Final Capstone Project

CP194

Growth Company Valuation

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Abstract

Discounted Cash Flow (DCF) is the most popular technique for a firm's valuation. However, conventional DCF valuation was created for mature, stable companies that yield stable growth and returns, with long-standing financial history and data. When the financial analysts discuss DCF valuation in the context of young growth companies one of its biggest weaknesses is that it does not account for the uncertainty and the lack of financial or operational data available for these firms. The goal of this paper is to build a probability-based approach towards young growth company valuation that uses Monte Carlo (MC) Simulation to integrate uncertainty and randomness.

Author's Note

I start by presenting my question, which is to find a way to use DCF valuation on young growth companies. Why is conventional not appropriate for these companies? And what characteristics of these companies make them hard to value? After that, I present my own method to a simulated DCF approach that finds the key variables that impact the company value the most and finds the most relevant probability distribution for those variables. And run the simulation and present the results in a histogram.

Introduction

Valuing growth companies is a major challenge faced by most investors (Damodaran, 2001). These companies tend to have little or no revenues and operating losses. The ones that have might not have a long history to support any future growth predictions thus making the future potential of the firm highly uncertain (Maya, 2004). Conventional DCF approach was devised to cater to traditional companies' valuation, with stable growth rates and long-standing revenues and earnings history. It assumes that future cash flows will be stable and predictable (Mun, 2002). In order to account for these uncertainties and risks, this paper proposes a new method of performing DCF valuation for growth companies. This method is based on stochastic or Monte Carlo (MC) simulation. DCF valuation aggregates the future cash flows in one single estimate by discounting them back in time, it uses a risk-adjusted interest rate to discount it to today's value, thus giving an expected value of the firm. This presents a variety of drawbacks when the conventional DCF model is used for growth companies. One major obstacle is tackling the uncertainty that characterizes the future cash flows of growth companies (Booth, 2003). In such a volatile and uncertain environment, a company’s cash flows cannot be predicted to be a single point estimate, but rather Monte Carlo Simulation will help identify a range of multiple outcomes that will be derived by multiple possible values (Mun, 2002). In such stochastic situations, using conventional models such as the deterministic DCF approach can lead to a flawed valuation of growth companies (Booth, 2003; Damodaran, 2001).

In order to tackle the uncertainty, and account for this drawback in the conventional DCF valuation method, financial analysts started performing sensitivity or scenario analysis to complement the DCF approach (Savvides, 1994). This helped the analysts understand among a myriad of variables, which variables have the greatest impact on the DCF value, and characterize these variables based on their significance on the impact of the DCF value they have (Ragsdale, 2004). Even though sensitivity analysis helped the analysts understand the importance of different variables and their impact on the DCF value, it still did not account for the correlation among different variables. Sensitivity analysis did not account for the interdependencies between variables since the ceteris paribus assumptions made when changing one variable at a time is rarely realistic (Kelliher and Mahoney, 2000). Therefore, analysts started performing scenario analyses where alternative scenarios are constructed based on different variable values. Even though this did account for interdependencies of different variables and heed analysts analyze different scenarios, it still did not provide them with the probabilities of occurrence of a particular scenario (Goldman and Emmett, 2003).

Monte Carlo simulation uses pseudo-random numbers which can help solve deterministic problems (Law & Kelton, 2000). It is a proven technique that considers risks and uncertainties, which allows analysts to assign different probability distributions to different variables which account for the range of possible values for each variable (Powell and Baker, 2004). Monte Carlo simulation uses random sampling from these probability distributions to perform hundreds of thousands of scenario analyses. The distribution of these several scenarios is thus created and decisions can be made with the knowledge of the whole distribution rather than one estimated aggregate value (Winston, 2004). Monte Carlo simulation was first used for Capital Budgeting in finance in the 1960s to evaluate risks and uncertainty inherent in investment decisions (Kelliher and Mahoney, 2000). This paper will be using a Monte Carlo simulation approach that could be used to grow the company's valuation.

This paper will be looking towards a specific subset of growth companies, in the technology industry. The paper will first describe what constitutes a growth company in the technology space. After that, it proposes a novel Simulated DCF model to value these subsets of companies. After that, it examines how the model incorporates the uncertainties in the DCF analysis using Monte Carlo Simulation. Lastly, it evaluates the results and summarizing the empirical analysis.

Valuation Issues

The paper lists some common characteristics among young growth companies. The fact that they have short or no financial history is dependent upon financing from private sources (private equity), and are susceptible to failures in their early life makes it harder to account for all these uncertainties, limited data, and risks. Which eventually makes it more difficult to value these companies.

Analyzing how these problems play their role in making DCF valuation harder is of utmost importance as they create uncertainty in the future value of a firm. There are four pieces that make up the DCF valuation puzzle - the cash flows from existing assets, the expected growth from new investments and improved efficiency on existing assets, the discount rates that involve risk assessments, and the terminal value that assesses when the firm will have stable growth (Damdodaran, 2004).

Existing Assets

Conventional DCF approach takes the value of existing assets from the current financial statements of the company. The model then estimates the value of these existing assets using the history and anticipated future cash flows generated from these assets to attach a value to them.

With young growth companies, especially in the technology sector, these existing assets are either so small compared to the overall value of the firm that it does not make sense to estimate their value based on past or future estimations. Or there is not many historical data available for the analysts to predict the value of these assets. Having little background data available means that it is not possible to be sure that the revenues from existing assets were influenced by macroeconomic trends or some other confounding variable. The lack of data makes it harder for analysts to understand the effect of the change on macroeconomic trends on the revenues generated from these existing assets.

Similarly, unlike traditional well-established companies, young companies' expenses also do not report a very clear picture of cash flows. It is not unusual to see Selling, General, and Administrative (SG&A) expenses at some young growth companies to be three to four times larger than revenues (Damodaran, 2004). This can be because of multiple reasons. A new company is trying to penetrate into a new market, they are trying to increase their customer base, so the expenses incurred right now are being used for lining up future customers. Because of these reasons, it gets harder to differentiate between the genuine operating expenses from these expenses. And in order to value the existing assets of young growth companies, it is essential to be able to distinguish between them.

Growth Assets

Most of the young growth company's value comes from the growth assets (Damodara, 2004). The reason why conventional DCF valuation poses a problem here is because of the uncertainty associated with the future value of these growth assets which are of immense importance to value these firms. The reason why estimating the value of these growth assets is a problem is first, absence or lack of history of revenues. This means that either these firms are not revenue-generating yet, and if they are then the history is too short to make a predictable forecast from the data. That means the conventional model has to rely on the company's own estimations for their future revenues that can be biased.

Similarly, even if the estimates of the revenues can be made precise, the uncertainty will still be there as to how earning will evolve with the growth of revenues. As explained above that it is hard to differentiate between the genuine operating expenses versus the actual expenses. Also, young growth companies tend to incur losses at the start, which makes it harder to predict what the future profit margins will look like and value them accordingly.

Lastly, it is also important to take into account the quality of the growth as well. Growth by itself can be constructive or destructive. To assess the quality the new model will have to look at how much the firm has reinvested in future growth projects and whether or not the returns on those reinvestments are greater than the cost of capital invested in them. The reason why this is an issue for conventional DCF valuation is that young growth companies have little investments in the past that analysts can use that data to predict the return on capital. Furthermore, the current return of capital, which can be used as a starting point for estimating future return, is generally negative for young growth companies (Damodaran, 2004).

Discount Rate

Discount rates assess the risk in a company. The standard way of calculating discount rates is by using a regression model that estimates the beta for equity on stock against the return on a market index and cost of debt by looking at the prices of publicly traded bonds (Damodaran, 2004). With young growth companies that is not the case. Firstly, most young companies are not publicly traded. That means that it is not possible to run a regression of the past returns to get equity beta or use the interest rate of the market.

Conventional DCF approach accounts for risk by focusing on market risk to estimate the cost of equity. However, in the case of young growth companies, the equity is held by a myriad of different investors (founders, venture capitalists, etc) who have different perspectives towards risk for their investments. Because in young companies equity can be raised from multiple sources, each source will have a different risk attached to it. That means that there can be different costs of equities for different equity claims (Damodaran, 2004).

Terminal Value

The terminal value of a firm reflects the value of all expected future cash flows (Higson and John, 2000). It accounts for a very large proportion of a company's value. This value provides the investors an estimate as to how much potential there is to a particular firm. In the case of young growth companies, this value poses a big problem. It is not uncommon for the terminal value of a young growth company to be 90%, 100%, or even more than 100% of the current value of the firm (Damdodaran, 2004). Therefore, assumptions that when the firm will reach stable growth, will the firm reach stable growth or what stable growth will look like financially for the firm is important to consider since it accounts for a very big percentage of the valuation for young growth companies.

The paper discussed above how young growth companies are more prone to failures. This estimation and probability associated with a firm's success rate are of importance when analysts have to account for whether the firm will reach stable growth? And if yes then when the firm will reach stable growth? Finally, it is not only the if and when stable growth will be achieved for the firm. For young growth companies, it is also important to determine the effect and consequences of a stable growth rate. At such an early life cycle of a firm, it is hard to predict what this stable growth rate would yield. What would the risks and returns look like during a stable growth phase?

These estimations, probabilities, and judgments make it hard for analysts and investors to value any young growth firm with a lack of historical data and an uncertain future.

Valuation issues for growth companies

Characteristics of Young Growth Companies

It is important to first describe what constitutes a young growth company in the technology industry. Even though young companies are diverse, they share some common characteristics (Damodaran, 2004). This section will be looking into these shared attributes of young growth companies in the technology industry and how these traits pose valuation problems for analysts and investors.

Little or no history

As described above the biggest issue with conventional DCF valuation is that it assumes that the future cash flows are certain and stable. However, these companies have very limited histories. Most of these companies have one to two years of financial data available on operations (Damodaran, 2004).

Little or no revenues/ operating income

Another challenge faced in implementing conventional DCF valuation for these companies is that the revenues or operating income provide little or no details. So even though companies might have short financial histories, that data is rendered useless by the fact that the revenues and income/ losses have little operating details in them. In most cases, the revenues are small or unavailable for young growth companies, and the expenses are often for setting up the business and kickstart generating revenues (Damodaran, 2004). Thus, using these figures to forecast the data for future revenues/ operating income is not possible.

Dependant on Private Equity

Another common characteristic among these young growth companies in the technology sector is that these companies are dependent upon equity from private sources, rather than public markets (Damodaran, 2004).

Uncertain Survival

The US Small Business Administration found that on average, 39.8% of the new firms survive six or more years. This is equivalent to a failure rate of three out of five firms failing within the first five years (Phillips & Kirchhoff, 1989). A study of 5196 start-ups in Australia found that the annual failure rate was around 9%. And furthermore, along the lines of the failure rate of Phillips & Kirchhoff's study, 64% of the new businesses failed in a ten-year period (John Watson & Jim Everett, 1996). In 2005 Bureau of Labor Statistics Quarterly Census of Employment and Wages (QCEW) performed a census containing information on more than 8.9 million US businesses in both the public and private sector. Knaup and Piazza used this data to conclude that only 44% of all businesses that were founded in 1998 survived 4 years and only 31% made it through all seven years (Knaup, Amy, Piazza, 2007). In the context of DCF Valuation, this poses a problem to how to account for the risk of survival and control for it. Therefore, it is important to account for the probability that the business will not survive at the discount rate (Damodaran, 2004).

Why are they important?

Even though young growth companies tend to be small in size and represent only a small part of the overall economy. Their importance and impact on the economy are disproportionately high due to the following reasons:

Employment Opportunities

The National Federation of Independent Businesses estimates that two-thirds of the new jobs created in recent years have been created by these young growth companies. That means a lot of the economy's employment rate is dependent on these companies doing well financially.

Innovation

Clayton Christensen coined the term disruptive innovation. Disruptive innovation is an innovation that creates a new market and value network and eventually disrupts an existing market and value network, displacing established market-leading firms, products, and alliances (Clayton Christensen, 2015). This innovation was unlikely to come from well-established firms but rather from the startups that will boost the innovation and explore new avenues for economic growth. For example: the online retail industry was established by a new startup, Amazon.com rather than a well-established firm.

Economic Growth

Startups, even though they are small, they play a big role in economic growth. They not only increase employment as mentioned above but they also play a major role in economic dynamism (Ahmad Fahim Dar, 2000). This means they spur innovation and boosts the economy to grow through bridging new ideas in the economy and promoting entrepreneurial competition. The US was able to generate more rapid growth than Western

Europe during the 1990s. This was primarily due to the growth of small, new technology companies (Damodaran, 2004).

What is Discounted Cash Flow Analysis

There are typically three major methods in business valuation:

1. Income Approach
2. Asset Approach
3. Market (comparable sales) Approach

Among the income approach methodology, the Discounted Cash Flow (DCF) method is the most widely used one (360financialliteracy, 2020). Discounted cash flow is a valuation method that can be used to determine the value of privately-held companies. DCF approach projects the series of future cash flows of a firm, its Earnings Before Income Tax and Depreciation and Amortization (EBITDA) or earnings and then discounts the earnings back to the present value with a discount factor based on the time value of the money (Equation 1). The discount factor and time value of the money is a concept that states that the value of one dollar today is worth more than the value of one dollar in the future. This is because that one dollar can be invested today for earning a risk-free interest on it (White. R, 2020).

The reason why the basis of the simulation is chosen to be this method in this paper is that this methodology is more relevant where future operating conditions and cash flows are variables and uncertain and they are not projected to be materially consistent with current performance levels of the business. This is the typical behavior that can be seen in young growth companies (discussed in a later section in detail) where the company is not producing a consistent stream of cash flows or revenues, is in the early-stage, and projection of the business's finances in the future can be uncertain due to lack of historical data.

The discounted cash flow formula is equal to the sum of the cash flows in each period divided by the discount rate (WACC) raised to the power of the time period to get the present value of the future cash flows of the company.

$$DCF = \frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \ldots + \frac{CF_n}{(1+r)^n} \tag{1}$$

The way conventional DCF analysis is conducted is by making estimates about the future cash flows of the business and the end value of its equipment and its assets at the end of the forecasting timeline. The DCF analysis also requires a single estimate of the discount rate for the model. This discount rate varies based on the volatility of the market, the riskiness and uncertainty of the business, and the risk profile of the investments.

Assessing these variables and predicting the right value for the risk-free rate, company's beta, and market risk premium, the values that go into calculating the WACC of a company is hard. Therefore, estimating the WACC as a single value and applying it all across the time periods can lead to very biased results based on an analyst's bias on whether the company profile is risky or not. Similarly, it is very hard for investors to also predict the future cash flows, especially in the case of young growth companies. These companies have no historical financial data from which an analyst can extrapolate future predictions. Thus, it adds an additional barrier to predicting future cash flows. These constraints of a conventional DCF analysis make it hard to properly value a business. And if these point estimates are not predicted properly, DCF will not have much value.

What is MC Simulation

Monaco's city "Monte Carlo" is famous for its main attractions in casinos. Casinos involve games such as roulettes, dice and slots, basically games that come under the umbrella term "games of chance". One key commonality among all these games is that they provide entertainment by exploiting the random behavior of each game. This means that no matter how skilled or experienced the player is, due to the random behavior of these games, the player cannot predict the next scenario based on the previous outcome. Monte Carlo Simulation methods also follow the same trajectory where they randomly select values to create multiple scenarios, each not affected by the previous outcome or scenario. These values are taken from a pre-defined, fixed range of different probability distributions. There are multiple types of probability distributions, such as normal distribution, uniform distribution, triangular distribution, etc. This can be thought of as rolling a fair die. The outcome range is fixed between 1 and 6 and follows a uniform distribution. This means that the likelihood of any number to be the result is equal.

Monte Carlo (MC) Simulation, as a form of risk assessment, was developed in the early 1960s by Hertz (1964), who applied it to a capital budgeting decision in Harvard Business Review. Monte Carlo Simulation will allow assigning key uncertain cash flows a probability distribution that will help represent a range of possible scenarios with a variety of possible values of different variables (Powell and Baker, 2004). In Monte Carlo Simulations, the sampling from the distributions, the process of random selection, is repeated multiple times. This creates multiple scenarios of the outcome or results. Each time a value from a distribution is randomly selected, it forms one possible scenario. This process is repeated over then or thousand of times to give a range of possible solutions to the problem, some of which are more probable than the others. The average of these solutions gives an approximate answer to the problem. The accuracy of these solutions is determined by the proportion to the square root of the number of scenarios (Schumann CP, 2006). This means that increasing the number of iterations will improve the approximation as well

Why MC Simulation

When dealing with the financial modeling of young growth companies, investors and analysts rely heavily on assumptions. These companies do not have any historical financial data, most of them are not producing any sales/ revenues or profits, and their survival is uncertain. Therefore, the assumptions that go into modeling the financial forecasting of such start-up companies mostly have associated uncertainties and risks involved in them. Not being able to predict the future, makes financial forecasting harder to model and predict the probability of different outcomes. In such situations, Monte Carlo simulations can help in building different scenarios. The Monte Carlo simulation is a tool for risk assessment that instead of just specifying expected values of different variables, can specify different probability distributions for revenues, costs, margins, and growth rates. And based on these distributions it can simulate a range of scenarios that a company might face which can help understand and calculate the probability of success or failure of a firm.

Monte Carlo simulation is a tool for risk assessment that aids in evaluating the possible outcomes of decisions and quantify the effect of uncertain variables in the model to the potential outcome. This helps analysts to gauge the inherent risks in decision-making and quantitative analysis (Dikov, 2020). Since, the simulation iterate over multiple values for the key uncertain variables chosen randomly from a predefined probability distribution, the Monte Carlo simulation technique this paper devised has some distinct advantages over the traditional Discounted Cashflow Analysis.

The results that are derived from the simulation have probabilities associated with them. That means investors and analysts can check the most probable valuation of a company, based on a number of different scenarios. It also helps build a better sensitivity analysis that not only described the changes in the model's selected assumptions but also analyzes which inputs have the most significant impact on the outcome. Thus helping the analyst figure out the key uncertain variables in the system for which the model can be built accordingly to accommodate the uncertainty. The resultant data in this paper's Monte Carlo Simulation can easily be presented in graphical form[1]. The data is also represented in the form of Excel file that shows the base case Free Cashflow Statements and the Cash Flow statement of the resultant valuation. This will lead for better communication with stakeholders, as analysts will be able to show their work behind the valuation and the resultant cash flow statements that the simulation built. This will also show the stakeholders the exact combination of values for each variables in the model that contributed to a specific outcome. This is better than traditional scenario analysis as it is hard and time-consuming to prepare a whole set of values for different inputs for the model through conventional approach.

DCF Analysis using Monte Carlo simulation

The conventional approach to the Discounted Cash Flow (DCF) analysis is usually performed in Excel or any other spreadsheet software. It can be quite tedious and cumbersome to automate the process of building the financial statements from the scratch in these spreadsheet softwares. Since the companies in question have no financial history or mostly no existing revenue streams or earnings, all the values have to be entered manually. Then the same process will have to be repeated tens or thousands of times to create a working simulation and build proper figures and graphs to help the stakeholder understand the concept that went behind this new valuation approach.

Fortunately, using python solves the aforementioned problems. By identifying the key uncertain variables, the user can easily change their values. The financial statement are then build automatically using the prediction of the analyst in terms of its Year 0 revenues and the assumptions of the expenses of the company. These assumptions can also change

[1] Case study provides the graphical representation of the simulation results.

dynamically over the course of the forecasting time period of a particular company. Since growth companies experience rapid change in their organizational structures, proportion of expenses, and risk profile of the company, the financial forecasting is done based on the changes in these variables. Python implementation helps in automating many of these valuation steps.

Furthermore, python also helps in implementing the Monte Carlo simulation. Unlike spreadsheet softwares where a user will need to use an external tool or an ad-on to implement the simulation and structure the data accordingly so it is compatible with the tool, python implementation of Monte Carlo simulation in this paper on the financial statements saves the analyst from all these hassles. The simulation creates thousands of such financial statement each built dynamically based on the random sampling from probability distribution for key uncertain variables and automatically carries out DCF analysis. The Net Present Values (NPVs) of all these simulations are then stores and used for visualizing the distributions of potential DCF outcomes. The distribution helps the analysts and the stakeholders to analyze the volatility in the valuation, associate probabilities to the potential outcomes, and see the sensitivity analysis of which key uncertain variables have the biggest impact on the overall outcomes, and how different variables impact the outcomes of company's valuation differently.

Finally the python code also outputs the excel file with the Free Cash Flow statements so that the stakeholders can see the potential future Free Cash Flow statements of the company. This provides them information regarding how the revenues will grow, the expenses (COGS, SG&A) will change over time, when does the company starts earning profits, the potential breakeven point, or how Net profits change over the course of the forecasting period. This also provides stakeholder and analysts to perform more analysis if required if they are more comfortable with spreadsheet softwares, as the financial statements has been built for them automatically.

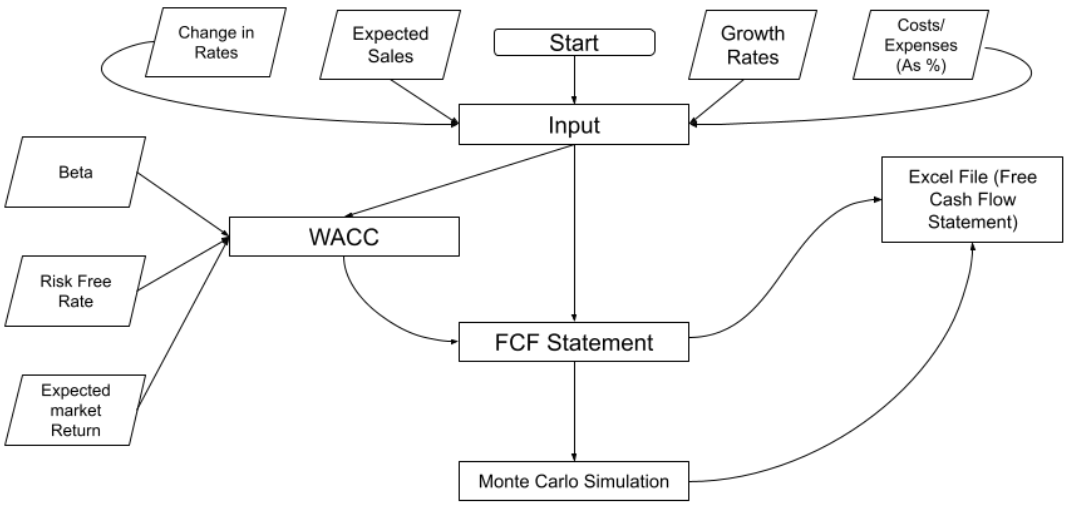


Figure 1: Flow chart of the algorithmic process of Simulated DCF Model

Step 1: Estimating Revenues Growth

Damodaran suggests that revenue growth can be estimated in three ways:

1. Historical Growth Rates
2. Analysts' Estimates
3. Growth as a function of quality of reinvestments

Estimating revenue growth rate is a key first step toward building the simulation model. This is a difficult task of predicting uncertainty in future technology, financials, development of the company's structure, and predicting management and markets (Brealey and Myers, 2018; Reilly and Keith, 2003). The new DCF model described in the paper will build a probability distribution using the historical growth rates or Analysts's estimation approach. The technique will depend on whether or not the company is generating revenues or not.

Step 2: Estimating costs, earnings, and reinvestments

After the first step of estimating the revenues, the next crucial part is to estimate the costs, earnings, and reinvestments. The technique employed to estimate the costs, earnings, and reinvestments is called "*percentage of sales approach"*. This approach is based on the assumption that the revenues are the driver of these costs and reinvestment needs (Brealey and Myers, 2018).

The following method can be implemented in two ways. Firstly, the model can rely on historical data and see the percentage of revenues being consumed as costs and reinvestments. From there it can forecast these values out of the estimated revenues the model forecasted in the first stage. However, this technique has a big assumption that the historical trends of costs and reinvestments will continue to hold as the revenues change in the future, which is not a reasonable assumption (Brealey and Myers, 2018). The second approach is more reasonable as it uses regression to forecast the future trends of costs and reinvestments based on the revenues (Benninga, 2001). The model will perform a simple regression that fits a straight line to a scatter plot of forecasted revenues with costs and see the trend as to how the costs and revenues are correlated. Thus it can forecast the costs and reinvestments based on this method.

Step 3: Estimating Cash flows

After estimating the revenues, costs, earnings, and reinvestments, the DCF model can now calculate the free cash flow (FCF) of young growth company. In the case, the FCF of the company would be operating profits less taxes less investments the company makes for future growth or projects (capital expenditure).

$$FCF = EBIT(1 - t_{tax}) - (CapEx - D_p) - \Delta WC$$

(2)

Here:

$FCF \ = \ Free\ Cash\ Flows$

$EBIT \ = \ Earnings\ before\ Interest\ and\ Tax$

$t_{tax} = \ Tax\ rate$

$CapEx \ = \ Capital\ Expenditure$

$D_{p} = \ Depreciation$

$\Delta WC \ = \ Change\ in\ Working\ Capital$

So using the forecasts of revenues which is done by forecasting annual growth rates. Then forecasting costs out of forecasted revenues the model estimates the operating costs. And finally, it forecasts the reinvestments needs for future growth or CapEx (Fernandez, 2001).

Step 4: Estimating Discount Rates

As mentioned above, the discount rate is the assessment of risk in a company. In DCF valuation context it is the opportunity cost of investment by an investor when investing into a company. The way to understand this is by thinking of the value of a company as the sum of all future cash flows discounted at their required rate of return. And that required rate of return would be the discount rate. Copeland describes this opportunity cost that an investor bears as the weighted average cost of capital (WACC) (Copeland et al., 2000).

$$WACC \ = \ C_{E}\left(\frac{W_{E}}{W_{E}+W_{D}}\right) + C_{D}(1 \ - t_{tax})\left(\frac{W_{D}}{W_{E}+W_{D}}\right) \tag{3}$$

Here:

$WACC \ = \ Weighted\ Average\ Cost\ of\ Capital$

$C_E = \ Cost\ of\ Equity$

$C_D = \ Cost\ of\ Debt$

$t_{tax} = \ Tax\ rate$

$W_D = \ Weight\ of\ Debt$

$W_E = \ Weight\ of\ Equity$

From the equation above it can be seen that in order to calculate the weighted average cost of capital of a young growth company it is required to perform four estimation- cost of financing in the shape of either debt or equity and the relative weights of debt and equity (Higson and John, 2000).

Let's start with the cost of debt estimation. In the case of a young growth company, the cost of debt would be the interest rate charged to the firm if the firm wants to borrow, this will be adjusted for any tax benefits associated with borrowing (Fernandez, 2001). The cost of equity will be more complicated as it is the rate of return an investor expects on its initial investment, which for young growth companies can be highly unpredictable and uncertain. In order to estimate the cost of equity, capital asset pricing model (CAPM) will be implemented (Graham and Harvey, 2001). As described in the issues with discount rate section above, the capital asset pricing model will require three additional inputs- *risk free rate* and *market rate of return* and *beta* of the company, as shown below:

$$C_E = r_f + \ (r_m - r_f)\ \beta \tag{4}$$

Here:

$C_E = \ Cost\ of\ Equity$

$r_f = \ Risk\ free\ rate$

$r_m = Market\ rate\ of\ return$

$\beta = Company's\ beta$

The risk free rate is the return on the security that has no default risk and is not related to other securities in the economy (Higson and John, 2000). The model will use the government issued security returns in the simulation.

The market rate of return less risk free rate, multiplied by the beta, is the opportunity cost an investor incurs by moving his investment from a risk free investment opportunity to a riskier investment. With that risk, the investor looks for premium on the return on investment to make up for the risk taken. Since it's the risk associated with the company, hence it is thus associated with the company’s beta as well. Which is a relative measure of risk added on to a diversified portfolio, rather than total risk (Reilly and Keith, 2003). As described above in the issues with estimating discount rates section, normally the calculation of the discount rates is carried out by using a regression model that estimates the beta for equity on a stock against the return on a market index and cost of debt by looking at the prices of publicly traded bonds (Damodaran, 2004). In this case, the new DCF model will be using a relative valuation for the *risk premium* which will be based on the regression model. However, in the case, the regression will be implemented on the data of similar young growth companies' risk premiums, rather than looking at returns on the market index.

Step 5: Estimating Terminal Growth Rates

In order to estimate the terminal growth rate of a young growth company, the model will be using the constant growth model of Gordon. The Gordon growth model assumes that the company’s growth will be stable and constant after a certain period in time, thus allowing to discount it to infinity (Reilly and Keith, 2003).

$$TV = \frac{FCF_n}{WACC_n + (1-g)}$$

$$(5)$$

$TV = terminal\,Value$

$FCF_n = Free\,Cash\ \ flow\,at\,Year\,n$

$WACC_n = Weighted\,Average\,Cost\,of\,\,Capital\,at\,Year\,n$

$g = Constant\,growth\,rate$

The major concern for young growth companies as explained in the section of Terminal Value issues is that there is uncertainty involved regarding the time period when the constant growth will come and what the constant growth would look like. In order to account for this uncertainty, Monte Carlo Simulation will help integrate distributed values of constant growth rates so that model builds a range of different scenarios based on probability distributions.

Step 6: Building a Discounted Cash Flow (DCF) Model

After calculating all these values, they will be added to the discounted value of free cash flows (FCF) and terminal value (TV).

$$V = \sum_{n=1}^{n}\left(\frac{FCF_n}{(1+WACC)^n}\right) + \left(\frac{TV}{(1+WACC)^n}\right) \tag{6}$$

Here:

$V = Value\,of\,the\,company$

$n = Year/\,Time$

$FCF = Free\,Cash\,flows\,at\,period\,n$

$WACC = Weighted\,Average\,Cost\,of\,Capital$

$TV = Terminal\,Value$

The sum of the discounted Free cash flow and terminal value gives the estimated overall valuation of the company. In order to take the model further to get the stock value, which currently this paper is not going to do since the companies under question are young growth companies that barely make any revenues or profits, the only calculation required to do is to subtract company's liabilities and debts to get Value to Common Equity, and divide it by current outstanding shares to get share price or stock price (Damodaran, 2001)

Step 7: Determining key Uncertain variables

The next part of the model is to model for uncertainty in the DCF valuation using Monte Carlo Simulation. The way this will be calculated is by including following steps in the simulation model described by French and Gabrielli (2004):

1. Determining the variables that are uncertain and random, and match their uncertainty (Damodaran, 2001)

2. Identifying the key variables that are affected heavily by uncertainty and have large impact on the output (Maya, 2004)

3. Understanding the analyses of the results and effects on uncertainty on the overall value (Damodaran, 2001)

Through the tornado analysis cash flows are identified as the key variables in the model, which has the biggest impact on the final resulting output valuation. This means that volatility in the cash flows accounts for the most significant impact on the value while other uncertainties might have little or minimal effect on firm's company's value (Ragsdale, 2004).

In the method proposed above on how to calculate the Free Cash Flows (FCF) of the company it can be seen that there are a number of variables being estimated that can lead to a different FCF value. This causes a major issue as employing a variety of probability distributions will make the model less predictable and transparent. Not only this, it will create inconsistent scenarios because of correlations among different variables. Also, spending too much computational and analytical resources on determining the perfect distributions for those variables that have little to no effect on the valuation have more costs than benefits. So it is necessary to account for this as well.

Understanding the fact that there is not a single rule that tells which variables should be stochastically distributed and which ones should be derived from the others, the paper has simplified this model by taking into account already done research by M. Ali et al. Sensitivity analysis is necessary to account for the importance of these variables and to determine precise probability distributions (Savvides, 1994).

The graph below shows how different estimations made during calculating the Free Cash Flows have an impact on the final value. The Tornado chart is a deterministic sensitivity analysis where a change is made to a single variable while keeping others controlled and see how change in that particular variable has an impact on the final value. This is important because in order to need to identify those key variables that will impact the final value mostly because of the reasons explained above.

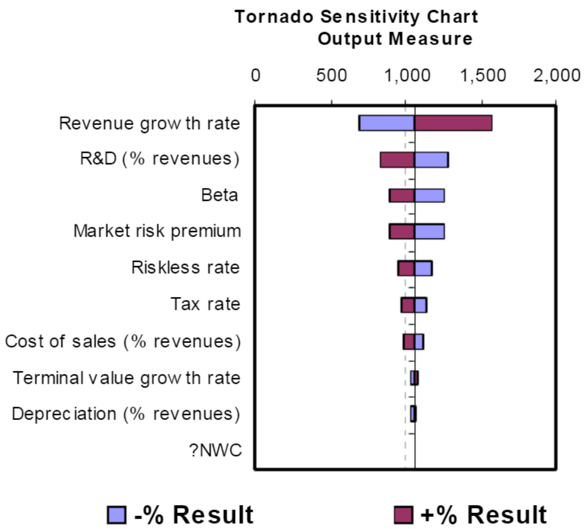


Figure: Taken from M. Ali et al.

Figure 2: Tornado analysis to identify the key uncertain variables

The graph above shows that the valuation output is influenced the most by revenue growth rate, research and development (R&D) expense, company beta, market risk premium. From here it can be seen that company beta and market risk premium can be calculated to some degree precision based on comparables in the market. Thus, this helps focus on the probability distributions of the other two variables.

Step 8: Specifying probability distribution

After identifying the key variables that impact the final output valuation the most, their probability distributions can be analyzed in more depth. Starting with the revenue growth rate of the company, it can either use historical data of the growth rate or in case analysts do not have that available or if historical growth rates are not representable of the future, analysts can use comparables from the market of similar companies to estimate the distributions. Here using probability distributions give room and advantage to be more accurate and precise. Since the model is not estimating one predicted value that can either run the company value very accurately or very inaccurate, choosing from a range of values gives the model room to be able to make mistakes and learn from them.

2004).

Step 9: Run the simulation

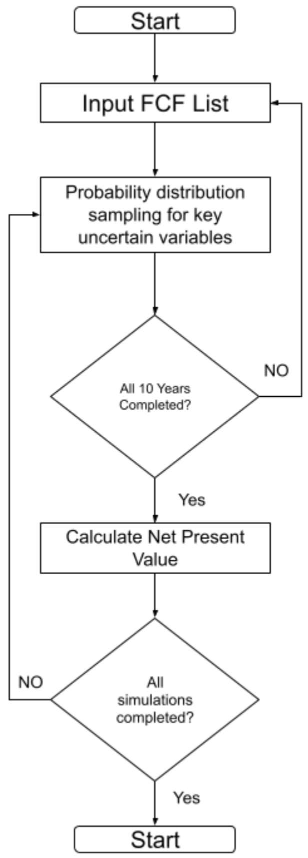


Figure 3: Flow chart of the working of Monte Carlo Simulation

After the key variables have been identified, the data has been imported, and the probability distribution has been analyzed, the computer takes over. Once all these assumptions have been inputted the computer takes random values from the probability distributions and input them to calculate the value of the company. After that it will repeat these steps hundreds of thousands of times to generate many random valuation paths (Seila, 2004).

After calculating the value of the company thousands of times, on each iteration this value is stored. Since the model is taking random value out of the described probability distributions, the output is a different final value of the company. The paper then shows the final results in the form of a histogram that can be used to analyze the likelihood of the company's valuation.

Step 10: Analysis of the simulation results

Interpretation of the final result is very important. It's the final step in getting the value of the company probabilistic correct. Having a histogram as the output of the company valuations allows to associate probabilities with different ranges of valuation of a company. For example: analysts can find the 95% confidence interval of the histograms and analyze how likely it is that 95% of the time the value of the company will fall under this range of value. Analysts can calculate the mean value of the company and analyze how volatile the valuation is and how sure they can be that the fluctuations are either large or small enough to be confident in the final valuation result.

Applications and Implications of the Model

Valuations for years have been thought of as unnecessary or impossible for young growth companies. However, as more and more investment has been streaming in these companies it is necessary to build a solid model that quantifies the value of these firms and saves the investors and other stakeholders from potential downside due to a faulty valuation that can be overly-optimistic or too pessimistic. Therefore, the following model is created to cater for the needs of the key stakeholder that can gain advantage by having a proper valuation model that can help them invest, make a case for raising a specific amount of investment, and for businesses to acquire a specific startup.

Investors

Investors are always skeptical of the growth of a young startup. The potential they see can be based on very intangible observations and the likelihood of survival of such young growth companies is very uncertain. Associating a probabilistic value to the valuation of the firm, show the volatility in the potential valuations based on different scenarios, and having projected financial statements at such an early level provides an investor with a thorough analysis of the potential outcome of a particular startup.

Financial Markets

A lot of companies when they IPO in the public market suffer based on unreal, too much optimistic valuations. Similarly, a lot of investors who invest in these early IPO companies also face loses as the company's actual valuation is far beyond what market predicts. Thus, this model can also be used pre-IPO in order to create a reasonable and robust analysis of the company's valuation and protect both the company and the investors from downsides.

M&As

Mostly, startups end up getting merged or acquired by big players in the industry. However, looking at the previous M&As and the history of successful M&As it becomes apparent that something is being done wrong. There is an argument of having no synergies and compatibility between two firms. However, one of the biggest problems is the inflated prices of the young growth firms that these big companies pay for and end up realising the returns cannot match the expectations. The simulated DCF model can also help these firms as well to create a more robust analysis of whether to go with potential M&As.

Conclusion

The simulated DCF approach can be considered as an extension to the traditional DCF analysis for valuation of young growth companies. This paper points out in detail how the traditional DCF analysis lacks the incorporation of uncertainties associated with the cash flows of such firms and how the extension model incorporates those uncertainties under its umbrella. The quantitative results of the Monte Carlo simulation helps the investors and stakeholders better understand the impact of risks and volatility in the finances of such companies and give a better estimation of the company's value. Not only a better estimation but it also provides additional analysis on the distribution, and spread of the valuation based on different individual trials. In order to better understand the implications of such models, future research will validate the proposed model of simulated DCF valuation by conducting a case study.

Case Study

Finance Company Valuation

About the company

The example used in the Case Study to illustrate the working of the model and the analysis of the results involves an Internet software finance company. Due to confidentiality reasons, the name of the firm is not going to be reported. The company will be henceforth named as Finance Company. Finance company is a B2C financial service provider. The company's mission is to help its clients make it as hard as possible to mess up their personal finance. The company provides its clients with 401(k) Match. Which basically means that when you put money into a company-sponsored retirement account like 401(k), your employer will put money into the account as well. This perk helps the employees grow their retirement savings. This concept is known as "free money" because basically the employer is giving the employees thousands of dollars to simply place their money in an investment account.

The way Finance company works is that it gives its clients a cash advance specifically to use for their 401(k) match. They receive exactly the amount they need to get their 401(k) match. The clients then pay back the loan through a service fee that the Finance company charges.

Background

Two young Black men from west-side Dayton, Ohio realized that their parents are not saving and investing effectively. They realized this after their investment banking internship back in 2003 where the financial institution instilled the financial knowledge in them that helped them understand why so many people are financially dysfunctional. They realized that even though their families have been saving money for their retirement, they could have been saving thousands of dollars more if they otherwise have been financially sound.

They realized their parents are not potential outliers. 1 in 4 Americans does not get their 401K match. This results in a potential $24 billion employers contributions going unmatched (Jones, 2020). They realized that the reason why so many people do not take advantage of this matching is because of lack of disposable income. From students trying to pay off their student loans to working parents prioritizing the needs of their children before their retirement funds. New house owners trying to pay off mortgages, to older couples trying to pay off their medical bills. They wanted to devise a strategy that will allow all these individuals to pay off their necessities while taking advantage of their employer's 401K match.

They build the Finance company to help these individuals not to make the painful choice of letting their employers 401K match go to waste. The basic idea behind the company is that they provide the matching amount to the people while they earn commission on the amount they provide. This makes the employer also contribute more based on the company policy of 100% to 50% matching. The company also provides financial advice to its clients to allow them to save and invest in a smarter manner to maximize their savings or returns.

How does 401(k) matching work

The companies that offer its employees 401k, they often include a 401k match where they will match the portion of your contributions to your 401k account. The percentage match differs across companies but typically this is on average is 3 - 4 percent of an employee's salary.

To better understand the concept of 401k matching take the example of employee X. Employee X makes $75,000 per annum and its company offers a 5% match. This means that the contribution of the company for the employee X's 401k match is going to be $3750. However, there is a catch in 401k matching. Employees will only contribute as much as employee X will put into its account. If employee X does not contribute any amount to the 401k account, its employer will not contribute anything, and employee X will miss out on the match.

Another benefit of contributing to the 401K account is that employees earnings are tax-deferred. That means if employee X contributes to its 401K account, that will be before taxes. This will lower the current tax liability on employee X's pre-tax income. Another benefit of matching is that the employee does not have to pay taxes on the employer's match until they withdraw the funds. And if the employee withdraws after they are fifty nine and a half years old, they will pay the ordinary taxes based on their current tax bracket.

Growth strategy of the firm

The growth strategy of the firm is currently most based on establishing a value proposition. Currently, there are little to no competitors in the market that allow employees the benefits of providing them with their 401K payments. That means that the $24 billion market is currently untapped and the Finance company has a huge potential to leverage first movers advantage.

The implications of the future growth of the company can be seen through two levels. One is economical level, and the second is individual level. The reason why it is necessary to look at the growth of the firm through two different levels is because in order to project the financial metrics of the company in the future, we have to take into account what might affect the numbers? In this case since the company provides a financial service, macro and micro economic trends can have a huge impact on the projected growth of the company in the next 10 years.

Looking through the economical lens, after COVID-19 the economy is going back into a bull phase. People have realized more and more how important it is to have liquidity for the long term and how much saving can prove to be detrimental in situations like lockdows and increased unemployment rates. Both these provide good news for the growth projections for the company as employers are increasing their 401K match based on good economic performance that incentivizes the employees to invest more into their retirement funds. And as people are getting back to the employment phase, they are more eager to save this time in case of such a situation erupting again.

At individual level people have realized the importance of savings after the long-term unemployment and lockdowns. This time around people's attitude towards savings have changed and that too is a good sign for the company. However, since the economy is again in a bull state, these individuals also have other investment opportunities where they can invest in and potentially earn higher returns. Even though they are risky.

The reasons to analyze these two aspects is this helps analysts understand the future projection of the revenues of the company and how they will translate over the years. In order to build the DCF model for the Finance company, these aspects were taken into consideration and the growth rates, the projected expenses, and the initial revenues were estimated.

Challenges in Estimation Firm's Financials

The first step to building a DCF model for FInance Company was to predict its revenues. This was a major challenge in the valuation of the firm as the company is a start-up and has no historical financial records, does not produce the cash flows or the accounting earnings that typically are used for DCF valuation. Another potential constraint in the valuation is the uncertainty in the industry. The industry company operates is relatively new and there are not a lot of comparable companies present in this industry. This also pointed out a very big limitation of the conventional DCF analysis that assumes the future financial estimation of the Finance Company is certain. Therefore, the Simulated DCF Valuation came to the rescue when the valuation of the Finance Company was done based on the simulated DCF Model described in the previous section.

Inputs for the Simulated DCF Model

Forecast Period	The model will forecast the value of the company for the next 10 years (2020 - 2030). The reason why the model does 10 years is to not to have an unreasonable time period in which the company will operate in so that the projections are not complete shots in the dark because of change in market conditions any potential mergers and acquisitions or any new funding round that can lead to change in organizational or financial structure of the firm.
Revenue Growth Rate	The revenue growth rate is predicted to be 52%. This is based on the financial analysts of the firm. The analysts' estimates are based on the I\B\E\S - Institutional Brokers' Estimate system. The I\B\E\S is a system that gathers and compiles the different estimates made by the stock analysts on the future revenues and earnings (M. Ali et al, 2010).
Terminal Growth Rate	The terminal growth rate for now is assumed to be 2.5%. Although the multi-stage growth rate model is a powerful tool for discounted cash flow analysis, it is not without drawbacks. To start, it is often challenging to define the boundaries between each maturity stage of the company (CFI, 2021). Therefore, the paper takes the industry standard for young growing software companies.
Tax Rate	The tax rate is the standard rate that the company will be charged once it starts earning revenues 35%.
SG&A	Analysts are assuming SG&A costs as 15% of revenues. SG&A costs are again estimations of financial analysts based on their expenditure on SG&A activities during their seed funding stages.
Depreciation	Depreciation is assumed to be 5% of the revenues. The idea behind pinning the costs and depreciation with the revenues is that as the company grows there will be more costs associated with them in terms of labor and equipment.
Operating Expenses	The operating expense currently for the company is 80% of revenues and they are predicted to be 20% by 2030. This is because as a software company as the client base of the company expands the underlying architecture such as website and operational expenses more or less will stay the same. So even for higher revenues the company does not have to bear additional costs that will grow the costs proportional to revenues.

Capital Expenses	The capital expenses are assumed to be 40% of revenues in 2020 decreasing to 10% by 2030. The same logic applies as operating expenses. With the increase in revenues the company does not necessarily have to expand its office space or buy additional hardware or software equipment based on the STO and financial analysts of the company. Therefore, as the revenues grow the costs do not necessarily go down but as a percentage of revenues it will definitely go down.
WACC	The company's capital structure involves no debt. That is why the Weighted Average Cost of Capital does not include the cost of debt for the company. Therefore, the WACC is calculated by solely using the Capital Asset Pricing Model (CAPM). The assumptions and the calculations are provided in the ipython notebook.

Table 1: Estimations of Finance company's financials to project FCF Statements

Identifying Key uncertain variables

In order to identify the key variables that include revenue growth rate, NWC, beta, market risk premium etc, the paper figures out the key variables that have the highest impact on the valuation of the company based on their uncertainty. Therefore, in the simulation the model will be focusing on these key variables. The way this paper identified these key variables is through sensitivity and tornado analysis. Here while keeping all the other variables constant while changing the value of one variable and identifying how big of an impact that variable has on the overall value of the firm.

Below in the sensitivity analysis it can be seen that WACC, Revenue Growth Rate, and Operating expense as a percentage of revenues have the biggest impact on the final valuation of the company. Hence in the Simulated DCF model, the model will be using probability distributions to account for uncertainty in these three key variables.

Senstivity Analysis		Firm's Value		
		Growth Rate		
		42%	52%	62%
WACC	5%	**$51,826,177**	**$95,549,879**	**$169,419,479**
	7.75%	**$33,242,232**	**$61,281,100**	**$108,642,181**
	10%	**$29,731,236**	**$54,815,511**	**$97,188,269**

Senstivity Analysis		Firm's Value		
		Operating Expense		
		70%	80%	90%
WACC	5%	**$115,372,603**	**$95,549,879**	**$75,727,156**
	7.75%	**$74,039,037**	**$61,281,100**	**$48,523,162**
	10%	**$66,227,095**	**$54,815,511**	**$43,403,927**

Figure 4: Sensitivity analysis for finding out the key uncertain variables

Specifying Input models for key uncertain variables

Revenue growth rate	The revenue growth rate is estimated using a mean of 54% increase annually. With a standard deviation of 5% based on the uncertainty in the economic, political, social, and cultural uncertainties in the future.
Operating Expense	The operating expense is estimated based as a percentage of revenue. The model used a normal distribution with a mean of 80% in the first year that decreases 6% every year as the revenues grow. The standard deviation is 10% based on the uncertainty in the innovation in technology and new laws that might come into action based on the growth of this particular industry.
WACC	The WACC is calculated using CAPM since the firm has no leverage. The variables that go into CAPM are listed in the ipython notebook. The model uses a triangular distribution with a mean of 7.75%. This is the value analysts of the Finance Company calculated based on the best estimation. The standard deviation of 0.5% is used based on the riskiness and uncertainty in the beta of the company, the market risk premium and risk free rate.

Table 2: Estimations of Finance company's probability distributions

Analysis of the difference in simple DCF and Simulated DCF

The simulation is run for 1,000,000 times and sampled all the possible outcomes in the form of a histogram.The simulation results are presented in the form of a probability distribution. The distribution shows the entire range of the possible valuations of the Finance Company. The mean here is the most likely outcome and on the y-axis the number of times the simulation results falls in the same range (Frequency). Looking at the mean it can be seen that the model predicted the mean valuation of the firm is approximately $60 million. However, looking at the upper and lower bounds of the distribution it can be seen that the valuation ranged from $50 million to approximately $70 million. This can further narrow down the confidence on what will be the most certain valuation of the firm by looking at the standard deviation of the graph. It shows a fluctuation of around $3 million. That means the analysts can be confident in the valuation that it will lie within the range of $57 million to $63 million. It is still a very big interval of $6 million but at least this provides the investors with the confidence about the up and downside and evaluate the risks associated with the company. They now know that at worst the company's valuation will fall down to around $50 million if it does not go bankrupt, which according to the financial analysts of the company say that the probability of that happening is zero.

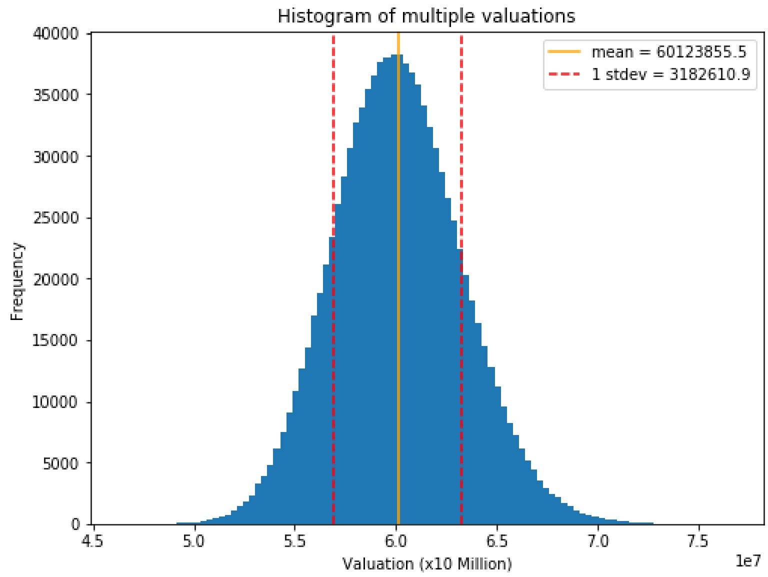


Figure 5: The resultant distribution of the Finance company's valuations

This can also be compared with the conventional valuation carried out based on the mean values used in the distribution. In this case the conventional valuation results are very close to the simulated valuation results, as you can see in the figure below. However, there are still key things to point out.

PV of FCF	$1,320,382
Terminal Value	$26,762,740
PV Terminal Value	$59,960,717
Firm's Total Value	**$61,281,100**

Annual Cashflows With Investment

Year:	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Sales		$100,000	$152,000	$231,040	$351,181	$533,795	$811,368	$1,233,280	$1,874,585	$2,849,369	$4,331,041
Operating Expenses		$80,000	$112,480	$157,107	$217,732	$298,925	$405,684	$542,643	$712,342	$911,798	$1,126,071
Capital Expenses		$40,000	$56,240	$78,554	$108,866	$149,463	$202,842	$271,321	$356,171	$455,899	$563,035
SG&A		$15,000	$22,800	$34,656	$52,677	$80,069	$121,705	$184,992	$281,188	$427,405	$649,656
Depreciation		$5,000	$7,600	$11,552	$17,559	$26,690	$40,568	$61,664	$93,729	$142,468	$216,552
Taxable income		-$40,000	-$47,120	-$50,829	-$45,654	-$21,352	$40,568	$172,659	$431,155	$911,798	$1,775,727
Taxes		-$14,000	-$16,492	-$17,790	-$15,979	-$7,473	$14,199	$60,431	$150,904	$319,129	$621,504
NOPAT		-$26,000	-$30,628	-$33,039	-$29,675	-$13,879	$26,369	$112,228	$280,250	$592,669	$1,154,222
Depreciation		$5,000	$7,600	$11,552	$17,559	$26,690	$40,568	$61,664	$93,729	$142,468	$216,552
Free Cashflow		**-$21,000**	**-$23,028**	**-$21,487**	**-$12,116**	**$12,811**	**$66,938**	**$173,892**	**$373,980**	**$735,137**	**$1,370,774**

Figure 6: Conventional DCF analysis of Finance company's valuation

It can be seen that the conventional DCF valuation came around $61 million. But it still does not tell the whole story. This is based on if everything the analysts predicted, estimated, and calculated go according to the plan. But no one can predict the next 10 years with complete certainty. So there can be cases where analysts end up with a very different valuation result in the future and the company will not be expecting the potential downside.

Limitations

Understanding the future trends and predicting extraneous variables has always been a constraint for financial forecasters and data analytics. Even though this model tried to mitigate the uncertainties through Monte Carlo simulation, it still cannot predict any phase shift in the economy and does not cater for such changes. For example: a recession or the case of Covid-19. Future research still has to be done as this model is an extension of the traditional DCF valuation. We can integrate machine learning APIs and network theory to create better predictions of what type of distribution best fits the predicted data and what value to input in order to accommodate for accounting for major uncertainties.

Another limitation of this model is the flexibility to adapt to a subset of companies. No matter how much narrowing an industry can get, how homogenous its finances, strategy, and operations can get, no two companies can be similar. This means that each company will require additional variables to be accounted for, finding key uncertain variables, and different probability distributions might be better fit for a different company.

The code written to implement this model has the flexibility to a major extent to accommodate for these changes so that the analysts can easily tweak the input variables and get the valuation of the firm. More development is required to make the implementation of this script more robust where we can leverage micro and macro economic trends in our forecasting function using Machine Learning and other Financial Markets APIs to better adapt to the future changes and forecast certain phase shifts that we might predict are going to take place within the specific time period.

Conclusion

The results of the simulated DCF analysis and the traditional DCF analysis came very close in the case study. However, in the traditional DCF analysis we only get a single point estimate. Whereas, looking at the results of the simulation DCF model we can also talk a lot about how likely different valuation are? After this valuation was carried out in early January, the Finance company recently received its series A funding. The company managed to raise over $6 million dollars at a $60 million valuation. This shows that the investors believed in the valuation carried out in the case and were able to value the company based on the company's expectations.

Exhibits

Exhibit 1

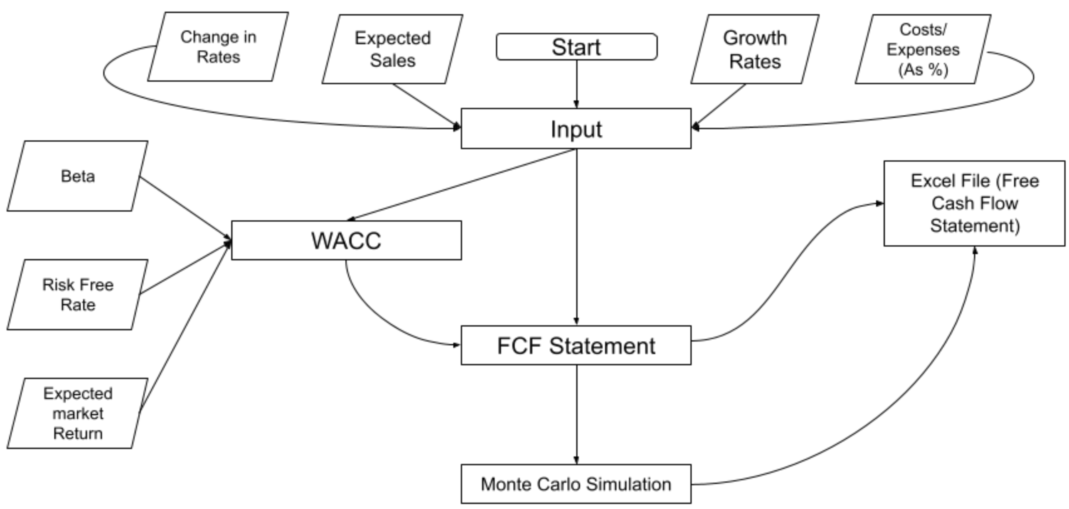
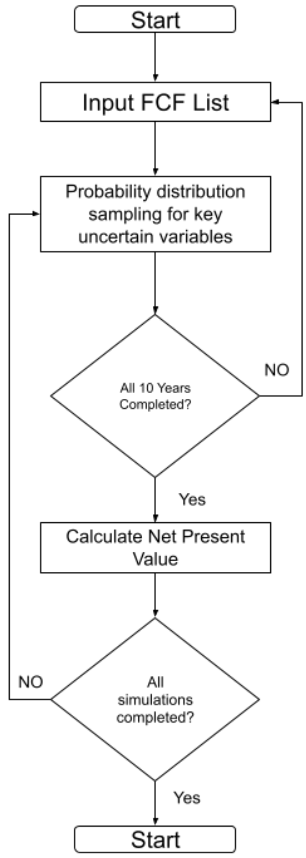


Exhibit 2



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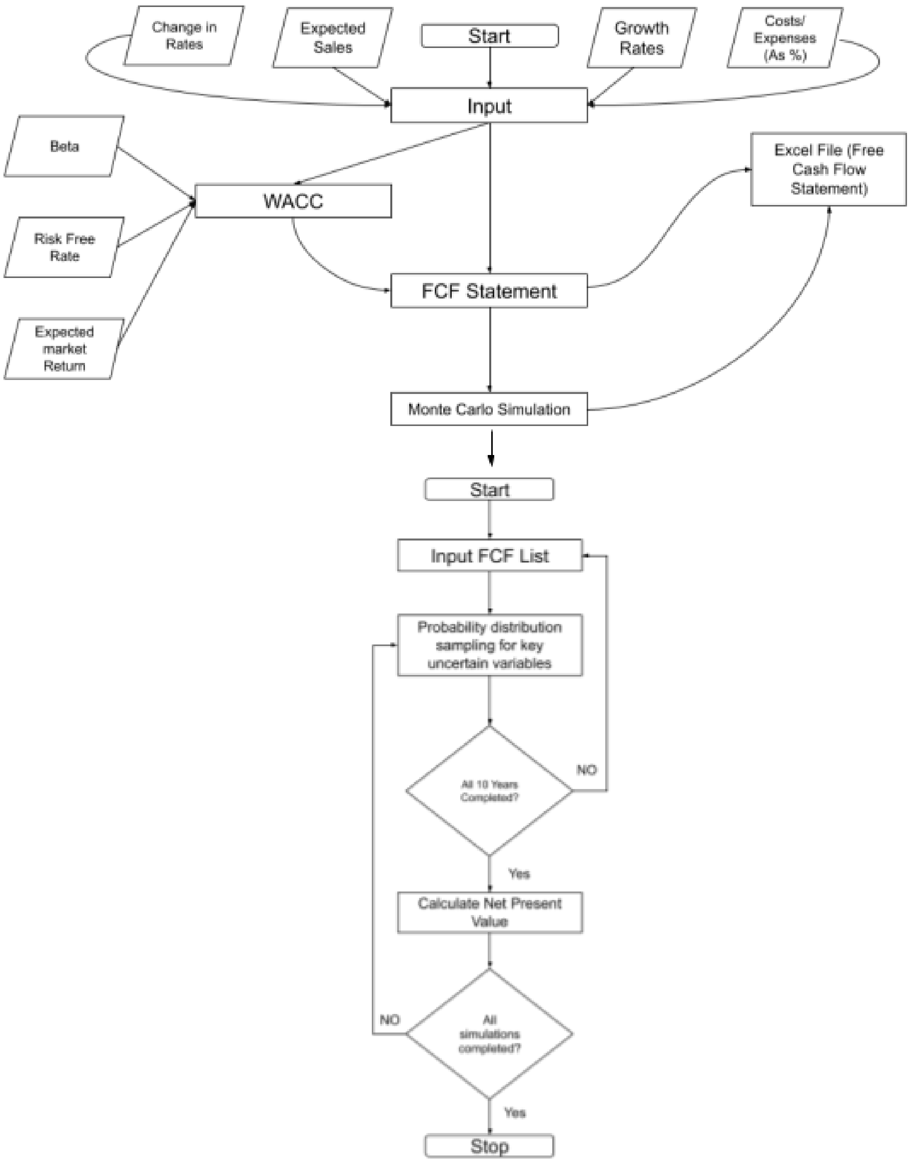

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Appendix

Spreadsheet Link:

https://docs.google.com/spreadsheets/d/1cvb_VFZEixCEqMemKmpolUGMt6T2NEwQ5jYd11sgkUQ/edit?usp=sharing

Github Link: https://gist.github.com/arhamhameed/1272d218170d01f15cd34fb0dd5f65eb

Code

```python
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import xlsxwriter



'''
The following function automates the process of constructing FCF
statement of a company for the next 10 years
Based on the following parameters:
- Revenue Growth Rate (rev_g)
- Operation expense growth rate (op_exp_g)
- Capital expenditure growth rate (cap_exp_g)
- SG&A growth rate (sga_r)
- Depreciation rate (dep_r)
- Tax rate (tax_r)
The reasons for the values chosen behind these rates is given in
the Table 1 of the project
'''
def FCF_forecaster(rev_g,op_exp_g,cap_exp_g,sga_r,dep_r,tax_r):
    #revenue estimation
    revenue_lst = [1000000]
    for i in range(9):
        revenue_lst.append(revenue_lst[-1]*(1+rev_g))
    #print(revenue_lst)
    revenue_lst

    # Operating expense
    op_exp_lst = []
    for i in range(len(revenue_lst)):
        op_exp_lst.append(revenue_lst[i]*(op_exp_g-0.06*i))
    op_exp_lst

    # capital expense
    cap_exp_lst = []
    for i in range(len(revenue_lst)):
        cap_exp_lst.append(revenue_lst[i]*(cap_exp_g-0.03*i))
    cap_exp_lst, revenue_lst

    #SG&A estimation
    sga_lst = []
```

```
    for i in range(len(revenue_lst)):
        sga_lst.append(revenue_lst[i]*(sga_r))
    sga_lst

    #Depreciation estimation
    dep_lst = []
    for i in range(len(revenue_lst)):
        dep_lst.append(revenue_lst[i]*(dep_r))
    dep_lst

    #taxable income calculation
    tax_in_lst = []
    for i in range(len(revenue_lst)):

tax_in_lst.append(revenue_lst[i]-op_exp_lst[i]-cap_exp_lst[i]-sga_
lst[i]-dep_lst[i])
    tax_in_lst

    #taxes calculation
    tax_lst = []
    for i in range(len(tax_in_lst)):
        #if statement to check if income is postive otherwise no
tax
        if tax_in_lst[i] >= 0:
            tax_lst.append(tax_in_lst[i]*tax_r)
        else:
            tax_lst.append(0)
    tax_lst

    #net income calculation
    net_income_lst = []
    for i in range(len(tax_in_lst)):
        net_income_lst.append(tax_in_lst[i]-tax_lst[i])
    net_income_lst

    FCF_lst = []
    for i in range(len(net_income_lst)):
        FCF_lst.append(net_income_lst[i]+dep_lst[i])
    return(revenue_lst, op_exp_lst, cap_exp_lst, sga_lst, dep_lst,
tax_in_lst, tax_lst, net_income_lst, FCF_lst)

'''
```

```
The following function performs the simualtion.
This function calls the FCF_forecast function several times to
build the FCF statements.
These statements are built by random sampling of key uncertain
variables:
- Revenue Growth
- Operational Expense Growth
- Weighted Average Cost of Capital (WACC)
'''
def valuation_simulation(sims):
    #initializing company value list
    company_value = []
    for i in range (sims):
        #normal distribution of revenue growth with mean 54% and
standard deviation of 5%
        rand_rev_g = np.random.normal(0.54,0.05)
        rand_op_exp_g = np.random.normal(0.8,0.05)

        # Using FCF_forecaster function to get the FCF
        lst = FCF_forecaster(rev_g = rand_rev_g, op_exp_g =
rand_op_exp_g,cap_exp_g = 0.4,sga_r = 0.15,dep_r = 0.05,tax_r =
0.35)
        FCF_lst = lst[-1]
        WACC = np.random.normal(0.075,0.005)
        # NPV OF CASH FLOWS
        npv = np.npv(WACC, FCF_lst)
        #calculating terminal value
        terminal_value = ((FCF_lst[-1])/((1+WACC)+(WACC-0.025)))

        #discounting the terminal value to get the present value
        terminal_value_discounted = terminal_value/(1-WACC)**10

        #calculating the company value
        company_value.append(terminal_value_discounted + npv)

    #returns the list of the multiple valuations of the company
    return(company_value)

'''
The following function converts the python lists into first panda
dataframe
Then it converts into an excel file
```

```
The reason being this model tries to make the output of the
valuation results as easy as possible for the potential
stakeholders
'''
def python_excel_covert(lst):
    # dataframe columns
    df = pd.DataFrame({'Sales': lst[0],
                    'Operating Expense': lst[1],
                    'Capital Expenses' : lst[2],
                    'SG&A' : lst[3],
                    'Depreciation' : lst[4],
                    'Taxable income' : lst[5],
                    'Taxes' : lst[6],
                    'NOPAT' : lst[7],
                    'FCF' : lst[8]})

    npv = np.npv(0.075, lst[8])
    df1 = pd.DataFrame({'NPV' : [npv]})

    df = pd.concat([df,df1], axis=1)

    df = df.transpose()

    # Create a Pandas Excel writer using XlsxWriter as the engine.
    writer = pd.ExcelWriter('FCF Statement.xlsx',
engine='xlsxwriter')

    # Convert the dataframe to an XlsxWriter Excel object.
    df.to_excel(writer, sheet_name='Sheet1', index=True)

    #worksheet.write(1, 0, 1234.56)  # Writes a float

    # Close the Pandas Excel writer and output the Excel file.
    writer.save()

# the inputs for the FCF statement projections
rev_g = 0.52 # revenue growth rate
op_exp_g = 0.8 # Operating Expense as 80% of revenues decreasing
to 20% by 2030
cap_exp_g = 0.4 # Capital Expense as 40% of revenues decreasing to
10% by 2030
sga_r = 0.15 # SG&A as 15% of revenues
```

```
dep_r = 0.05 # Depreciation as 5% of total revenues
tax_r = 0.35 # 35% tax rate

lst = FCF_forecaster(rev_g = rev_g, op_exp_g = op_exp_g, cap_exp_g
= 0.4,sga_r = 0.15,dep_r = 0.05,tax_r = 0.35)
python_excel_covert(lst)

'''
The following function builds the histograms by taking in the list
of multiple valuations from the FCF statement
'''
def plot_hist(sim):
    plt.figure(figsize=(8, 6))
    plt.title('Histogram of multiple valuations')
    plt.xlabel('Valuation')
    plt.ylabel('Frequency')
    plt.hist(sim, bins = 100)
    mean = np.mean(sim)
    stdev = np.std(sim)
    plt.axvline(mean, color='orange', linestyle='-', label=f'mean
= {mean:.1f}')
    plt.axvline(mean + stdev, color='red', linestyle='--',
label=f'1 stdev = {stdev:.1f}')
    plt.axvline(mean - stdev, color='red', linestyle='--')
    plt.legend()
    plt.show()

#Number of simulations
sims = 10000000
sim = valuation_simulation(sims)
plot_hist(sim)
```