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Abstract

This thesis investigates how different valuation techniques - the DCF, the First Chicago Method, and option valuation - perform on companies at different stages in their life cycle. We compare the results of each of these valuation techniques on three groups of companies: startups and young companies; high-growth firms; and steady-state companies.

We have used Excel to create models for each of the valuation methods, meaning that a number of assumptions had to be made. The assumptions include, for instance, a benchmark for probabilities in the First Chicago Method, how to forecast the financial statements, and how to obtain reasonable discount rate and volatilities. Also, we compare our values to the true values, that is, the acquisition price or the enterprise values of publicly traded companies.

By comparing the yielded values to the true values, we find that the standard discounted cash flow method is the most accurate method when considering the sample as a whole. However, the First Chicago Method is way more accurate than the DCF when separating the group of startups and young companies, with an average error of 0.95% and 18.10%, respectively. Option valuation, on the other hand, is the least accurate for all the groups of companies. Still, we find it to yield more accurate values when the debt ratio is low, which coincides with it performing worst on the steady-state companies.
1.0 Introduction

In the period between 2004 and 2013 there was established 101 582 stock based companies, so-called “aksjeselskap”, only in Norway. In our thesis, we aim to examine how valuation of these companies differ from high-growth and steady state companies. We group startups and young companies together, and therefore include both startups without any, or minimal, historical cash flows to base our forecast on and young companies with up to five years of historical accounting information. We find that these young companies in most cases provide the same challenges as startups do, due to the lack of operating detail in the young companies’ financial statements (Damodaran, 2009). As the main bulk of a startup’s expenses are related to other things than generating revenue, a few years of accounting information is of little use in forecasting. As such, we categorize them as one group in this thesis.

In recent years, we have seen multiple cases where companies, often within social media or technology, are valued at enormous amounts. Google announced that they were buying the video-sharing website YouTube on October 9th 2006. The first video uploaded to the site found place late April the year before. Kafka (2010) has found the monthly accounting numbers for YouTube prior to the acquisition, which show that the total revenue, from January 2005 until August 2006 accumulated to roughly 5 million USD (MUSD), while the profit in the same period accumulated to -3 MUSD. Google (2006) reported that they acquired YouTube and paid 1.65 billion USD, in a stock-for-stock transaction. It is clear that this value is based more on the expected future cash flow, and hence, profit, than on historical performance.

We will investigate not only the valuation of startups and young companies, although it is the main empirical problem, but also the valuation of high-growth firms and steady-state companies. We use three valuation methods: the standard discounted cash flow (DCF) model; the First Chicago Method; and option
valuation to evaluate the performance of these models against each of the company stages. In the final comparison and discussion, we will explain how the standard DCF model is the practical, and most accurate, allrounder, while the First Chicago Method is more accurate in valuations that involve great uncertainty. On the other hand, option valuation yielded disappointing and rather imprecise values, and we will explain these results in detail.

1.1 Motivation

In today’s ever-changing world, where some are able to found a company and sell it only one and a half year later for over one and a half billion dollar, the rapid value creation is a common interest for both of us. There are several examples of companies being valued above what is reasonable. For instance, Ghosh (2017) reports that Snapchat’s valuation numbers do not add up, and that the stock is overvalued, even compared to the likes of Facebook, Google and Twitter. Titcomb (2017) even reports that Snap Inc lost $515m last year, with already slowing user growth. Similarly, Ravon (2017), on behalf of Techcrunch, claims that unicorns such as Uber and Airbnb are massively overvalued, by 23.5% and 54% respectively. The uncertainty revolving valuations and the different ways they might be calculated for potential investors is a practical problem that always can be improved. Being able to contribute is a motivating factor in choosing this topic for the thesis. It also seems that the problem of valuing startups is somewhat unanswered, and we seek to gain insight about the reasons behind this. In this thesis, we will aim to describe both the advantages and disadvantages with the different methods in regards to the company stages in question. Our research question is therefore as follows:

*Which valuation method yields the most accurate value in the valuation of companies in different stages of their life cycle?*
2.0 Literature Review

Understanding company valuation is an essential part of corporate finance and various actors can value a company differently (Fernandez, 2002). The importance of valuations is underlined by the fact that every major resource-allocation decision a firm makes is made on the basis of some calculation of the move’s worth (Luehrman, 1997). There are a number of valuation methods that are appropriate in different situations and Fernandez (2002) find that there are six main groups of valuation methods: balance sheet methods; income statement methods (which includes multiples); mixed methods; DCF; value creation; and options. The emphasis, however, will be put on discounted cash-flows (DCF), the First Chicago Method, and option valuation. The choice of DCF is due to it being a solid, popular and basic method (Koller et al., 2010), and it should therefore be used as a starting point and as a comparison to the other methods. The First Chicago Method is an extension of the DCF in that it uses the same approach, but with several scenarios. In that way, it incorporates more of the uncertainty as it weights the different scenarios. Hence, it is likely to yield more accurate values than the DCF for companies with high uncertainty (Desaché, n.d.; Schumann, 2006). The final method, option valuation, is chosen due to its inclusion of flexibility (Damodaran, 2009), which, in turn, should be able to provide precise valuations for startups that are dependent on being flexible throughout the first years. Moreover, how to value startups and young companies is an essential question within corporate finance - a question that has gone unanswered or only partly answered for a long period.

There is a great amount of uncertainty related to startups in general, and when considering technology startups, the uncertainty further increases. For instance, Steffens and Douglas (2007) claims that ventures with disruptive technology are typically subject to high mortality risk, that is, if the venture can survive through consistently renewing, innovating and staying on top of competitors (Douglas, 2006; Schwartz and Zozaya-Gorostiza, 2003). Also, Steffens and Douglas (2007)
claim that technology ventures are subject to high firm-specific risk, in addition to an average level of market risk.

Savage (2005) argues that the problem with many of the standard valuation methods is that they do not take flexibility into account. For instance, the DCF method assumes that the investment has to be made now, without the opportunity to making a decision in the future. This is supported by Koller, Goedhart and Wessels (2010), who claim that company-wide valuation models rarely include flexibility, that is, they do not describe the possible future actions managers could respond with, and therefore underestimates the uncertainty. On basis of this argument, Savage (2005) further finds that the real options method is better suited to value a startup than other models, such as the discounted cash-flow model. This is because startups face great future uncertainty, much greater than an older firm with steady cash-flows, which in turn requires flexibility. Steffens and Douglas (2007) underline the advantages of real options valuation by describing that real options provide a framework for how to make decisions under uncertainty. Furthermore, the value of the investment is increased due to the flexibility of future options, which, according to Savage (2005) is the main reason why the real options method is a good alternative for valuing startups. However, Steffens and Douglas (2007), despite agreeing with Savage on the advantages of real options, have a slightly different take on its use in valuation.

Instead of using real options as the valuation method, Steffens and Douglas (2007) argue that real options rather should be used as an analytical tool in order to provide a valuation for new technology companies. That is, using managerial flexibility to take advantage of opportunities while minimizing the impact of threats. Still, they find that real options valuation is inferior to traditional decision tree analysis when attempting to value new technology ventures. They argue that there are two reasons for this: First, real options valuation techniques do not deal with firm-specific risk, which is important for technology ventures. Second, the first step of real options valuation is to value the company as if there were no real
options, which makes no sense when dealing with technology ventures, as real options are an integral part of the venture.

While Savage (2005) finds that the discounted cash-flows method is inadequate in the valuation of start-ups, Hudson (2015) argues that one approach is not sufficient due to different methods being useful in different situations. Furthermore, Hudson highlights the main problem related to the valuation of startups: The lack of history, revenue, and earnings. Thus, she proposes to find historical clues about similar startup deals, and use these clues as parameters in the startup valuation in question. On the other hand, Steffens and Douglas (2007) argue that valuation of new technology ventures is difficult and underlines that traditional valuation techniques each have significant shortfalls. Yet, finding similar startups to compare is, Steffens and Douglas argue, rarely an optimal solution, as even though a comparable company is identifiable, it is unlikely that the technology development and sales process is identical. Damodaran (2009) also acknowledges the lack of revenues and earnings as a problem. He argues that most young companies are dependent upon private capital, which makes the standard techniques used to estimate cash flows, growth rates and discount rates irrelevant: They either do not work, or they yield unrealistic numbers. He also finds that most startups do not make it through the first years, and hence fail to succeed, adding to the problem of uncertainty, which in turn enhances the need for flexibility.

3.0 Theory

In this section, we will present a deeper view of the theory relevant to answering our research question: Company stages (3.1); discounted cash flow (3.2); the First Chicago Method (3.3); and option valuation (3.4). Also, we will present our hypotheses grounded in the economic theory presented in the following.
3.1 Company Stages

3.1.1 Startups and Young Companies

Despite the variations in industries, sectors, products, and innovations, one factor attributable to most startups is that they do not face only risk, but also future uncertainty (Sommer, Loch, and Dong, 2009). That is, being able to identify all future performance-related variables is impossible, and hence, the startups’ futures are uncertain. Byers, Dorf, and Nelson (2010) argue that modern startups arise as a result of entrepreneurs’ ability to identify opportunities, and as today’s opportunities and innovations mostly stem from new technologies, we find new technology ventures to be a logical starting point when discussing startups. Elg (2015) supports this by claiming that successful innovation requires actors who capitalize on change and technology, in addition to facilitating long-term learning.

New technologies are often referred to as ‘disruptive’, or ‘radical’, in a way that it challenges and disrupts an existing market by creating a new market (Byers et al., 2010). As a result, there is a great deal of uncertainty related to technology companies (Steffens and Douglas, 2007; Damodaran, 2009; Hudson, 2015). For instance, Steffens and Douglas (2007) highlights that companies who rely on disruptive technology are subject to a high level of mortality risk, as other firms can invent a better solution overnight. This uncertainty makes most firms unable to survive the early years and end up as stable and profitable companies, and therefore, projecting future cash flows, growth rates and discount rates is troublesome (Damodaran, 2009). In fact, Damodaran (2009) finds that only 25% of firms in the information sector, which includes technology, survive seven years.

As a possible solution, many venture capital (VC) investors include some control mechanisms in the contracts that allow them to change the venture’s course of actions, for instance by focusing on markets or products other than what was initially intended (Sommer, Loch, and Dong, 2009). In fact, Drucker (1985) argue that successful startups more often than not become profitable in other markets.
than planned. For instance, the telecom giant Nokia originally sold paper, while Hasbro started selling textile remnants before making the leap to toys after the introduction of Mr. Potato Head in 1952 (Trex, 2013).

There are many typical characteristics of startups and young companies. For instance, they have no, or little, history, making it difficult to predict future cash flows and thus valuing them (Damodaran, 2009). Also, the revenues are usually small, with operating losses, which means that if these companies actually do have some accounting history, it is less useful in forecasting than what would be the case with older companies. Essentially, it lacks operating detail, as the expenses often are associated with getting the company up and running instead of generating revenues. As a result, many young companies are dependent on private equity, often from venture capitalists.

3.1.2 High-Growth Firms

First, we need to establish what constitutes a high-growth firm. We follow OECD’s guidelines in which a high-growth company is an enterprise with average annualized growth greater than twenty percent over a three-year period, and with ten or more employees at the start of this period (Audretsch, 2012). Young companies often experience high growth as well, often even higher, but there are other criteria that separate young companies and high-growth firms in our sample.

First, the uncertainty attached to what we define as high-growth firms are significantly lower than the uncertainty of startups. These firms are more experienced, that is, they are more or less incorporated in the market in which they operate, as opposed to startups who are merely challengers hoping to enter the market.

Second, as the high-growth firms are older, they no longer have operating expenses related to getting the company up and running, meaning that more of their expenses are directly linked to the generation of revenue. For valuation
purposes, this means that their operating accounting history is more trustworthy. In addition, high-growth firms with a substantial market share might generate economies of scale or first mover advantages that could enhance their profitability.

However, growth must be combined with return on invested capital (ROIC) relative to its cost in order to determine the value creation (Koller et al., 2010). For instance, high growth combined with a ROIC lower than the cost of capital destroys value. Also, sustaining the high growth over time requires a significant competitive advantage, which in most cases will be imitated or neutralized in other ways by competing companies unless the company is constantly innovating its products (Cho and Pucik, 2005). The value creation also depends on which type of growth the company utilizes: While growth from creating new markets through new products generates a lot of value, growth from making large acquisitions creates much less value (Koller et al., 2010).

Contrary to the belief that high growth and profitability is minimally or negatively correlated (Hoy, McDougall, and D'Souza, 1992; Covin and Slevin, 1997), Markman and Gartner (2002), while investigating firms with extraordinary high growth, found that growth rate is unrelated to profitability. On the other hand, they found that firm age was significantly, and inversely, related to profitability in that younger firms have slightly higher profitability rates.

### 3.1.3 Steady-State Companies

Steady-state companies are, in our research, categorized as stable firms, most likely older than the other firms in our sample, without any excessive growth, and with minimal risk of bankruptcy. In turn, this means that there is much less uncertainty regarding future performance than what is the case when predicting the future of startups and high-growth firms.
3.2 Discounted Cash Flow (DCF)

When valuing a company, one of the most used theories applied is the Discounted Cash Flow method (DCF-method). This method is widely examined amongst academics and practitioners. The method consists, as its name implies, of the expected future cash flow discounted at the cost of capital.

\[
Value\ of\ Business = \sum_{t=1}^{\infty} \frac{E(CF_t)}{(1 + r)^t} = \sum_{t=1}^{N} \frac{E(CF_t)}{(1 + r)^t} + \frac{Terminal\ Value_{N}}{(1 + r)^N}
\]

(Damodaran, 2010)

This method can be used on companies, shares and bonds, to name some. The terminal value term in the equation from Damodaran (2010) is a sum of the cash flows, which could be challenging to estimate. Damodaran (2010) has also re-written the equation to:

\[
Value\ of\ Business = \sum_{t=1}^{N} \frac{E(CF_t)}{(1 + r)^t} + \frac{E(CF_{N+1})}{(r - g_r)(1 + r)^N}
\]

In this thesis, where the focus is on different company stages, a problem might arise in estimating the future cash flows of startups. For startups and young companies, the most significant cash flows are expected to be in the future, and one have to make decisions on two variables. The first, how much of the earnings are to be reinvested. One could expect that a company that reinvests 80 % of its earnings would generate more future positive cash flows than a similar company that reinvests 20 % of its current earnings. The second decision is the quality of reinvestments, measured by excess return, as investing in an investment that will generate returns of 10 % will add value as long as the cost of capital is below 10 %. In other words, a company should not invest only for the cause of investing (Damodaran, 2010).
The variables in the formulas described above are easy to observe in the past, but estimating their future value may be difficult. The first variable to be estimated is often the cash flow (CF), either as free cash flow to equity (FCFE) or as free cash flow (FCF). The way of calculating these and its pitfalls will be further examined later in the paper. There is also a need for the cost of equity, noted \( r \) in the formula above. One way that this can be done is by the following formula:

\[
\text{Cost of Equity} = (\text{Risk} - \text{Free rate}) + (\beta \times \text{Equity Risk Premium})
\]

Even the risk-free rate could be difficult to estimate correctly, as a 3-month t-bill is not risk-free when the time horizon is several years. The \( r \) can also be considered as the required rate of return, which an investor demands for the chosen investment. These numbers differ between investors, and Plummer (1987) lists these required rates of return for venture capital companies when investing:

<table>
<thead>
<tr>
<th>Stage of Development of Company</th>
<th>Required Rate of Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed-capital stage</td>
<td>50-75%</td>
</tr>
<tr>
<td>1st stage</td>
<td>40-60%</td>
</tr>
<tr>
<td>2nd stage</td>
<td>35-50%</td>
</tr>
<tr>
<td>3rd stage</td>
<td>30-50%</td>
</tr>
<tr>
<td>4th stage</td>
<td>30-40%</td>
</tr>
</tbody>
</table>

\textit{Table 1: Required Rate of Return}

Morris (1988) agrees on the first stage, but writes that investors require a rate of return of at least 50%, and slightly disagree on the second stage. Here Morris writes that investors require a 30 - 40% return. The more common way of discounting in the DCF method is by calculating the weighted average cost of capital (WACC), which takes into account the firm’s capital structure. However, the WACC is lower than what would be considered the required rate of return for most startups, which could pose a problem.

The discount rate, which earlier is mentioned as cost of equity and required rate of return, is also expected to be constant over time, which is not necessarily the truth, as an investment over several years also impose a time-varying risk, which is typical for startups (Steffens and Douglas, 2007). It seems likely that the DCF
works better for companies with low uncertainty in future performance, and hence we propose the first hypothesis:

*Hypothesis 1: The DCF method will yield the most accurate values for steady-state companies, and the least accurate values for startups.*

### 3.3 The First Chicago Method

According to Desaché (n.d), the First Chicago Method could be seen as a compromise between the Venture Capital Method, in which a very unlikely success outcome is discounted heavily, and real options, which takes flexibility into account and will be discussed further in the next chapter. The approach is an extension of the standard DCF as it basically runs three (or even more) separate DCFs with slightly different assumptions, before weighting the values into one total enterprise value based on the probabilities of each outcome. It is a multiple scenario approach that encourages the one behind the valuation to think about possible and probable outcomes for the firm. Thus, probabilities are assigned to a number of scenarios, which also points to one of the flaws of the method: It is highly subjective and judgmental (Schumann, 2006).

Fowler (1990) cites a survey by Venture Economists, which have calculated the outcomes for over two hundred venture capital investments. The results show that 40% of the investments lost money, while 30% went sideways or was classified as “living dead”. 20% of the investments yielded a return between 2 to 5 times the invested capital. 8% of the companies returned 5 to 10 times the invested capital, while only 2% gave a return on invested capital at a multiple above 10.

While the standard DCF, as proposed in hypothesis 1, is likely to work better on stable firms with little risk and a solid accounting history, the First Chicago Method, if logical probabilities are assigned, is likely to better account for the uncertainty. More so, it seems well suited for startups due to their normally massive upside, compared to their current value, which could be accounted for by
adding a scenario where the company succeeds. At the same time, the higher probability of default will be accounted for. Hence, we propose another hypothesis:

_Hypothesis 2: The First Chicago Method is the valuation technique in our research that yields the most accurate values on startups._

### 3.4 Option Valuation

We will also entertain the idea of valuing the shareholders’ equity of a levered company as a call option. For option valuation, the value of the debt equals the strike price, while the maturity is the time until the debt is payable. When this time is up, the shareholders exercise their call option on the operating assets and repay the debt outstanding if the value of the operating assets exceeds the amount of debt to be repaid. The main advantage of option valuation is that it includes flexibility, as will be thoroughly discussed in the following.

#### 3.4.1 Valuing Flexibility

The standard discounted cash flow (DCF) approaches do not consider the value of managerial flexibility (Koller et al., 2010). Instead, the DCF techniques assume that the investment must be made now, without the possibility of making or changing the decision in the future (Savage, 2005). Yet, managerial flexibility is not a synonym of uncertainty, but rather “choices between different plans that managers may make in response to events” (Koller et al., 2010, 679). That means that the process of starting up a company can be divided into several stages, and the manager will have to decide whether or not to proceed at each stage. As such, option valuation is more thorough than the DCF and the First Chicago Method, and therefore more challenging and time consuming. Keeping this in mind, we propose the third hypothesis:
Hypothesis 3: Option valuation is a good alternative to the other two models, and is likely to yield rather accurate values for all the company stages.

In order to model flexibility, you have to identify the set of specific decisions managers could make to respond to future events (Koller et al., 2010). In real life, flexibility can be hard to define, and is dependent on the management’s recognition of opportunities for creating value from flexibility. First, the events have to be identified, that is, finding the events that will provide new information. Second, it is important to consider what decisions the management can make in response to the events, and third, estimate the payoffs related to these decisions.

3.4.2 Real-Option Valuation (ROV)
Real-option valuation (ROV) uses a replicating portfolio or risk-neutral valuation in order to value a project or a company and is one of few valuation techniques that accounts for flexibility. According to Koller, Goedhart and Wessels (2010, 690), “the ROV approach lets you correctly value complex, contingent cash flow patterns”. The replicating portfolio includes the option to defer, and if the priced securities in the portfolio have the same payouts as an option, the portfolio and option should have the same price. The ROV approach hence recognizes that the managerial flexibility to delay decisions is important and can be linked to financial options (Steffens and Douglas, 2007).

The mentioned managerial flexibility is the option, and is included in all real-option valuations (Steffens and Douglas, 2007). Also, the technique uses market-based price information to value the volatility of the investment without accounting for the option. The original ROV approach therefore requires historical price movements (Steffens and Douglas, 2007), which offers a problem when dealing with startups without historical data such as revenues and earnings (Damodaran, 2009; Hudson, 2015). These situations are normal in the application of real options, and Steffens and Douglas (2007) propose that the prevailing ROV
approach is to use a traditional NPV analysis in order to establish a value of the underlying project. For instance, when dealing with new disruptive technology, finding a replicating portfolio is not feasible. The volatility of this value is then estimated based on historical clues from similar startup deals, as is supported by Hudson (2015).

3.4.3 Black-Scholes Option Pricing

The breakthrough in option pricing came in 1973 when Fisher Black and Myron Scholes published their paper “The Pricing of Options and Corporate Liabilities”. In our thesis, as we are considering the companies’ equity to be an option with an expected lifetime of ten years, we must also consider dividends.

When valuing a company as an option, the face value of debt is considered as the strike, whereas the underlying asset value, or in option pricing known as the stock price, is the company’s market value (Ødegaard, n.d.).

The reason behind considering the debt as the strike is that an investor is protected from the downside in a limited responsibility firm. Following this line of thought, the only loss an investor may incur is the initial investment. If a company is liquidated, the residual is distributed to investors.

When calculating the option price, i.e. the company value, some modifications are needed to the standard Black-Scholes option pricing model, namely Merton’s formula. This is a generalization to the Black-Scholes in order to consider the dividend yield. Since our thesis focuses on the long-term price of the company, the dividend is unknown, thus our best estimate is the current dividend yield.

The model is based on four main assumptions. First, that the underlying, which in our case is the company value, satisfies a stochastic differential equation. This equation is basically a Wiener process with drift. Second, that the price of the option is twice differentiable function of t and S, C(S,t). The third assumption is that one can trade continuously and take immediate large long and short positions without transaction costs. The last assumption is that one is able to invest in risk
free assets with a known rate of return (Weatherall, 2017).

The input needed in a Black Scholes option valuation is as follows: The price of the underlying assets; the strike; the time to maturity; the continuous interest rate (Benninga and Sarig, 1997); and the volatility.

Yalincak (2005) lists several criticizes the Black Scholes model through six specific cases. The model assumes constant volatility throughout the period. As seen by both the VIX index and the NOVIX, this is clearly unrealistic over long periods. The original model did not consider dividends at all, but when applying Merton’s formula this is included as a continuous dividend yield that is assumed constant which might not be the case. Lastly, Yalincak (2005) criticizes the ignorance of transaction costs, perfect liquidity and constant trading. Normally this assumption is breached by investment banks not letting you sell and buy fractions of a share.

3.4.3.1 - Calculation of company value with options

When calculating the value of a company using Merton’s formula, the following formulas are used (Ødegaard, n.d.). First, we calculate $d_1$:

$$d_1 = \frac{\ln \left( \frac{S}{X} \right) + (r - q + \frac{1}{2} \sigma^2)(T - t)}{\sigma \sqrt{T - t}}$$

Where $S$ is the asset value and $X$ is the strike. As the underlying asset value, we have chosen to use the company’s value as calculated in the DCF-approach. The strike is the recognized debt in the last available balance sheet from the company. $r$ is the continuous risk free interest rate for a time period equal to time to maturity, and $q$ is the dividend yield. The last term in the numerator is the time to maturity. In the denominator one multiplies the standard deviation of the stock returns with the square root of time to maturity.
Second, \( d_2 \) must be calculated, as shown below. This is done by subtracting the shares’ standard deviation multiplied with the square root of time to maturity from \( d_1 \).

\[
d_2 = d_1 - \sigma \sqrt{T - t}
\]

When both \( d_1 \) and \( d_2 \) are calculated, they are put into the following formula

\[
c = S e^{-r(T-t)} N(d_1) - X e^{-r(T-t)} N(d_2)
\]

This formula gives us the price of the call option. It is done by raising minus the dividend yield multiplied with time to maturity in the power of \( e \) multiplied with the asset value. This is again multiplied, but now with the normal distribution of \( d_1 \) with mean zero and standard deviation one. Then we multiply the strike with minus the risk-free interest rate multiplied with the time to maturity in the power of \( e \). This is then multiplied with the normal distribution of \( d_2 \) with average zero and standard deviation one.

### 4.0 Methodology

According to Halvorsen (2008) and Johannessen, Christoffersen and Tufte (2011), the purpose of the methodology is to examine the reality, and then provide a guideline on how to proceed to obtain or test knowledge. With our research question and the theoretical framework as a starting point, this section will present the framework for our research. More specifically, we will present our research design and explain how we will investigate the issue.

In our master thesis, we are going to use a quantitative deductive approach due to the lack of agreement among the limited existing literature regarding the valuation of companies in different stages of their life cycle. More specifically, our approach is mainly deductive, as it is grounded in testing the validity of existing theory, but also partly inductive in that it lets us apply potential findings to the
existing theory along with the new acquired insight (Bryman and Bell 2011). In deductive research, hypotheses based on existing literature are empirically tested before being either accepted or rejected.

4.1 Framework
The framework we will use, explaining how we will go about investigating the issue, consists of four stages: sample selection; data collection; modeling; and testing the hypotheses.

4.1.1 Stage 1: Sample Selection
In order to answer our research question, we have to determine some criteria for the companies interesting for our research:

As our research focuses on the valuation of companies in three different stages of their life cycle, we needed to find companies that fit into one of the three categories, being startups and young companies, steady-state companies, and high-growth companies. For the startups and young companies, only companies that have a maximum of five years of accounting history are relevant. The steady-state companies are older firms that have a solid and stable position in the market, without any excessive growth. In order to find companies that fit into the last category – high-growth companies – we use Bloomberg as a tool to find enterprises with average annualized growth greater than twenty percent over a three-year period, in addition to having ten or more employees at the start of this period.

Hence, the selection of companies is based on both growth and age, but does not include geographical or industry restrictions, although the majority of companies in our sample is Norwegian. The full list of companies in our sample is found below.
### 4.1.2 Stage 2: Data Collection

Once we have identified the companies that fit into our research, we collect the data, that is, we must collect the accounting history where possible. For companies that lack accounting history, we will look at historically similar startup deals in order to identify clues that will help us make assumptions about future revenues, earnings, growth rates, etc. There are a number of tools that can be used to obtain the accounting history from some of the companies, and we will mainly use “ProffForvalt” and “PureHelp”.

Finding the accounting history is only one of the challenges in terms of collecting the data. We also need an acquisition price, or some other value that can be used in comparison with our valuations. For publicly traded companies, knowing the share price and the total number of shares will give us this value. For private companies, on the other hand, that is not an option. Instead, we use Bloomberg and other tools to find companies that have been acquired in recent years, using the acquisition price as the company value, conditional on knowing the proportion of the company acquired.

<table>
<thead>
<tr>
<th>Startups</th>
<th>Steady-state</th>
<th>High-growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mytos AS</td>
<td>Kongsberg Automotive</td>
<td>Aker BP ASA</td>
</tr>
<tr>
<td>Dwellop</td>
<td>Norsk Hydro ASA</td>
<td>Next Biometrics</td>
</tr>
<tr>
<td>HAG Anlegg</td>
<td>Schibsted ASA-A</td>
<td>Norway Royal Salmon</td>
</tr>
<tr>
<td>OncoInvent</td>
<td>Telenor</td>
<td>NRC Group ASA</td>
</tr>
<tr>
<td>News55 AB</td>
<td>Totens Sparebank</td>
<td>Pareto Bank ASA</td>
</tr>
</tbody>
</table>

*Table 2: Companies in the sample*
4.1.3 Stage 3: Modeling
Using Excel, we create models that allow us to value all the companies in our sample. These models are grounded in the theoretical framework presented earlier, and hence use the DCF model, the First Chicago method, and option valuation as the valuation techniques. Besides being constructed to fit the valuation methods, the input from the second stage is imported into the models, leaving us with values that are compared to the buyout amounts in the fourth stage.

4.1.4 Stage 4: Testing the hypotheses
In the final stage, comparing the values of the three valuation techniques to the real buyout values tests the hypotheses. One important aspect to consider is the possibility that some companies may benefit from synergy effects not taken into consideration in our models. Thus, the price may be higher in reality than we find reasonable. However, it is near impossible to take this into account, and as this will affect all the models, we choose to ignore this aspect.

In order to measure the difference between the estimator and what is estimated we use the mean squared error (MSE), which is a quadratic loss function (Brooks 2014). We argue that due to the difficulty of modeling the exact same value as the real price is difficult, and values that are close are seen as satisfying. Therefore, large forecast errors should be seen as disproportionately more serious than small forecast errors, which is an advantage of MSE. The MSE is calculated by:

\[
MSE = \frac{1}{T - (T_1 - 1)} \sum_{t=T_1}^{T} (y_{t+s} - f_{t,s})^2
\]

Using these measures, we will conclude on which of the valuation techniques that is the best for valuing each of startups, high-growth firms, and steady-state companies, why that is, and whether different situations require different
valuation methods.

**4.2 Assumptions**

When valuing a company, or as in this thesis, several companies, one crucial determiner is the chosen assumptions. In the following we will present the assumptions that make up our forecast, and therefore valuation, of the companies.

### 4.2.1 True Values

Levin (2004) uses bidding theory to illustrate how company valuation is subjective, as a bidder does not necessarily know the true value of the company. While the publicly traded companies’ values could be considered accurate in that we know the share price as well as the number of shares, valuation of private companies depends on too many factors and assumptions to claim that a blueprint exists. As the ‘true values’ of the private companies in our sample depends on the purchase price at some point in time, it is important to recognize the possibility of mispricing and synergy effects only available to the acquirer. As these synergy effects are impossible for us to measure accurately, we assume there are no such effects, meaning that the acquisition price is in fact the true value or due to mispricing.

### 4.2.2 Growth

One crucial assumption when valuing companies, publicly traded or not, is the growth, and especially the terminal, or long-term, growth, as this has the greatest effect on the total enterprise value. On the publicly traded companies, growth for the first two years are analysts’ consensus downloaded from Bloomberg. For the three years later the growth is gradually converging towards the terminal growth
reported by the companies in their annual reports. In situations where the target
terminal growth is not reported, or we deem it unrealistic, we use the expected
rate of inflation as a benchmark before analyzing the companies. According to
Rotkowski and Clough (2013), companies that are expected to improve their
economic position should be given a long-term growth rate higher than the rate of
inflation – and vice versa. The inflation is likely to be approximately 2% in both
Norway and Sweden during the next years, maybe even less, according to Hegnar
(2017a; 2017b).

Estimating growth for startups is challenging, and the chosen growth is seen in
accordance with earlier growth as well as growth for more than a thousand listed
biotech companies around the world. The reason for this is because biotech
companies and startups face many of the same uncertainties and are often listed
on stock exchanges rather quickly.

4.2.3 Discount Rate

In order to calculate the discount rate, we chose the well-known CAPM-model to
find the cost of equity. First off, we started with data from Aswath Damodaran,
which is publicly available on his website. This splits up levered and unlevered
betas on companies in different industries in Europe. The unlevered beta was then
relevered with the appropriate tax rate and debt ratio for the company in question.

We found the risk-free rates from official sites, like Norges Bank, and chose the
10 years’ government bonds. Following CAPM’s formula:

\[ r_a = r_f + \beta_a (r_m - r_f) = r_f + \beta_a (MRP) \]

The implied market risk premium is also reported by Damodaran on a monthly
basis.

In order to complete the discount rate, we calculated the cost of debt by dividing
the historical interest costs by the total long-term debt in the corresponding years.
This was then used to calculate the weighted average cost of capital. If we saw a large deviation in interest cost or long-term debt, we chose those years that we expected to be representative for the company in the current situation.

### 4.2.4 Financial Statements

The companies’ balance sheets are first and foremost a result of their earnings, and hence it is important to understand the relationship between the balance sheet, income statement, and cash flow statement. If the companies are profitable, their retained earnings increase, as net income is added, while dividends are subtracted. First, consider the income statement and how we project future earnings. Most of the companies in our sample have at least a few years of accounting history, which makes the projection much simpler. However, there are still work to be done as there is a need to investigate how much of the revenues can be counted on in the future. Hence, any revenues, costs or other items deemed non-recurring are filtered out, meaning that only recurring revenues are used for further forecasting of the balance sheet and cash flow statement.

As mentioned in the previous chapter, we use historical growth as a benchmark for predicting future growth whenever possible. Furthermore, high-growth companies, which often include startups and young companies, will struggle sustaining the high growth for many years. According to Koller et al. (2010), only companies that have a constant competitive advantage will manage to sustain the high growth, which in turn requires constant renewals and innovation. Therefore, a decrease in growth for the high-growth companies seems reasonable in most cases. While the same is true for the startups, they are also likely to increase growth quite heavily if the company is successful in the early years.

When forecasting the balance sheet, there are several subjective decisions that have to be made. In many cases, especially for companies in steady state, we project the historical growth in each of the balance sheet line items and look for
trends. For instance: Telenor’s fixed assets increase gradually every year with sales, from 47.6% of sales in 2013 to 54.6% of sales in 2016. As a result, we forecast a similar growth in the years to come. Other examples of how we calculate ratios looking for trends are forecasting inventories and accounts payable as a percentage of cost of goods sold (COGS), and accounts receivable (AR), current assets and current liabilities as a percentage of revenues. Basically, most items connected to the operations of the firm are forecasted as a percentage of sales.

Further, a combination of items from the balance sheet and the income statement make up the cash flow statement, which shows the cash inflows and outflows of the company in question. The cash flow statement is organized using the indirect method, that is, starting with net income and adding or subtracting cash inflows and outflows in operations, investing activities and financing activities.

### 4.2.5 Probabilities

There are a number of assumptions that have to be made when considering the First Chicago Method, and mainly the probabilities assigned to the various scenarios. When dealing with all of startups, high-growth companies, and steady-state companies, there is no ‘one-suit-fits-all’. Instead, we pre-determine probabilities for each of startups, high-growth firms and steady-state companies, which of course can be altered when analyzing specific companies. The pre-determined probabilities are presented in table 3, and explained below.

<table>
<thead>
<tr>
<th></th>
<th>Startups</th>
<th>High-growth</th>
<th>Steady-state</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Success</strong></td>
<td>25 %</td>
<td>20 %</td>
<td>5 %</td>
</tr>
<tr>
<td><strong>Expected</strong></td>
<td>50 %</td>
<td>70 %</td>
<td>90 %</td>
</tr>
<tr>
<td><strong>Failure</strong></td>
<td>25 %</td>
<td>10 %</td>
<td>5 %</td>
</tr>
</tbody>
</table>
For startups, failure is equal to default. That is, there is a 25\% probability that the EV will equal zero. On the other hand, there is also a 25\% probability that the EV will skyrocket due to a successful development. In these cases, the scenario of success will be the main contributor to a high EV, despite of it being weighted by 25\%.

High-growth firms are difficult to assign probabilities to, as it is difficult to define what they would constitute as success. We argue that success for a company that already has reached immense growth is a long-term growth above the normal level, despite it being a significant decrease from current levels. Therefore, the success scenario and the expected scenario are much closer in terms of long-term growth and ultimately EV than what is the case for startups. Also, failure is not default in this case, but a growth level lower than, or close to, average, while the expected scenario is still likely to mean rather high growth.

Steady-state companies are somewhat boring in this respect, as there is a reason why we refer to them as being in a steady state. The uncertainty is at a minimum, meaning that the differences between the three scenarios are not as great as they are for the other company stages. For instance, failure in terms of default is not taken into consideration due to the minimal chance of it happening. Nevertheless, there are possibilities for higher or lower than expected growth, and these are assigned with a 5\% chance each.

### 4.2.6 Volatility

The chosen volatility plays an important role in option valuation, and obtaining a reasonable volatility for unlisted startups and young companies can prove challenging. In accordance with Hudson (2015), we decided to find comparable companies in order to retrieve historical clues regarding the volatility of these firms. Due to the great, and comparable, uncertainty revolving both startups and
BioTech companies, the volatilities of thirteen BioTech companies were used to estimate the average volatility for different time periods. As such, the volatility of the startups is based on the volatilities of similar, in terms of uncertainty faced, companies. On the other hand, the volatilities for all the publicly listed companies in our sample are calculated from stock prices easily retrieved from Netfonds.

4.3 Valuation Models

Our results, presented in the following chapter, are all rooted in the three valuation models used in our research: The DCF method, the First Chicago method, and option valuation. This section will provide a detailed explanation of how we arrived at these results, one model at the time. In order to illustrate how the models work, the valuation of News 55 will be used as an example throughout this chapter. Also, we highlight the main decisions that difference startups to high-growth companies and steady-state companies.

4.3.1 News 55

News 55 is a Swedish online platform that offers news, entertainment, and media content (Nyemissioner, 2017). It was founded in 2015, and is listed on Nordic MTF as of July 21st, 2017. It is a news platform that specializes on content for the Swedish senior citizens, that is, for those above 55 years old. As the company was only two years old at the time of the listing, and therefore at the time we obtained the price, it falls into the group of startups and young companies.

From 2015 to 2016, News 55 increased its sales from approximately 2.6 million to 4.5 million SEK, which equals an increase of 72%. Considering its young age, we find it likely that the sales will continue to increase in the years to come, however at a slowing rate. Therefore, we estimate a sales growth from 2016 to 2017 of 50%, before gradually decreasing to 15% in 2021. Although there are endless
innovation possibilities for technology ventures, News 55 seems determined to continue its aim toward the senior citizens, which in our opinion has a somewhat dampening effect on future growth.

Despite the sales growth, News 55 reports an EBIT of -5.2 million in 2015 and -4.6 million in 2016. However, as described by Damodaran (2009), the high operating expenses of startups are of little use in forecasting due to it being more related to getting the company up and running than to generate revenues. The declining operating expenses in 2016 supports this claim, and we believe that the cost margins will continue to improve in the coming years. As a result of sales growth and improving cost margins, we estimate that News 55 will reach a positive net income in 2019, which will further increase in both 2020 and 2021.

In contrast, a steady-state company such as Norsk Hydro ASA is forecasted under different assumptions. The reason for this can be explained by its name: It is in a steady state, meaning that sales growth and margin costs do not fluctuate as much. Of course, there may be variations from year to year, but they are likely to cancel each other out and on average remain stable. Therefore, our forecast is colored by the stability of such firms, resulting in modest growth increases, often within the range of 1 to 2 percent, as is the case for Norsk Hydro.

From 2015 to 2016, News 55 also nearly tripled its balance sheet, meaning that it took up loans to buy assets. We do not expect this to be a continuing trend – at least not of that magnitude. While assets and liabilities increased from 3.4 to 9.7 million the first year, we expect it to increase to almost 14 million by 2021, allowing News 55 to continue its growth due to its young age, without taking up too many loans.

4.3.2 The DCF Model

Using the cash flow statement as a starting point, the DCF model calculates both the present value of the free cash flows and the present value of the terminal
value. Added, these numbers represent the enterprise value that is compared against the true value later.

The DCF model is the simplest of our models, as it merely extends the cash flow statement by discounting the free cash flows by the appropriate discount rate, thereby calculating the present values of each of the free cash flows. For News 55, we calculated the discount rate to be 6.41%. These free cash flows are then added together, resulting in the sum of the present value of free cash flows for the firm. In News 55’s case, this equals SEK 5,967,523:

![Figure 1: Present value of FCF](image)

Furthermore, the sum of the present value of the free cash flows needs to be supplemented by the present value of the terminal value in order to find the total enterprise value. As mentioned earlier, the long-term growth plays an important role in this respect, as the main bulk of the value is represented in earnings beyond the first five years. Choosing the long-term growth (LTG) rate is subjective and thus needs to be thoroughly considered before making a decision. In the case of News 55, we see a company with a specific target group and high initial growth. This leads us to believe that the expected long-term growth will stabilize around the targeted inflation, which for Sweden is 2% (Sveriges Riksbank, n.d.). The formula used to calculate the terminal value (TV) is as follows:

$$TV = \frac{FCF_{t+1}}{WACC - LTG}$$

Using the final free cash flow from our initial forecast, the one in 2021, and increasing it with the long-term growth rate, we calculate FCF_{t+1}, which in this case equals SEK 1,920,108. By inserting the required numbers into the formula above and discounting it, we end up with a PV of the terminal value of SEK 0,988,906.
28,155,900. Hence, the enterprise value according to the DCF is

$$SEK \ 5,967,523 + SEK \ 28,155,900 = SEK \ 34,123,422$$

For steady-state companies, we use the DCF method similarly. The lack of differences between startups, high-growth firms, and steady-state companies in the application of the DCF model is an issue that will be discussed further in Chapter 5.

### 4.3.3 The First Chicago Method

The First Chicago Method is in many ways similar to the DCF. Yet, it allows for more differencing between companies at different stages and a way to account for uncertainty. In short, our First Chicago Method is the weighted average of three DCFs, one for each scenario. These growth rates assigned to these scenarios differ from company to company, depending on several factors. First, what would constitute success in terms of performing greater than expected for this particular company? Second – and this is equal to the standard DCF presented above – how do we expect the firm to perform? And finally, what constitutes failure for the company?

In terms of success, we argue that a long-term growth greater than the targeted inflation would be a magnificent achievement for News 55 – a company in a very competitive market with a rather specific target group. As a result, we set the
long-term growth to 4%. The expected case is equal to the scenario entertained under the DCF model, and therefore long-term growth is set equal to the expected inflation: 2%. The final question concerning failure consistently differs startups and steady-state companies in our sample, as we believe the worst-case scenario for the startups and young companies is bankruptcy. As such, failure for News 55 means losing it all, which equals an enterprise value of zero. On the other hand, the pessimistic scenario for Norsk Hydro is not nearly as damning, due to the extremely low probability of them going bankrupt. Instead, we have set the long-term growth rate to 1% in Norsk Hydro’s worst-case scenario.

Naturally, due to the difference in terms of uncertainty, the probabilities of each scenario also differ. While the expected scenario in the case of Norsk Hydro is given a probability of 90%, with 5% on each of the best- and worst-case scenarios, it is more challenging to assign probabilities for companies that face high uncertainty. As goes without saying, the expected scenario will always be the scenario that is assigned the highest probability. Earlier, we presented a benchmark of 25%, 50%, and 25% for the three scenarios of how startups and young companies will perform. However, these are merely starting points, as is the case for News 55. Within technology and media, there are potentially great opportunities for successful firms. As a startup, limiting the content to senior citizens could be smart. However, it also means that for a growing business, there are plenty of opportunities to extend the business, for instance to include other markets. As a result, we slightly increase the probability for success, while adjusting the probability of failure in the opposite direction. A summary of the First Chicago Method is presented in figure 3:

As visible, the enterprise values derived from the DCF and the First Chicago
Method is fairly equal – and fairly accurate. The true value, that is, the acquisition price, is SEK 35 million. It is also worth noting that the DCF yields a value slightly below the true value, while the First Chicago Method yields a value slightly above the true value, which will be further discussed in the next chapter.

4.3.4 Option Valuation

In order to value News 55’s equity as a call option, we need several parameters, including the risk-free rate, volatility, dividend yield, and underlying option value. The risk-free rate is collected from Norges Bank by using 10-year government bonds, meaning that we also have a time to maturity of 10 years.

As proposed by Hudson (2015), the volatility of the value is estimated based on historical clues from similar firms. We use BioTech companies when estimating the volatility due to the high uncertainty surrounding both startups and BioTech companies. Hence, the volatility of News 55 is estimated to 64.65%. On the other hand, the publicly traded companies, such as Norsk Hydro, do not require such an estimation of volatility, as the historic volatility is given. As such, we use 46.35% as Norsk Hydro’s volatility. We follow Steffens and Douglas (2007) and Koller et al. (2010) in that, due to the lack of better solutions, a traditional DCF needs to provide the value of the underlying asset. The dividend yield is calculated using the latest available share prices and dividends from Nordnet.

Following the Black-Scholes formula, we are given the option value as a function of \( d_1 \) and \( d_2 \), as presented in the theory section, yielding values of 30 847 719 SEK and 53 250 519 521 NOK for News55 and Norsk Hydro, respectively. Hence, both values, and especially that of Norsk Hydro, are lower than what is considered the true value. It is also worth noting that the option valuation is the valuation method that misses by the most in the valuation of these two companies.
5.0 Results and Discussion

This chapter will present the results of our research regarding which of the valuation techniques, being DCF, First Chicago method, and option valuation, that is best suited for valuing companies in different stages of their life cycles, namely startups, high-growth companies, and steady-state companies. Our findings can be divided into, and thoroughly discussed in, three sub-chapters: The valuation of startups; the valuation of high-growth companies; and the valuation of steady-state companies.

5.1 The Valuation of Startups

The valuation of startups proved challenging due to the lack of accounting history, as warned by, among others, Damodaran (2009). Yet, the analysts’ estimates of expected growth in biotech companies for the next two years helped serve as a benchmark. After comparing the true values to the ones we achieved through our valuations, the difference between the two is presented, in percentage, in table 4.

<table>
<thead>
<tr>
<th>Valuation Technique</th>
<th>Error (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCF</td>
<td>18.10 %</td>
</tr>
<tr>
<td>First Chicago Method</td>
<td>0.50 %</td>
</tr>
<tr>
<td>Option Valuation</td>
<td>19.45 %</td>
</tr>
</tbody>
</table>

*Table 4: Error (%) for startups*

As visible, the First Chicago Method is, without a doubt, the most accurate valuation technique for startup valuation purposes. These results confirm our second hypothesis; that the First Chicago Method yields the most accurate values for startups. There are several possible reasons why this is the case:

The First Chicago Method is more flexible than the DCF model in that it accounts
for different scenarios. Startups, as discussed by Steffens and Douglas (2007), are subject to high mortality risk among other risk factors. More so than companies in other stages of their life cycle are. This further increases the uncertainty, as supported by Damodaran (2009), and underlines the importance of including both the risk of default and the hope of success.

Another finding is that both the DCF and the option valuation yields values consistently lower than the true values, meaning that these models underprice the companies. One possible explanation for the constant underpricing by the DCF method is the failure to account for the possible upside. Startups have both a higher probability of excessive growth and a higher probability of default than companies that have already found their place in the market. The DCF method will not be able to account for this uncertainty sufficiently as it only entertains one scenario – more specifically, the expected scenario in our research.

By using probabilities such as 25 %, 50 %, and 25 %, for success, expected, and pessimistic outcomes respectively, the final value is weighted among the possibilities. On the other hand, the DCF only accounts for the expected scenario and will therefore weigh it by 100 %. In other words, as long as the possible upside outweighs the possible downside, the enterprise value will be higher. As previously discussed, a startup’s most significant cash flows are believed to be in the future. A model that is not able to account for the probability of success is likely to yield lower values than what their true value is. This is because, as opposed to in the valuation of steady-state companies, being able to incorporate the probability of success, if ever so little, will have a huge impact on the enterprise value. That is why, as predicted, the First Chicago Method is a better fit when valuing startups and young companies compared to DCF and option valuation.

More disappointingly, the option valuation is way off, and not even close to respectable results, contrary to what we hoped and believed. As option valuation incorporates the flexibility, which is believed to be of great importance when valuing startups (Koller et al., 2010; Savage, 2005), we had reasons to believe that
using options as a valuation tool would prove an accurate method in valuing startups – much more accurate than the DCF.

Another discussable subject is that the true value we have chosen – the acquisition price – is very much dependent on the optimistic scenario actually happening. If not, the value will be lower, meaning that the acquirer has paid overprice for the company. One can therefore argue that acquirers of startups are willing to take a calculated risk in that the upside is so great compared to the present value of the company. They pay for the optimistic, and not the expected, scenario, and therefore pay little attention to what could be considered the fundamental value of the company. This factor is one of the reasons why valuation of startups is so difficult: The purchase price is often the result of a gamble, and not necessarily the result of as accurate or likely predictions as in valuations of older, stable companies.

5.2 Valuation of High-Growth Companies
High-growth companies are interesting in that they share some characteristics with both steady-state companies and startups. First, high-growth firms experience, obviously, very high growth currently. This is similar to what startups hope to achieve, and will if successful, within a relatively short period of time. High growth comes with uncertainty, as the competitive advantage that allows for the high growth in most cases will be imitated or neutralized in other ways, as described by several authors (Cho and Pucik, 2005; Koller et al., 2005). Second, although there is uncertainty related to sustaining the high growth, the mortality risk in high growth firms is more similar to steady-state companies than it is to startups. The high-growth companies have found their place in the market and are solid, without much risk of default. As a result of these characteristics, success for these companies might mean maintaining a long-term growth higher than average, even if it probably means a significantly lower growth than in recent years.

Hence, the probabilities assigned in the First Chicago Method are different from
both those for startups and for steady-state companies. The results in table 5 show that, quite surprisingly, the DCF is more accurate than the First Chicago Method, while the option valuation is still way off, with an average error of 43.71%.

<table>
<thead>
<tr>
<th>Valuation Technique</th>
<th>Error (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCF</td>
<td>4.15 %</td>
</tr>
<tr>
<td>First Chicago Method</td>
<td>6.13 %</td>
</tr>
<tr>
<td>Option Valuation</td>
<td>43.71 %</td>
</tr>
</tbody>
</table>

Table 5: Error (%) for high-growth firms

In our valuations, we took the likelihood of not being able to maintain such a high growth for longer periods of time into consideration, by gradually adjusting growth to more normal levels. The fact that DCF outperforms the other models might point to the accounting history of the high-growth firms being a good indicator of future performance when we consider that high growth eventually converges to normal growth. As the First Chicago Method only yields remotely satisfying results, one might also infer that the uncertainty concerning high-growth firms is lower than what we initially thought. This could have led us to judgmental errors in our analysis of the various outcome probabilities, which in turn leads to imprecise valuations.

Interestingly, the high-growth companies represent the only company stage in which the DCF and the First Chicago Method agree on which companies that are underpriced and which are overpriced, with three and two, respectively. Even the option valuation, which for the exception of Next Biometrics consistently yields lower values than the true value throughout the entire sample, agrees with the other models on four out of the five companies in this stage. Mispricing is a valid possibility as subjective decisions must be made during the entire process, and especially given the nature of high-growth companies. Predicting the exact duration of their competitive advantage, and therefore their higher-than-average growth, is difficult, leaving it open for mistakes. For instance, as can be seen in
Appendix F, Next Biometrics yields similar values for all of our valuation methods, and all point to the company being undervalued at its true value.

### 5.3 Valuation of Steady-State Companies

Out of the three company stages considered – steady-state, startups and high-growth – the valuation of steady-state companies yields the best results in general. The DCF model performs better on steady-state companies than on any of the other company stages. Even the First Chicago Method can show for a respectable 3% average error, while the option valuation yields its highest average error among the company groups, as shown in table 6 below.

<table>
<thead>
<tr>
<th>Valuation Technique</th>
<th>Error (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCF</td>
<td>2.19 %</td>
</tr>
<tr>
<td>First Chicago Method</td>
<td>3.00 %</td>
</tr>
<tr>
<td>Option Valuation</td>
<td>50.46 %</td>
</tr>
</tbody>
</table>

*Table 6: Error (%) for steady-state companies*

The values found by the First Chicago Method is once again consistently higher than the ones found by the DCF, due to it factoring in a successful scenario. This time, however, the pessimistic scenario is not as drastic as default, as it is in the valuation of startups. Instead, failure is measured with a lower long-term growth, because of the low mortality risk faced by steady-state companies.

Three out of five steady-state companies are overpriced according to our DCF valuations, but the margins are too tight to draw any general conclusions from it. On the other hand, four out of five companies, with the exception being Telenor, are underpriced according to the First Chicago Method, even with only 5% probability of the optimistic scenario. The differences in values between the DCF and the First Chicago Method is not nearly as great as when considering the
previous two company stages, and still, the methods disagree on whether the majority of firms in our sample is under- or overpriced. It seems reasonable to credit this disagreement to the precision of the DCF model. Also, the steady-state companies are the biggest, meaning these have the greatest room for error in value. Considering that the First Chicago Method consistently yields higher values than the DCF, we argue that the overpricing is due to putting too much faith in the optimistic scenario. All in all, the First Chicago Method is quite accurate in valuing steady-state companies, but even with only 5% chance of great success, it changes the conclusion for some of the companies compared to the DCF values.

The option valuation once again fails in finding a similar value to the true value, and if we could not before, there is no doubt that the third hypothesis, that option valuation provides a good alternative to, and better overall results than, the other two methods, can be firmly discarded. At the same time, the first hypothesis, which states that the DCF provides its best values for steady-state companies and its worst values for startups, can be confirmed, with 2.19% and 18.10%, respectively.

6.0 Conclusion

All in all, the values derived from the DCF and the First Chicago Method are quite satisfying and in line with what we expected. However, the option valuation model somewhat failed, as it yielded inconsistent values, with the only consistency of them being incorrect compared to the true values. Still, there are a number of consistencies and conclusions to be drawn from our research:

First, the First Chicago Method is the best model for valuing startups. We argue that this is due to it accounting for the uncertainty by allowing us to define appropriate probabilities for three different scenarios before weighting them
accordingly. The DCF, on the other hand, constantly undervalues the startup companies. One probable explanation is that acquirers see the target startup as a possible gold mine with a relatively cheap downside, and therefore takes a gamble on it realizing its full potential, making it hard to justify the purchase price at the time of the acquisition.

Second, and no surprise here either, the DCF performs better the less uncertainty the companies face, making it ideal for steady-state companies. A more surprising observation is that it outperforms the First Chicago Method in valuing high-growth companies. This points to a consensus on the difficulty of maintaining high growth in the future, as our valuations included a gradually decrease in growth with its long-term growth being around normal levels.

Third, the DCF model is the best overall model. It is inaccurate in valuing startups and young companies due to the great uncertainty in future performance, leading to too low valuations, but is consistently better than the other models for the remainder of our sample. This is supported by the MSE, which penalizes large errors. The MSE (and the RMSE) is significantly lower for DCF than it is for the First Chicago Method, and especially than it is for option valuation. This is despite the fact that the First Chicago Method has an average error margin of only 3.36 % compared to DCF’s 8.15 %. The shift when considering (R)MSE can be attributed both to DCF being the allrounder with no particularly large errors. Also, its greatest errors in percentage are in the valuations of the startups, which are the smallest companies and therefore require a smaller difference between estimated and actual value to yield high error percentages.

Finally; we find that option valuation yields more accurate values when the debt ratio is low. When calculating d1, we use \( \ln \left( \frac{S}{X} \right) \) to calculate the probability of the option being “in-the-money”. This means that a lower strike, i.e. debt, compared to the value of the underlying asset yields a higher probability. The following graph shows how the errors in value are related to the companies’ debt ratio.
To sum up; different companies require different assumptions, which in turn means that there are room for error in every valuation. The DCF model is generally a very popular model, and with good reason. It provides the most accurate valuations throughout our sample, with its only drawback being the valuation of startups, where the First Chicago Method is significantly better. Yet, using the First Chicago Method when valuing any of the other company stages can be argued as a waste, as it merely disrupts the already accurate valuations from the standard DCF.

6.1 Critique and Future Research

The main criticism regarding this thesis revolves around the option valuation. Despite occasionally yielding rather precise values, the overall option valuation results are disappointing. We believe more accurate values could have been obtained by including several periods, in which the flexibility of managers’ options would be made better use of.

However, in the valuation of fifteen companies, being able to identify these
managerial options is hard. The detailed analysis required for it to be successful is better suited for an analyst doing a valuation of a firm in which he or she has full access. As such, a possible direction for future research could be focusing on fewer firms and ensuring a higher level of access, meaning that it would be possible to better identify the future managerial options, and hence add more periods.

Another direction for future research would be to investigate why the standard DCF yields more accurate values for high-growth firms than the First Chicago Method does, which we found a bit surprising. High-growth firms share many characteristics with startups, and many are young companies. Therefore, the uncertainty concerning future sales growth, for instance, has a greater resemblance with startups than with steady-state companies.
7.0 Bibliography


from: https://mpra.ub.uni-muenchen.de/63208/1/MPRA_paper_63208.pdf

8.0 Appendix
8.1 Appendix A – Assumptions
8.2 Appendix B – Income Statement

<table>
<thead>
<tr>
<th>Income Statement</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
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<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Revenue</td>
<td>$1,200,000</td>
<td>$1,300,000</td>
<td>$1,400,000</td>
<td>$1,500,000</td>
<td>$1,600,000</td>
</tr>
<tr>
<td>Costs</td>
<td>$600,000</td>
<td>$660,000</td>
<td>$720,000</td>
<td>$780,000</td>
<td>$840,000</td>
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<tr>
<td>Gross Profit</td>
<td>$600,000</td>
<td>$640,000</td>
<td>$680,000</td>
<td>$720,000</td>
<td>$760,000</td>
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<tr>
<td>Operating Expenses</td>
<td>$200,000</td>
<td>$220,000</td>
<td>$240,000</td>
<td>$260,000</td>
<td>$280,000</td>
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<tr>
<td>EBIT</td>
<td>$400,000</td>
<td>$420,000</td>
<td>$440,000</td>
<td>$460,000</td>
<td>$480,000</td>
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<tr>
<td>Taxes</td>
<td>$100,000</td>
<td>$110,000</td>
<td>$120,000</td>
<td>$130,000</td>
<td>$140,000</td>
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<tr>
<td>Net Income</td>
<td>$300,000</td>
<td>$310,000</td>
<td>$320,000</td>
<td>$330,000</td>
<td>$340,000</td>
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8.3 Appendix C – Balance Sheet

<table>
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<th>Account Title</th>
<th>Amount</th>
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<tr>
<td>Assets</td>
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<td>Current Assets</td>
<td></td>
</tr>
<tr>
<td>Non-Current Assets</td>
<td></td>
</tr>
<tr>
<td>Liabilities</td>
<td></td>
</tr>
<tr>
<td>Current Liabilities</td>
<td></td>
</tr>
<tr>
<td>Non-Current Liabilities</td>
<td></td>
</tr>
<tr>
<td>Equity</td>
<td></td>
</tr>
<tr>
<td>Capital</td>
<td></td>
</tr>
<tr>
<td>Reserves</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
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</tbody>
</table>

Note: The table above represents the balance sheet of a company, detailing the assets, liabilities, and equity as at a specific date. The amounts are in currency units.
8.4 Appendix D – Discounted Cash Flow

<table>
<thead>
<tr>
<th></th>
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<th></th>
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<tbody>
<tr>
<td>Depreciation, Deposition, &amp; Amortization</td>
<td>-254,545</td>
<td>704,175</td>
<td>3,477,975</td>
<td>1,479,658</td>
<td>1,452,800</td>
<td>1,257,254</td>
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<td>Change in Receivables</td>
<td>-760,016</td>
<td>-366,711</td>
<td>-1,004,502</td>
<td>-1,321,446</td>
<td>-971,537</td>
<td>-1,262,822</td>
<td>-5,649,814</td>
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<td>Change in Inventory</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Change in Prepaid Assets</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Change in Payables &amp; Accrued Expenses</td>
<td>724,950</td>
<td>1,718,684</td>
<td>569,245</td>
<td>-401,720</td>
<td>-621,426</td>
<td>-1,088,942</td>
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<tr>
<td>Change in Working Capital</td>
<td>-</td>
<td>-</td>
<td>561,599</td>
<td>-603,791</td>
<td>1,737,483</td>
<td>1,560,872</td>
<td>1,039,312</td>
</tr>
<tr>
<td>Change in Working Capital</td>
<td>1,637,430</td>
<td>3,238,095</td>
<td>681,599</td>
<td>-603,791</td>
<td>1,737,483</td>
<td>1,560,872</td>
<td>1,039,312</td>
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<td>Change in Deferred Tax</td>
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<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Stock-Based Compensation</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Net Change in Liabilities</td>
<td>-8,218,606</td>
<td>343,136</td>
<td>-1,866,235</td>
<td>54,476</td>
<td>2,335,966</td>
<td>3,027,370</td>
<td>2,291,364</td>
</tr>
<tr>
<td>Change in PPE &amp; Long-Term Investments</td>
<td>-254,548</td>
<td>-304,175</td>
<td>-1,472,975</td>
<td>-3,479,666</td>
<td>-1,462,160</td>
<td>-1,227,254</td>
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<td>Investment Purchased/Trades</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Change in Common Stock</td>
<td>5,650,639</td>
<td>7,643,349</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Dividends</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Net Change in Equity</td>
<td>5,650,639</td>
<td>7,643,349</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Exchange Rate Effect</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Net Change in Liabilities</td>
<td>3,304,915</td>
<td>10,449,912</td>
<td>-1,931,555</td>
<td>-729,192</td>
<td>2,785,128</td>
<td>7,262,770</td>
<td>2,026,099</td>
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<tr>
<td>Free Cash Flow</td>
<td>3,304,915</td>
<td>10,449,912</td>
<td>-1,931,555</td>
<td>-729,192</td>
<td>2,785,128</td>
<td>7,262,770</td>
<td>2,026,099</td>
</tr>
<tr>
<td>Less: Capital Expenditures</td>
<td>-251,548</td>
<td>-619,830</td>
<td>-764,795</td>
<td>-695</td>
<td>17,408</td>
<td>251,006</td>
<td>2,169,747</td>
</tr>
</tbody>
</table>

### Terminal Value

| Growth in perpetuity method | 2.00% |
| WACC | 6.41% |
| Free Cash Flow | 21,022,883 |
| Terminal Value | 28,662,782 |
| Present Value of Terminal Value | 27,957,315 |
| Enterprise Value | 10,171,408 |

### WACC

| Paid Interest | 32,102 |
| Total Debt | 545,834 |
| Cost of Debt | 5.28% |
| Tax Rate | 24% |
| After-Tax Cost of Debt | 4.07% |
| Risk-Free Rate | 1.25% |
| Market Risk Premium | 5.29% |
| Beta | 1.42 |
| Cost of Equity | 10.90% |
| Total Debt | 6,111,618 |
| Total Equity | 3,212,989 |
| Total Capital | 9,324,607 |
| Debt Weight | 64% |
| Equity Weight | 36% |
| WACC | 6.41% |
8.5 Appendix E – Option Valuation

<table>
<thead>
<tr>
<th>Option Valuation</th>
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<tbody>
<tr>
<td>Time to maturity</td>
</tr>
<tr>
<td>Underlying asset value</td>
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<tr>
<td>Strike</td>
</tr>
<tr>
<td>Risk free rate</td>
</tr>
<tr>
<td>Volatility</td>
</tr>
<tr>
<td>Dividend Yield</td>
</tr>
<tr>
<td>d1</td>
</tr>
<tr>
<td>d2</td>
</tr>
<tr>
<td>Option Value</td>
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</table>
### Appendix F – Results

<table>
<thead>
<tr>
<th>Company</th>
<th>Category</th>
<th>Trust Value</th>
<th>DCF</th>
<th>DPR Value</th>
<th>Diff %</th>
<th>MSE</th>
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<tbody>
<tr>
<td>KONGSBERG AUTOMO</td>
<td>SS</td>
<td>2,961,271,977.84</td>
<td>2,973,153,725.81</td>
<td>2,977,021,285.00</td>
<td>2,675,147,786.81</td>
<td>-0.40%</td>
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<tr>
<td>NORSK HYDRO ASA</td>
<td>SS</td>
<td>95,133,285,437.50</td>
<td>94,586,611,717.58</td>
<td>99,068,972,825.16</td>
<td>53,250,519,521.97</td>
<td>0.83%</td>
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<tr>
<td>SCHIBESTAD ASA-A</td>
<td>SS</td>
<td>43,917,259,825.60</td>
<td>43,172,100,062.97</td>
<td>47,362,507,166.80</td>
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<td>-3.16%</td>
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<tr>
<td>TELENOR</td>
<td>SS</td>
<td>207,600,541,937.00</td>
<td>202,124,093,075.08</td>
<td>204,670,614,867.31</td>
<td>48,245,781,127.39</td>
<td>2.06%</td>
</tr>
<tr>
<td>TOTENG SPAREBANK</td>
<td>SS</td>
<td>622,252,871.00</td>
<td>629,522,097.59</td>
<td>624,110,493.03</td>
<td>1,950,780.01</td>
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<tr>
<td>AKER BP ASA</td>
<td>HG</td>
<td>41,541,657,888.80</td>
<td>37,920,056,275.26</td>
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<td>37,501,552,321.34</td>
<td>8.72%</td>
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<tr>
<td>NEXT BIOMETRICS</td>
<td>HG</td>
<td>1,046,938,820.00</td>
<td>1,116,131,019.85</td>
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<td>1,100,758,343.63</td>
<td>-4.41%</td>
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<tr>
<td>NORWAY ROYAL SAL</td>
<td>HG</td>
<td>3,533,691,384.00</td>
<td>3,187,414,954.71</td>
<td>3,194,289,657.29</td>
<td>2,089,490,999.07</td>
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<tr>
<td>NRC GROUP ASA</td>
<td>HG</td>
<td>2,144,439,751.00</td>
<td>2,133,025,045.91</td>
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<td>1,555,354,345.78</td>
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<tr>
<td>PARETO BANK ASA</td>
<td>HG</td>
<td>3,098,588,360.40</td>
<td>2,116,338,108.71</td>
<td>2,190,265,747.77</td>
<td>40,091,932.92</td>
<td>-8.65%</td>
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<tr>
<td>Mytros AS</td>
<td>SU</td>
<td>121,967,292.48</td>
<td>100,740,048.02</td>
<td>123,043,883.79</td>
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<td>17.20%</td>
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<tr>
<td>Dallotech</td>
<td>SU</td>
<td>255,106,763.44</td>
<td>229,238,584.53</td>
<td>253,209,652.13</td>
<td>200,576,746.60</td>
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<tr>
<td>HAG Anlegg</td>
<td>SU</td>
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<td>103,223,954.18</td>
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<td>18.99%</td>
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<td>OnexInvest</td>
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<td>34,123,422.00</td>
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</tbody>
</table>