyst could end up recommending against a worthwhile project”. Stated differently, Dixit and Pindyck, (1995:107) “a low discount rate gives more weight to cash flows that a project is expected to earn in the distant future. On the other hand, a high discount rate gives distant cash flows much less weight and hence makes the company appear myopic in its evaluation of investment projects”. Figures 2.0, 2.01 and 2.02 represent typical DCF equations subject to the points made by Dixit and Pindyck (1995) and Kingston (2001) since the compounding effect of the discount rate clearly becomes more dramatic as time passes.

Steffens and Douglas (2007) point out that the shortcomings of the DCF model can be described in two parts. First, and in support of Phelan (1997), Steffens and Douglas (2007) suggest that analysts often fail to make adjustments for variations of risk by adjusting the discount rate. Further, Steffens and Douglas (2007) suggest that analysts find considerable difficulty in determining to what degree the discount rate should be adjusted according to *perceived* risk. In order to compensate, Dixit and Pindyck (1995) point to studies that confirm that managers regularly use discount rates that are three to four times the weighted average cost of capital. In further support of this point, Giat, Hackman and Subramaniam (2007) present empirical evidence that Venture Capitalists typically use arbitrary discount rates in the forty-percent range to correct for presumed entrepreneurial optimism that may influence cash flow projections. The second point raised by Steffens and Douglas (2007) and supported by Damodaran (2001) and others is that traditional DCF models fail to capture the manager’s ability to change the course of the investment in order to maximize economic value or avoid potential loss.

To address the first shortcoming pointed out by Steffens and Douglas (2007), Trigeorgis (1996) suggests that DCF models can be adjusted in such a way that the equation disaggregates the time value of money from the uncertainty of cash flows. For example, the discount rate used in the equation can be changed to the risk free rate of return if the periodic expected cash flows are adjusted with a certainty equivalent coefficient that adjusts for the risk of the expected cash flows. Specifically, this disaggregation method suggested by Trigeorgis (1996) essentially transfers the risk from the discount rate to a probability coefficient that adjusts cash inflows for each period t .

To illustrate, the certainty equivalent equation suggested by Trigeorgis (1996) is presented in Figure 2.05 where α represents the certainty equivalent coefficient and $E(c)$ represents the expected cash flows in period t . The letter I represents the present value of cash outflows and r represents the risk free rate.

Figure 2.05

$$NPV = \sum_{t=1}^T \frac{\alpha_t E(c_t)}{(1+r)^t} - I$$

Recall that the certainty equivalent equation suggested by Trigeorgis (1996) in figure 2.05 was first introduced by Robichek and Myers (1966) and provides for the ability to use the risk free rate of return as the discount rate while adjusting cash inflows by a coefficient that changes the numerator from an uncertain value to one that is more likely to occur. This method decouples risk and the time value of money in the discount rate and transfers the risk portion from the denominator into the numerator by way of the certainty equivalent coefficient. The decoupling process helps avoid problems associated with commingling risk and time, not the least of which is the compounding of error over time. The last point has been noted previously by Gallagher and Zumwalt (1991). Adjusting cash flows based upon the probability of realization with a certainty equivalent coefficient makes intuitive sense. However Pike (1996) citing the work of Ho and Pike (1992) provide evidence that the adoption of such probability techniques does not lead to a meaningful difference in capital expenditures nor does it lead to an improvement in economic performance.

In addition to inherent weaknesses in the DCF model itself, Pindyck, (1991) points out that the NPV rule that governs most decision makers that use DCF models is flawed as well. For example, the traditional DCF rule according to Higgins (1998) states that an investment with a NPV greater than zero should be accepted and if the NPV of the investment is less than zero it should be rejected. Higgins (1998) reasons further that investments that exhibit NPV of zero can be considered a marginal investment, implying that it is neither inferior nor is it superior to the firm's cost of capital. Not all academics agree however. For example, Pindyck (1991) and later Dixit and Pindyck (1995) suggests that the NPV must *exceed* the investment by an amount at least equal to the foregone option value of the investment. Kulatilaka (1984) citing the work of

McDonald and Siegel (1982) supports this point stating in essence that project investments should be postponed until such time that NPV is greater than or equal to the initial investment cost of the project in order to cover the value of losing the option to invest elsewhere.

In summary, DCF models seek to answer one question: What is the present value of future cash flows generated by the specific investment opportunity? Critics of the model point out major weaknesses of the DCF model to include the use of fixed or constant discount rates, the use of erroneous discount rates, uncertainty associated with future cash flows, the assumption that the investment is reversible or that it cannot be delayed, the assumption that the investment is made in one moment in time at the beginning of each period, the inability to account for synergy and the model's failure to capture the value of managerial flexibility (Phelan 1997; Trigeorgis 1996; Kingston 2001; Damodaran 2001; Dixit and Pindyck, 1995).

Option pricing models seek to address several limitations of the DCF approach. A real-option is widely known throughout the finance literature as having the right but not the obligation to buy, sell or develop a specific *real* tangible or intangible asset. As a frame of reference, a real option is often cited as being analogous to a *financial* option (Pindyck, 1991). A financial option is based upon the option to buy or sell a security that is a function of the value of some *underlying* asset. Not unlike the financial option, a real asset may contain rights in the form of embedded options that can be extended to the investor including the option to defer, postpone, abandon or the option to change the course of the investment (Trigeorgis, 1996). Such managerial flexibility provides the decision maker with the ability to alter the investment strategy as uncertainty is resolved, thereby limiting potential economic loss (Trigeorgis, 1996). To demonstrate one example of managerial flexibility, the SaaS subscriber may elect to cancel the subscription if the application fails to perform as expected, thereby limiting future losses.

Real Options

Real option valuation techniques represent one method that seeks to overcome the weaknesses of conventional DCF models. In contrast to financial options which are based upon the right but not the obligation to acquire a security that is based upon the value of the underlying stock price, a real option provides the right but not the obligation to *invest* in a specific asset (Trigeorgis, 1996). And while the word *real* seems most appropriate to describe tangible or hard physical assets, it should be noted that examples of real option pricing for intangible assets such as intellectual property exist throughout the literature (Bose and Oh, 2003). The value of the real option is derived from asymmetry that exists between the specific rights and obligations of the buyer with respect to the asset as the passing of time allows uncertainty to be resolved (Trigeorgis, 1996). The option to wait for example may represent infinite upside opportunity as new information becomes available that impacts the investment decision. At the same time, the option holder is protected somewhat from downside loss since economic exposure is limited to a finite value that consists of the cost to acquire the option to invest (Benninga, 2000).

Real option value is often derived by applying financial option pricing strategies to specific investment projects (Chang, Hung and Tsai, 2005). However Odening, *et al.* (2005) makes it clear that three conditions must be present in order for a real-options valuation approach to be viable. First, the return on the investment must be uncertain. Second, the investment must be at least partially irreversible and finally, the investment must be flexible with respect to time (Odening, *et al.* 2005). In the context of products and services delivered via SaaS, each of the three conditions would appear to exist. For example, the decision maker contemplating the purchase of a CPM system delivered via SaaS cannot know with certainty the degree to which the application will yield economic benefits to the firm, if any. Second, the investment costs to acquire the benefits of the service are partially refundable and therefore reversible. Finally, flexibility exists in the SaaS model since the decision maker may elect to choose against renewing the subscription or may cancel the subscription prior to the end of the full term. Techopitayakul and Johnson (2001) confirm that options exist in a subscription environment illustrating a similar software delivery method known as ASP, or application service provider. The authors demonstrate that three embedded options may impact the value of the application; the option to switch from a subscription to a usage based fee, the option to bring the software in-house and finally, the option to terminate the contract prior to expiration.

While ASP and SaaS are widely known to be similar, differences do exist. According to the Software & Information Industry Association (SIIA, 2006) and Wesker (2007), it is important to make the distinction between SaaS and ASP or application service provider models. Specifically, ASP models often require a separate instance of the software for each customer which is in contrast to SaaS applications that are designed to accommodate multiple customers with a single instance of the software (Wesker, 2007). In further contrast to ASP models, SaaS costs behave in a manner that is “inversely proportional to the number of customers” (Wesker, 2007:1). For the purpose of the research at hand, it is important to draw a distinction between ASP and SaaS since inherent differences in scale and cost may impact the degree of flexibility and the subsequent options that can be extended to the customer (Techopitayakul and Johnson, 2001) and Trigeorgis (1996).

Several types of options exist. A call option for example provides the option holder with the right to purchase the underlying asset at the exercise price and is profitable if the value of the asset is greater than the exercise price (Damodaran, 2001). Further, the difference between the asset value and the exercise price represents the gross profit of the investment and the net profit can be found by subtracting costs associated with acquiring the rights to exercise the option from the gross profit. However if the value of the asset proves to be less than the exercise price then the option expires without value (Damodaran, 2001). Similarly, a put option provides the option holder the right to sell, or *put* the underlying asset to the buyer at the exercise price and becomes profitable when the value of the underlying asset plus the cost to acquire the option is below the

exercise price (Black and Scholes, 1973). Should the value of the underlying asset be greater than the strike price at expiration, the option will expire worthless (Damodaran, 2001).

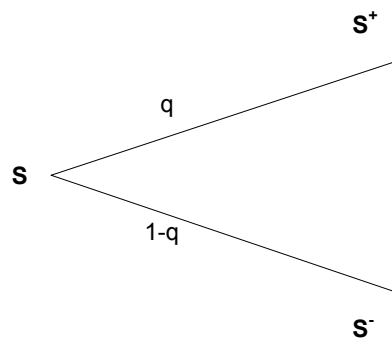
Relating real-options to the subscription environment, Techopitayakul and Johnson (2001) explain that cancelling the ASP contract represents the real option holder's right to abandon or walk away from the contract prior to expiration. Following the same line of thinking, the act of canceling the SaaS subscription in exchange for a refund can be thought of as exercising the option to abandon. According to Trigeorgis (1996) the option to abandon can be valued by calculating a series of put options for each future time interval using a binomial lattice. Benninga (2000) supports the idea that the value of the option to abandon can be found using a binomial lattice. Critics contend that lattice methods may be unsuitable for calculating real options that contain multiple sources of uncertainty however Pindyck (1991) and Trigeorgis (1996) point out that multiple sources of risk and a fixed level of uncertainty pose a problem for nearly all contemporary valuation models and suggest that stochastic improvisations such as Ito's Lemma or a generalized Weiner process be employed to account for uncertainty that fluctuates over time.

General examples of real options according to Trigeorgis (1996) include the option to defer, contract, expand or abandon the investment in the asset. As opposed to purchasing the asset outright, the SaaS subscription entitles the investor the right but not the obligation to take possession of the benefits provided by the asset at a cost that is paid in annual increments. In the case at hand, the ClearFinancials[®] subscriber holds the right to a refund of a certain unused portion of the subscription value should the asset not live up to the subscriber's expectations. The right to cancel the SaaS subscription can be thought of as the right to end or terminate the SaaS contract prior to expiration, entitling the subscriber to *put* the product or service back to the vendor in exchange for the unused value of the subscription, or to avoid future payments. The subscriber may find that it makes economic sense to exercise this option in the event that the redemption value exceeds the economic benefit provided by the application. The right to abandon the subscription in this case is consistent with option flexibility that provides the option holder the right to *put* the asset back to the seller in exchange for a specific value and is best valued as a *put* option (Trigeorgis, 1996; Damodaran, 2001).

Several methodologies exist to value real options. Binomial option pricing models for example perhaps represent the most basic technique to value real options (Benninga, 2000). The binomial model follows a decision-tree format that illustrates all possible investment outcomes and depicts the expected value of the investment along different nodes or points in the tree according to probability (Damodaran, 2001). The combined present values, adjusted and weighted according to their probabilities produce the binomial option value (Trigeorgis, 1996). Figure 2.06 represents an illustration of the basic up and down movement of the price of an underlying asset from which the option's value is derived.

Binomial movement of price

Figure 2.06



Grabski (2007a) Adapted from Cox, Ross and Rubenstein (1979) and Trigeorgis (1996)

Following the diagram in Figure 2.06, S represents the current price of the underlying stock, S^+ represents the value of the underlying stock at the end of the period if the stock moves in an upward manner, S^- represents the value of the underlying stock if its value moves in a downward manner, q represents the probability of upward movement and $1-q$ represents the probability of downward movement.

Using a financial option as the basic format to value real options can be established by constructing a synthetic or replication of a portfolio that is comprised of a certain number of shares of the underlying asset and borrowing against them at the risk free rate of return, a value that replicates the future returns of the option (Damodaran, 2001). According to Trigeorgis (1996) and Damodaran (2001) the specific number of shares expressed as N presented in Figure 2.07 can be found by:

Figure 2.07

$$N = \frac{C^+ - C^-}{S^+ - S^-}$$

In this case, C^+ represents the value of the option in the up position, C^- represents the value of the option in the down position, S^+ represents the value of the underlying stock in the up position and S^- represents the value of the stock in the down position. Both the up and down value of the option (C) in this case, represent the value of the stock price at the end of the period minus the exercise price of the option. It is important to note that the number of shares required to replicate precisely one option over one future period is known as the hedge-ratio (Trigeorgis, 1996) or the option delta (Damodaran, 2001). And the appropriate amount to borrow, expressed as B , according to Trigeorgis (1996) can be found using the equation expressed in Figure 2.08.

Figure 2.08

$$B = \frac{NS^- - C^-}{1+r}$$

Where N represents the number of shares found using the equation presented in Figure 2.07, S^- represents the value of the underlying stock in the down position, C^- represents the value of the option in the down position and r represents the risk free rate (Trigeorgis, 1996). Using equations in Figure 2.07 and 2.08, the option's value is replicated with a portfolio consisting of N shares of the underlying stock at the current price S and borrowing an amount equal to B at the risk free rate r . The value of the option according to Trigeorgis (1996) can be found using the equation presented in Figure 2.09.

Figure 2.09

$$C = \frac{pC^+ + (1-p)C^-}{1+r}$$

Figure 2.10

$$p \equiv \frac{(1+r)S - S^-}{S^+ - S^-}$$

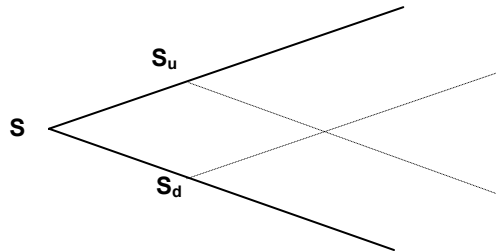
In this case, C^+ represents the value of the option in the up position, C^- represents the value of the option in the down position, S represents the current price of the underlying, S^+ represents the value of the underlying in the up position, S^- represents the value of the underlying in the down position and r represents the risk free rate. The p in Figure 2.09 is found using the equation presented in Figure 2.10.

Damodoran (2001) states in essence that the value of the option, in this case a call option, is the current value of the underlying asset multiplied by the option delta minus the amount needed to borrow to replicate the option. To address the need for a straightforward method of option price valuation, Cox, Ross and Rubenstein (1979) proposed the multiplicative binomial option pricing formula. The methodology is based upon the principle of portfolio replication indicated in Figures 2.07 and 2.08 but follows a structured multiplicative process where the underlying stock price will increase or decrease by a specific multiplier along with an assigned probability (Trigeorgis, 1996) and Cox, Ross and Rubenstein (1979).

The basic discrete-time single period model is represented in Figure 2.11 and is founded upon the premise that the underlying asset price may move only one of two directions at any given point in time, up or down (Cox, Ross and Rubenstein, 1979). The value path is diagramed in a hierarchy that resembles a tree often referred to as a lattice. The binomial lattice is organized as a two dimensional framework that reflects *value* at specific *time* intervals, depending upon whether the underlying asset follows the up or down path.

Figure 2.11

Single Period Binomial Asset Price

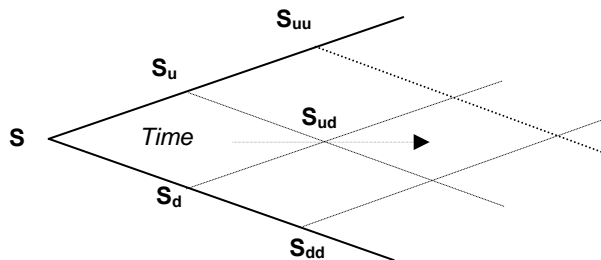


Grabski (2007b) Sketch based upon Cox, Ross and Rubinstein (1979) and Trigeorgis (1996)

Periods can be added to the binomial lattice to accommodate additional time intervals and the corresponding asset price depending upon the path that the asset pricing follows.

Figure 2.12

Two Period Binomial Asset Price Path



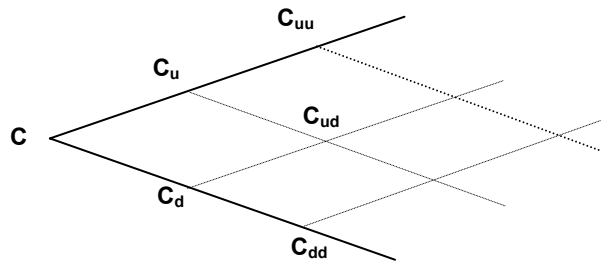
Grabski (2007c) Sketch based upon Cox, Ross and Rubinstein (1979) and Trigeorgis (1996)

For example, Figure 2.12 illustrates that the price of the asset may assume five different positions across two discrete time periods. One upward movement is denoted as S_u and one down movement as S_d , while two up movements are illustrated as S_{uu} . The asset may follow the path of one or two movements up, one up and one down, one down and one up, or two down.

To determine the value of the option, Figure 2.13 illustrates a payoff diagram that represents the value of a call option at each point in the lattice. The expected payoff at each point is a function of the exercise price minus the expected value of the asset.

Figure 2.13

Two Period Binomial Call Option Price



Grabski (2007d) Sketch based upon Cox, Ross and Rubinstein (1979) and Trigeorgis (1996)

Knowing the exercise price and the stock price illustrated in Figure 2.12, the value of the option can be found for each point along the path in the lattice (Damodaran, 2001). For example, allowing X to represent the exercise price, the value of the call in the first up position can be found using the equation, $\max(0, S_u - X)$. The value of the option at each *individual point* can be found by taking the present value of the difference between the asset value and the exercise price. The multiplicative binomial option pricing model assumes that the asset value will follow an up or down path for each time period that is based upon a specific multiplier and a predetermined probability. Accordingly, the value of the two period model illustrated in Figure 2.13 can be found by solving for the call option value in the up position as presented in Figure 2.14 where p represents the probability of each movement.

Figure 2.14

$$C_u = \frac{pC_{uu} + (1-p)C_{ud}}{1+r}$$

And then, solving for the value of the option in the down position as illustrated in Figure 2.15.

Figure 2.15

$$C_d = \frac{pC_{ud} + (1-p)C_{dd}}{1+r}$$

Using the values of C_d and C_u , the value of C can now be found using the equation presented in Figure 2.16. The cash flow is discounted back to present value with the denominator $1+r$.

Figure 2.16

$$C = \frac{pC_u + (1-p)C_d}{1+r}$$

Or, alternatively, the value of C can be found in one step using the equation expressed in Figure 2.17.

Figure 2.17

$$C = \frac{p^2 C_{uu} + 2p(1-p)C_{ud} + (1-p)^2 C_{dd}}{(1+r)^2} .$$

In this case the cash flow is discounted back to present value with denominator $(1+r)^2$ as opposed to $(1+r)$ since two periods elapse in this model. The equation essentially returns the present value of the asset assuming that the value of the asset follows a probabilistic path consisting of a specific number of up or down movements in value across specific increments of time.

Black and Scholes (1972) argue that under the principles of arbitrage, the value of the option can be ascertained by creating a matching portfolio consisting of the underlying asset combined with a risk free asset that produces identical cash flows as the option. Cox and Ross (1976) furthered this idea maintaining that the replicating portfolio be comprised of a basket of *marketable-securities* and one riskless asset. Later and with respect to real options, Trigeorgis (1996) argues that this approach is relevant provided that the underlying asset share similar risk attributes when compared to a basket of marketable securities and that the two are sufficiently correlated. To create a replicating or matching portfolio that mirrors the return of the option, the number of shares (N) or the hedge-ratio can be found according to Trigeorgis (1996) using the equation presented in Figure 2.18.

Figure 2.18

$$N = \frac{C^+ - C^-}{(u - d)S}$$

Once again, C^+ represents the value of the option in the up position, C^- represents the value in the down position and S represents the current value of the underlying and u and d, presented in Figure 2.19 can be found by:

Figure 2.19

$$\text{where... } u \equiv \frac{S^+}{S}$$

$$\text{and... } d \equiv \frac{S^-}{S}$$

In this case, u and d represent the rate of return, either up or down (Trigeorgis, 1996).

And, the amount to borrow, B is found as illustrated in Figure 2.20 where r represents the risk free rate.

Figure 2.20

$$B = \frac{dC^+ - uC^-}{(u - d)(1 + r)}$$

The equation for the value of the option represented by C is identical to the previous equation in Figure 2.09:

$$C = \frac{pC^+ + (1 - p)C^-}{1 + r}$$

However according to Trigeorgis (1996) p in this case is found using the equation presented in Figure 2.21.

Figure 2.21

$$p = \frac{(1 + r) - d}{u - d}$$

In this case, p represents one plus the rate of return minus the downward return divided by the upward rate of return minus the downward rate of return which delivers the relative probability of upward and downward movement of C.

Another popular methodology used to value real options is known as the aforementioned Black Scholes method. Perhaps one of the most important breakthroughs in modern finance, the Black Scholes stock option model was developed by Fischer Black and Myron Scholes in 1973 (Williams, 2006). The model was later refined by Robert C. Merton and Myron Scholes and earned the Noble prize in Economics in 1997 (Jarrow, 1999) and (Merton, 2007).

As expressed by Damodaran (2001) the original Black Scholes model was designed to establish the value of a European call option. However according to Jarrow (1999) the efforts of Fisher Black, Myron Scholes and Robert Merton not only advanced the concept of valuation but launched the field of study known today as derivatives that would later prove to change the perspective on modern corporate finance, capital budgeting and the financial markets. The Black and Scholes (1973) option pricing model essentially solves for the solution with a partial differential equation illustrated in Figure 2.22, 2.23 and 2.24. According to Damodaran (2001) and others, the value of the call option, c , is presented in Figure 2.22 using inputs listed in Figure 2.25.

Figure 2.22

$$c = SN(d_1) - Xe^{-r(T-t)}N(d_2)$$

where d_1 is presented as the equation illustrated in Figure 2.23 can be found by:

Figure 2.23

$$d_1 = \frac{\ln\left(\frac{S}{X}\right) + \left(r_f + \frac{\sigma^2}{2}\right)(T-t)}{\sigma\sqrt{T-t}}$$

and where d_2 can be found using the equation presented in Figure 2.24.

Figure 2.24

$$d_2 = d_1 - \sigma\sqrt{T-t}$$

The five input variables contained in Figures' 2.22 and 2.23 are defined and presented in Figure 2.25 for clarity.

Figure 2.25

Inputs Variables to the Black Scholes Equation

S represents the current value of the underlying asset

X represents the strike price

T-t represents the time until the option expires

r_f represents the risk free rate of return

σ represents the volatility of the underlying asset

As illustrated in Figures' 2.22, 2.23 AND 2.24, the Black and Scholes (1973) equation follows a process that begins with finding the values of d_1 and d_2 based upon the five input variables followed by the conversion of d_1 and d_2 into $N(d_1)$ and $N(d_2)$ where $N(d_1)$ and $N(d_2)$ represent the cumulative standard normal distribution of d_1 and d_2 after which the equation in Figure 2.22 will return the value of the call option.

Similarly, the value of the Black and Scholes (1973) put option can be found using the equation in Figure 2.26

Figure 2.26

$$p = Xe^{-r(t-t)}N(-d_2) - SN(-d_1)$$

Jarrow (1999) points out that the Black Scholes model makes two key assumptions that impact the applicability of the formula and specifically explains that the model assumes that both the risk-free rate as well as the volatility of the underlying asset remains constant throughout the life-cycle of the asset.

In greater detail however, Black (1989:67, 68) reflecting on his own work, insists that the Black and Scholes (1973) formula relies upon no fewer than ten key assumptions presented in Figure 2.27.

Figure 2.27

Assumptions of the Black Scholes Equation

- 1) The stock's volatility is known and doesn't change over the life of the option.
- 2) The stock price changes smoothly: it never jumps up or down a large amount in a short time.
- 3) The short-term interest rate never changes.
- 4) Anyone can borrow or lend as much as he [or she] wants at a single rate.
- 5) An investor who sells the stock or the option short will have the use of the proceeds of the sale and receive any returns from investing these proceeds.
- 6) There are no trading costs for either the stock or the option.
- 7) Investors trades do not affect the taxes he [or she] pays.
- 8) The stock pays no dividends.
- 9) An investor can exercise the option only at expiration.
- 10) There are no takeovers or other events that can end the option's life early.

Damodaran (2001) and others explain that the Black and Scholes (1973) model is not an alternative to the binomial model but is rather in and of itself a single limiting case of the binomial model. And while the binomial model is clearly simple and intuitive, the model demands a high number of input variables that capture the expected prices and values at each decision point in the investment life-cycle (Damodaran, 2001). In comparison, the Black and Scholes (1973) method is based upon five input variables and assumes a continuous price process. Since the option holder has the right to profit from the underlying asset if it performs well, but may elect to do nothing if it does not, the risk-reward characteristics of the option is asymmetric (Trigeorgis, 1996). The inherent asymmetry associated with the option helps explain why an option based upon an underlying asset that is volatile and generally considered to be risky is worth more than an option that is based upon an underlying asset that is not volatile (Trigeorgis, 1996).

Not unlike the evolution of DCF models, academics and practitioners proposed and developed modifications to traditional OPM models to overcome perceived weaknesses. For example Chen and Chen (2005) modify Black Scholes inputs by substituting the *probability of success* for the cumulative standard normal distribution used in the traditional Black Scholes model. Williams and Sutherland (2006) seek to overcome several drawbacks that one might expect when using Black Scholes OPMs to value real-options such as the assumption that the variance of the value of the underlying asset is constant and that the value of the asset may not be immediately observable since the asset may not be freely traded in the market. In the award winning paper, Williams (1992) suggests that idiosyncratic competencies that determine the project's economic half-life¹¹ plays a major role in corporate strategy, sustainability and ultimately value. Later,

¹¹ Economic half-life is defined as "the amount of time until the per-unit profit margin drops to one half its highest amount" (Williams and Sutherland, 2006:6).

Williams and Sutherland (2006) expand on this concept by introducing a convex or concave scaling multiplier that can be used to modify Black Scholes call option pricing in a manner that reflects cash flows that are more in line with economic reality. For example the scaling factor will render the option worthless if the lapsed time exceeds the product life cycle while at the same time optimizing the value during the project's peak return period (Williams and Sutherland, 2006). The convex multiplier essentially converts continuous time to a time-value more in line with the economic truth that is associated the real option project. Further, Williams and Sutherland (2006) suggest that economic time can be adjusted for leakage that is associated with value erosion due to competitive forces. Figures 2.28 and 2.29 and 2.30 illustrate the difference between the original and the modified equation.

Figure 2.28

$$c = SN(d_1) - Xe^{-r_f(T-t)}N(d_2)$$

To compare, a version of the original equation is illustrated in Figure 2.28 and Figure 2.29 where c represents the value of the call option and S represents underlying stock price, X represents the strike price and T represents the option life in years and N represents the number of shares, $(T-t)$ represents the period of time remaining in the option's life, r_f represents the riskless rate of return and σ represents the volatility of the underlying asset.

Figure 2.29

$$\text{And where: } d_1 = \frac{\ln\left(\frac{S}{X}\right) + \left(r_f + \frac{\sigma^2}{2}\right)(T-t)}{\sigma\sqrt{T-t}} \quad \text{and} \quad d_2 = d_1 - \sigma\sqrt{T-t}$$

Williams and Sutherland (2006) point out that the Black and Scholes (1973) OPMs can be adjusted for leakage by inserting a *dividend* yield $e^{-d(T-t)}$ that essentially continuously decreases the value of the option as a function of the natural logarithm, the rate of decay and time. The modified equation is presented in Figure 2.30.

Figure 2.30

$$c = Se^{-d(T-t)}N(d_1) - Xe^{-rf(T-t)}N(d_2)$$

The approach suggested by Williams and Sutherland (2006) to address leakage is consistent with Damodaran (2001) that adjusts the Black and Scholes (1973) model to account for dividends, a circumstance for which the Black-Scholes was not originally designed to value. Damodaran (2001) illustrates the value of the Black and Scholes (1973) call option adjusted for dividends using the equation defined in Figure 2.31.

Figure 2.31

$$c = Se^{-yt}N(d_1) - Ke^{-rt}N(d_2)$$
and where;

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

Adjusts for leakage →

← *Adjusts for leakage*

Damodaran (2001) uses slightly different notation, substituting y for d , K for X and t for $(T-t)$, however the equations that Williams and Sutherland (2006) suggest for leakage and the equation that Damodaran (2001) recommends for dividends produce the same result. Williams and Sutherland (2006) suggest that a real options project that deteriorates in value over time is analogous to a financial option based upon an underlying asset that pays a dividend to the owner while the option holder waits for the option to mature in the money. Adjusting the Black and Scholes (1973) model for dividends, according to Benninga (2000) was first introduced by Merton (1973).

In order to satisfy the Black and Scholes (1973) model's need to account for market volatility in a real-options environment, Williams and Sutherland (2006) suggest a combined volatility approach that essentially represents a weighted sum of the standard deviation of various risk factors that are known to impact cash flows. Figure 2.32 provides one example of how such a combined volatility approach might be applied in the context of a CPM application that is delivered via SaaS:

Figure 2.32

$$\sum_{i=1}^n w_i \sigma_i^2 \dots w_4 \sigma_4^2$$

where $\sigma_1 \dots \sigma_4$ represent the volatility of four known underlying factors that impact the outcome of free cash flow and W represents their weight in relation to one another.

Like the evolutionary trend of traditional DCF models that seek to overcome problems with erroneous discount rates, the modification trend for option pricing models would appear to focus on overcoming problems associated with the model's assumption that volatility is constant and that the underlying asset returns follow a normal cumulative

distribution as illustrated by Williams and Sutherland (2006), Trigeorgis (1996) and Damodaran (2001). Despite apparent weaknesses of option pricing models, Bose and Oh (2002) suggest that option pricing models represent a superior approach compared to DCF models and state in essence that they overcome many common problems associated with the conventional models. Bose and Oh (2002) suggest that part of the popularity of the Black Scholes model is due to the fact that four of the input variables are directly observable and that only the variance must be estimated making it practical and easy for managers to use it in a capital budgeting setting. Boylan, Latham and Watkins (2004:4) argue in favor of Black Scholes model stating, "Although binomial models give the appearance of more precision, they will not produce an expense number that is any less flawed than Black Scholes". They go on to say that binomial theory suggests that more decision trees lead to more precision and further state "that the more trees are used, the closer the binomial estimate becomes to the Black Scholes estimate" (Boylan, Latham and Watkins 2004:4). Recall however that Black and Scholes (1973) method is but one limiting case of the binomial model (Damodaran, 2001).

Literature review summary

The literature clearly supports the use of OPMs compared to conventional DCF methods and a close look at the mathematics in Chapter II explains why. While the binomial model may be cumbersome, it has the support of Benninga (2000), Trigeorgis (1996), Damodaran (2001) and other noted real-options authorities. However, if the modified Black Scholes methodology to value real assets continues to gain support, the work of Williams and Sutherland (2006) may be especially important since it would appear that they put forth a plausible strategy to overcome at least three assumptions made by the Black Scholes model, perhaps making the modified model a candidate for SaaS asset valuation. While it is clear that not everyone agrees on the optimal valuation method for real options, Damodaran (2001), Trigeorgis (1996), Williams and Sutherland (2006), Benninga (2000) and many others agree that option pricing models are almost always more appropriate than traditional DCF models that ignore the value of flexibility.

CHAPTER III

Methodology

Chapter III will review the methods and framework used to orchestrate the research in the context of the SaaS environment. The chapter will provide a description of the methodologies used in the research project along with the rationale for their use. In each case, sufficient detail is provided to facilitate a firm grasp of the concept, the underlying principles and the applicability to the research at hand. Specifically, chapter III will describe the research design, simulation model, pilot study, survey, sampling methodology, validity of the data and methods used to measure error, confidence intervals, and the method used to test the null hypothesis. The chapter will conclude with an explanation of the sample composition, reliability of the data and will describe the research from the perspective of ethics and confidentiality.

Research Design

In keeping with best case-study practice according to White (2000) the research is a keenly focused on two specific valuation methods, DCF and OPM, in the context of the SaaS environment. The design is inductive in the sense that the outcome is intended to be generalized to a wider population of decision makers whose responsibility it is to either buy or sell products or services delivered via SaaS. Method triangulation is engaged where both qualitative and quantitative research methods are combined with the case study for a three perspective analysis in order to achieve a thorough understanding of DCF and OPM models in the context of the SaaS environment.

Methodologies used for the DCF and OPM valuation model

A software model was developed to measure the value of the CPM system according to option pricing theory as well as the conventional DCF method. The model is designed to accept changes to input variables in order to observe valuation behavior under a variety of conditions. A mathematical illustration of the model is presented in Figure 3.9. For continuity, the steps, numbered 1 through 6 describe the model functionality in the sequence that they occur.

Both the DCF and OPM valuation methods seek to assign value to the cash flows that are expected to be generated as a result of implementing the CPM system. In order to estimate the expected cash flows, a before and after forecast of Balance Sheets and Income statements was developed to capture changes to free cash flows and EBITDA. A Proforma was created using actual Balance Sheet and Income statement data for fiscal year end 2006 as the starting point. A sixty (60) month forecast was produced. The model was frozen and used as baseline data representing a picture of the company's performance assuming that the company performed exactly as it had in the most recent twelve months. In order to measure the economic impact of the CPM, model factors were adjusted to represent expected improvements to SG&A costs and Material as a result of implementing the CPM system. The data were frozen to compare against

the baseline data in order to capture the change to both Free Cash Flow and EBITDA. Free Cash Flow in this case was calculated using the equation illustrated in Figure 3.0. The equation is widely used throughout the literature and is consistent with Higgins (1998), Benninga (2000) and others.

Figure 3.0

$$FCF_t = Ebit(1-t) + Depr_t - \Delta I_t + \Delta NWC_t$$

Where FCF represents free cash flows, Ebit represents earnings before interest and taxes, Depr represents depreciation, I indicates changes to net investments in fixed assets and NWC represents net working capital. In this case, net working capital represents the changes in current assets net of current liabilities. To summarize, a *before and after* Balance Sheet and Income statement Proforma was created to observe the changes to Free Cash Flow and EBITDA that could be expected as a result of implementing the CPM system.

The value of the cash flow is ascertained using a conventional DCF approach, a modified Black Scholes model, and binomial option pricing model. The DCF valuation follows the Trigeorgis (1996) method illustrated in Figure 3.1.

Figure 3.1

$$NPV = \sum_{t=1}^T \frac{\alpha E(C_t)}{(1+r)^t} - I$$

Where $E(C_t)$ represents the expected cash free flows, α represents the certainty equivalent coefficient, r represents the discount rate, t represents time and I represents the present value of the subscription cost. The certainty equivalent coefficient was chosen to compliment the DCF technique in this case in order to separate idiosyncratic uncertainty associated with the CPM from macro-uncertainty that may impact the cash flows unrelated to the CPM system. In order to evaluate the CPM objectively, the certainty equivalent provides a mechanism to adjust expected cash flows according to management's view of the probability of realizing the cash flows without bundling the expected risk in the discount rate (Trigeorgis, 1996). The base discount rate used in the model reflects the company's weighted average cost of capital. The method used to calculate the weighted average cost of capital is widely known and illustrated in Figure 3.2.

Figure 3.2

$$K_w = \frac{(1-t)K_d D + K_e E}{D + E}$$

Where K_w represents the weighted cost of capital, K_d represents the cost of debt, D represents total debt, E represents total equity and K_e represents the cost of equity.

The conventional DCF model makes several assumptions. The investment may be more or less risky than the company's average investment represented in this case by the company's cost of capital. Further, it is assumed that risk can be adjusted at management's discretion by adjusting the certainty coefficient. In addition, the model does not recognize a terminal value at the end of the five year time horizon since salvage income and or costs are determined to be zero. In addition, the model assumes that the discount rate will remain constant through the five year time horizon.

Two OPM techniques were used to value the cash flows. First, a modified Black Scholes put option was used to model the value of flexibility, in this case the option to abandon the subscription on the first day of the year for simplicity. The model is modified to follow Williams and Sutherland (2006) who suggest that underlying sources of volatility can be combined to create one input value. However since volatility is not additive if correlated, steps were taken to refine the process by accounting for correlation that may exist between the underlying sources of volatility. Accordingly, the input modification follows the Markowitz (1952) approach to solve for combined volatility where two underlying variables that contribute to volatility may be correlated prior to their input into the model. Correlation is measured in the model using two widely known equations presented in Figure 3.3 and Figure 3.4.

The covariance was determined using equation 3.3 and represents the sum of products of the two variables deviation from their respective means divided by the number of observations less one degree of freedom.

Figure 3.3

$$\text{Cov} = \frac{\sum_{i=1}^n (X_i - \bar{X})(Y_i - \bar{Y})}{n - 1}$$

Correlation, ρ , was found using the covariance determined using the equation in Figure 3.3 and then following the equation represented in Figure 3.4.

Figure 3.4

$$\rho = \frac{\text{Cov}(X, Y)}{\sigma_X(\sigma_Y)}$$

Correlation between the SG&A and Material was calculated using the equation represented in Figure 3.4. Since the estimated cash flows that determine the value of the CPM application in the case study depend upon two underlying drivers that exhibit slight positive correlation to one another, the equation in Figure 3.5 was used to determine their combined volatility prior to input into the Black Scholes model.

Figure 3.5

$$\sigma_p = \sqrt{w_1^2 \sigma_1^2 + (1-w_1)^2 \sigma_2^2 + 2w_1(1-w_1)\rho_{1,2}\sigma_1\sigma_2}$$

While Markowitz (1952) expressed the equation a bit differently in 1952, the equation essentially returns the combined volatility of two assets given their weight in proportion to one another, their individual variance, and the degree to which the two assets are correlated 'p'. It should be noted that 'w' in this case represents the weighting of the two variables, SG&A and Material. For simplicity, the variables were weighted equally.

The input variables required by the modified Black and Scholes (1973) OPM include the gross present value of the expected cash flows, the subscription cost, time, the risk free rate of return and combined volatility. The Black and Scholes (1973) *put* option equation was used to determine the option to abandon. A visual basic model was developed (Appendix, C) that follows the equation in Figure 3.7.

Figure 3.7

$$p = Xe^{-r(t-t)}N(-d_2) - SN(-d_1)$$
$$d_1 = \frac{\ln\left(\frac{S}{X}\right) + \left(r_f + \frac{\sigma^2}{2}\right)(T-t)}{\sigma\sqrt{T-t}}$$
$$d_2 = \frac{\ln\left(\frac{S}{X}\right) + \left(r_f + \frac{\sigma^2}{2}\right)(T-t)}{\sigma\sqrt{T-t}} = d_1 - \sigma\sqrt{T-t}$$

In this case, p represents the value of the option to abandon, X represents the Subscription Cost, S represents the Gross PV of expected cash flows, T-t represents time, r_f represents the risk free rate of return and σ represents the combined volatility of the underlying sources of risk. Converting d_1 and d_2 into $N(d_1)$ and $N(d_2)$ where Nd_1 and Nd_2 represent the cumulative standard normal distribution of d_1 and d_2 and completing the equation will return the value associated with the option to abandon the subscription. The model was developed in visual basic and checked for accuracy against known good input and output values according to Benninga (2000). The inputs into the Black Scholes algorithm were adjusted according to Williams and Sutherland (2006) and the combined volatility methodology was adopted from Markowitz (1952).

The third method used to value the cash flows follows a binomial put option and is presented as the equation in Figure 3.8.

Figure 3.8

$$\text{Putvalue} = \sum_{i=0}^n \binom{n}{i} q_u^i q_d^{n-i} \max \left[X - S_0 (1+u)^i (1+d)^{n-1}, 0 \right]$$

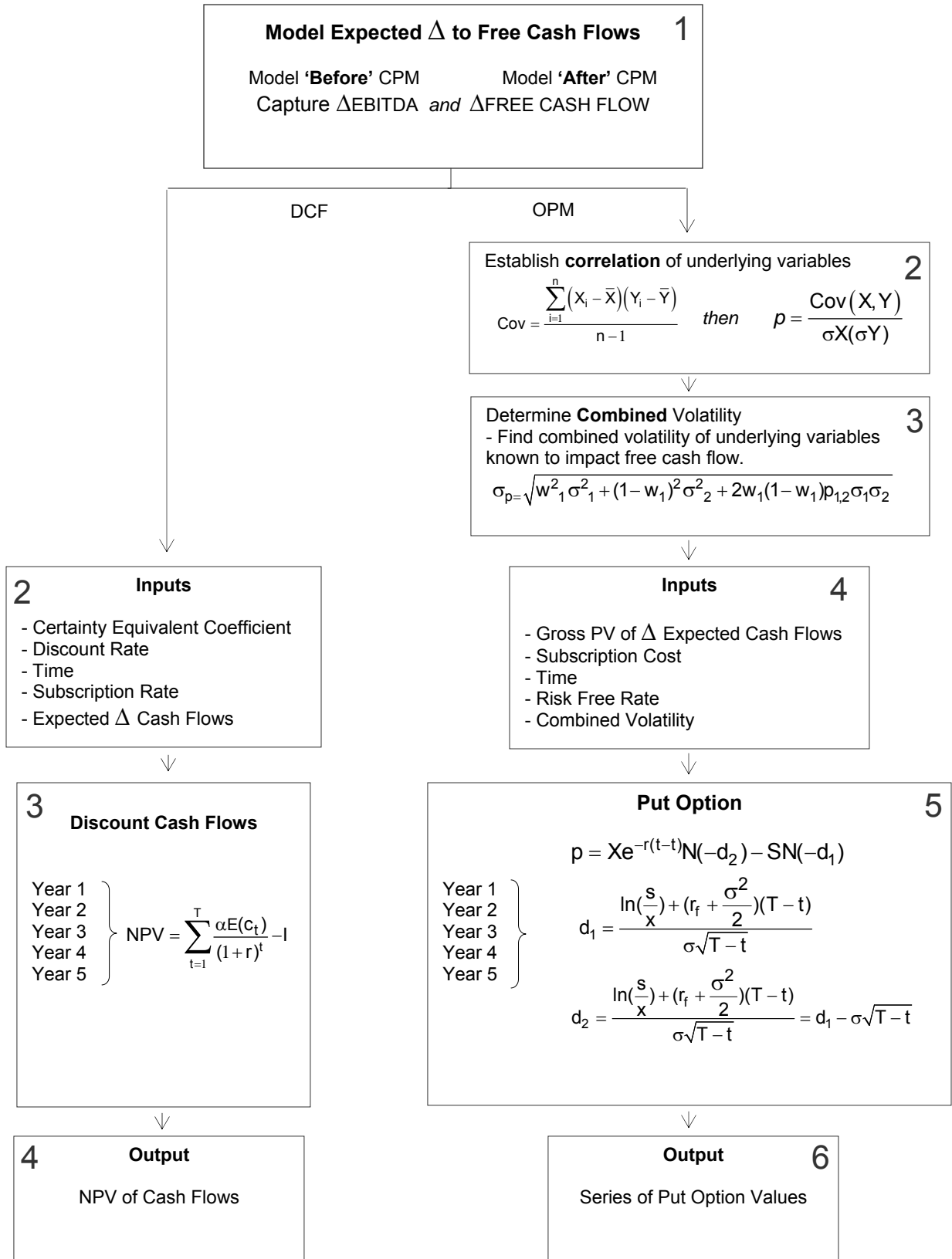
A visual basic model (Appendix D) was developed following Benninga (2000) where q_u and q_d represent the number of up and down movements in the valuation process and u represents the value in the up and d , the value in down. The American binomial put equation is followed here since the American put option can be used to value a European put however the European put option cannot be used to value an American style put that may be exercised early (Trigeorgis, 1996).

Since the expected volatility in the modified Black Scholes model depends upon the combined volatility of two underlying variables that influence cash flow, a regression was performed to test the explanatory power of underlying independent variables, SG&A and Material on the dependent variable, free cash flows. A subsequent regression was conducted using EBITDA as the dependent variable to isolate the impact of SG&A and Material on the portion of Free Cash Flows not impacted by changes to net investments to fixed assets. This proved to be a necessary alternative since the company made frequent investments to fixed assets that were unlikely to be repeated in the future. Since EBITDA is not affected by net changes to fixed assets but explains a large portion of free cash flow with the exception of changes to working capital, it was determined to be the best metric for which to test management's choice of variables that impact free cash flow. The R squared and t were both examined, the F-Ratio was compared to a F-critical table adjusted for the appropriate degree of freedom and a Durbin Watson test was performed to determine whether or not autocorrelation between the variables presented a problem. Each is explained in detail in the results and discussion section.

A mathematical representation of the valuation model is presented in Figure 3.9 and includes both the DCF method as well as the *modified* Black Scholes OPM method. A visual basic representation of the code used in the DCF, modified Black Scholes and the American binomial put option is presented in Appendix B,C,D, E and F.

Figure 3.9

Overview of the Sensitivity Valuation Model ¹²



¹² The model was developed in visual basic and checked for accuracy against known good input and output values according to Benninga (2000). The modified Black Scholes algorithm was adjusted according to Williams and Sutherland (2006) and the combined volatility methodology was adopted from Markowitz (1952).

Survey Methodology

A survey was conducted to learn which model, DCF or OPM, finance professionals use or intend to use when making capital budgeting decisions that involve products and services delivered via SaaS. The survey was designed so that one important conclusion can be made about the state of the population. Specifically, the survey contains five multiple choice questions designed to allow the population to be divided into two distinct proportions (APPENDIX A). One proportion represents the percentage of the binomial population that use or intend to use conventional DCF valuation methods to value products and services delivered via SaaS while the remaining proportion represents those that use or intend to use OPM including Black Scholes, modified Black Scholes or Binomial Lattice methods.

A database containing every known company located in the U.S. between one hundred million and one billion U.S. dollars in revenue was purchased from Hoovers Dunn & Bradstreet to gain access to a complete population of companies within one specific revenue range. The database is widely known to be of excellent quality and is updated frequently as companies grow in and out of specific revenue ranges, merge, fail or become acquired by other companies. The target population includes both private and publicly traded companies. Only headquarters were chosen to eliminate the chance that a respondent's valuation preferences may be influenced by a parent company. The target population does not discriminate between industries, government owned or non-profit companies and only the senior most financial officer was chosen to participate in the survey.

In order to achieve a confidence level of 95% and a sufficiently narrow confidence interval, a sample-size model was designed to solve for the optimal sample quantity by specifying the desired half length of the interval B , the Z-score for two standard deviations or a 95% percentile confidence interval, and the estimated proportion \bar{p} as illustrated in Figure 3.0. The equation is widely known and used to determine the optimal sample size for a single binomial proportion with one of two expected outcomes. The equation represented in Figure 3.9.1 is appropriate since the survey seeks to understand the extent to which finance professionals use option pricing models compared to conventional DCF techniques.

Figure 3.9.1

$$n = \left(\frac{Z}{B} \right)^2 \bar{p}(1 - \bar{p})$$

A random number generator was used to assign unique numbers to each company in the population, frozen and then organized in ascending order. The top 542 companies were chosen to represent the sample population assuming the survey achieved the same response rate observed in the pilot survey. To achieve optimal precision, the design follows a systematic random sampling process without replacement consistent with White (2000) and Albright,

Winston and Zappe (2005). For the purpose of the research project, the optimal sample size is considered to be the lowest number of sampling units that will return a result that can be statistically generalized to the population with a degree of confidence that is ninety five percent or better. Orchestrating the sampling strategy in this manner allows for research resources to be focused on the reduction of non-sampling error due to non-response bias and is consistent with efficient sampling design and practice suggested by White (2000), Albright, Winston and Zappe (2006) and Studenmund (2005).

The sampling methodology was designed with the expectation that the results and conclusions be generalized to a wide range of industries that either buy or sell products and services delivered via SaaS. According to Albright, Winston and Zappe (2006), the relevant population includes the entire population for which the proposed research intends to make inferences. The relevant population in this case represents the entire population of financial professionals that may purchase products or services delivered via SaaS in a revenue range that extends between one hundred million and one billion U.S. dollars. While the sample frame does not capture every company in the U.S., it captures every company in the revenue range that the company considers its target market. To be clear, the single purpose of the survey is to find the valuation method that finance professionals use or intend to use when making capital budgeting decisions involving SaaS within the company's target market.

Prior to conducting the main survey, a pilot survey was undertaken to estimate both the proportion as well as the response rate in order to gauge the estimated sample size necessary to produce a statistically significant outcome. The pilot study was carried out to replicate a smaller version of the primary study precisely. For example, the pilot sample was chosen using a random number generator that distributed a unique identifier to each individual company in the sample frame that consisted of the entire population of companies in the specified revenue range. The unique random numbers were permanently assigned to each company and then sorted. A *pilot* sample size of 42 was chosen based upon the Mukhopadhyay (2005) pilot sampling methodology for selecting the best normal population when the mean variance is unknown. While the pilot data is not used for purposes other than determining the optimal survey sample size and finding the expected response rate, the Mukhopadhyay (2005) method was used to maximize the reliability of the pilot data. For purposes other than determining the proportion, the *natural* average of the pilot data was used to estimate the sample means since this particular method exhibits good theoretical properties and is the most common method of averaging point estimates (Albright, Winston and Zappe, 2006).

The method used to measure the standard error of the sample of the proportion is consistent with Brayer (1957), Albright, Winston and Zappe (2006) and Studenmund (2005). The standard error, Se of the sampling distribution of the sample proportion is calculated as illustrated in Figure 3.9.2.

Figure 3.9.2

$$Se = \sqrt{\frac{\hat{p}(1-\hat{p})}{n}}$$

Where \hat{p} represents the sample proportion and n represents the sample size. In this case, the aim is to determine what proportion of the population of finance professionals that we can reasonably expect to find that use or intend to use OPM when making capital budgeting decisions involving assets delivered via SaaS within a 95% confidence interval of which the standard error represents the increment on either side of the mean.

A test to determine whether the sample size was sufficiently large was performed in order to determine validity of the confidence intervals and is presented in Figure 3.9.21. In this case, n represents the number of observations, p_L represents the lower limit bound of the proportion confidence interval and p_U represents the upper limit bound of the confidence interval.

Figure 3.9.21

Test for Sufficient Sample Size

$$np_L > 5$$

$$n(1-p_L) > 5$$

$$np_U > 5$$

$$n(1-p_U) > 5$$

The confidence interval was deemed to be valid if each statement represented in Figure 3.9.21 produced an outcome greater than five (Albright, Winston and Zappe, 2006).

For the purpose of measuring the confidence interval of the variability of the underlying drivers of free cash flow, the CI¹³ is calculated using the right skewed Chi-Square distribution which indicates the distribution of the estimate of the variance of the error (Studenmund, 2006). For the purpose of the research project, the confidence interval is calculated as illustrated in Figure 3.9.3 in excel or can be found using the CI for standard deviation using Statools or other statistics software.

Figure 3.9.3

$$\sqrt{\frac{(n-1)s^2}{x_1^2}} < \sigma < \sqrt{\frac{(n-1)s^2}{x_2^2}}$$

Where x_1^2 and x_2^2 can be found using excel functions CHIDIST and CHIINV respectively and S^2 represents the sample standard deviation or using a standard Chi-Square distribution table (Studenmund, 2005).

¹³CI is the acronym for Confidence Interval

The survey represents the *proportion* of finance professionals that intend to use option pricing models when making capital budgeting decisions involving SaaS. In order to observe the expected upper and lower limit bounds of the population proportion, the confidence interval was calculated using the equation presented as Figure 3.9.4.

Figure 3.9.4

$$\hat{p} \pm z \sqrt{\frac{\hat{p}(1-\hat{p})}{n}}$$

In this case, \hat{p} represents the proportion, z represents the z score and n represents the number of observations in the sample population. Alternatively, the confidence interval range for the proportion can be found by adding and subtracting the Z value multiplied by the standard error which is found using the equation illustrated in Figure 3.9.2 from the estimated proportion \hat{p} . The z -value used in Figure 3.9.4 represents the number of standard deviations to the right or left of the mean and is calculated as shown in Figure 3.9.5.

Figure 3.9.5

$$z = \frac{X - \mu}{\sigma}$$

Where X represents the observed value, μ represents the mean and σ represents the standard deviation expressed in Figure 3.9.6.

Figure 3.9.6

$$\sigma = \sqrt{\frac{\sum_{i=1}^n (X_i - \bar{X})^2}{n}}$$

The standard deviation used in finding the Z score was found by taking the square root of the sum of the squared deviations from the mean divided by the number of observations as illustrated in Figure 3.5 (Studenmund, 2006) and Albright, Winston and Zappe (2006).

The survey was designed to learn whether the majority of finance professionals use or intend to use option pricing models to value products or services delivered via SaaS. Accordingly, the null hypothesis presented in Figure 3.9.7 states that the majority of finance professionals use or intend to use OPM valuation techniques when making capital budgeting decisions involving SaaS.

Figure 3.9.7

$$H_0 : p \geq .50 \text{ and } H_a : p < .50$$

In order to determine whether or not the null hypothesis holds, a z-test with a corresponding p -value was produced with the intent to either accept or reject the null hypothesis. The z-test illustrates the likelihood of observing a distribution, in this case representing a majority-proportion of finance professionals employed by companies between one hundred million and one billion dollars that intend to use OPM valuation techniques when making capital budgeting decisions that involve SaaS.

Figure 3.9.8

$$z = \frac{\hat{p} - p_0}{\sqrt{\frac{p_0(1 - p_0)}{n}}}$$

Figure 3.9.8 illustrates the method used to calculate the z-value for the proportion of finance professionals that intend to use one specific valuation method over another. In this case, p_0 represents the cutoff value specified in the hypothesis, \hat{p} represents the observed proportion and n represents the sample population. To further strengthen the interpretation of the results, confidence intervals were determined at the 95% level of significance as illustrated in figure 3.9.4 in order to observe whether or not the target proportion falls within the interval.

The method to calculate the standard error of the proportion is presented in Figure 3.9.2. The criteria used to accept or reject the null hypothesis follows the statement: Reject H_0 if the observed $z > z_c \alpha$. Else do not reject H_0 . In this case, z represents the observed test statistic and z_c represents the z-critical value specified at the α level of significance, in this case 99%. The calculated z value in Figure 3.6 is compared to a z critical value found using the excel function NORMSINV. The corresponding p value is found using NORMSDIST (Albright, Winston, Zappe, 2006).

Reliability of the data, ethics and confidentiality

The data used to value the CPM delivered via SaaS is based upon the actual cost of the CPM and the expected cash flows after implementing the system. It should be noted that expected future cash flows associated with the investment were based actual corporate data. As with all valuation modeling that involves projecting the future state of the world, a degree of uncertainty, risk and subjectivity is involved in estimating future events and is a shortcoming of any discounted cash flows model (Higgins 1998). For the purpose of this research however, it is important to make the distinction that the research is interested in whether or not the valuation models capture the value of products and services delivered via SaaS and not the reliability of the management estimates such as expected growth. The research project including the sensitivity model and the survey is designed for reproducibility, reflective of a sound research framework (White, 2000). Every opportunity was taken to simplify the design where possible with the aim to reduce or eliminate opportunity for bias and subjectivity and to maximize the reliability of the outcome.

CHAPTER IV

Results

Chapter IV presents the data produced by the methodologies defined in Chapter III. The results include data that explain the degree to which the underlying drivers explain free cash flow, the DCF and OPM valuation output and the results of the survey including test data to validate the confidence intervals.

Validating the input data

Several tests were performed to determine the reliability of the input data. Volatility of cash flow in this case was determined to be influenced by two underlying drivers, SG&A and Material. To validate whether the two variables explain cash flow to a reasonable degree, a linear regression analysis was performed to explain the relationship between the two independent variables, SG&A and Material on the dependent variable cash flow. And since combined volatility is a function of the volatility of these same two variables, confidence intervals of the underlying standard deviation were created to observe the expected upper and lower limit bounds. For example, a combined volatility of .043991 is used in the modified Black Scholes put option model and represents the combined standard deviations of the material cost to sales, and SG&A to sales adjusting for a positive correlation between the two variables of .015. Identifying the specific degree of correlation between the independent variables is important for two reasons. First, the relationship between the variables must be understood in order to establish the combined variance between the two variables and second, correlation may suggest a possible violation of Classical Assumption IV, a condition addressed later in this chapter. As noted in chapter III, the combined variance is used as a single input variable in the modified Black Scholes put option model. The approach follows the modified Black Scholes methodology put forth by Williams and Sutherland (2006) that transforms multiple sources of volatility into a single input variable however solves for the combined volatility of the two variables using the approach put forth by Markowitz (1952) in Figure 3.5. It should be noted that the two variables were weighted equally in the equation. The volatility and correlation between the variables was ascertained using company data that represents the most current 36 months of performance. The confidence interval for SG&A to Sales exhibited a lower limit bound of .20864 and an upper limit of .24580 around a mean of .22722 at the 95% level. The confidence interval for the *standard deviation* spanned a lower and upper limit bound of .04454 and .07162 respectively around a mean of .0549 at the 95% level and with 35 degrees of freedom. Material cost to sales, also viewed by management to be a key underlying driver impacting cash flow exhibited a mean of .48994 with a lower and upper limit bound of .46877 and .51112 respectively at the 95% level. The standard deviation bounds for material cost to sales ranged from .05076 for the lower limit to an upper limit.08164 around the mean of .06258 representing a 95% confidence interval expressed with 35 degrees of freedom.

As previously noted, in order to demonstrate that the choice of underlying drivers to free cash flow is a reasonable one, a linear regression was performed to establish the degree to which the independent variables, SG&A and Material explain free cash flow. Correlation between the variables as well as the fact that the data are time-series may suggest a possible violation of the Classical Assumption IV that states in essence that observations of the error term must be uncorrelated (Studenmund, 2005). Accordingly, a Durbin-Watson test was performed to test for positive autocorrelation of the data. Since the Durbin-Watson test produced a value of 1.72 well above the minimum of 1.2 suggested for a small number of independent variables, the results were determined to be relevant and included for review (Albright, Winston and Zappe, 2006). Figure 4.0 represents the degree to which the variables are correlated.

Figure 4.0

<u>Correlation</u>		
Variables	<u>SG&A</u>	<u>Material</u>
SG&A	1.000	0.015
Material	0.015	1.000

Strength of the underlying variables of free cash flow

A linear regression analysis was performed to gauge the degree to which the two variables explain the dependent variable, free cash flow. Since the company made significant and sporadic investments to fixed assets throughout the period, a meaningful relationship between free cash flow and the independent variables proved difficult to capture. Therefore, it was determined that EBITDA, a metric that illustrates earnings but *excludes* the effect of investments to fixed assets and the changes in working capital provides more meaningful insight into the explanatory power of SG&A and Material on cash flow. The logic behind the decision to utilize EBITDA is that it represents a significant portion of free cash flow while excluding the impact of cash flows resulting from investments in fixed assets or changes in working capital requirements. It should also be noted however that EBITDA does not recognize the impact of taxes on free cash flow.

Figure 4.1

Regression SG&A & Material on EBITDA

Summary	Multiple	R-Square	Adjusted	SE	Durbin	
	<u>R</u>		<u>R-Square</u>	<u>Estimate</u>	<u>Watson</u>	
	0.7329	0.5371	0.5090	0.064076563	1.7231	
Anova	Degrees of	Sum of	Mean of	F-Ratio	p-Value	
	<u>Freedom</u>	<u>Squares</u>	<u>Squares</u>			
Explained	2	0.157205626	0.078602813	19.1443	< 0.0001	
Unexplained	33	0.135491596	0.004105806			
Regression	<u>Coefficient</u>	Standard	<u>t value</u>	<u>p-Value</u>	Lower	Upper
		<u>Error</u>			<u>Limit</u>	<u>Limit</u>
Intercept	0.551961182	0.095910051	5.7550	< 0.0001	0.356830716	0.747091647
SG&A	-1.023740222	0.197277596	-5.1893	< 0.0001	-1.425104509	-0.622375935
Material	-0.569588815	0.173083841	-3.2908	0.0024	-0.921730537	-0.217447094

The regression data presented in Figure 4.1 illustrate that independent variables SG&A and Material explain the dependent variable to a moderate degree. The moderate explanatory power indicated by the R-square value of .5371 was expected in this case since other independent variables such as labor cost for example are known to impact EBITDA and were purposely excluded from the regression. The F-ratio of 19.14 provides more comprehensive insight into the explanatory power of the variables and is below the F-critical value of 19.5 associated with two degrees of freedom in the numerator and 33 in the denominator at the 95% level (Studenmund, 2005).

Figure 4.2

Fitted Line Explaining SG&A and Material influence on EBITDA

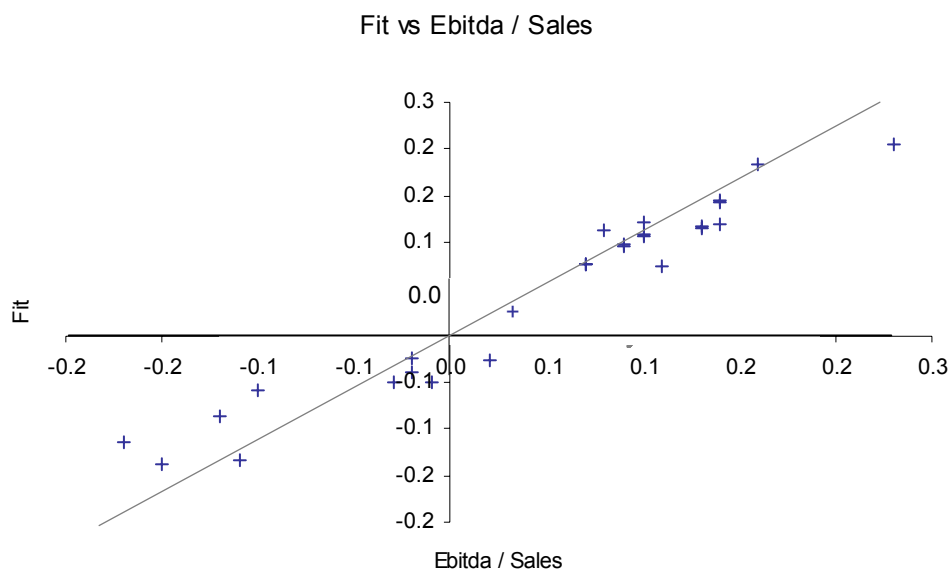


Figure 4.2 illustrates the best fit line produced by the regression equation. Following the linear equation $Y = a + b(x)$ where Y represents EBITDA and a represents the Y-intercept or constant value. The regression equation can be expressed as $EBITDA = .552 + -1.024(SGA) + -.57(Material)$.

In this case, the data suggest that management correctly chose relevant underlying drivers with respect to their impact on EBITDA and ultimately free cash flow and that the underlying variables explain EBITDA and cash flow to a moderate degree. After validating that the two underlying drivers, SG&A and Material explain free cash flow to a moderate degree, the change in free cash flows were estimated for sixty months. Adjusting the two variables for expected performance increases resulted in an annual increase in free cash flows of \$362,794.

Valuation Results

The valuation model assumes a project life-cycle of five years, a terminal value of zero, and a fixed subscription cost throughout the time horizon. The discount rate reflects the company's cost of capital and company revenue growth and cash flows remain constant unless otherwise indicated.

Conventional NPV – DCF

Figure 4.3

Year	<u>Δ in FCF</u>	<u>Subscription</u>	<u>PV in</u>	<u>PV out</u>	<u>NPV</u>
0	\$0	\$24,000	\$0	\$24,000	(\$24,000)
1	\$362,794	24000	\$306,000	\$20,243	\$285,757
2	\$362,794	24000	\$258,097	\$17,074	\$241,023
3	\$362,794	24000	\$217,694	\$14,401	\$203,292
4	\$362,794	24000	\$183,615	\$12,147	\$171,468
5	<u>\$362,794</u>	<u>24000</u>	<u>\$154,871</u>	<u>\$10,245</u>	<u>\$144,625</u>
	\$1,813,970	\$144,000	\$1,120,277	\$98,110	\$1,022,167

Figure 4.3 depicts a DCF valuation of the expected cash flows using the traditional net present value approach. This view of the data represents a scenario where management expects to achieve the CPM objectives with certainty. In essence, this valuation assumes that the total increase in free cash flows of \$362,794 is attributable to the CPM system.

Following the assumptions used to calculate Table 4.3, Table 4.4 illustrates the value of a series of the modified Black Scholes put options using the equation illustrated in Figure 3.9. A visual basic representation of the code used to produce to value of the put option is presented in Appendix C and D.

Conventional NPV-DCF plus the put option to abandon

Figure 4.4

<u>Year</u>	<u>Δ in FCF</u>	<u>Subscription</u>	<u>PV in</u>	<u>PV out</u>	<u>NPV</u>	<u>Put Option</u>
0	\$0	\$24,000	\$0	\$24,000	(\$24,000)	
1	\$362,794	24000	\$306,000	\$20,243	\$285,757	0
2	\$362,794	24000	\$258,097	\$17,074	\$241,023	0
3	\$362,794	24000	\$217,694	\$14,401	\$203,292	0
4	\$362,794	24000	\$183,615	\$12,147	\$171,468	0
5	<u>\$362,794</u>	<u>24000</u>	<u>\$154,871</u>	<u>\$10,245</u>	<u>\$144,625</u>	<u>0</u>
	\$1,813,970	\$144,000	\$1,120,277	\$98,110	\$1,022,167	0

In this case, certainty is assumed to be high, NPV is high and the put option is worthless. The data in Figure 4.5 follow the same assumptions outlined for Figures 4.3 and 4.4 however recognize the degree of management confidence by adjusting cash flows with a certainty equivalent coefficient of ten percent.

Adjusted with a certainty equivalent coefficient of 10%

Figure 4.5

<u>Year</u>	<u>Δ in FCF</u>	<u>Subscription</u>	<u>PV in</u>	<u>PV out</u>	<u>NPV</u>	<u>Put Option</u>
0	\$0	\$24,000	\$0	\$24,000	(\$24,000)	
1	\$36,279	24000	\$30,600	\$20,243	\$10,357	0
2	\$36,279	24000	\$25,810	\$17,074	\$8,736	1,392
3	\$36,279	24000	\$21,769	\$14,401	\$7,368	9,829
4	\$36,279	24000	\$18,361	\$12,147	\$6,215	17,360
5	<u>\$36,279</u>	<u>24000</u>	<u>\$15,487</u>	<u>\$10,245</u>	<u>\$5,242</u>	<u>0</u>
	\$181,397	\$144,000	\$112,028	\$98,110	\$13,918	28,582

The cash flows presented in Figure 4.5 reflect management's viewpoint that ten percent of the free cash flows can be expected for certain and that the company expects no growth over the five year time horizon. In this case, the data show the put option to abandon the subscription to be valuable. The put option is obviously worthless at the end of year five.

NPV Adjusted for certainty and growth

Figure 4.6

<u>Year</u>	<u>Δ in FCF</u>	<u>Subscription</u>	<u>PV in</u>	<u>PV out</u>	<u>NPV</u>	<u>Put Option</u>
0	\$0	\$24,000	\$0	\$24,000	(\$24,000)	
1	\$36,279	24000	\$30,600	\$20,243	\$10,357	0
2	\$38,093	24000	\$27,100	\$17,074	\$10,026	0
3	\$39,998	24000	\$24,001	\$14,401	\$9,600	3,598
4	\$41,998	24000	\$21,256	\$12,147	\$9,109	14,023
5	<u>\$44,098</u>	<u>24000</u>	<u>\$18,825</u>	<u>\$10,245</u>	<u>\$8,579</u>	<u>0</u>
	\$200,467	\$144,000	\$121,781	\$98,110	\$23,671	17,621

The data illustrated in Figure 4.6 are presented to reflect management’s view that ten percent of the cash flows attributable to the CPM can be expected for certain while adjusting company growth to five percent. In this case the option would appear valuable however less valuable than illustrated in Figure 4.5.

In order to illustrate the relationship between the valuation methods further, Figure 4.7 was produced to observe the difference between the conventional DCF and the option to abandon or unsubscribe from the contract against revenue growth. Figure 4.7 illustrates the value of both the put option and the conventional NPV of cash flows as the Proforma model revenue is increased from negative ten percent growth to positive ten percent while holding material and SG&A constant according to management objectives. Figure 4.7 represents the change in the option value versus the change in the discounted cash flows shown as NPV value as the company grows from a negative ten percent to positive ten percent, illustrating the potential to obscure the influence and subsequent value of the CPM unless growth is constrained.

Figure 4.7

Sensitivity Analysis between DCF, the Put Option to Abandon and Revenue Growth.

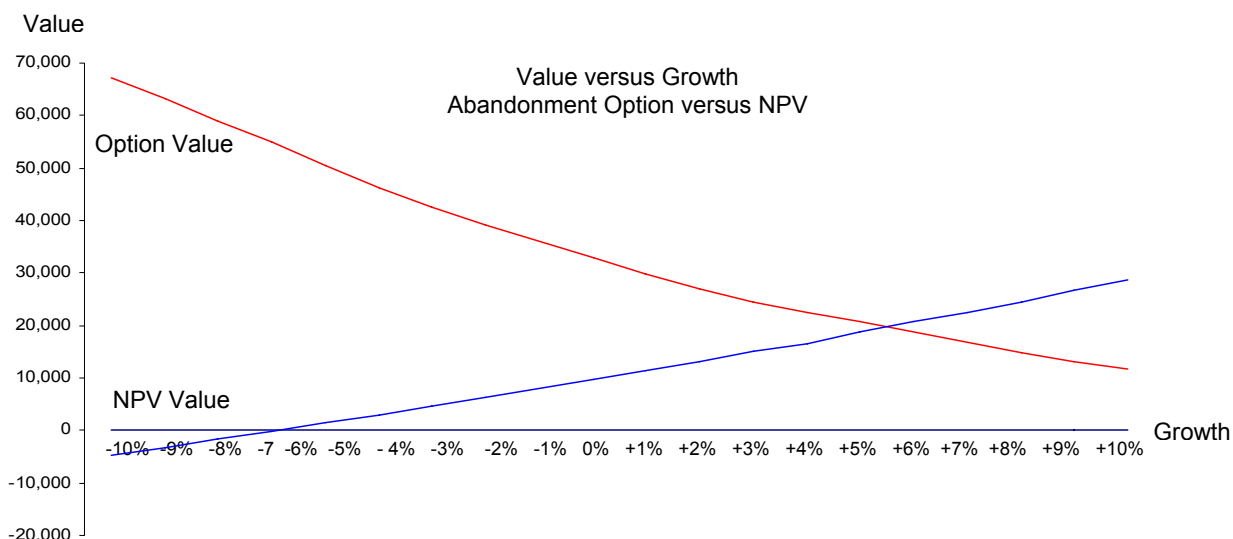


Figure 4.7 illustrates that the put option is most valuable when the certainty of collecting the expected cash flows produced by the CPM is low and the expected company growth is low. In this view of the data, the certainty of collecting the expected cash flows is held constant in order to observe the relationship between the option to unsubscribe and value of the discounted cash flows with respect to growth.

Survey Results

A total of 542 finance professionals were surveyed resulting in 105 responses with four unusable due to incomplete data. The data obtained from the survey was used to test the null hypothesis and is presented in Figure 4.8. Of the 101 respondents, 87.13% indicate that they use or intend to use a conventional form of DCF when making capital budgeting decisions that involve SaaS, while 12.87% chose some form of OPM.

Figure 4.8

Z test and Corresponding p-value	
Target Proportion	0.5
Intend to use OPM for SaaS	13
Number of Respondents	101
OPM Proportion	0.1287129
Standard Error of Sample Proportion	0.04975
z test	-7.463
One tailed p-value	0.0000
Confidence Interval Proportion	
Confidence Level	95%
Standard Error (SE)	0.033
z multiple	1.96
Lower Limit	0.063
Upper Limit	0.194

The null hypothesis $H_0 : p \geq .50$ and $H_a : p < .50$ states that the majority of finance professionals intend to use OPMs when making capital budgeting decisions that involve SaaS.

The rejection statement reads: Reject H_0 if the observed $z > z_c \alpha$. Else do not reject H_0 . In this case, the z statistic -7.46 is well to the left of z critical -1.32 allowing the null hypothesis to be rejected at the 99% level of significance. In addition to the z test, the confidence interval illustrates with approximately 95% certainty that the general population of finance professionals that intend to use OPM for valuing SaaS will range between 6.3% and 19.4%, well below the majority.

In order to validate the integrity of the confidence interval, a test was performed to insure that a sufficiently large sample was used to draw the conclusion. The results of the test are presented in Figure 4.9.

Figure 4.9

Test for sufficiently large sample	OPM
$npl > 5$	6.404
$n(1-p) > 5$	94.596
$npu > 5$	19.596
$n(1-pu) > 5$	81.404

Each of the four parametric tests produce an outcome that exceeds the minimum level of five indicating that a sufficiently large sample size was used to produce the confidence interval.

Question number five of the survey asked the respondent whether or not they recognize or give credit to those that provide economic flexibility as part of the investment decision. In this case, 90.29% of the respondents indicate that they recognize or give credit to those providing economic flexibility. Figure 4.91 illustrates the 95% confidence interval indicating that one might reasonably expect the population to range between a lower limit bound of 84.57% and upper limit of 96%.

Figure 4.91

Confidence Interval Proportion	
Confidence Interval	95%
Respondents that value flexibility	0.9029126
Standard Error	0.0294607
Respondents	101
z-multiple	1.96
Lower Limit	0.8451706
Upper Limit	0.9606546

CHAPTER V

Discussion

The Results of the Sensitivity Analysis

The results of the sensitivity analysis illustrates that the CPM application contains flexibility and that same flexibility is valuable when the environment is uncertain. The model supports claims by (Trigeorgis, 1996) and others that the value of flexibility, in this case the option to abandon can be measured to some degree. And while this is arguably important, the sensitivity analysis also shows that the put option is *only* valuable under a very specific set of circumstances. In the case at hand, the value of flexibility is only meaningful when the uncertainty of cash flow increases or when the growth of the firm is negligible. Further, the data show that an increase in revenue growth does not diminish the option value if the uncertainty of collecting the cash flows remains high. The economic value of flexibility is clearly most important when the uncertainty of collecting the expected cash flows is high and the expected growth is low. The data show for example that when the certainty of cash flow is adjusted to five percent and revenue growth is a low five percent, the put option is valued at \$70,772 in spite of a negative NPV of \$14,736. This makes intuitive sense since the option to exit the investment is at its highest when the CPM application either does not perform as expected, or if the firm experiences declining growth that may render the expected free cash flows unattainable. On the contrary, the data show that when the certainty of collecting the cash flows is relatively high at twenty percent and revenue growth is a robust twenty percent, the value of the put option becomes worthless. Once again, this makes intuitive sense since the firm would arguably have no incentive to abandon the investment when the CPM application is performing as expected and when free cash flows are high. To be sure, Damodoran (2001) Trigeorgis (1996) and others make clear the relationship between the value of the option and the presence of uncertainty. Accordingly, the outcome of the sensitivity analysis was not unexpected. What was unexpected however was the significance of the option value relative to the value of the SaaS subscription when uncertainty is present, and high. The DCF portion of the valuation model proved unremarkable in comparison to the OPM. By itself, the DCF value responds as expected when the certainty equivalent coefficient increases or decreases but does not respond to the option to abandon or in this case cancel the subscription since it assumes that all costs are invested at one moment in time and that those same costs are sunk (Trigeorgis, 1996).

Limitations

The terms that govern the option to abandon in this case study make estimating the option to unsubscribe using a modified Black Scholes or Binomial Lattice relatively straightforward. However, cancellation terms may vary between SaaS applications and in such cases the binomial OPM may represent the best option pricing model for the task. In some cases, the value of the option to abandon may be more dependent on avoiding future negative cash flows when the investment does not perform as expected. Other limitations may exist as well. For example, as

the name implies, a CPM system is designed to improve corporate performance. The data would suggest that caution must be exercised when valuing corporate performance based upon changes in free cash flow since stochastic macro economic variables unrelated to the CPM application may influence cash flows and confound the outcome. To illustrate, Table 4.7 presents the behavior and relationship between the value of the DCF, the option to abandon and the revenue growth of the firm. Understanding this behavior is arguably important since it illustrates the potential to obscure the value of the option as a function of growth. In other words, a company producing strong cash flows unrelated to the CPM may undervalue the option to abandon the investment in the CPM. It follows then that it may be important to hold revenue growth and other variables constant while adjusting improvements to underlying cash flow drivers when valuing the impact of the CPM. Exceptions may exist however if management can assign a specific portion of the revenue growth directly to the CPM.

Results of the Survey

The survey was designed to answer one important question for those engaged in the business of developing or marketing CPM systems delivered via SaaS. Specifically: Which method, DCF or OPM, is most likely to be used by finance professionals employed by companies that range from one hundred million to one billion dollars in revenue when making capital budgeting decisions involving SaaS? While many surveys and research questions have been undertaken with respect to valuation choices in the past, to the knowledge of the author, none address the specific question pertaining to the valuation technique that is most likely to be used when valuing products or services delivered via SaaS. Since products and services delivered via SaaS may contain flexibility, and not all valuation methods capture the value of flexibility, the appropriate choice of techniques may be critical. Indeed, the data suggest with 99% confidence that a majority of finance professionals representing U.S. firms that range between one hundred million to one billion dollars in annual revenue intend to use a conventional form of DCF to value CPM systems delivered via SaaS. The survey data represents important information for those that intend for their products and services to be valued fairly and favorably in the midst of competition where scarce resources shape the capital budgeting decision making process.

In some respects, the survey was not dissimilar from others conducted previously. Pike (1996) for example demonstrates that companies do not use a single valuation method while excluding all others and further explained why DCF methods were gaining in popularity. In addition, Hall (2007) illustrates the impact that MBA programs have had upon the use of valuation techniques. With MBA programs gaining in popularity, it is little wonder that DCF methods have increased in popularity compared to the less sophisticated methods that had been used in the past.

The survey response rate of 18.63% is consistent with similar surveys directed toward CFOs including Sangster (1993) at 21.8% and Graham and Harvey (2002) at 9.0%. While Sangster (1993) points out that capital budgeting surveys have a long history of low response rates and

design flaws that make them difficult to generalize, great care was taken to focus the survey on one important question. The survey and data collection process was designed with the goal of generalizing the results to a very narrow and specific audience and to help address the need for specific case studies that apply various valuation techniques to very specific investment opportunities.

Results in the context of the literature

The sensitivity analysis data suggest that the optimal valuation methodology to support capital budgeting decisions that involve products and services delivered via SaaS is the option pricing model. However the survey results suggest that this is *not* the valuation technique that will be used by a majority of finance professionals when making future capital budgeting decisions involving SaaS. The results of the sensitivity analysis support positions of Techopitayakul and Johnson (2001), Trigeorgis (1996), Damodaran (2001), Bose and Oh (2003) and others that state that traditional DCF models are ill equipped to value complex technological investments. The sensitivity analysis by itself makes no claim to confirm the work of the preceding authors since this has been done many times in the past. However the sensitivity analysis extends the previous work of others by applying their ideas and methods to one specific capital budgeting decision, in this case capital budgeting decisions that involve products and services delivered via SaaS. In doing so, valuable practical insight has been gained since both the analysis and the current state of the literature suggest that conventional DCF models cannot capture the value of products and services delivered via SaaS if uncertainty is present.

At one time, it was widely understood throughout the literature that valuation techniques correlated with the size of the company. The general thinking in this regard was that the most sophisticated techniques were the domain of large organizations where finance executives were more likely to have attained higher levels of education. However, Sangster (1993) citing the work of Pike (1982) found that the use of more sophisticated valuation techniques were more likely due to the availability of computers and the evolution of spreadsheets that made complex valuation tasks easy to perform. If this holds true, the findings of Pike (1996) as well as Hall (2007) may explain why the results of the survey at hand found that DCF techniques appear overwhelmingly the valuation technique of choice. In contrast, Graham and Harvey (2002) found a higher percentage of respondents using option pricing models for general purpose valuations however Pike (1996) cautions against comparing survey valuation preferences based on different sample frames, time frames and questions placed in different contexts.

What is clear in the literature is that valuation techniques have followed a very distinguishable evolutionary path. To be sure, (Pike, 1996) and (Sangster, 1993) as well as Graham and Harvey (2002) demonstrate periods of time where it would appear that one method or the other reigns the supreme favorite among all others. Absent from the literature however are research projects that line up optimal methods for specific valuation tasks that vary in complexity and certainty.

Accordingly, the research at hand helps fill a gap that currently exists in the literature. While it is interesting to compare the valuation techniques resulting from various surveys, it is important to note that the survey at hand was designed to find the answer to one specific question. That is: Which valuation technique *will* be used to value products or services delivered via SaaS? To be clear, the survey was designed not so much to learn about the valuation technique in general favor today, but rather which *specific* valuation technique is most likely to be used to value products or services that are delivered via SaaS.

The survey results indicate that a majority of finance professionals intend to use conventional DCF methods to make capital budgeting decisions that involve SaaS. At the same time, the research shows that DCF models fail to capture the value of flexibility in the SaaS application when uncertainty is present in the environment. Perhaps one of the most interesting points uncovered by the survey is that while the majority of finance professionals recognize the importance of flexibility in the investment decision, most use or intend to use a valuation technique that may not capture the value of flexibility. This leads one to question why OPMs are not a more popular choice for the purpose of valuing products and services involving SaaS. One might hypothesize that the unpopularity of OPMs may be due to their lack of intuitive appeal. If this is so, it may prove worthwhile to examine techniques that outperform DCF models in their ability to capture the economic value of flexibility, however are less complex than Black Scholes or lattice models. For example, assuming that the SaaS investment does not perform as expected and produces future negative net present values, the data suggest that the option to abandon, at a minimum, should represent the present value of avoiding the future negative cash flows. Techopitayakul and Johnson (2001) for example state in essence that the value of the option to stop usage is represented by the difference between having the right, and not having the right to *stop* usage. If this is true, a model that captures the value of avoiding negative NPV for each year may represent a straightforward method to value the option to unsubscribe from the SaaS system. Figure 6.0 represents a general example of such a model. The values in the Abandon column represent the cumulative sum of the annual negative NPV that may be avoided with the option to unsubscribe assuming that prior NPVs are sunk, the subscription is cancelled on the last day of the year and the change in free cash flow benefits are set to zero.

Figure 5.0

OPM to Avoid Negative Cash Flows

Year	Δ in FCF	Subscription	PV in	PV out	NPV	Binomial	Abandon
0	\$0	\$24,000	\$0	\$24,000	(\$24,000)		
1	\$0	24000	\$0	\$20,243	(\$20,243)	77,867	74,110
2	\$0	24000	\$0	\$17,074	(\$17,074)	59,793	53,867
3	\$0	24000	\$0	\$14,401	(\$14,401)	46,392	36,793
4	\$0	24000	\$0	\$12,147	(\$12,147)	34,245	22,392
5	\$0	24000	\$0	\$10,245	(\$10,245)		

While the model in Figure 5.0 is essentially a reversible DCF model and fails to account for volatility or probability, its ability to accommodate a wide range of SaaS subscription terms and its intuitive appeal may make it worthy of discussion. Early in the project's life-cycle, and for the case study at hand, the model produces a value somewhat comparable to the binomial put option.

Discussion with respect to data collection

Every effort was made to insure the integrity of the data collection process. The random sample was pulled from a complete frame that consists of every U.S. company between one hundred million and one billion dollars as of Friday January 4th, 2008 (Hoovers, 2007). Prior to the primary survey, a pilot sample was randomly chosen based upon the Mukhopadhyay (2005) pilot sampling methodology for selecting the best normal population when the mean variance is unknown. Minimal deviation in the pilot sample results allowed for a relatively small sample size for the main survey. Surveys were mailed to the CFO of five hundred forty two companies. The sample was chosen without respect to SIC or NAICS code and it was assumed that all CFO's were familiar with the capital budgeting process and various valuation techniques.

Non response bias may play a role in the results. Indeed, it would seem plausible that the respondents most likely to respond to the survey are those most interested in the subject of valuation and perhaps most educated as a result of their interest. If this is true however, the results and subsequent conclusion may be further strengthened since it would seem clear that those less interested and less educated would also be less likely to choose more sophisticated valuation methods.

CHAPTER VI

Conclusion

This research project set out to answer two important questions faced by those engaged in the business of buying or selling products and services in the SaaS environment. First, do option pricing models represent a superior alternative to discounted cash flow techniques when making capital budgeting decisions that involve SaaS? And second, which of the two models is most likely to be used by finance professionals when valuing products or services involving SaaS? The answers to both questions are arguably important since the failure to capture the economic benefits of products and services delivered via SaaS creates opportunity for loss on both sides of the buy-sell transaction.

The research shows that conventional DCF models fail to capture the value of the option to abandon or in this case, unsubscribe from the product or service delivered via SaaS while the option pricing models capture this value to some degree. And while this is clearly important on the surface, the research shows it to be meaningful only when uncertainty is present in the environment. The research also highlights the importance of isolating the specific cash flows associated with the product or service undergoing valuation. For example, in the case study at hand, the research shows that the abandonment value may be obscured if the firm experiences significant growth, underscoring the need to constrain the appropriate variables in the sensitivity model in order to isolate and uncover the value of the cash flows *directly* related to the CPM under evaluation.

Since the conventional DCF and OPM models differ with respect to their ability to capture the value of flexibility, it follows that it is important to understand the specific model that is most likely to be used by finance professionals when making capital budgeting decisions involving SaaS. This may be especially important for those that sell products or services via SaaS since the prospective buyer may fail to recognize the full value of the product or service when using a conventional DCF technique to perform the valuation. The research shows that a convincing majority of finance professionals employed by companies that range between one hundred million and one billion U.S. Dollars use or *intend* to use a conventional DCF method when making capital budgeting decisions involving SaaS. This should be a concern for those that sell products via SaaS and especially so when competing against a traditional licensed based model.

Opportunity for future research

This research suggests that the optimal choice of capital budgeting techniques may be a function of the dynamic nature of the product or service to be valued including the manner in which they are delivered. Accordingly, case studies that apply specific valuation techniques to various capital budgeting investment opportunities would appear to represent an ideal opportunity for further research. For example, a decision-maker contemplating a new equipment purchase to

support an existing product line versus outsourcing the manufacturing might benefit from research that compares a traditional DCF approach to an OPM that includes a William and Sutherland (2005) convex-scaling factor that reflects the economic half-life of the product line. Such a project may represent an exciting opportunity to contribute to further research.

The way forward

The knowledge gained in the research project provides a practical way forward. To begin, the CPM organization in this case study will benefit with the knowledge that the specific valuation method most likely to be used when the customer is engaged in a capital budgeting decision involving SaaS is the DCF model. Perhaps more importantly, the organization can show that the DCF method to be used by the potential customer in the valuation process may fail to capture the full value of the CPM system. This is especially true in highly uncertain environments. The important take-away here is that most finance professionals intend to use a valuation method that may not present a complete picture of the CPM system's value. There may be little that the company can do to change the customer's preferred method of valuation. However, with the help of a model that includes option pricing, the company's sales approach can be expanded to articulate the value of flexibility and explain that same value with some degree of confidence. Taking this approach, the company might encourage the customer to recognize the value of flexibility in the SaaS environment when compared to a license based model that requires an investment that represents sunk costs.

Specific to ClearMomentum, the research produced a model that will help the organization gain a competitive advantage by helping the company articulate the value of flexibility inherent in the CPM application. In this case, sales and marketing personnel in the organization will arguably be better equipped to help the customer recognize the value of flexibility provided by SaaS. In addition, the model provides insight into how customers are likely to perceive the value of the application as a function of the net expected change in free cash flow realized as a result of implementing the CPM system. With the knowledge that a majority of the company's customers will likely use the DCF approach to ascertain the value of ClearFinancials[®], the company may now offer the customer a cost benefit analysis that includes a model of expected increases in free cash flows, controlling for variables unrelated to the CPM application while producing a valuation that *includes* the value of flexibility. In a worse case scenario, the organization will create negotiation leverage if successful in helping the customer recognize that products and services delivered via SaaS contain flexibility and that the flexibility is valuable when uncertainty is present.

Most U.S. finance professionals employed by companies between one hundred million and one billion dollars intend to use a DCF method to support capital budgeting decisions that involve SaaS. This may change however as popular valuation techniques have indeed evolved over time (Pike, 1996; Sangster, 1993). And, if history repeats itself, and if the adoption of valuation

techniques continue to evolve as a function of technology and higher education as Hall (2007) suggest, then it will only be a matter of time before option pricing models become more popular. Meanwhile, this research shows that it is perhaps doubly important for business managers to realize that the full value of their complex assets, products and services delivered via SaaS may go unrecognized if they are subject to DCF valuations techniques alone. In order to capture value in the SaaS environment, this research suggests that option pricing techniques such as binomial lattices and modified Black Scholes models represent a superior alternative to conventional DCF models.

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Appendix B

VBA CODE and TEST

A visual basic (VBA) application model was developed to solve for the value of a real SaaS option using the Black Scholes formula as illustrated in Figure 2.15, 2.16 and 2.17. Function d1 represents the equation illustrated in Figure 2.16 and 2.17 and FunctionRealOption represents the equation found in Figure 2.15.

Appendix C

RealOption – Call Option, Black Scholes Version

```
Function d1(PVFutureCF, SaaS Cost, Duration, RiskFreeRate, ProjectValueUncertainty)
d1 = (Log(PVFutureCF / SaaS Cost) + RiskFreeRate * Duration) / (ProjectValueUncertainty * Sqr(Duration))
+ 0.5 * ProjectValueUncertainty * Sqr(Duration)
End Function
```

```
Function RealOption(PVFutureCF, SaaS Cost, Duration, RiskFreeRate, ProjectValueUncertainty)
RealOption = PVFutureCF * Application.NormSDist(d1(PVFutureCF, SaaS Cost, Duration, RiskFreeRate,
ProjectValueUncertainty)) - SaaS Cost * Exp(-Duration * RiskFreeRate) *
Application.NormSDist(d1(PVFutureCF, SaaS Cost, Duration, RiskFreeRate, ProjectValueUncertainty) -
ProjectValueUncertainty * Sqr(Duration))
End Function
```

```
'where S = StockPrice = PVFutureCF
'X = Exercise = SaaS Cost
'T = Time = Duration
'rf = Interest = RiskFreeRate
'sigma = Volatility = ProjectValueUncertainty
```

Appendix D

RealPut – Put Option, Black Scholes Version

```
Function RealPut(PVFutureCF, SaaS Cost, Duration, RiskFreeRate, ProjectValueUncertainty)
RealPut = RealOption(PVFutureCF, SaaS Cost, Duration, RiskFreeRate, ProjectValueUncertainty) +
SaaS Cost * Exp(-RiskFreeRate * Duration) - PVFutureCF
End Function
```

Trigeorgis (1996) suggests that the Black Scholes formula and the traditional NPV formula converge to the same value in the absence of flexibility in one time period. In order to check the models for accuracy, the following values were inserted into the models:

Test Input Values

Gross PV set to 12,500
Investment set to 5,000
Duration set to 1 Period
Risk Free Rate set to .01
Uncertainty set to .001

Using the test input values both the NPV (DCF) and the VBA code based upon the Black Scholes equation return the same value of 7,426.

Appendix E

Figure (x.x) Binomial OPM – Put Option

Illustrates a VB representation of a Binomial Option Pricing Model designed to find the value of a put option used to value the option to abandon (Benninga 2000).

$$\text{Putvalue} = \sum_{i=0}^n \binom{n}{i} q_u^i q_d^{n-i} \max \left[X - S_0 (1+u)^i (1+d)^{n-1}, 0 \right]$$

Function AmericanPut(S, X, T, rf, sigma, n)

delta_t = T / n

up = Exp(sigma * Sqr(delta_t))

down = Exp(-sigma * Sqr(delta_t))

r = Exp(rf * delta_t)

q_up = (r - down) / (r * (up - down))

q_down = 1 / r - q_up

Dim OptionReturnEnd() As Double

Dim OptionReturnMiddle() As Double

ReDim OptionReturnEnd(n + 1)

For State = 0 To n

OptionReturnEnd(State) = Application.Max(X - S * up ^ State * down ^ (n - State), 0)

Next State

For Index = n - 1 To 0 Step -1

ReDim OptionReturnMiddle(Index)

For State = 0 To Index

OptionReturnMiddle(State) = Application.Max(X - S * up ^ State * down ^ (Index - State), q_down * OptionReturnEnd(State) + q_up * OptionReturnEnd(State + 1))

OptionReturnEnd(State) + q_up * OptionReturnEnd(State + 1))

Next State

ReDim OptionReturnEnd(Index)

For State = 0 To Index

OptionReturnEnd(State) = OptionReturnMiddle(State)

Next State

Next Index

AmericanPut = OptionReturnMiddle(0)

End Function

Appendix F

Figure X.X Five Year NPV

Illustrates a VB representation of the valuation model used to find the Net present Value, NPV of a future stream of cash where both inflows and cash outflows occur each year.

```
Function NPVfive(CashOutTZero, CashInTOne, CashInTTwo, CashInTThree, CashInTFour, CashInTFive,  
CashOutTOne, CashOutTTwo, CashOutTThree, CashOutTFour, CashOutTFive, Rate)  
NPVfive = (CashInTOne / (1 + Rate) ^ 1 - CashOutTOne / (1 + Rate) ^ 1) + CashInTTwo / (1 + Rate) ^ 2 -  
CashOutTTwo / (1 + Rate) ^ 2 + (CashInTThree / (1 + Rate) ^ 3 - CashOutTThree / (1 + Rate) ^ 3) +  
(CashInTFour / (1 + Rate) ^ 4 - CashOutTFour / (1 + Rate) ^ 4) + (CashInTFive / (1 + Rate) ^ 5 -  
CashOutTFive / (1 + Rate) ^ 5) - CashOutTZero  
End Function
```