EQUITY VALUATION MODEL ACCURACY: AN EMPIRICAL RESEARCH IN THE U.S. TECHNOLOGY AND INDUSTRIAL SECTORS 2010-2021

Lappeenranta–Lahti University of Technology LUT

Bachelor's thesis

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Examiner: Associate Professor Sheraz Ahmed

ABSTRACT

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Equity valuation model accuracy: An empirical research in the U.S. technology and industrial sectors 2010-2021

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Valuation is in the center of the business world. Still, empirical research into valuation model accuracy has not reached its deserved attention and there is debate which valuation models should be used. Therefore, the main objective in this thesis is to find empirical evidence, whether certain models can provide better accuracy in equity valuation than others. Furthermore, perspective is broadened to examine if valuation accuracy can be utilized to increase risk-adjusted portfolio returns

Thesis compares discounted cash flow (DCF) model and price multiple valuation model accuracy in technology and industrial sectors between 2010-2021. The study covers 1700 valuation estimates from the 20-firm sample. Used multiples are trailing price-to-earnings (PE), price-to-book (PB), combination model (PE-PB) and one-to-three year forward PE. Models are also tested in a stock screening model to see whether valuation accuracy can be utilized to increase portfolio returns.

Results indicate that trailing multiples models provide better valuation accuracy compared to forward-looking models such as DCF. Results support previous studies as PE model was found to provide the best valuation accuracy among multiples. However, the results were not unambiguous. When valuation models were utilized in stock screening, forward-looking models provided the best risk-adjusted returns.

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Arvonmääritys on rahoitusmaailman keskiössä. Silti empiiriset tutkimukset valuaatiomallien tarkkuudesta eivät ole saaneet ansaitsemaansa huomiota ja mallien käyttö jakaa edelleen mielipiteitä. Tästä johtuen tutkielman päätavoite on löytää empiirisiä todisteita arvonmääritysmallien paremmuudesta. Lisäksi näkökulmaa on laajennettu tutkimaan, mikäli valuaatiotarkkuutta voidaan hyödyntää portfolion riskikorjattujen tuottojen kasvattamisessa.

Tutkielma vertailee vapaan kassavirta mallin (DCF) ja markkinaperusteisten mallien valuaatio tarkkuutta teknologia- ja teollisuustoimialoilla vuosina 2010–2021. Tutkimus kattaa yhteensä 1700 erilaista hintaestimaattia 20 yrityksen otoksesta. Käytetyt markkinapohjaiset arvonmääritys mittarit ovat price-to-earnings (PE), price-to-book (PB), yhdistelmä malli (PE-PB) sekä 1, 2 ja 3 vuoden eteenpäin katsova PE. Arvonmääritysmalleja testataan myös osakepoiminta strategiassa, jotta nähdään voidaanko valuaatio tarkkuuden avulla kasvattaa portfolion riskikorjattuja tuottoja.

Työn tulokset osoittavat, että taaksepäin katsovat markkinaperusteiset mallit tuottavat paremman valuaatio tarkkuuden kuin eteenpäin katsovat mallit, kuten vapaan kassavirran malli. Tulokset tukevat aikaisempia tutkimuksia, sillä PE-mallin todettiin antavan paras arvostustarkkuus. Tulokset eivät kuitenkaan ollut yksiselitteisiä. Kun arvonmääritysmalleja hyödynnettiin osakepoimintaan, eteenpäin katsovat mallit tuottivat parhaita riskikorjattuja tuottoja.

List of abbreviations

CAPM	Capital asset pricing model
DCF	Discounted cash flow
EBIT	Earnings before interest and taxes
EBITDA	Earnings before interest, taxes, depreciation, and amortization
FCFE	Free cash flow to equity
FCFF	Free cash flow to firm
IQR	Interquartile range
LTM	Last twelve months
MAVE	Mean absolute valuation error
PB	Price to book
PE	Price to earnings
PE-PB	Composite model of price to earnings and price to book
PS	Price to sales ratio
Q1	25% quartile
STD	Standard deviation
TRBC	The Refinitiv Business Classification
VS	Value to sales ratio
WACC	Weighted average cost of capital

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1 Introduction

Valuation is in the core of day-to-day life in finance. Analyzing investments, preparing financial statements, pricing corporate transactions, and making real estate decisions - all require valuation. Valuation errors have massive consequences as proved in 2008, when revaluation of marked assets had a catastrophic influence on giant institutions' portfolios. (Calhoun 2020.) When it comes to equity valuation, determining company valuation has become more problematic. Looking at academics and practitioners working with business valuation, there is only little agreement on which valuation method should be applied. (Hamadi & Hamaleh 2012, 104.) Furthermore, different geographic regions, analysts, and firms are found to have significant differences in valuation practices (Pinto, Robinson & Stowe 2019, 230). One of the reasons behind this phenomenon is that there is not a single valuation model that stands out being more accurate than the others (Roosenboom 2012). Therefore, this thesis makes its contribution to the research for more accurate valuation principles, by comparing equity valuation models' accuracy in ex-post analysis during 2010-2021.

Giving the centrality of valuation in business life, one would assume that business valuation would be well researched. In reality, empirical research into valuation models and metrics is quite spotty (Berkman, Bradbury & Ferguson 2000; Damodaran 2007). Especially cash flow estimations and reconciling different valuation models has not reached deserved attention. (Damodaran 2007.) From prior literature, it is difficult to determine if one valuation method is superior to another. Theoretically, different models provide equivalent valuations, when cash flows are estimated consistently, and comparable discount rates are applied. However, in practice reasonable future cash flow projections are limited and discount rate estimations are subject to error. These practical issues cause analysts to prefer some models. (Hamadi & Hamadeh 2012.) Kaplan & Ruback (1995), also agree that both discounted cash flows (DCF) and comparable multiples are inherent to errors. They argue, if comparable firms' future cash flow expectations and risks similar, the comparable valuation will outperform DCF model in accuracy. This is because comparable method incorporates contemporary market expectations of future cash flows in the multiple. However, in practice, future cash flows are rarely proportional, and risks are not matching. Also, there is not clear conclusion, which value driver is the most suitable for valuations. Discounted cash flow's reliability on the other hand, relies on the accuracy of future cash flow estimation and risk premiums as well as, cost of capital assumptions.

One way to measure valuation models' accuracy and usage, is to compare used valuation models and their accuracy in equity research reports. Prior research indicates that multiples are more popular among analysts as they are less time-consuming and easier to apply compared to DCF model (Asquith, Mikhail & Au 2005, 280; Barker 1999, 393; Bradshaw 2002, 40; Demirakos, Strong & Walker 2004, 237). In some extent, this is justified since price-to-earnings (PE) outperformed DCF model in accuracy based on equity research reports valuation error and target achieving percentage (Asquith et al. 2005, 279; Demirakos, Strong & Walker 2010; Sayed 2017). However, more recent studies indicate that DCF model has become more popular among analysts (Deloof, De Maeseneire & Inghelbrecht 2009; Glaum & Friedrich 2006, 172). Demirakos et al. (2010) and Sayed (2017) found that DCF was used significantly more often to value small, loss-making, high-risk firms to justify bold target prices. Sayed (2017) further discovered that Asian emerging markets are implementing PE model more often compared to DCF model. However, in contrary Pinto et al. (2019, 229) found that Americas had lower usage in DCF model compared to Asia Pacific, Middle East, Africa, and Europe.

Another way to measure valuation models pricing accuracy and performance is to do empirical research. Kaplan & Ruback (1995) valuated a sample of 51 management buyouts between 1980 and 1989 and found that DCF model had 6% median valuation error when firm's own beta is applied in the discount rate, compared to median multiple error -18,1% from comparable firms. When cost of equity was calculated using industry betas, the median error for DCF was 6,2 % and 2,5% for market-beta estimations. On the other hand, when multiples were calculated comparable transaction based the mean error was 5,9%, whereas industry-based error was 0,1%. Discounted cash flows were calculated using compressed adjusted present value, or all-equity method. Terminal values were calculated using 4%

terminal growth rate which corresponds to real growth rate around 0-1 %. Risk-free rates were measured with 20-year treasury bond yields. Comparable multiples were calculated using EBITDA measures, to make it comparable with capital cash flow estimations. (Kaplan & Ruback 1995, 1068-1073.)

Berkman, Bradbury & Ferguson (2000) on the other hand, found that DCF and PE valuations provided similar accuracy. Research done for 45 newly listed firms in New Zealand, showed that both methods had median valuation error around 20% and the models explained around 70% of variation in market value, when scaled by book value. Furthermore, research shows that industry-based valuations yield higher valuation errors than market-based models. Unlike Kaplan & Ruback (1995) Berkman et al. (2000) estimated DCF using weighted average cost of capital (WACC) instead of all-equity assumption. Both industry and market betas are applied when calculating WACC for DCF valuation. Also, PE valuations were calculated using industry and market-based comparables. Market based comparables were adopted when there was lack of industry comparables which is typical in narrow markets. Median absolute errors for industry-based DCF and PE are 30,8% and 38,3%, whereas market-based errors are 20,1% and 20,5% respectively. The Reason behind large industry-based valuation errors, are attributed to thin markets in New Zealand, where comparable data is hard to obtain. (Berkman et al. 2000, 72.)

Cheng & McNamara (2000) evaluated the accuracy of PE, price-to-book (PB) and combination of price to earnings and price to book (PE-PB) valuation models with sample of 30310 firms between 1973 and 1992. Comparable firms are selected based on industry, size, return to equity and combination of previously mentioned. Results suggest that PE-PB valuation using industry comparable firms outperforms other methods with an average error of 22,7%. Furthermore, P/E outperformed P/B in accuracy. In general, industry-based benchmarks provided the best accuracy. Boatsman (1981, 46) also, found that price to earnings multiple valuation accuracy increases when industry comparable firms are applied, but added that the valuation accuracy further increases, when comparable firms also have similar historical earnings. (Cheng & McNamara 2000.)

Deloof & Maeseneire (2009, 157), Kim & Ritter (1999), Keun Yoo (2006, 115), Liu, Nissim & Thomas (2002, 163) and Rossi & Forte (2016) found that forward earnings as a value driver increases valuation accuracy. Liu et all. (2002) and Keun Yoo (2006) got further similar results in the multiple accuracy and ranked models from most accurate to least accurate as follows: forward earnings measures, historical earnings measures, cash flow and book value to equity tied for third position, and sales performs the worst. Keun Yoo (2006, 108, 120) further found, that combining historical and forward earnings does not yield into better accuracy. Rossi & Forte (2016, 116-118) did similar research for larger sample of 2560 US market traded stocks from 1991 up to 2014. They found that forward PE models outperformed all the other multiple models. They also indicate that PE models' outperformance is similar in industrial and IT sectors. Multiples were found to increase the valuation accuracy when the industry segmentation was more detailed. However, when stock selecting strategies were tested, the results indicate, that extra focus in the selection does not improve performance from investing standpoint. They also found that during financial crisis, multiple valuation accuracy quickly declines, whereas less market-based models become more accurate.

Further, Rossi & Forte (2016) were the first ones to adapt pricing error screening factor into empirical research. They select each year the most undervalue stocks based on the valuation errors to gather three different portfolios based on GICS sectors, subsectors, and entire sample. They found that the screening undervalued stocks based on multiple models, delivers higher risk-adjusted performances compared to S&P 500 index. Further they found that utilizing historical multiples, does not increase portfolio returns, whereas forward multiples does. Interestingly, the models which presented best valuation accuracy yielded into worst portfolio returns and the models with worst valuation accuracy yielded highest portfolio returns.

1.1 Research objectives

The main objective in this thesis is to find which valuation model provides the best accuracy in technology and industrial sectors. By comparing discounted cash flow and multiple models, thesis aims to figure how markets value stocks and whether some models can predict future performance better than the others. Giving the importance and difficulty of equity valuation, the objective and empirical research into valuation models is justified. Based on these objectives the main research question is:

1. *Which valuation model is the most accurate in technology and industrial sectors?*

Used valuation models are discounted cash flow model (DCF) price-to-earnings (PE) multiple, price-to-book (PB) multiple and a combination (PE-PB) multiple. In addition, PE model is tested using one, two and three year forward earnings. Thesis continues Kaplan & Ruback (1995) and Berkman et al. (2000) empirical comparison of DCF and multiple models, utilizing sensitivity analysis in cost of equity and terminal growth rates. Further, multiple valuations are calculated utilizing comparable, industry and market comparables. Sensitivity analyses are used to reduce errors based on different assumptions. In contrary to Kaplan & Ruback (1995) and Berkman et al. (2000) analysis in IPOs, this thesis focuses on large cap firms which are producing more stable cash flows. Models are tested in two different industries: technology and industrial sectors, to discover how different financial characteristic, such as capital intensity, affect the valuation accuracy. These sectors and their differences are further discussed in section 3.1. The study covers a total of 1700 valuation estimates from 20 firm sample. Valuation estimates are compared to actual market prices each year between 2010 and 2021. Then valuation errors and deviations are compared to figure, which model provides the most accurate valuations.

In prior literature, multiple models have provided great accuracy and it is proved that these models are widely used. However, there is still debate, which value drivers should be used and whether the multiples should be combined. To answer these objectives, second research question compares only multiple models' accuracy as an extent to the first research question.

2. *Among multiple models, which model provides the best valuation accuracy?*

One of the main reasons behind research into valuation, is to discover misvalued securities to increase investment returns. Empirical studies on the usage of valuation accuracy as an investment strategy have been limited. Also, most value investing studies are based on overall equity sample, rather than sector or industry groupings. (Rossi & Forte 2016, 197.) Therefore, this thesis aims to answer to the third research question:

3. *Can valuation accuracy screening model increase portfolio returns?*

To answer this question, seven portfolios are built based on each models' performance in sensitivity analysis. This means that the most accurate models are used to select firms to the portfolios. Hence, one portfolio is built based on DCF, PE, PB, PE-PB and forward PE models. Stocks are selected based on the largest undervaluation indicated by each model. This is done by sorting the mispricing of each firm and selecting the lowest quartile to the portfolio each year. Portfolio size is 5-6 firms each year. Then portfolios annualized average returns are compared. Further, portfolio returns are adjusted in their risks by measuring the Sharpe ratio, Treynor's ratio and Jensen's alpha.

1.2 Structure

Thesis consists of five chapters, which are introduction, theoretical framework, research data and methodologies, results, and conclusions. Introduction gives a brief scan into the literature background, research objectives and delimitations. Theoretical framework dives into equity valuation principles, DCF model and multiple valuation models. Theoretical framework is followed by research data and methodologies, where the sample data and selected valuation principles are presented. Further, this section introduces portfolio construction principles and portfolio measurements. Then results are presented, where valuation accuracy results are reviewed first. This is followed by portfolio performance results, where portfolios' returns, and risks are compared. Lastly, conclusions summarize the research objectives, results, and sets reference for further research.

1.3 Delimitations

Company valuation relies on future projections and risk analysis, where operating environment has its own influence. Business conditions, such as geographical, demographical, economic, political, and cultural differences set boundaries for businesses which are out of their control (Puusa, Reijonen, Juuti & Laukkanen 2014, 53). For example, many firms in United States uses straight-line depreciation costs for financial reporting, whereas firms in Japan or Germany use accelerated depreciation which underestimates reported revenues compared to U.S. counterparts (Damodaran 2001, 73). Therefore, research is delaminated geographically to companies which are headquartered in United States, where business conditions are comparable.

Another way to delimitate the research material is to give financial boundaries for the selected companies. Growth firms are more often measured on the top row values, such as revenue, whereas profitable, mature companies are measured with cash flows. Therefore, research is delimitated to mature, large-cap firms which have been making positive cash flow for at least last five years. Further, companies are required to have at least five analysts following to get a reasonable mean for future predictions. This is important, because otherwise valuation errors could be explained with single analysts forecast error, rather than the model's misvaluation. In the sample selection phase, companies were also filtered with price to earnings ratio between 1 to 100, and price to book ratio between 0.1 to 20 to limit the search results.

There are many reasons behind financial delimitations. First, large companies are widely followed by analysts, so there is enough data for relevant analysis. Second large companies usually have operated before 2010, so it is likely that needed data is available and the companies have turned profitable. Third, market cap, price to book ratio and price to earnings ratio – all add up financial requirements, which makes peer group more comparable. Lastly, different industries and companies have broad differences in financial metrics and suitable valuation models. For example, technology firms are typically low capital intensity growth firms which makes it hard to estimate future cash flows, whereas industrial firms are typically mature, stable cash flow firms where it is more convenient to discount future earnings. Therefore, two different industries are analyzed to get a better overview of the best valuation model.

2 Theoretical framework

Theoretical framework first reviews valuation as a concept and presents different approaches to the topic. Then, two different valuation models are presented precisely. First valuation model is discounted cash flow model, where the focus is on different cash flow and discount rate measures. The second presented model is multiple model which primarily deals with comparable company selection and value drivers.

2.1 Valuation

Valuation is a process where forecasts are turned into valuation of a certain business unit or company (Palepu, Healy & Bernard 2000). Corporate valuation is a set of methods used to determine appropriate value to a firm or a stock (Rossi & Forte 2016, 5). All management decisions are based either implicitly or explicitly on some valuation model. Therefore, it is important to know, which valuation model reflects most accurately the share value. (Copeland, Koller & Murrin 1994, 70.) Analyst use wide spectrum of valuation models ranging from highly sophisticated models to more simpler ones. In broader terms, this classification can be done based on assumptions and fundamentals that determine the value. (Damodaran 2007.) Calhoun (2020) presents three professionally recognized methodologies for enterprise valuation:

1. Financial accounting
2. Financial modelling
3. Market Multiples

Financial accounting refers to measures called book values. Financial modelling refers to techniques that rely on the concept of discounted cash flows, which calculate net present value of a company based on current and forecasted future cash flows. Market multiples, produce valuation ratios based on price signals generated by the financial markets. (Calhoun 2020.) Classification of business valuation models has several advantages. It makes it easier to recognize where valuation model fits in the big picture, why provided results can differ and when models have fundamental errors (Damodaran 2007).

When estimating company valuation, on must deal with number of issues which effect the valuation task. There are three most common complications: negative book values, excess cash, and accounting distortions. Accounting methods and practices should not have effect on firms' value. Yet, abnormal returns and earnings vary with accounting method choices. Negative book values of equity earnings, makes it difficult to measure accounting-based valuation models. This is common for instance to technology firms and start-ups, which are going to produce positive cash flows in the future. To get around this problem, one can value the firm based on its assets instead of equity. Excess cash flows also pose valuation errors, if large cash flows are not paid in dividends or as a stock repurchases, and this excess cash is not invested optimally. (Palepu et al. 2000.)

According to efficient market hypothesis, market prices reflect all the information available. As new information flows, stock prices adjust to the changes. (Kambeu, Mpofu & Muchochoma 2017, 38.) However, recent finance literature indicates that stock prices follow random walk and are stochastic (Mittermayer 2004). As a result, stock prices are constantly changing and rarely stable, which is attributed to the information flow. Normal volatility exists when prices move from one equilibrium to another as a response to new information. Transitory volatility exists when new information is absorbed to the market prices due to market inefficiency. (Kambeu et al. 2017, 42.) Unexpected changes to cash flows causes volatility in businesses and stock prices. Volatility is a measure of the deviation in stock prices and returns over time. Increase in volatility decreases stock prices due to increase in risks. (Bag 2022.) Most common measure for stock price volatility is standard deviation which is often measured from S&P 500 percentage changes. What is essential to recognize in this measure of volatility is that higher stock prices mean higher volatility. (Easterling 2022.) At the level of stocks, higher volatility also means higher risk tolerance, wider margins, and stop-losses (Bag 2022).

Valuation can be used to determine sound investments in security analysis. According to Graham, Dodd & Cottle (1934) security analysis are divided into three functions: descriptive, selective, and critical security analysis. Descriptive analysis compares companies' statistics, selective analysis judges whether the security should be bought or sold, and critical analysis monitors corporate management, policies, and structure. From this standpoint Graham et al. (1934) created investment strategy called value investing, where stocks that are trading below their intrinsic value are seen as sound investment opportunities. However, the intrinsic value is rarely unambiguous. Determining the intrinsic value can be done using different valuation models such as discounted cashflow model or multiple models which are presented in next two chapters.

2.1.1 Discounted cash flow models

Discounted cash flow (DCF) model is the present value of any asset's projected future cash flows, discounted at a rate which reflects the risks of the cash flow (Copeland et al. 1994, 71). This valuation approach is the most used by academics and comes with best theoretical results. It relies on proposition that the assets value is equal to expected cash flows on the assets, not what someone perceives it to be. Simply, this means that assets with low, volatile cash flows should be valued lower compared to high cash flows that are predictable. (Damodaran 2007.) Discounted cash flow or intrinsic value of a firm or an asset can be estimated using equation:

$$Value\ of\ a\ asset = \sum_{t=1}^{t=N} \frac{E(Cash\ Flow_t)}{(1+r)^t} + \frac{\frac{E(Cash\ Flow_{t+1})}{(r-g)}}{(1+r)^{t+1}} \tag{1}$$

where	N	total number of years
	r	discount rate
	t	year
	g	growth

Asset’s life is presented with N describes the period that asset is creating cash flows. If a firm is viewed as a collection of cash flows, firm’s value can be estimated by extending the equation to cover firm’s cash flows over its lifetime and using discount rate that reflects the risks of firm’s assets. (Damodaran 2001, 750.)

The only equity investors’ cash flow from publicly traded companies are dividends. Therefore, the firms value can be calculated as present value of these expected dividend cash flows. However, there are two significant problems when it comes to valuation based on dividends. First, publicly traded firms can return cash to owners, by buying back own stocks and private firms can withdraw cash without calling it dividends. The second issue is that firms do not pay all the dividends back they could afford. Therefore, the dividend discount model will estimate the value of equity incorrectly. To counter these problems cash flows can be estimated more broadly using free cash flow to equity (FCFE), which is cash flow left after operating expenses, interest expenses, net debt payments, and reinvestment needs. (Damodaran 2001, 128, 131.)

Firms have more stakeholders than just its equity investors. From claim holders’ standpoint, all the cash flows need to be valued based on what is left to the firm. This can be measured using free cash flow to firm (FCFF), which is cash flow after operating expenses, taxes, and reinvestment needs, but before interest and principal payments. There are two main differences between FCFF and FCFE. FCFF starts with after tax operating income, which is before interest payments, whereas FCFE begins with net income, which is a considered after interest expenses and taxes. Second difference is that FCFE includes net debt in free cash flow, whereas FCFF is calculated before net debt. FCFF measures cash flow generated before financing costs or in other words the cash flow used to service all claim holders’ needs. (Damodaran 2001, 133.) The FCFF formula is presented in Table 1:

Table 1. Free cash flow to firm

Earnings before interest and taxes * (1 – tax rate)
(+) Depreciation and Amortization
(-) Capital Expenditures
(-) Change in noncash working capital
= Free cash flow to the firm

Estimation of FCFF starts with earnings before interest and taxes (EBIT) or operating income. In some literature EBIT is referred as after-tax operating income, but since the operating income used in FCFF is estimated before capital and financing expenses, the accounting operating income needs to be adjusted. To calculate after-tax operating income, EBIT is multiplied by appropriate tax rate. Tax rate can be estimated using effective tax rate, which is calculated form income statement by dividing taxable income by taxes due. Another way to apply tax rate is to use marginal tax rate, which is the tax rate that is paid for income. Alternatively, taxes can be calculated separately and then deducted from the operating income. Then, all depreciation and amortization costs or noncash charges are added back to after-tax operating income. Further, all capital expenditures or cash outflows are subtracted. Lastly changes in networking capital are netted out from the cash flow. This means that increase in accounts receivable, accounts payable and inventory, is decreased from free cash flow and other way around. (Damodaran 2001, 270-271, 751-755.)

As previously mentioned, cash flows need to be discounted using rates which reflect the riskiness of the cash flows. In finance, risk has different and broad definitions, but it can be seen as likelihood of receiving unexpected returns. For instance, claim holders must incorporate default risk into the cost of debt and equity investors need to include risk premium for equity risk. What makes the measurement of risk challenging, is that it depends on the adopted perspective. (Damodaran 2001, 149-150.) To value firms' assets, both debt and equity holders cash flows need to be discounted. Therefore, the used discount rate needs to be calculated as weighted average cost of capital. (Palepu et al. 2000) Equation 2 presents estimate DCF formula when free cash flows to firm is applied. Equation 3 further presents how weighted average cost of capital is estimated to discount the cash flows properly.

$$DCF = \frac{FCFF_1}{(1+WACC)^1} + \frac{FCFF_2}{(1+WACC)^2} + \cdots + \frac{FCFF_t}{(1+WACC)^t} + \frac{\frac{FCFF_{t+1}}{WACC-g_t}}{(1+WACC)} \tag{2}$$

WACC weights cost of equity and cost of debt according to their value. WACC is presented in equation 3:

$$WACC = \frac{V_d}{V_d+V_e} * r_d\ (1-T) + \frac{V_e}{V_d+V_e} * r_e \tag{3}$$

where	V_d	value of debt
	r_d	cost of debt
	V_e	value of equity
	r_e	cost of equity
	T	tax rate

The weights assigned to equity and debt measured in market value present their fraction of total capital. If interest rates have remained stable from the time debt was issued, it is reasonable to use book values instead of market values in the value of debt and equity. However, if interest rates have changed, market values can be calculated by discounting the projected future payouts by current market rates applicable to the firm. Value of debt is equivalent to long-term dept in the balance sheet. Operating liabilities such as accounts payable, or accruals are left out of the total debt since those are considered in the free cash flow calculations. The tricky part comes with assigning the value of equity, because it is the value that one is trying to estimate in the first place. One way to estimate the amount of equity is to set a target ratio for debt to capital. Another way to define the amount of equity is simply use book value of equity to determine weights. (Palepu et al. 2000.)

The cost of debt (r_d) in WACC measures the costs of financing its projects using debt. In general terms it is calculated based on three variables. First, is the current level of interest rate, which determines how much the debt costs to the firm. Second, is the default risk of the company, which affect to the interest rates needed to cover the risk of default. Third is the tax benefit of debt. Since interests are tax deductible, tax benefits are calculated into the cost of debt. As a result, when tax rate increases, it makes the after-tax cost of debt lower. (Damodaran 2007, 212.) The cost of debt (r_d) should be calculated net-of-tax which can be done by multiplying cost of debt by one minus the effective tax rate (Palepu et al. 2000). Cost of equity (r_e) can be estimated using capital asset pricing model (CAPM), where cost of equity is expressed equal to the sum of riskless assets yield requirement and a systematic risk premium:

$$r_e = r_f + \beta[E(r_m) - r_f] \tag{4}$$

where		
	r_f	riskless rate
	$E(r_m)$	expected market return
	β	systematic risk (beta)

Riskless rates or risk-free rates are discounts for returns that are certain and unconnected to market returns. Therefore, risk-free returns variance and market covariance are zero. (Vishwanath, 2007, 87.) Applied riskless rates by analysts are often treasury bonds with intermediate term since cash flows that are being discounted are beyond short term. Thus, the risk-free rate is the rate of governments zero-coupon bond that matched with the cash flow horizons being analysed. (Damodaran 2001, 188.) Expected market return can be based on average stock return, for example average of Standard and Poor's 500 index return average. Then expected market return minus riskless rate gives market risk premium, which is multiplied by systematic risk to reflect the sensitivity of market movements to firm's value. (Palepu et al. 2000.)

While riskless rate and market premium are equivalent for all companies, systematic risk or beta is the only connection between market returns and investor's expected returns. Therefore, it is important that the beta estimation is accurate. (Vishwanath 2007, 88.) Kurian (2013) defines beta coefficient as measure of stock's volatility, which indicates associated risk. The CAPM is intended to be forward-looking estimate, but academics often use historical beta as proxy for the future. Standard practise for estimating beta is to regress stock returns against market portfolio returns to plot security characteristics line, which explains relationship between stock returns and market returns. Beta for any individual asset is determined using equation 5:

$$\beta = \frac{COV(R_i, R_m)}{Var(R_m)} \tag{5}$$

where beta (β) is equivalent to excess returns (R_i-R_m) covariance divided be market return's (R_m) variance. There are four factors which effect the estimate of beta. First there is not any specified period which should be used in the estimation of beta. The most used period for beta estimation is five-year data because it provides enough datapoints, and the firm's risk complexion remains comparable. Second issue is starting and ending points of estimation interval, which means that abnormal stock earnings due to seasonality might affect the estimation of beta. Third issue is the used market returns, which vary between different indices and therefore affect the estimation of security characteristic line. Lastly, different return intervals, provide different results for beta. Nevertheless, the most used interval is weekly return. (Vishwanath 2007, 88.)

Although cost of capital is frequently calculated using CAPM, the model is still incomplete. Assuming that stocks are priced effectively, cost of capital should be close to the stock returns in the long run and vary over the systematic risk. However, factors beyond the systematic risk, such as the market capitalization, seem to play a role in the variation of average returns in the long run. Another debate is about used market risk premium. Many analysts think that historical premium is invalid measure of expected risk, because of the changes in the U.S. economy. Since the debate is unresolved, it is important that analyst use a range of risk rates, when measuring firms cost of capital. (Palepu et al. 2000.)

Public traded firms at least in theory should have infinite lives and could possibly keep growing over time. When valuing firms based on cash flows, the infinite cash flows need to be considered with constant growth. (Damodaran 2001, 62.) The present value of future cash flows after the forecast period is called terminal value (Vishwanath 2007, 181). The most consistent and straight forward way to estimate terminal value is to make assumption that the cash flows grow after the terminal year with constant rate. Terminal value with stable growth is estimated as follows in equation 6:

$$Terminal\ value = \frac{FCFF_{t+1}}{Cost\ of\ capital - g_t} \tag{6}$$

where $FCFF_{n+1}$ is free cash flow to firm after terminal year and g_n is constant growth rate after terminal year. Since terminal value represent the remainder of cash flow after the forecast period, analysts must adopt some assumptions that simplifies the process. The estimation of high growth period is one of the biggest challenges in valuations. (Damodaran 2001, 762.) There are three growth patterns for different growth stages. First is a stable growth model, where the growth is assumed stable forever. Second is 2-stage growth model, where first growth is higher and after certain period the growth is reduced to the stable growth level. Third is 3-stage or n-stage model, where the growth is high for certain period and then it slowly reduces to the stable growth level. (Damodaran 2020, 6.) Suitable firms for the stable growth model are large, operate with beta closer to one and are growing at the rate closer to the growth of the economy. Furthermore, firms with stable growth have tendency to use more debt, since their capacity increases. (Damodaran 2001, 762-764.) Suitable firms for 2-stage growth model are large and growing at a moderate growth rate, which is less than 10%. These firms also have some barriers to entry to the industry. Suitable firms for 3-stage or n-stage growth model are small and grow at overall growth rate higher than 10 percent. These firms also have significant barrier to entry and characteristics which differentiate from the norm. (Damodaran, 2020, 6.)

2.1.2 Multiple valuation models

Multiple valuation is based on expectation that identical assets, have identical valuation. Hence, multiple valuation or relative valuation is derived from the value of one or more comparable firms. (Serra & Fávero 2018.) Since multiples are based on peer company valuations, they do not require multiple-year forecast, assumptions, or parameters. Therefore, the primary reason for price multiples valuation popularity is the simplicity. (Palepu et al. 2000; Rossi & Forte 2016, 6.) Damodaran (2007, 776) argues that this is a misconception because assumptions remain implicit in the relative valuation, whereas it is explicit in the cash flow models.

Ideally, multiples are gathered from comparable firms which have similar operating and financial characteristics. Usually, the best candidates for matching metrics are from the same industry. However, on narrow industries it is hard to find comparable firms, especially when many listing firms are operating on multiple industries. In addition, differences in financial strategies and metrics, such as growth orientation and profitability cause issues with comparability. One way of dealing with this problem is to take averages on certain industry and implicitly hope that various noncomparability metrics “cancel out” so the valuated firm is set to perform on industry average. (Palepu et al. 2000.)

Another way to solve the comparability issues is to focus on industry comparables with similar financial characteristics. Further issues might be caused by possible outliers in the multiple averages, which is common especially with cash flow value drivers. Also, firms’ poor performance can be caused by transitory shocks or write-offs, which increase the average benchmark. This firms can be excluded from the peer group or, yearly values can be removed from the method. Lastly, outliers can be avoided by using future values in the denominator instead of past measurements. Forecast based multiples are termed as leading multiples, whereas multiples based on historical value drivers are called trailing multiples. Leading multiples attenuate the one-time gains or losses, simply because such changes in flow measures are hard to anticipate. (Palepu et al. 2000.)

After determining the comparable firms, Palepu et al. (2000) divide the multiple valuation process into three steps:

1. Select a multiple valuation measure for the calculations.
2. Estimate the multiples for comparable firms based on selected measure
3. Apply multiples of to the firm being analysed.

Keun Yoo (2006) presents two types of measures for multiple calculations: simple multiple measure and composite multiples, where simple multiples are combined into one model. Consequently, the simple multiple valuation measures need to be determined first. In simple valuation approach equity value is derived from value driver by multiplying the value driver with corresponding valuation multiple as follows:

$$EV = \frac{P_j}{X_j} * X_i \tag{7}$$

where	EV	Equity Value
	P_j	Comparable price
	X_j	Comparable value driver
	X_i	Value driver of the analysed firm

EV is the estimated equity value, P divided by X is the multiple or benchmark, where comparable firms price is divided by selected value drives. Lastly, the multiple is multiplied with the firm’s value driver. (Keun Yoo 2006, 111) Damodaran (2001, 775) presents three main categories for value drives. First and the most used value driver is earnings. It is intuitive to compare to compare generated earnings to the market capitalization. This price to earnings ratio can be estimated by dividing stock price with the last financial year earnings per share, which is called trailing PE. Alternatively, the value driver can be expected future earnings, which is called forward PE. When the whole firm is acquired, it is common to use operating income or (EBITDA) instead of equity. As an acquirer, the lower the multiple the better, since higher multiples generate higher total values of the companies. (Damodaran 2001, 775-776.)

Where markets provide one estimation of a business, accountants have a different approach to value business, which often provides very different valuations. The most used accounting estimate is price to book (PB) ratio, which is estimated by dividing stock market price with book value. Investors compare the price to the assets or book value they will receive to determine if stock is over- or undervalued. The book value estimates are affected by the growth potential and quality of investments and therefore they can vary widely across industries. Also, since the book value estimate is determined according to accounting rules it is heavily influenced by the rules, such as depreciation methods applied. (Damodaran, 2001, 776.)

Earnings and book values are accounting measures, which are affected by different accounting approaches and principles. To reduce the accounting methods affection, value of an asset can be determined based on its revenues. For equity investors, assets to revenue ratio can be determined by dividing stock price with revenues or sales generated per share and is called price to sales ratio (PS). When buying the whole business, the equity value can be replaced with total value of the firm, forming value to sales ratio (VS). The advantage of using revenue ratios is that its more comparable between industries, using different accounting rules. Still, the ratio varies widely across industries, largely affected by the profit margins in each industry. (Damodaran, 2001, 776.)

Combining the valuation outcomes of multiple simple valuation models into one model, may increase the valuation accuracy compared to the simple valuation models. This is because composite valuation models incorporate incremental information since several accounting values are included into one model. Furthermore, multiples based on historical value drivers and forward value drivers can be combined into one model. (Keun Yoo 2006, 111.) Also, combining multiples does not limit to two models, but numerous multiples can be included into one model. Weighting of each model in the combination can be determined with even distribution or weighted with the models with better valuation accuracy.

3 Research data and methodologies

Research data and methodologies section is divided into four parts. First part, research data, explains data collection principles and factors behind stock selection. Then, technology and industrial samples' financial characteristics, and premises for the valuations are presented. Second part, valuation process, presents how cash flow and multiple models are estimated and which precepts are followed. Third part, portfolio construction, presents what kind of portfolios are built and how the stocks are selected. Lastly portfolio measures, introduces methods which are used to measure portfolios risk-adjusted performance.

3.1 Research data

Research data is divided into technology and industrial sector samples, which both include ten stocks. Financial data and stock screening is mainly based on Refinitiv Eikon database. First criterion in the stock selection process was country of headquarters, which for both samples was United States. Second criterion was economic sector. Sample is divided into technology sector and industrial sector, to test if valuation accuracy changes between different industries and financial characteristics. However, according to Damodaran (2022, n.d.) each grouping is imperfect partly because companies are operating in multiple industries and partly because industries are changing rapidly. Either grouping is too broad and misses differences in key business area or grouping is too specific and it is hard to find reasonable samples. This thesis is done on broader terms and therefore, grouping is based on economic sectors, which are filtered using The Refinitiv Business Classification (TRBC). Then, price to book and price to earnings filters were applied to narrow firms to PB between 0.1 and 20 and PE between 1 and 100. These filters were applied to the overall industry benchmarks, to reduce large outliers. PB is calculated as five-year average and PE according to current share price divided by last twelve months (LTM) earnings per stake from continuing operations. Then firms are arranged from largest to smallest based on market cap. Then the largest companies are validated to the sample once previous requirements are met and companies have been making positive earnings and cash flows at least last five years. Furthermore, at least five analysts need to be following the firms and there need to be at least four-year forward estimates available in Refinitiv Eikon database. Accounting values are captured at the end of each fiscal year, whereas stock prices at the end of each year. Since most of the firms end their fiscal years at the end of the year, an assumption is made that the markets are efficient, and the new information is absorbed into the stock prices immediately.

Technology and industrial samples both include 10 firms, which all are headquartered in United States. These firms are utilized as comparables in the multiple valuation and in DCF models CAPM sensitivity analysis. Firms are selected based on country of headquarters, industry, and size. Appendix 1 and 2 shows samples' more detailed industry breakdown using The Refinitiv Business Classification (TRBC). In technology sample, four firms are operating in semiconductors, two in software and online services, one in communications & networking and one in phones & handle devices. In industrial sample, five out of ten firms are operating in aerospace & defence, two firms in logistics and electrical components and one firm in industrial machinery.

There are several differences in these industries which effect the valuation model selection and accuracy. The most severe difference is that industrial firms typically need to pose large tangible assets, whereas technology firms typically have no real tangible assets. This yields into valuation differences, especially in terms of PB multiple. Industrial business model also yields into higher capital expenditures which affects directly the DCF valuation. Technology sector has been a high growth industry for the past 20 years, which makes it harder to estimate free cash flows compared to stable industrial firms. As the capital is invested in growth, dividends are more rarely paid in technology sector, whereas industrial sector is more mature, and businesses have large barriers to entry, so earnings are returned to the equity investors more often. Furthermore, high growth means higher risks, so the technology sector has been more volatile in general.

Appendix 3 presents financial characteristics of the technology sample. Market caps are ranging from 2,5 trillion to 110 billion, whereas median is 376 billion in USD. Price to book ratios measured as five-year average are ranging from 17.5 to 2.9, while median is at 8.9. Price to earnings, on the other hand, is ranging from 59 to 10 while median is 22. Appendix

5 shows that median beta for technology sector is 1,13 and for the technology comparable firms 1,07. Appendix 4 presents financial characteristics of the industrial sample. Market caps are ranging from 165 billion to 20 billion, whereas median for market cap is 65 billion in USD, which is 5,7 times less than in technology sector comparable. Price to book ratio is ranging from 19,45 to 1,75, while median is 5,31, which is 40% less than comparable median in technology sector. Price to earnings ratio is ranging from 38 to 10, while median is 24 which is 8 percent more than in technology sector. Appendix 5 shows that median beta for industrial sector is 1,17 and for the industrial comparable firms 1,09. As comparison between the two sectors shows, ratios are giving mixed signals about the median valuation.

3.2 Valuation process

This section presents how valuation errors are calculated and which principles are applied in the valuation models. Every company is calculated yearly between 2010-2021 using DCF model and six different multiple models. Further, all models are optimised in sensitivity analysis to see which assumptions provide the best valuation accuracy. Valuations are done at the end of each year and valuations are compared to stocks' market prices at the end of each year. Calculations are performed using Microsoft Excel spreadsheet system. All the estimates are performed using the same valuation principles and formulas in order to maintain comparability. Valuation models are addresses more profoundly in sections 3.2.1 and 3.2.2.

In previous literature, there is no consensus on how to measure and compare valuation errors. Most common way is to use either absolute errors or absolute percentage errors. However, it does not indicate whether the error is due to under- or overvaluation. Kaplan & Ruback (1995, 1070) use log ratios to calculate valuation errors, because it is symmetric with over- and underestimates. An advantage of using percentage errors, is that it can be interpreted to comparing errors in different magnitudes. Meaning that positive and negative valuation errors can be easily compared. Following Liu et al. (2002) and Keun Yoo (2006), valuation errors are calculated as percentage errors, defined as stock price minus valuation estimate deflated by the actual stock price.

$$Valuation\ error = \frac{Stock\ price - Valuation\ estimate}{Stock\ price} \tag{8}$$

Based on equation 8, negative valuation errors mean that the valuation model overestimates the stock price. This can be also seen so that the market has undervalued the stock price. Positive valuation errors indicate that the model overestimates the stock price, respectively. However, percentage errors may give skewed results if they are distributed into under and overvaluation. For example, if the errors were evenly distributed between negative and positive valuation errors, the average percentage error could be 0 even though most estimates are inaccurate. Therefore, valuation errors are also calculated using mean absolute valuation errors (MAVE). Absolute valuation errors are estimated as follows:

$$Absolute\ error = \left| \frac{Stock\ price - Valuation\ estimate}{Stock\ price} \right| \tag{9}$$

Absolute error takes the errors as absolute values, which eliminates the statistical bias caused by positive and negative valuation errors.

3.2.1 Discounted Cash flow

When analysts use discounted cash flow model, free cash flow models are by far the most used model globally. Further, free cash flow to firm is found to be used twice as much as free cash flow to equity. (Pinto et al. 2019, 226, 227.) Since the main objective in this thesis is to find how markets valuate firms, DCF model is estimated using FCFF since this model is the most popular. It also takes better into account the differences in capital structure. FCFF during years 2010-2021 are based on ex-post forward cash flows which are used as proxy for future cash flows, which is considered as rational expectations in the prior literature (Barth, Cram & Nelson 2001, 30; Penman & Sougiannis 1998). This means that the cash flows are not estimates, but actual cash flows calculated from the realized financial statements. Cash flows after 2021 are derived from consensus estimates. FCFF is discounted to present value by using four different beta estimates in WACC. The first beta value is the five-year average of the company's own beta, second is the median of the comparable group, third is the median of the industry and fourth is the market beta. Further sensitivity analysis is also applied to terminal growth rates, to reduce errors in the growth model.

Free cash flows to firm are calculated as presented in Table 1. Earnings before interest and taxes is calculated by taking net income before taxes, adding back non-operating interest expenses, such as interest on debt and bonds, then subtracting any interest capitalized to net income before taxes. Tax provisions are derived directly from annual statements and mean estimates. WACC is estimated each year during the research period using equation 3. Cost of debt is calculated by dividing non-operating interest expenses with total debt. Cost of debt is then amended to after-tax by multiplying it with one minus tax-rate. Further, tax-rate is calculated by dividing income tax provision, with net income after tax. Cost of equity is calculated using CAPM, which is the most used model among 13,500 investment analysts according to Pinto et al. (2019). CAPM is calculated using equation 4 where yearly risk-free rates are based on 10-year U.S. treasury bond rates. T-bonds are used because all firms are headquartered in United States and 10-year T-bond is common risk-free rate for cost of equity calculations. Most used estimate among analysts for equity risk premium is historical equity risk premium. (Pinto et al. 2019, 226.) Therefore, market risk premiums are calculated as difference between S&P 500 returns and 10-year treasury bonds returns.

Beta estimates are derived from Eikon database where they are calculated as 5-year monthly average. This is calculated in the database using minimum of 40 monthly price close changes in the 5-year period to estimate least squares linear regression line. As discussed in theoretical framework, beta can be estimated in many ways and the value of capital can differ among different models. Therefore, CAPM is calculated using firms’ own beta, comparable firm median beta, economic sector median beta, and overall market beta. Appendix 5 presents these different in previously mentioned estimates. Weights for the equity and debt are calculated by dividing each of them with total value. Total value is estimated by adding book value of total debt to the market value of equity. Equity market value is the stock price at the end of each, multiplied by number of common shares outstanding which is derived from last annual report.

According to Damodaran (2007) terminal value should calculated using stable-growth rates, when the firm is considered mature, large cap firm, with beta closer to one. Since sample firms are large cap and median betas for technology and industrial samples are 1,07 and 1.09, it is safe to say that the risks based on price volatility are relatively low and sample data meets stable-growth conditions. However, median growth in 2010-2021 market caps for technology sample data is 26 percent and for industrial peers' 18 percent. This is considerably higher than median market growth, which is 13 percent, measured from Standard and Poor's 500 index returns. This would suggest the usage of Damodaran's (2007) 2-stage or 3-stage models, but there are several issues with these methods. All the firms are valuated 12 times during years 2010 and 2021, so it would be extremely time consuming to estimate high growth period for each valuation. Also, applied growth rates have large impact on the firm's valuation and therefore, it would decrease the comparability. Due to these reasons terminal growth rates are estimated using stable growth rates for all the firms. To decrease the estimation errors due to applied growth rates, sample data is estimated using 2%, 2.5% and 3% terminal growth rates.

3.2.2 Multiple valuation

Multiple analysis is conducted using price to earnings multiples, price to book multiples and a combination of PE and PB. PE and PB models are selected, because in valuation literacy PE and PB are the most used multiples. Thus, it is reasonable to measure and compare models which are the most used in the markets. In recent literacy, combination of simple multiples has increased its popularity and provided promising results. Therefore, the composite model of PE and PB is selected as third model. These models are derived from multiple benchmarks which are defined according to Cheng and McNamara (2000, 352) as:

$$\overline{PE_{\imath t}} = median_{jt}\{\frac{P_{jt}}{E_{jt}}\} \tag{10}$$

$$\overline{PB_{\iota t}} = median_{jt}\{\frac{P_{jt}}{B_{jt}}\} \tag{11}$$

where $\overline{PE_{\iota t}}$ is the benchmark for PE multiples and $\overline{PB_{\iota t}}$ is the PB multiples benchmark at time t for target firm i. Further, benchmarks are medians of sample's all firms j at time t. P_{jt} is represents firm's price at time t, E_{jt}, stands for firm's earnings at time t and B_{jt} for firm's book value at time t. It is important to note that, only comparable benchmarks are estimated using previously mentioned equation, since industry and market benchmarks are gathered from Refinitiv database. After the estimation of benchmarks, PE and PB models can be derived from equations 10 and 11 as:

$$EV^{PE} = \overline{PE}_{it} * E_{it} \tag{12}$$

$$EV^{PB} = \overline{PB}_{it} * B_{it} \tag{13}$$

where EV^{PE} is equity value based on PE multiple valuation and EV^{PB} is equity value based on PB multiple. Equity value is calculated by multiplying value driver E_{it} or B_{it} with the corresponding benchmark. Earnings value driver E_{it} is estimated in four different ways. In the most common form, PE models' earnings are gathered from previous fiscal year's actual earnings. However, multiple studies have indicated that PE multiple model's accuracy increases when applied earnings are forward earnings. Therefore, this study measures three different models using one to three years ex-post forward earnings. Lastly, the composite model PE-PB, presented in equation 14 is derived from the simple multiples in equations 12 and 13:

$$EV^{PE,PB} = \frac{(E_{it}*\overline{PE}+B_{it}*\overline{PB})}{2} \tag{14}$$

where EV stands for equity valuation for composite model PE-PB. The model is weighted using equal distribution between the models which is calculated by adding PE valuation to PB valuation and dividing the sum by two. In simple terms, this composite model provides an average of PE and PB models equity valuation.

3.3 Portfolio construction

Valuation accuracy is turned into stock screening strategy to determine undervalued stocks. Seven portfolios are constructed based on each valuation models screening of undervalued stocks. This means that based on DCF model's cost of equity and perpetual growth rate sensitivity analysis, the most accurate assumptions are used in the DCF stock screening. The same procedure is adjusted to multiple model portfolios. Each multiple model's accuracy is optimised in sensitivity analysis. Then the most accurate benchmarks are used to determine the undervalued stocks in the screening.

The sample of 20 technology and industrial sector firms are first sorted into ascending order and then divided into quartiles based on the pricing errors determined by each valuation model. The portfolios are constructed on the lowest quartiles, where the underpricing indicated by the valuation models are largest. Lowest quartiles are used, because the highest return potential is for stocks with largest negative percentage error. This is because valuation errors are calculated by deducting the target price from the actual stock price and then deflating that with the actual stock price. Since the whole sample is 20 firms and the portfolios constructed on the lowest quartiles, the portfolio size is five to six firms. Portfolios are updated at the beginning of each year, so that the portfolio always consists of the stocks with biggest profit margins.

3.4 Measures of portfolio performance

This sub-chapter presents portfolio performance metrics which are used to analyse portfolios' risk-adjusted returns. According to Brentani (2004) measuring risk associated with portfolio measurement is one of the most important aspects in portfolio performance analysis. Performance evaluation involves comparing portfolio performance to certain yardstick after adjusting the risks. Evaluation enables the investors to see how risks are managed compared to returns and how well the investment strategy works. (Brentani 2004, 33, 42.) Each portfolios' performance is compared to the overall 20-firm sample to identify if used models can increase risk-adjusted returns. Against normal principles, returns are not compared to the actual market performance, for instance S&P 500 returns, because it would not be relevant since the data is only from technology and industrial sectors. Also, sample's average return is well above market returns, which makes it even harder to compare portfolio performance to market returns. Returns are calculated yearly between 2010 and 2021 and the results are presented as an average of the 11-year returns. Risk-adjusted measures are calculated using Sharpe ratio, Treynor ratio and Jensen Alpha. Used volatility and return measures in the models are averages from the research period.

3.4.1 Sharpe ratio

Reward to variability ratio or latter named Sharpe ratio, is used to measure risk-adjusted portfolio returns. The model measures portfolio's unsystematic risk per unit, by deflating portfolios excess returns, with its volatility (Sharpe 1995). Excess returns are calculated by deducting risk free returns from portfolio returns (Kallunki, Martikainen & Niemelä 2019.). The Sharpe ratio results are considered good when the ratio is above one, because the portfolio is creating good returns compared to the volatility (Ianthe 2005). In principle. the higher the value the better, since risk gets smaller compared to returns (Brentani 2004, 43). Sharpe ratio is defined as follows:

$$Si = \frac{R_i - R_f}{\sigma} \tag{15}$$

where	R_i	portfolio rate of return
	R_f	risk free return
	σ	the standard deviation of returns

In the equation 15 numerator, portfolios' rate of return R_i is deducted by its risk-free rate, which in this research is one-year U.S treasury bill rate. Then the excess return is divided by standard deviation of returns or in other words volatility. Hence, the ratio obtained tells the excess return adjusted by its risks. Since standard deviation represents total risk, the model is more suitable for less diversified portfolios. (Brentani 2004, 43.)

3.4.2 Treynor ratio

Treynor (1965) introduced ratio, where excess returns are deflated by beta multiplier or systematic risk. Treynor ratio differs from Sharpe ratio with its risk variable, where the beta multiplier describes the portfolios market risk (Kallunki et al. 2019). Thus, it represents abnormal returns per unit of systematic risk (Hubner 2005, 418). Treynor ratio is estimated as follows:

$$T_i = \frac{R_i - R_f}{\beta_i} \tag{16}$$

where R_i portfolio rate of return

R_f risk free return

β_i portfolio beta

Equation 16 presents the calculation of Treynor index, where first excess returns are calculated from portfolio returns (R_i) and risk-free return (R_f) similarly to Sharpe ratio. Then, excess returns are deflated by the systematic risk, portfolio beta. Treynor is usually better for highly diversified portfolios because the model ignores unsystematic risk. This is based on assumption that unsystematic risk disappears when the portfolio is well diversified. (Brentani 2004, 43.)

3.4.3 Jensen alpha

Jensen ratio calculates portfolio’s excess return which it generates over the market model’s systematic risk. CAPM can be used to compare benchmark returns and portfolio returns achieved by portfolio manager. (Brentani 2004, 43.) Jensen (1968, 390) presents the model as follows:

$$\alpha_i = R_i - R_f - \beta_i(R_m - R_f) \tag{17}$$

where	R_i	portfolio rate of return
	R_f	risk free rate
	β_i	portfolio beta
	R_m	market return

Equation 17 implies that the expected return of investment is equal to risk-free rate and systematic risk multiplied by the risk premium of market portfolio. Thus, the ratio simply tells, what the portfolio is expected to return given its systematic risk. (Jensen 1968, 391.)

4 Results

Results are presented in four parts. First two sub-sections present valuation accuracy results for DCF and multiple models. Then, seven portfolios are constructed and measured, which are presented in sub-sections 3 and 4.

4.1 Discounted cash flow model valuation accuracy

Summary statistics for DCF model using different assumptions are presented in Tables 2 and 3. Errors are calculated as shown in Equation 8. and presented as median errors. This means that negative values indicate overvaluation and positive values indicate undervaluation compared to the market price. MAVE column shows mean absolute valuation errors, where the statistical bias from percentage errors is removed. Errors' deviations are presented as standard deviation (STD), interquartile range (IQR), 25% quartile (Q1) and percentage of valuation errors within 15% (15% error). Q1 shows an average of the quartile with largest overvaluation by the model. DCF is calculated using firm beta, comparable average beta, industry median, and market median beta in WACC. Overall is an average of previously mentioned. Further, DCF errors are presented using three different terminal growth rates.

Table 2. Discounted cash flow – summary statistics for technology sector valuation errors

Terminal growth 2%	**Beta**	**Median**	**MAVE**	**STD**	**IQR**	**Q1**	**15% error**
DCF	Firm	-54 %	82 %	91 %	111 %	-102 %	13 %
	Comparable	-44 %	69 %	80 %	95 %	-85 %	24 %
	Industry	-27 %	56 %	73 %	82 %	-65 %	18 %
	Market	-57 %	81 %	88 %	106 %	-103 %	19 %
	Overal	-46 %	72 %	84 %	98 %	-90 %	19 %
Terminal growth 2,5%	**Beta**	**Median**	**MAVE**	**STD**	**IQR**	**Q1**	**15% error**
DCF	Firm	-65 %	92 %	101 %	118 %	-116 %	13 %
	Comparable	-55 %	77 %	84 %	103 %	-100 %	21 %
	Industry	-33 %	60 %	75 %	89 %	-72 %	22 %
	Market	-71 %	92 %	92 %	109 %	-119 %	17 %
	Overal	-55 %	80 %	89 %	108 %	-104 %	18 %
Terminal growth 3%	**Beta**	**Median**	**MAVE**	**STD**	**IQR**	**Q1**	**15% error**
DCF	Firm	-80 %	108 %	119 %	126 %	-137 %	11 %
	Comparable	-68 %	87 %	88 %	108 %	-112 %	18 %
	Industry	-41 %	66 %	77 %	96 %	-83 %	25 %
	Market	-87 %	106 %	97 %	118 %	-138 %	9 %
	Overal	-69 %	91 %	98 %	114 %	-118 %	16 %

Table 3. Discounted cash flow – summary statistics for industrial sector valuation errors

Terminal growth 2%	Beta	Median	MAVE	STD	IQR	Q1	15 % error
DCF	Firm	-23 %	75 %	103 %	101 %	-88 %	22 %
	Comparable	-30 %	59 %	73 %	83 %	-80 %	23 %
	Industry	-21 %	52 %	68 %	75 %	-66 %	24 %
	Market	-43 %	70 %	80 %	93 %	-98 %	19 %
	Overal	-28 %	64 %	82 %	88 %	-103 %	22 %
Terminal growth 2,5%	**Beta**	**Median**	**MAVE**	**STD**	**IQR**	**Q1**	**15 % error**
DCF	Firm	-35 %	90 %	121 %	120 %	-114 %	19 %
	Comparable	-44 %	71 %	82 %	96 %	-101 %	20 %
	Industry	-32 %	61 %	75 %	87 %	-85 %	23 %
	Market	-59 %	85 %	90 %	103 %	-121 %	13 %
	Overal	-39 %	77 %	94 %	100 %	-103 %	19 %
Terminal growth 3%	**Beta**	**Median**	**MAVE**	**STD**	**IQR**	**Q1**	**15 % error**
DCF	Firm	-51 %	112 %	151 %	148 %	-152 %	15 %
	Comparable	-60 %	87 %	93 %	108 %	-125 %	14 %
	Industry	-45 %	74 %	85 %	99 %	-106 %	21 %
	Market	-75 %	106 %	104 %	119 %	-152 %	12 %
	Overal	-56 %	94 %	112 %	116 %	-129 %	15 %

Table 2 and 3 median errors show that DCF model overestimates market prices with all assumptions. Lowest median and MAVE errors for both samples are calculated using 2% terminal growth rates. In contrary to Kaplan & Ruback (1995) and Berkman et al. (2000), DCF model based on industry betas yields to lowest median and MAVE errors compared to market beta, comparable beta, and firm beta models. Further, standard deviation and interquartile range increase when firm and market betas are applied, which is also in contrast to previous research. Median error for industry-based model using 2% terminal growth rate is -27% for technology sample and -21% for industrial sample. As expected, DCF model's accuracy is found to be better in stable cash flow industrial sector compared to fast-growth technology sector. Errors deviation measured with standard deviation and interquartile range are in technology sector industry-based model 73% and 82%, whereas in industrial sector 68% and 75%. These results are considerably higher than Berkman (2000, 78) results. Also, almost 50% less DCF errors are found within 15% error compared to Berkman et al. (2000) research. However, this can be also seen as positive thing if DCF model can be used to verify undervalued stocks in portfolio analysis. Column Q1 show the quartile with largest overvaluation in each model, which indicates that market has potentially undervalued the stock.

4.2 Multiple models’ valuation accuracy

Multiple models’ valuation accuracy in Table 4 is presented with the same metrics as in the DCF model tables. All models, PE, PB, PE-PB and forward PE models are estimated based on different benchmarks: comparable, industry, and market benchmarks. Overall performance is an average from previously mentioned models’ errors. Comparable benchmarks are averages from ten sector comparable firms presented in appendix 1 and 3. Industry benchmark is an average of 235 largest technology firms and 300 largest industrial firms operating in the U.S, which were accepted in the previously presented selection. Market benchmark is S&P 500 median, gathered from Eikon database.

Table 4. Multiple model - valuation accuracy technology and industrial sector

Multiple model	Benchmark	Median	MAVE	STD	IQR	Q1	15% error
P/E	comparable	4 %	35 %	50 %	53 %	-22 %	31 %
	industry	-18 %	47 %	64 %	64 %	-49 %	25 %
	market	-11 %	44 %	60 %	60 %	-45 %	22 %
	Overal	-7 %	42 %	59 %	62 %	-40 %	26 %
P/B	comparable	0 %	40 %	61 %	65 %	-40 %	31 %
	industry	-73 %	102 %	110 %	116 %	-143 %	13 %
	market	-61 %	96 %	91 %	100 %	-122 %	14 %
	Overal	-41 %	80 %	102 %	113 %	-106 %	20 %
P/E - P/B	comparable	2 %	34 %	48 %	50 %	-26 %	32 %
	industry	-41 %	68 %	77 %	82 %	-91 %	15 %
	market	-35 %	64 %	64 %	76 %	-81 %	20 %
	Overal	-24 %	55 %	70 %	82 %	-71 %	22 %
PE 1 yr forward earnings	comparable	-5 %	35 %	51 %	52 %	-29 %	33 %
	industry	-27 %	52 %	69 %	70 %	-65 %	22 %
	market	-21 %	48 %	64 %	61 %	-55 %	22 %
	Overal	-17 %	45 %	63 %	61 %	-51 %	25 %
PE 2 yr forward earnings	comparable	-17 %	39 %	52 %	52 %	-40 %	25 %
	industry	-38 %	61 %	67 %	77 %	-83 %	18 %
	market	-35 %	56 %	64 %	66 %	-72 %	17 %
	Overal	-30 %	52 %	62 %	67 %	-66 %	20 %
PE 3 yr forward earnings	comparable	-30 %	48 %	56 %	59 %	-62 %	22 %
	industry	-59 %	75 %	71 %	80 %	-102 %	10 %
	market	-54 %	69 %	68 %	72 %	-93 %	13 %
	Overal	-46 %	64 %	67 %	73 %	-88 %	15 %

Results indicate that trailing PE model outperforms all the other models in overall performance. The finding that PE outperforms PB in accuracy is in line with previous studies. However, the finding that PE also outperforms PE-PB is contrast with Cheng &

McNamara (2000) empirical findings. This can be explained with industrial sample's low PB ratios, which results in large overvaluation when industry and market comparables were applied. PE model also outperforms forward PE models in overall accuracy, which is in contrast with previous literature, where forward earnings have outperformed historical earnings. This can be explained with sample firms' stable earnings. All models provided the best accuracy when comparable benchmarks were applied. The errors differences between models are insignificantly when comparable multiples are applied, since all models MAVE is found to be between 34% and 48%. Therefore, the superiority of neither model cannot be unequivocally proven. This finding shows that the determination of comparable peers is important, since the valuation errors are substantially lower with comparable benchmarks compared to models utilizing industry and market benchmarks. Further, industry-based models outperform market-based models, which is in contrast with Berkman et al. (2000) findings. Deviations between models are similar, except with PB model. PB and forward PE models are found to have larger valuation errors in the Q1, which means that the models indicate larger overvaluation than the trailing PE and PE-PB model.

4.3 Accuracy comparison

Comparison between DCF and multiple models in tables 2-4 suggest that multiple models outperform DCF model in valuation accuracy. From best to worst, the ranking in overall performance measured with MAVE is following: trailing PE (42%), One-year forward PE (45%), two-year forward PE (52%), PE-PB (55%), three-year forward PE (64%), DCF with 2% growth rate (68%) and PB (80%). DCF model's underperformance compared to PE model is in contrast with Kaplan & Ruback (1995) and Berkman et al. (2002) results who presented relatively similar accuracy for DCF and multiple model accuracy in their empirical research. One explanation behind this is that research is delimitated to mature, large cap companies with relatively stable cash flows, whereas Kaplan & Ruback (1995) and Berkman et al. (2000) evaluated IPOs. Further Berkman et al. (2000) research was done in narrow markets, which was lacking industry comparable firms. However, the finding that PE model is more accurate than DCF model is in line with Asquith et al. (2005), Demirakos et al. (2010) and Sayed (2017) who evaluated models accuracy based on equity reports. Another resemblance to previous research is that the DCF model tends to overvalue the market prices.

This can be also explained with the sample, since all the models are found to overvaluate the market prices, indicating possible investment opportunities. Largest overvaluation is found with forward looking models such as DCF and forward PE models. In addition, PB multiple presents high overvaluation which is due to industrial sample's capital structure.

Deviation measures advocate the findings that PE model outperforms the other models. In overall performance trailing PE model has 59% standard deviation and 62% interquartile range. DCF model errors yield to higher deviation, with smallest standard deviation being 73% in technology sector and 68% in industrial sector. This was expected since DCF model is so sensitive to different assumptions. DCF models quartile with highest undervaluation yielded -66% error, whereas trailing multiples around -20% when comparable benchmarks were applied. Higher deviation is due to sensitivity of the model's assumption and challenges in multiperiod forecasts. The sensitivity can be also utilized to determine over or undervalued stocks. Based on percentage within 15% error, there is also substantial difference in DCF model and multiple model accuracy, when multiples are measured based on comparable benchmarks. The percentage of results within 15% pricing error is highest with trailing PE when measured with overall performance. However, when multiples are measured with comparable companies the percentage within 15% error is around 30% for all multiple models. DCF model has around 20% of valuation errors within 15% error. In comparison to Kaplan & Ruback (1995) and Berkman et al. (2000), errors deviations are relatively larger, especially with DCF model.

4.4 Portfolio performance

The most accurate valuation models based on tables 2-4 results were chosen to be used in stock screening model. The best accuracy for DCF model was captured using 2% terminal growth rate and industry betas for both technology and industrial sectors. Thus, the DCF model used to determine undervalued stocks to the portfolio is industry-based. Multiple models resulted coherent results for both technology and industrial sectors and therefore, all multiple models used in the stock screening are based on comparable benchmarks. Table 5 presents each portfolios annualized average gross return, standard deviation (STD), Sharpe ratio (Sharpe), Treynor ratio (Treynor) and Jensen alpha (Jensen). First three rows present annualized average returns for the whole sample and technology and industrial sector separately. These portfolios are used as benchmarks in comparison to DCF, PE, PB, PE-PB and forward PE portfolios.

Table 5. Portfolio performance

Portfolio	Return	STD	Beta	Sharpe	Treynor	Jensen
Sample	20 %	33 %	1,11	57 %	17 %	14 %
Technology sector	23 %	38 %	1,10	60 %	21 %	17 %
Industrial sector	16 %	27 %	1,13	56 %	14 %	10 %
DCF (industry)	32 %	40 %	1,21	79 %	26 %	26 %
PE (comparable)	15 %	26 %	1,09	53 %	13 %	9 %
PB (comparable)	14 %	24 %	1,09	56 %	12 %	8 %
PE-PB (comparable)	15 %	24 %	1,09	57 %	13 %	9 %
PE 1 yr forward earnings	20 %	35 %	1,09	54 %	17 %	14 %
PE 2 yr forward earnings	22 %	39 %	1,09	54 %	19 %	16 %
PE 3 yr forward earnings	24 %	42 %	1,09	56 %	22 %	18 %

Results show that DCF model and three-year forward PE model were the only portfolios that outperformed technology sector sample. Trailing multiple portfolios on the other hand yielded into lower returns compared to the sample. DCF portfolio yielded into 32% yearly average gross returns and three-year forward PE 24%, whereas overall sample averaged 20% return during 2010-2021. In risk-adjusted returns DCF portfolio clearly outperforms the sample, whereas forward PE model does not. Results indicate, that DCF model can be used to increase portfolio returns, since its returns and risk-adjusted returns were higher compared to the sample. However, risk-adjusted returns are still not considered good based on Jeanne Dugan (2005) guideline, since Sharpe ratio is under 100%. This on the other hand can be explained with lack of diversification in the portfolio, since all the firms are from two sectors. The most interesting finding is that even tough DCF model generated largest valuation errors, it presents best performance in the portfolio measurement. This finding supports Mittermayer (2004) finding that markets are not efficient, since DCF model can be used to find undervalued stocks. Therefore, DCF model's inaccuracy is also justified. Multiple based portfolios on the other hand presented better valuation accuracy but underperformed compared to the sample. This finding supports Rossi & Forte (2016) finding about this inverted relationship where forward looking models outperform models based on historical data.

The only requirement in the portfolio construction was that selected stocks needed to have high undervaluation. Since there were no other requirements, it is important to investigate how evenly the portfolios are distributed among the technology and industrial sectors. Portfolios weights are presented in Table 6.

Table 6. Portfolio weights

Portfolio Weights	Technology	Industrial
DCF (industry)	38 %	62 %
PE (comparable)	52 %	48 %
PB (comparable)	58 %	42 %
PE-PB (comparable)	55 %	45 %
PE 1 yr forward earnings	52 %	48 %
PE 2 yr forward earnings	50 %	50 %
PE 3 yr forward earnings	50 %	50 %

Table 6. shows that DCF model found more undervalued stocks from industrial sector than technology sector. DCF portfolios constructed by 62% industrial firms and 38% technology sector firms. In contrary, multiples models found larger profit margins from technology compared to industrial sector. Biggest difference to DCF models weighting was in PB portfolios where the weights were 58% for technology and 42% for industrial sector firms. This finding is interesting, because DCF portfolio outperformed all multiple portfolios even though it was weighted by industrial sector stocks, which had lower average return compared to technology sector average return in Table 5.

5 Conclusions

Valuation is affecting everyday business life and yet, empirical research into valuation models' accuracy has not reached deserved attention. Especially empirical research into more profound models, such as discounted cash flow models' accuracy is quite spotty. Therefore, the main objective in this thesis was to find which valuation model provides the best valuation accuracy. Consequently, the main research question is: "*Which valuation model is the most accurate in technology and industrial sectors?".* To answer this, thesis examines DCF and multiple models' valuation accuracy in U.S technology and industrial sectors between 2010-2021. The study covers a total of 1700 valuation estimates from the 20-firm sample during the period. In prior literature multiple models have provided great accuracy in valuations, but still there is debate which value drivers should be used. Therefore, thesis seeks a confirmation to previous studies by comparing multiple models' valuation errors with second research question: "*Among multiple models, which model provides the best valuation accuracy?*". Used multiple models are trailing PE, PB, PE-PB and one-to-three year ex-post forward PE models. In previous literacy the perspective has remained only at the level of pricing error. In this study the perspective is broadened to examine if valuation accuracy can be utilized to increase risk-adjusted portfolio returns. Based on this objective the third research question is: "*Can valuation accuracy screening model increase portfolio returns?".* To answer this, the most undervalued stocks were selected into seven different portfolios. Then, performance of each portfolio was compared using Sharpe ratio, Treynor ratio and Jensen alpha.

Answer to the first research question is that PE model provides the best valuation accuracy in U.S technology and industrial sectors during 2010-2021. However, results are not unambiguous since all multiple models provided similar accuracy when the models were calculated using comparable benchmarks. All multiple models provided better accuracy than DCF model when comparable benchmarks were applied. In overall performance the ranking from best to worst measured with MAVE is following: trailing PE (42%), One-year forward PE (45%), two-year forward PE (52%), PE-PB (55%), three-year forward PE (64%), DCF with 2% growth rate (68%) and PB (80%). When the quartiles with the highest overvaluation are compared, results show that DCF, forward PE and PB model yield into larger overvaluation. However, this can be seen as an advantage if the models can be used to recognize undervalued stocks which will later recover to their true value.

In comparison to previous empirical research, DCF valuation underperformed compared to multiple models in valuation accuracy. Kaplan & Ruback (1995) and Berkman et al. (2000) found that DCF and PE multiple models had similar valuation accuracy in IPOs. However, PE model's outperformance compared to DCF model is in line with several equity report studies. PE models' outperformance compared to PB model was in line with previous literature, whereas comparison to PE-PB was slightly different from Cheng & McNamara (2000) findings. Furthermore, trailing PE outperformed forward PE models in valuation accuracy, which is in contrast to previous studies.

The most accurate valuation models were utilized in a stock screening model to select the most undervalued stocks to construct seven different portfolios. DCF screening model used 2% terminal growth rate and industry beta, whereas multiple models utilized comparable benchmarks to determine the undervalued stocks. Results show that valuation accuracy and portfolio returns have inverted relationship, since DCF and three-year forward PE portfolio yielded into highest returns even though they were found inaccurate. Previously mentioned portfolios also gained higher risk-adjusted returns compared to the benchmark sample. Therefore, only DCF and forward PE models can be used to increase portfolio returns, whereas PB, PE-PB and trailing PE cannot. These results support Rossi & Forte (2016) findings that models with worst valuation accuracy can be used to increase portfolio returns. Alternatively, largest valuation errors can be seen as market mispricing which would explain the increased portfolio returns. This finding supports Mittermayer (2004) finding that markets are not efficient, since models can be used to find undervalued stocks. Furthermore, results, indicate that models based on future cash flows offer better portfolio returns compared to trailing models

There are several limitations associated with this study, especially with the DCF model. DCF requires several assumptions and a lot of financial data which results to limitations. To maintain comparability in the DCF model the calculations are made following the same formula for every company. This can cause calculation errors since DCF models should be optimized for each firm’s characteristics. Due to data issues, DCF models are also calculated using ex-post forward data as a proxy for forward estimates. This further causes calculation errors because stock prices, at least in theory, should reflect all the information available at the time. The sample size is also relatively small, due to data requirements and time consumption of the DCF model. Smaller sample size further decreases results reliability and generalizability. Furthermore, the study is limited to only one DCF model and three multiple valuation models. Therefore, a broader analysis on different valuation models would give a better view of the methods available.

For future research, thesis limitations provide a demand for more comprehensive research. Moreover, the importance of valuation in general sense has not received enough attention. Especially, empirical research into DCF model’s valuation accuracy and stock screening capabilities is incomplete. Similar research with larger sample size would enhance the results reliability. In addition, statical measures could be broadened to increase reliability. Further, an empirical analysis on how firms’ size, maturity and industry affect the valuation accuracy would be important. Moreover, research could be extended to measure whether valuation errors were caused by cash flow forecast errors, applied discount rates or some other factors.

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Appendices

Appendix 1. Technology sector sample

Company Name	Country of Headquarters	TRBC Economic Sector Name	TRBC Industry Name
Apple Inc	United States of America	Technology	Phones & Handheld Devices
Microsoft Corp	United States of America	Technology	Software
Alphabet Inc	United States of America	Technology	Online Services
NVIDIA Corp	United States of America	Technology	Semiconductors
Meta Platforms Inc	United States of America	Technology	Online Services
Cisco Systems Inc	United States of America	Technology	Communications & Networking
Adobe Inc	United States of America	Technology	Software
Intel Corp	United States of America	Technology	Semiconductors
Texas Instruments Inc	United States of America	Technology	Semiconductors
Applied Materials Inc	United States of America	Technology	Semiconductor Equipment & Testing

Appendix 2. Industrial sector sample

Company Name	Country of Headquarters	TRBC Economic Sector Name	TRBC Industry Name
Union Pacific Corp	United States of America	Industrials	Ground Freight & Logistics
Raytheon Technologies Corp	United States of America	Industrials	Aerospace & Defense
Lockheed Martin Corp	United States of America	Industrials	Aerospace & Defense
Northrop Grumman Corp	United States of America	Industrials	Aerospace & Defense
General Dynamics Corp	United States of America	Industrials	Aerospace & Defense
Norfolk Southern Corp	United States of America	Industrials	Ground Freight & Logistics
L3harris Technologies Inc	United States of America	Industrials	Aerospace & Defense
Parker-Hannifin Corp	United States of America	Industrials	Industrial Machinery & Equipment
Rockwell Automation Inc	United States of America	Industrials	Electrical Components & Equipment
Generac Holdings Inc	United States of America	Industrials	Electrical Components & Equipment

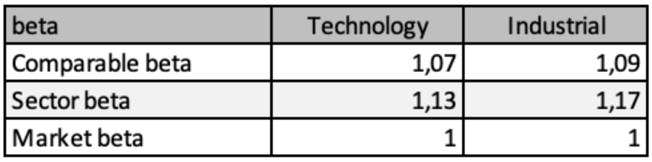
Appendix 3. Technology sector financials overview

Company Name	Company Market Cap (USD, Millions)	Price to Book 5 YR Avg	P/E (Daily Time Series Ratio)	Beta 5 Year	Number of Analysts (FY1)	Total Assets, Reported (FY0, USD, Millions)	Revenue (LTM, USD, Millions)	Capital Expenditures - Actual (FY0, USD)	Asset Turnover (FY0)
Apple Inc	$2 586 958	16,80	26,32	1,20	43	$351 002	$378 323	$11 085	1,08
Microsoft Corp	$2 141 030	11,07	30,38	0,92	44	$333 779	$184 903	$20 622	0,53
Alphabet Inc	$1 752 236	5,13	23,60	1,06	50	$359 268	$257 637	$24 640	0,76
NVIDIA Corp	$566 450	17,48	58,93	1,43	46	$44 187	$26 914	$976	0,74
Meta Platforms Inc	$531 350	6,45	14,16	1,40	58	$165 987	$117 929	$18 567	0,73
Cisco Systems Inc	$227 274	4,77	19,57	0,95	30	$97 497	$51 549	$692	0,52
Adobe Inc	$207 052	14,84	43,83	1,08	31	$27 241	$15 785	$348	0,61
Intel Corp	$189 952	2,93	9,60	0,55	45	$168 406	$74 718	$18 733	0,49
Texas Instruments Inc	$159 542	12,49	20,90	0,93	33	$24 676	$18 344	$2 462	0,83
Applied Materials Inc	$110 397	6,78	17,38	1,43	34	$25 825	$24 172	$668	0,96
Median	$379 312	8,93	22,25	1,07	44	$131 742	$63 134	$6 774	0,73
Average	$847 224	9,88	26,47	1,10	41	$159 787	$115 027	$9 879	0,72

Appendix 4. Industrial sector financials overview

Company Name	Company Market Cap (USD, Millions)	Price to Book 5 YR Avg	P/E (Daily Time Series Ratio)	Beta 5 Year	Number of Analysts (FY1)	Total Assets, Reported (FY0, USD, Millions)	Revenue (LTM, USD, Millions)	Capital Expenditures - Actual (FY0, USD, Millions)	Asset Turnover (FY0)
Union Pacific Corp	$165 371	6,60	26,05	1,14	31	$63 525	$21 804	$2 936	0,35
Raytheon Technologies Corp	$147 010	1,75	38,24	1,35	23	$161 404	$64 388	$2 134	0,40
Lockheed Martin Corp	$121 011	14,81	19,52	0,78	20	$50 873	$67 044	$1 522	1,32
Northrop Grumman Corp	$69 404	6,36	10,20	0,74	21	$42 579	$35 667	$1 415	0,82
General Dynamics Corp	$65 403	4,17	20,39	0,98	20	$50 073	$38 469	$887	0,76
Norfolk Southern Corp	$64 704	3,36	22,26	1,35	28	$38 493	$11 142	$1 470	0,29
L3harris Technologies Inc	$49 039	3,97	27,92	0,77	22	$34 709	$17 814	$335	0,50
Parker-Hannifin Corp	$35 412	4,26	19,90	1,68	20	$20 341	$15 293	$210	0,71
Rockwell Automation Inc	$30 507	19,45	30,62	1,43	27	$10 702	$7 289	$120	0,78
Generac Holdings Inc	$19 340	8,17	35,39	1,04	22	$4 878	$3 737	$110	0,92
Median	$65 054	5,31	24,16	1,09	22	$40 536	$19 809	$1 151	0,74
Average	$76 720	7,29	25,05	1,13	23	$47 758	$28 265	$1 114	0,68

Appendix 5. Comparable, sector and market beta



beta	Technology	Industrial
Comparable beta	1,07	1,09
Sector beta	1,13	1,17
Market beta	1	1