2 Literature Review

The literature review focuses on the connection between accounting numbers and equity value. The focus is on three flow-based models (FBMs) and the multiples model (MBM), where the empirical evidence for the application of these valuation models lies. Additionally, the paper examines which models are considered to be effective in the literature and which limitations and difficulties exist. Finally, four hypotheses based on the findings are presented.

2.1 The Principles of Equity Valuation

Lee (1999) describes valuation as a process that is both an art and a science. Fernández (2005) contradicts and argues that valuation is not a scientific fact, but the expression of an opinion, based on expectations.

Firms can either be valued at enterprise value, considering both equity and debt or at equity value, which is attributable solely to shareholders (Damodaran, 2006). While the structure of the discounted dividend model (DDM) and residual income valuation model (RIVM) directly values equity, two approaches can be used for the discounted cash flow model (DCFM) and the multiples model (MBV). The equity value can be determined directly or via the enterprise value from which the net debt is deducted, as the latter is not attributable to shareholders.

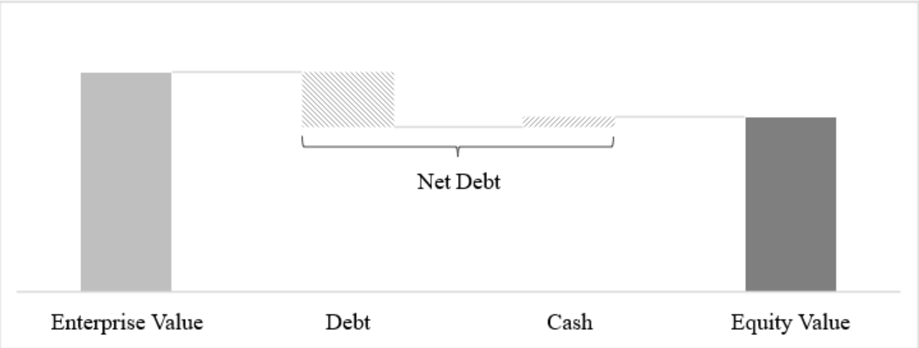

Figure 1- Calculation of Equity Value based on Enterprise Value (Damodaran, 2006)

Although both valuation types should result in the same equity value, Schreiner and Spremann (2007) and Fernández (2005) state that direct valuation methods provide more accurate estimates. One reason for this may be that no net debt component needs to be estimated, which is advantageous because default risks or changes in interest rates often make it difficult to determine (Penman, 2013).

While the enterprise value is not readily observable, share prices should in fact immediately provide equity value based on market capitalisation, but only on the assumption that the markets are efficient (Damodaran, 2006). In this thesis, the direct approach is used.

2.2 The Usage of Accounting Numbers in Valuation

Accounting information derived from fundamental analysis is a critical factor in valuation, as the accounting streams are directly included in the valuation. The performance of valuation models is assessed based on the extent to which its valuation is close to the share price (Francis et al., 2000). In return, mispricing can also be detected and used for investment purposes (Damodaran, 2006).

Ball and Brown (1968) investigate the influence of expected and unexpected elements of income changes on the share price and find that a positive surprise effect leads to higher stock returns and vice versa. They conclude that earnings influence the development of share prices and that accounting earnings contain information which is not timely.

This is contradicted by Lev (1989) who argues that the usefulness of returns is limited due to the "intertemporally unstable simultaneous correlation" between stock returns and earnings.

Beaver (1968) assumes, despite the lack of correlation, that associating earnings and share prices makes sense if it can change the decisions of investors. Ten years later he and Morse state that the earnings are partly made up of factors that are typical for that year but do not continue (transitory items) so conclusions are often difficult to draw (Beaver and Morse, 1978).

Dechow et al. (1998), in contrast to Lev, find a high correlation between earnings and share prices, at least in the short term, with only a low correlation with cash flows. According to them, earnings are therefore also timelier than cash flows. In another paper, she examines also accruals and again, cash flows are much worse, as they have problems to reflect the performance of companies, because of matching and timing problems (Dechow, 1994).

Nichols and Wahlen (2004) contradict this, arguing that both cash flows and accruals provide additional information on the profitability and wealth creation of companies.

Besides the timeliness and information content of the accounting streams, both Burgstahler and Dichev (1997) and Courteau et al. (2015) encounter the problem of earnings management in their analyses. Valuations can be distorted to such an extent that they are no longer have any usefulness. Nevertheless, even if market efficiency is not considered, accounting figures still provide a strong explanation for company values.

Overall, no consensus exists; while some argue that correlations to share prices exist, others find no evidence or find that valuations are manipulatable. However, accruals or earnings generally appear to be more correlated than cash flows.

2.3 The Valuation Models

Firstly, the models are discussed, and their advantages and disadvantages are pointed out. Moreover, the following section examines which models for the valuation of the intrinsic value are regarded as effective in literature and which limitations and difficulties exist. Finally, based on the literature review results, four hypotheses for the evaluation of the models are presented.

2.3.1 The Flow-based Valuation Models

Flow-based valuation models are constructed on multi-period forecasts and assumptions such as growth and discount rates. All models usually assume a terminal value at the end of the forecast, which represents the present value of all following flows (Damodaran, 2006). All models have in common that the flows occur in several periods and need to be discounted to the date of valuation using the cost of equity (*COE*).

The *COE* can be calculated using the Capital Asset Pricing Model (*CAPM*) or the Dividend Growth Model (*DGM*).

$$CAPM: r_E = rf + \beta(r_M - rf) \quad (2.1)$$

$$DGM: r_E = \frac{D_1}{P_0} + g \quad (2.2)$$

Where:

r_E	≙	Cost of equity
rf	≙	Risk free rate
β	≙	Beta (measures the systematic risk)
$r_M - rf$	≙	Market risk premium
D_1	≙	Expected dividend payment in year 1
P_0	≙	Current share price
g	≙	Growth rate

In the following, the three flow-based models are analysed, which - at least theoretically - should lead to the same value of equity (Francis et al., 2000).

2.3.1.1 The Discounted Dividend Valuation

Williams (1938) laid the foundation for the discounted dividends method, which is based on expected payouts in the form of dividends to shareholders (Penman and Sougiannis, 1998). The profit from shares is reflected in dividends and proceeds from selling it again for a higher price. The equity value in the form of the share price today should reflect all discounted future dividends (Penman, 2013).

Companies are supposed to exist forever, but forecasting a long period is hard and vulnerable to errors. For this reason, the terminal value (TV) is introduced, which calculates the present value of all future dividend payouts that occur after the initial forecast periods. For the TV calculation companies are assumed to grow at a fixed growth rate (Damodaran, 2006).

$$V_{te} = \frac{E_t[DIV_{t+1}]}{(1+r_E)} + \frac{E_t[DIV_{t+2}]}{(1+r_E)^2} + \frac{E_t[DIV_{t+n}]}{(1+r_E)^n} + \frac{E_t[DIV_{t+n}*(1+g)]}{(r_E-g)*(1+r_E)^n} \tag{2.3}$$

$$V_{te} = \frac{Et[DIV_{t+1}]}{(r_E-g)} \tag{2.4}$$

Where:

V_{te}	≙	Equity value at the time of the valuation
$E_t[DIV]$	≙	Expected dividends
r_E	≙	Cost of equity
g	≙	Growth rate
n	≙	Time in years

A main problem of the model is its lack of a link to value creation - at least in the short time. Since dividends are sticky and shareholders expect them, firms often find themselves obliged to pay dividends anyway even though the company is financially struggling and should not pay dividends (Hillier, 2016). Since the model is flow-based and follows the on-going business approach, it takes many forecast periods to work realistically, which is difficult to achieve reasonably. However, the model is simple, and the dividends are predictable as they are usually quite stable and can therefore be forecasted- at least in the short term (Penman, 2013).

In conclusion, the model can only be used if firms pay out dividends which is mostly the case for mature firms. Besides, it should only be used if dividends are linked to value creation like a fixed payout ratio as dividends and earning should be linked to each other (Penman, 2013).

2.3.1.2 The Discounted Cash Flow Valuation

Like for the DDM, Fisher (1930) also formed the basis for the discounted cash flow valuation. For the DCFM, free cash flows are used, which represent the value attributable to the firm (*FCFF*) or the shareholders (*FCFE*) after the deduction of all investments (Palepu, 2004).

Equity can be valued in two different ways using DCFM. First, the total enterprise value can be obtained by discounting the *FCFF* using the weighted cost of capital. By subtracting the net debt (debt - cash) the equity value is obtained. However, the equity value can also be calculated directly by discounting the FCFE with *COE* (Penman, 2013).

$$FCFF = EBIT * (1 - tax\ rate) + Depr - CAPEX - \Delta Working\ Capital \tag{2.5}$$

$$FCFE = NI + Depr - CAPEX - \Delta Working\ Capital + \Delta Net\ Borrowing \tag{2.6}$$

Where:

FCFF	≙	Free cash flow to the firm
FCFE	≙	Free cash flow to equity
EBIT	≙	Earnings before interests and taxes
NI	≙	Net income
Depr	≙	Depreciation
CAPEX	≙	Capital expenditure
Δ	≙	Change

In general, a firm represents the sum of all projects it undertakes, which require investments (CAPEX), lead to a change in working capital as well as depreciation to ultimately generate cash flows. The cash flows are *free* as they represent the sum that remains after deducting the cash from investments from the cash from operations (Damodaran, 2006).

For this paper, the direct way to value equity is chosen, which considers only the *FCFE*. The difference with *FCFF* is that flows to debt holders are not considered, hence net income is used instead of the tax adjusted *EBIT* and the change in net borrowing is included.

Like the DDM the expected future cash flows are discounted by the *COE* to generate the current value of equity (Penman, 2013).

$$V_{te} = \frac{E_t[FCFE_{t+1}]}{(1+r_E)} + \frac{E_t[FCFE_{t+2}]}{(1+r_E)^2} + \frac{E_t[FCFE_{t+n}]}{(1+r_E)^n} + \frac{E_t[FCFE_{t+n}*(1+g)]}{(r_E-g)*(1+r_E)^n} \quad (2.7)$$

$$V_{te} = \frac{Et[FCFE_{t+1}]}{(r_E-g)} \quad (2.8)$$

Where:

V_{te}	≙	Equity value at the time of the valuation
$E_t[FCFE]$	≙	Expected free cash flows to equity
r_E	≙	Cost of equity
g	≙	Growth rate
n	≙	Time in years

A major problem is that *CAPEX* minimises the *FCFE*. Therefore, a company would achieve a higher *FCFE* by reducing investments, although they are essential for future profitability. In general, the model fails to measure the added value in the short term and leads to a mismatch between the value gained and the value given up. Since investments do not have an immediate effect, the forecasted period must be long enough to consider the long-term effects of the *CAPEX* (Penman, 2013).

Besides, analysts do not usually forecast cash flows as their focus is on earnings. Despite the disadvantages, the DCFM has a major advantage over other FBMs as cash flows are hard to manipulate and earnings management is barely possible (Damodaran, 2006).

The model should be used when cash flows are positive due to investment alignments or the cash flows are increasing at constant growth rates. Companies that are in the cash cow phase or are part of a leveraged buy-out to pay out shareholders can be reliably valued using the DCF.

2.3.1.3 The Residual Income Valuation

The RIVM was first developed in 1938 by Preinreich (1938) and later made known by Ohlson (2005). Dechow et al. (1999) describe it as a restatement of the DDM as it can be transformed into the RIVM using the clean surplus relation method.

The residual income is a performance measure and compensates for opportunity costs that could be achieved by an alternative investment of the shareholders. The RI represents the return on ordinary share capital exceeding the required shareholder return (O'Hanlon and Peasnell, 2002).

$$Earnings = Cash\ Flow + Accruals \tag{2.9}$$

$$RI_t = NI_t - (r_E * BVE_{t-1}) \tag{2.10}$$

Where:

RI_t	≙	Residual income
NI_t	≙	Expected earnings
$(r_E * BVE_{t-1})$	≙	Required earnings (COE*Book value of equity at beginning of period[1])

In general terms, the model states equity value as the sum of the invested capital in form of equity and the present value of the discounted residual income from future (Lee et al., 1999). The TV usually has a smaller proportion compared to the other models as the RIVM consists of a flow and a stock component, which is good as the TV is based on many possibly unstable assumptions (Francis et al., 2000).

$$V_{te} = BVE_0 + \frac{E_t[RI_{t+1}]}{(1+r_E)} + \frac{E_t[RI_{t+2}]}{(1+r_E)^2} + \frac{E_t[RI_{t+n}]}{(1+r_E)^n} + \frac{E_t[RI_{t+n}*(1+g)]}{(r_E-g)*(1+r_E)^n} \tag{2.11}$$

$$V_{te} = BVE_0 + \frac{Et[RI_{t+1}]}{(r_E-g)} \tag{2.12}$$

Where:

V_{te}	≙	Equity value at the time of the valuation
BVE_0	≙	Current book value of equity
$E_t[RI]$	≙	Expected residual income
r_E	≙	Cost of equity
g	≙	Growth rate
n	≙	Time in years

According to Lee (1999), earnings are a “conceptually defensible and reasonably objective measure of firm performance”. Earnings are vulnerable to manipulation using earnings management, which is why the forecast should be done with an accounting quality analysis (Beaver and Morse, 1978). However, since the model is based on accruals, it helps to solve the mismatch and timing problems associated with the DCFM (Nichols and Wahlen, 2004). With the book value of equity, this model is the only one that uses an accounting number at the time of valuation that is not based on assumptions.

[1] The following book values to equity are calculated based on the previous year and the earnings remaining after the dividend payment. Dividends are calculated using the dividend payout ratio.

Additionally, it forecasts the income statement, which leads typically to a good measurement of the value-added compared to the DCFM. Another advantage over the DCFM is that the investments are treated as an asset rather than a loss and that the value given up corresponds to the value-added (Healy, 1984). Additionally, neither “accounting discretion nor accounting conservatism” influences the reliability of RIVM estimates significantly (Francis et al., 2000).

Since analysts tend to forecast earnings rather than dividends and cash flow, this model is suitable for almost all companies, since the residual income can be easily calculated from it. Additionally, the forecast horizon may be shorter than with the other models, and a higher value is usually recognised in the near future (Penman, 2013).

2.3.1.4 Findings of the Literature

A good starting point for the analysis is the work of Francis et al. (2000) as they analyse the FBMs mentioned above. They find that although all models should come to the same result, the RIVM achieves significantly better results and explains bigger variations in prices, while especially the DDM performs poorly. They assume that this is due to the greater reliability of abnormal returns and that accounting-related distortions of book values are less critical than measurement and forecasting errors in the other models.

Penman and Sougiannis (1998) carry out a similar analysis using ex-post forecasts instead of ex-ante forecasts looking at a finite time horizon. They also conclude that the RIVM provides greater accuracy as the basis of provisions and book values offers significant advantages over forecasted dividends and cash flows. They explain this with the improved presentation of the firm's situation using accruals, as future developments can be detected earlier.

The two papers are contradicted by the findings of Lundholm and O'keefe (2001), who argue that the RIVM, as well as the DCFM, lead to similar valuations when implemented correctly. They indicate that both papers show inconsistencies due to incorrect forecasts, differences between the *COE* and lack of cash flows.

Courteau et al. (2001) also conclude that both DCFM and RIVM are almost equally effective when using an ideal terminal value. Otherwise, the RIVM is better.

Like Lundholm and O'keefe (2001), Sougiannis and Yaekura (2001) consider missing or incorrect data to be the main problem in valuation. However, they encounter other problems in the analysis of the RIVM, namely the inaccurate earnings forecasts of analysts and the quality of accounting principles and their conservatism.

According to Dechow et al. (1999), the RIVM has only minor advantages over the DDM. They also find an information problem, because investors attach more importance to analysts' earnings forecasts than to current earnings and book values.

Overall, the RIVM is proposed as the best valuation method by almost all papers. However, the clarity is diminished by other papers which state that measurement errors and information problems are often responsible for the superiority of the RIVM.

2.3.2 The Multiple-based Valuation

The multiples model determines the value of a firm based on how similar firms are valued by the market. No multi-period forecasts are used; instead, a value driver based on comparable companies (peer group) is applied (Penman, 2013). The group should comprise firms that are comparable about the business model, risks and value driver. Thus, companies in the same industry are the most appropriate, as the companies are likely to be exposed to the same factors. Conversely, identifying a single industry is sometimes difficult because some companies operate in more than one sector and whole markets can be misvalued (Demirakos et al., 2004). Boatsman and Baskin (1981) suggest that the best result can be achieved by using companies from the same industry that have a similar average earnings growth rate in 10 years. Besides Bhojraj and Lee (2002) suggests a peer group that matches also in size.

The value driver should be selected according to how well it can capture the value-creating activities. To value the company, a positive benchmark multiple and a positive value driver is important, otherwise, the company value would be negative (Liu et al., 2002).

Multiples can be divided into trading multiples based on share prices and transaction multiples based on M&A transactions (Ernst and Häcker, 2007). The latter often include a premium and are therefore higher than trade multiples (Pinto et al., 2015).

A distinction can also be made between equity and enterprise multiples, whereby the numerator and denominator must refer to the same perspective. Hence, a value driver should be chosen that refers to a pre-interest figure such as *EBITDA* to determine the enterprise value, while a value driver figure that is attributable to shareholders like net income is used to determine equity

(Penman, 2013). Schreiner and Spremann (2007) conclude that equity multiples are more accurate than enterprise multiples.

To determine the equity value, the value driver of the valued firm must be multiplied by the benchmark multiple of the peer group, which can be determined using the median or mean.

$$V_{ti} = VD_i * \frac{P_j}{VD_j} \tag{2.13}$$

Where:

V_{ti}	≙	Enterprise or equity value at the time of the valuation
VD_i	≙	Value driver of the valued firm (VD > 0)
$\frac{P_j}{VD_j}$	≙	Benchmark multiple of peer group

The multiples can be applied using the following methods, whereby the arithmetic mean tends to overestimate due to outliers that are not problematic in the other models (Martin and Bridgmon, 2012). Schreiner and Spremann (2007) state that median-based estimates are more accurate while Beatty et al. (1999) argue that the harmonic mean is superior. Liu et al. (2002) find, that the harmonic mean seems to result in lower pricing errors.

$$Arthmetic\ mean = \frac{1}{n}\sum_{j=1}^{n} P_j \tag{2.14}$$

$$Weighted\ mean = \frac{1}{n}\sum_{j=1}^{n} \frac{P_j}{VD_j} \tag{2.15}$$

$$Harmonic\ mean = \frac{1}{\frac{1}{n}\sum_{j=1}^{n} \frac{VD_j}{P_j}} \tag{2.16}$$

$$Median = Median(P_j) \tag{2.17}$$

Where:

P_j	≙	Share price of the peer group

One of the major advantages is that multiples can be easily understood and calculated (Fernandez, 2001). Besides, no *COE* and forecasts, that are based on many assumptions, have to be determined (De Franco et al., 2015). Conversely, this leads to a neglect of risks as well as growth potentials, and the focus lays more on the past than on the future. However, the market opinion in the form of the multiples is an advantage in the valuation and allows investors to see how much was paid for similar companies. Since most multiples are based on earnings, the advantages and disadvantages mentioned for the RIVM also apply to the MBV. The valuation assumes that other companies are comparable to the company being valued and that a linear relationship between the value driver and the company value exists (Damodaran, 2006). These assumptions are often not fulfilled which is why many valuations are not accurate. Finally, the whole process is inconsistent as comparable companies are assumed to be correctly priced, but not the company actually valued (Pinto et al., 2015).

The multiples method is suitable for all companies if a suitable value driver can be found. In contrast to the other models, the multiples method can also be easily adapted for small, unprofitable or private companies without public market information (Penman, 2013).

2.3.2.1 Findings of the Literature

Liu et al. (2002) address the question of which value drivers lead to the best valuation results of a large sample of non-financial US firms. However, as they are limited to positive earnings forecasts and growth rates, their findings are not representative for all companies. By analysing the price scaled valuation error, they found that earnings seem to have a superiority over other value drivers. Besides, they argue that the forecasted earnings and the aggregated forecasted earnings produced the best performance, while sales produced the worst results.

Likewise, Lie and Lie (2002) and Schreiner and Spremann (2007) also find that forecasted earnings result in a better estimate of the company value than trailing earnings. However, the former also observe that historical book value-based multiples are more accurate than historical earnings-based multiples. Kim and Ritter (1999) find a performance advantage of forecasted earnings when analysing the *P/E* multiple in the valuation of IPOs.

The most common multiples based on the results of Francis et al. (2000) are shown below.

Table 1- Common Multiples
Based on the findings of Liu et al. (2002)

Based on	Multiples	Explanation
Aggregated forecasted earnings	*ES1/P*	Sum of *EPS* (forecasted year 1-5)
	ES2/P	Sum of the present value of ES1
Forecasted earnings	*EPS1/P*	One-year earnings forecast
	EPS2/P	Two-year earnings forecast
	EG1/P	*EPS*2 combined with growth
Historic earnings	*IACT*	Actual earnings from IBES
	EBITDA	Earnings Before Interest, Taxes, Depreciation and Amortization
Cash flows	*CFO/P*	Cash flow from operations

Multiples are listed in descending order of advantage, while sales and book value multiples are not mentioned as they perform poorly.

2.3.3 Comparison

The comparison between the flow-based and multiple-based models is difficult and experts disagree as shown hereafter. There is hardly any literature that analyses both FBMs and MBMs.

Courteau et al. (2006) argue that FBMs tend to be more accurate than multiple-based models but are also more expensive. However, they conclude that a hybrid approach considering both methods leads to the best results. Frankel and Lee (1998) find that the RIVM provides a better explanatory power of future returns than the ratios book to price and market to equity.

However, when Gilson et al. (2000), and Kaplan and Ruback (1995), examined highly leveraged transactions, they found that DCFM and cash multiples provide accurate estimates and that valuation errors are higher when stakeholders have incentives to misstate firm values.

Research comparing both multiples-based and flow-based valuation approaches is still limited. Therefore, this paper addresses the question by which approach the most reliable result can be achieved. The hypotheses are presented in the chapter after next.

2.3.3.1 Influence of R&D Intensity

In order to remain competitive, constant investment in R&D is increasingly important. Usually, the spending is immediately booked as expenses in the financial statements before it leads to long-term success. Initially, this leads to earnings figures that underestimate the "true" earnings (Eberhart et al., 2004). When recorded as an expense, it affects the net profit and thus the amount that can be distributed as dividends. In case of capitalizing, it has an impact on the free cash flow, as CAPEX reduce it (Damodaran, 1999). As the treatment of R&D spending has a strong impact on accounting streams and thus on firm valuations, this influence is investigated.

Lie and Lie (2002) describe current earnings as a poor predictor of value. All their estimates are lower than the actual values, which is probably because valuation methods do not fully recognise the value of growth potential generated by R&D activities in the future.

Sougiannis and Yaekura (2001) argue that analysts have difficulties predicting the earnings of firms with high R&D intensity, which is why the forecasts of firms with no or low R&D intensity are more accurate. Due to the realisation of R&D gains in the future, longer forecasting horizons should be considered, as otherwise, companies with little R&D are better off.

Schreiner and Spremann (2007) state that if R&D is capitalised rather than expended, accrual-flow multiples often penalise companies for spending more on the generation of intangibles through R&D than their competitors.

Francis et al. (2000) find that the RIVM, contrary to the other FBMs, is the most reliable when they examined whether accounting procedures such as the treatment of R&D expenditure have an impact on the valuation estimates. Consequently, they compare the RIVM in terms of high and low R&D investment and find no evidence of a difference in reliability. They find that the RIVM leads to better estimates, as a distortion of book values by R&D spending is considered less critical than errors in assumptions, such as the cost of equity. Although there is no difference in accuracy, the RIVM achieves a better explainability when R&D spending is high.

Damodaran (1999) sees a strong influence of R&D expenses on both the DCFM and MBV especially if the growth rate is calculated from the return on capital and the reinvestment rate or the multiples need to be adjusted because the basis changes.

Most of the researchers see a disadvantage for companies that invest strongly in R&D. This issue is examined, and a corresponding hypothesis is presented subsequently.

2.4 Hypotheses and Rationale

Considering all the literature mentioned above, the following hypotheses are stated.

The DDM is not linked to any value creation and, as dividends are sticky, they are often paid without any earnings-related justification and thus do not adequately reflect the firm's situation. Conversely, the DCFM has difficulty in reflecting added value instantly, as investments only show benefits in the long term. However, DCFM shows the pure cash movements and is not arbitrary like dividends nor easy to manipulate. Therefore, the DCFM is expected to perform better than the DDM, which is consistent with the results of Francis et al. (2000).
Consequently, the first hypothesis is as follows:

I. The discounted cash flow valuation model outperforms the discounted dividend model in terms of reliability and accuracy.

As the DCFM is considered better, a comparison is made with the RIVM. Although both are flow-based and based on assumptions, the RIVM has a fixed component besides the forecasted flows, namely the book value of equity. For this reason, also the TV has a relatively smaller

share than in the other FBMs. Moreover, the RIVM eliminates other disadvantages of the DCFM; like the use of accruals minimises the mismatch and timing problem and investments are considered as assets rather than losses as in the DCFM (Healy, 1984; Nichols and Wahlen, 2004). The RIVM is therefore considered to be better, as Francis et al. (2000) suggest too.
Hence, the second hypothesis is:

II. The residual income valuation model outperforms the discounted cash flow model in terms of reliability and accuracy.

The RIVM is expected to be superior of the flow-based models and is therefore compared to the MBV. Since most multiples are based on earnings, the advantages and disadvantages mentioned for the RIVM also apply to the MBV. Additionally, the MBV avoids the typical disadvantages of FBMs such as long forecast periods, error-prone assumptions and a high proportion of the terminal value. Moreover, it also reflects the current market sentiment and places the company in the context of enterprises from its industry. A disadvantage, however, is that the method only looks at the past but not at the future. Nevertheless, the MBV is expected to perform better than the RIVM, which contradicts the findings of Gilson et al. (2000), Kaplan and Ruback (1995) and Frankel and Lee (1998), whereby the former assume an identical performance and the latter assume a poorer performance. Forecast earnings, which are considered the best value driver by the literature, are used for the analysis.
Thus, the third hypothesis is as follows:

III. The multiple-based model is more reliable and accurate than the residual income valuation model.

Like Francis et al. (2000), I examine to what extent accounting procedures such as the treatment of R&D spending have an impact on valuation. As stated before, firms with higher R&D spending appear to have a disadvantage in valuation, as forecasts are more difficult to estimate, and the benefits are not realisable in the near future. Francis et al. (2000) find that the RIVM is considered more reliable as it contains a stock and a flow component, while the others are only flow-based. Contrary to the papers examined, they find no difference in reliability of the RIVM at different intensities of R&D spending, but a better explainability at a high R&D spending.

For this hypothesis, the findings of the examined studies are therefore combined, and I partly contradict Francis et al. (2000). Nevertheless, like them, I assume that estimates from RIVM are better than those from DDM and DFCM, as biases in book values due to R&D spending are less critical than errors in assumptions such as cost of equity or growth rates. However, I assume based on Sougiannis and Yaekura (2001) as well as Lie and Lie (2002) that a low R&D spending leads to better results.

Francis et al. (2000) did not consider the MBV, but I propose that this hypothesis should also reflect the previous ranking, as peer companies have relatively similar R&D spending due to their competitiveness and the MBV should therefore be even more reliable than the RIVM. The last hypothesis is, therefore:

IV. Firms with lower R&D expenditures are valued more accurate than firms with high R&D expenditures, whereby the order of superiority of the models does not change.

Concerning the hypotheses, the following must be considered. It should be noted that many papers were published several years ago, like Francis' paper in the 2000s. Therefore, assumptions such as the risk-free interest rate are not the same today. While the sample data for Francis' paper was collected from 1989 to 1993 this paper uses data from 2005 to 2015. Apart from the different length of the observation periods, the economy during the period is also important to consider. Although there was a recession in the USA at the beginning of the 1990s, the financial crisis in 2008/2009 had a greater impact.

It should also be noted that the models assume an efficient market. In a real market, valuations are influenced by many other factors that would make models too complicated. For example, asset prices often do not reflect their true value (Hillier, 2016). Besides, the assumptions are difficult to predict, and a small change in these assumptions, such as an increase in the growth rate, can lead to different results. Especially as the analysis is based on Francis's paper, it must be noted that no analysis of the MBV was performed in his work. Besides, this paper uses IBES as database instead of value line like Francis et al. (2000) and Courteau et al. (2001) did.

The previously mentioned research papers are already several years old and include other circumstances like today, such as the interest rate environment and economic conditions. Moreover, the research to date has mainly been based on flow-based models *or* the multiple-based model, and there have been hardly any joint analyses. Therefore, this paper intends to close the literature gap and shows recent research that covers both types.

3 Large Sample Analysis

In this chapter, a joint analysis is conducted for non-financial companies listed in the US. This analysis aims to test the previously established hypotheses. For this purpose, the valuation models mentioned in the literature review are applied and consideration is given to which method is most suitable. Besides, a sensitivity analysis is conducted and the influence of different levels of R&D spending on the performance of the valuation models is investigated. In general, the following research questions are answered:

- Which valuation type is best suited for the valuation of the listed US companies? Which valuation method performs worst?
- How sensitive are the models and which assumptions lead to the best results?
- What influence do R&D expenditures have? Does the advantageousness of the models change?

The dataset used for this analysis is described below and the adjustments are explained. Furthermore, the tools used for the analysis are described and the findings of the analysis are discussed. The results are then evaluated with a sensitivity analysis, followed by an analysis regarding R&D spending. After each analysis, the respective hypotheses are evaluated.

3.1 Methodology

3.1.1 Dataset

The dataset comprises information from 6,108 companies listed in the US from various industries for the years 2005-2015, which corresponds to a total of 37,106 observations. General descriptive information on companies as well as financial reporting data such as accounting variables are taken from Compustat®, analyst forecasts from I/B/E/S and share prices as well as *betas* from CRSP. The I/B/E/S forecasts represent average forecasts calculated using all monthly forecasts available. Accounting information and market data are provided with a delay of 4 months to ensure that prices show all information of the prior fiscal year (Pazarzi, 2014). The risk-free rates are taken from the FED website. All variables are stated in USD, while income statement and balance sheet variables are stated in millions.

3.1.2 Sample Adjustments

In the following, all adjustments and calculations that are needed to value the equity values are explained and important variables are described.

Since the dataset contains financial and utility companies that are either regulated industries or have special accounting or capital structures, the companies are removed like suggested by Lie and Lie (2002). Similarly, duplicates are dropped.

Initial tests revealed that outliers were frequently more than one hundred standard deviations off the mean, and sometimes had an excessive effect on the regression results. To prevent the results from being falsified by outliers and to have fewer data to delete, a winsorize level of 1% is set, where outliers exceeding the 1st and 99th percentile are assigned a value equal to the value of the percentiles (Boubaker and Nguye, 2014). The affected data is listed below.

Table 2- Variables affected by Winsorizing

Variables
Stock price 4 months after fiscal year-end
Book Value of Equity
Analyst forecast of *EPS* in year t+1
Analyst forecast of *EPS* in year t+2
Net Income
Capital Expenditures
Depreciation
Change in Working Capital
Change in Net Borrowing

The data is winsorized at a level of 1%. Winsorizing is chosen as it allows observations to be retained in the base but limits numerical outliers and smooths the result.

All negative values of the accounting streams are set to 0 as in Francis et al. (2000) and thus removed together with empty entries. This deliberately contradicts the approach of Lee et al. (1999), in which negative earnings are replaced by the total assets of the prior year multiplied by the long-term average *ROA* of 6%. By not applying this approach, companies with negative earnings are not better off than companies without any earnings.

For the MBV, sufficient observations must exist in each sector. To ensure that both the multiple method and the flow-based methods have the same amount of observations, all industry groups with less than ten observations are removed. A two-digit SIC code, as used by Alford (1992), is applied as the basis for this.

Table 3 in the following section shows the adjustments. The total number of observations used for the subsequent equity valuations is 4,932.

Table 3- Elimination of Variables

Exclusions	Observations
Total	37,106
Removal of financial companies	-7,926
Removal of utility companies	-1,358
Duplicates	-117
Subtotal	**27,705**
Removal of negative earnings, blanks or observations equal to 0	-5,767
Removal of negative dividends, blanks or observations equal to 0	-12,568
Removal of negative cash flows, blanks or observations equal to 0	-2,830
Removal of industry groups with less than 10 observations	-1,608
Total	**4,932**

All data are adjusted to the extent that an identical data basis is available for all valuation methods to achieve a high degree of comparability. To achieve an identical amount of observations for all methods, the above-mentioned removals are conducted.

3.1.2.1 The Multiple-based Model

Since current earnings often contain transitory items, fluctuate more and are more likely to be zero, forecasted earnings are used, as suggested by Liu et al. (2002) in conjunction with Kim and Ritter (1999) as well as Beaver and Morse (1978). The value driver is as follows:

$$Value\ Driver = \frac{Analyst\ forecast\ of\ EPS\ in\ year\ t{+}1}{Stock\ price\ 4\ months\ after\ fiscal\ year\ end} \tag{3.1}$$

The exclusion of negative earnings ensures that no negative value drivers exist, as is the case with Liu et al. (2002). The harmonic mean is used as suggested by Beatty et al. (1999) and Liu et al. (2002) because it should create lower pricing errors.

3.1.2.2 The Flow-based Models

All data is calculated on a per-share basis, which requires an adjustment of cash flows to equity as the components are reported for the entire company. For cash flows, it is also crucial to use lagged variables to calculate changes in working capital and net borrowing. All other flows are presented in such a way that no adjustments need to be made in this respect.

The dividend payout ratio, which is necessary for the RIVM and the DDM, is calculated based on earnings per-share and dividend per-share and is considered constant for the future like Liu et al. (2002) propose. If it is above 1, a ratio of 1 is used and values below 0 are dropped. This ratio is subsequently used to calculate dividends based on forecast earnings, with dividends increasing by the growth rate in the following year.

An adjustment is made to ensure consistent data as, unlike I/B/E/S and CRSP data, the per-share Compustat® data is not adjusted after dividend payments and stock splits.

3.1.2.3 Valuation

For most companies, only forecasts for one or two years are available in the dataset, which is why a forecast horizon of two years followed by a terminal value is applied, which is consistent with Frankel and Lee (1998).

In order to discount the FBMs, the *COE* using *CAPM* is calculated. For this, as with Pazarzi (2014), the rates of the annualised 3-month treasury bills closest to the balance sheet date are used for each company in each year. The *beta* refers to the annual share *beta* derived using CRSP data on the market's value-weighted return index and monthly company returns.

In order to avoid negative *betas* and to have a consistent and equal basis for the calculation of the *COE*, an average industry *beta* is determined for each industry as suggested by Ross et al. (2009) to reduce the estimation error.

A market risk premium (*MRP)* of 5% is assumed, which matches with Pazarzi (2014) and Liu et al. (2002) and also corresponds to the average *MRP* for the forecast period reported by Damodaran (2020).

$$CAPM: r_E = rf + \beta(r_M - rf) \quad (3.2)$$

Where:

$\mathrm{r_E}$	≙	Cost of equity
rf	≙	Risk free rate
β	≙	Beta (measures the systematic risk)
$r_M - rf$	≙	Market risk premium

Similar to Francis et al. (2000), the growth rate is based on the inflation rate. The average inflation rate for the forecast period is 2% and is assumed to remain constant thereafter (International-Monetary-Fund, 2020).

The valuation models already discussed are applied and the detailed calculation and explanation of the formula and models can be found in the literature review.

Below is a summary of the valuation models used to calculate the equity value estimates:

Discounted Dividend Valuation Model

$$V_{te} = \frac{E_t[DIV_{t+1}]}{(1+r_E)} + \frac{E_t[DIV_{t+2}]}{(1+r_E)^2} + \frac{E_t[DIV_{t+2}*(1+g)]}{(r_E-g)*(1+r_E)^2} \tag{3.3}$$

Discounted Cash Flow Valuation Model[2]

$$V_{te} = \frac{E_t[FCFE_{t+1}]}{(1+r_E)} + \frac{E_t[FCFE_{t+2}]}{(1+r_E)^2} + \frac{E_t[FCFE_{t+2}*(1+g)]}{(r_E-g)*(1+r_E)^2} \tag{3.4}$$

Residual Income Valuation Model

$$V_{te} = BVE_0 + \frac{E_t[RI_{t+1}]}{(1+r_E)} + \frac{E_t[RI_{t+2}]}{(1+r_E)^2} + \frac{E_t[RI_{t+2}*(1+g)]}{(r_E-g)*(1+r_E)^2} \tag{3.5}$$

Multiple-based Valuation Model

$$V_{te} = VD_e * \frac{1}{\frac{1}{n}\sum_{j=1}^{n}\frac{Analyst\ forecast\ of\ EPS\ in\ year\ t+1}{Stock\ price\ 4\ months\ after\ fiscal\ year\ end}} \tag{3.6}$$

Where:

V_{te}	$\triangleq$	Equity value at the time of the valuation
BVE_0	$\triangleq$	Current book value of equity
$E_t[RI]$	$\triangleq$	Expected residual income
$E_t[FCFE]$	$\triangleq$	Expected free cash flows to equity
$E_t[DIV]$	$\triangleq$	Expected dividends
r_E	$\triangleq$	Cost of equity
g	$\triangleq$	Growth rate
n	$\triangleq$	Time in years
VD_i	$\triangleq$	Value driver of the valued firm (VD > 0)
$\frac{P_j}{VD_j}$	$\triangleq$	Benchmark multiple of peer group

3.1.2.4 R&D Subsample

In order to test the fourth hypothesis, an analysis of R&D spending is carried out following the approach of Francis et al. (2000). As in their work, a ranking is constructed based on the ratio of R&D spending in the previous year to the total assets at the beginning of the same year.

Before the allocation to observation groups, all companies without R&D spending are removed (1,697 observations). Thus, it is avoided that missing data distort the ranking in case the firms may have R&D spending that is not included in Compustat®. In terms of the division into

[2] The prior fiscal year was used to calculate the change in working capital and net borrowing, that are crucial for the yearly FCFE.

observation groups, the procedure in this thesis differs in part from that of Francis et al. (2000). In their data set, 48% of the firms have no or immaterial R&D expenditure, which they combine into one observation group. In addition, they form a further group that includes the top quartile of companies with the highest R&D expenditure ratio.

However, their approach compares a different number of observations, which is what this paper is trying to avoid. The quartile approach, which Francis et al. used only for the companies with high R&D expenditures, is therefore applied to both comparison groups to achieve an equal number of observations in each group and thus a better comparability of the data.

This results in the following structure.

Table 4- Adjustments for the R&D Analysis[3]

Adjustments for R&D Analysis		
	Total Sample 4,932	
	Removal of blanks 1,697	
	Total Subsample 3,235	
1st Quartile (low R&D)	Excluded Observations	4th Quartile (high R&D)
809	1,618	808

For the analysis of the extent to which different levels of R&D spending affect the company valuation, two comparison groups (upper and lower quartile) are determined. The upper group consists of firms with the highest R&D expenditure and the lower group of firms with little or no R&D expenditure. All empty entries are removed, and the data is ranked based on the ratio of R&D spending in the previous year to the total assets at the beginning of the same year.

Based on this division, the same valuation models and measurements are applied to both groups as for the entire sample.

3.1.3 Important Variables

The initial sample is now narrowed to 4,932 observations, but the remaining data represent a good compromise between sufficiency and noise reduction.

The following table describes important variables as well as their relevant descriptive data.

[3] Since 3,235 is an odd number, the percentiles are not equal.

Table 5- Important Variables

Variables	Stock price 4 months after fiscal year-end	Earnings per Share - excl. extraord. items	Analyst forecast of *EPS* in year t+1	Analyst forecast of *EPS* in year t+2	Cash flow to equity in year t+1	Cash flow to equity in year t+2	Dividends in year t+1	Dividends in year t+2	Harmonic mean (*EPS* in year t+1 / share price)
N	4,932	4,932	4,932	4,932	4,932	4,932	4,932	4,932	4,932
Mean	46.320	2.714	2.833	3.206	3.842	3.919	1.062	1.204	0.067
Standard Deviation	31.715	2.542	2.152	2.374	5.403	5.511	1.182	1.319	0.056
Min	1.730	-8.440	0.030	0.120	0.000	0.000	0.000	0.000	0.001
Max	161.500	44.640	11.790	13.200	69.862	71.259	11.790	13.200	1.808
1st percentile	4.680	0.060	0.190	0.260	0.046	0.047	0.033	0.041	0.013
1st quartile	23.370	1.210	1.340	1.580	0.982	1.001	0.344	0.404	0.046
Median	39.030	2.145	2.320	2.620	2.236	2.281	0.719	0.829	0.060
4th quartile	61.560	3.480	3.700	4.170	4.536	4.627	1.340	1.519	0.076
99th percentile	161.500	11.540	11.790	13.200	28.587	29.159	6.115	6.670	0.217

For a first glance, the most important variables that are later used for the valuations are shown with their central tendency and dispersion. Some data of EPS and dividends are similar as the maximum payout ratio is set to 1 and dividends are based on EPS and the ratio.

3.1.4 Performance Measure of the Models

As in Francis et al. (2000) and Courteau et al. (2001), the relative performance of the valuation models is measured by the extent to which the mean and median equity value per-share and the market price correspond. Their methods are adopted and are described below.

The statistical significance testing of the accuracy and bias valuation errors is conducted by using t-tests and Wilcoxon tests. Each method tests for a significant difference from 0. The Wilcoxon test evaluates the median and the t-test the mean (Martin and Bridgmon, 2012).

$$Accuracy = \frac{|Equity\ value\ per\ share - Market\ price|}{Market\ price} \quad \textit{(Absolute Valuation Error)} \qquad (3.7)$$

$$Bias = \frac{Equity\ value\ per\ share - Market\ price}{Market\ price} \quad \textit{(Signed Valuation Error)} \qquad (3.8)$$

For the t-test, an approximately normal distribution is assumed. The hypotheses are:

$$H_0: Mean\ and\ Median\ Valuation\ Errors\ =\ 0$$
$$H_1: Mean\ and\ Median\ Valuation\ Errors\ \neq\ 0$$

For the comparison of valuation errors of two different models, a paired t-test is adopted, to examine which model is better. As with the single sample t-test, a nearly normal distribution is assumed, and that the variances are similar for both populations. The hypotheses are:

$$H_0: Mean\ and\ Median\ Valuation\ Errors_1 \ = \ Mean\ and\ Median\ Valuation\ Errors_2$$
$$H_1: Mean\ and\ Median\ Valuation\ Errors_1 \ \neq \ Mean\ and\ Median\ Valuation\ Errors_2$$

The explainability shows the extent to which the equity value estimates explain the variations in the share price on the market - shown by R^2 of a regression concerning this. The regression is based on a robust variance-covariance matrix to consider heteroscedasticity.

$$Share\ Price \ = \ \alpha + \ \beta \ * \ V_{te} + \ \varepsilon \tag{3.9}$$
$$H_0: \beta_0 = \beta_1 \ = \ 0$$
$$H_1: \beta_0\ and\ /\ or\ \beta_1 \neq \ 0$$

The dispersion is shown by the standard deviation of the regression and shows how much the values differ from the mean. The central tendency is shown by the median and the means.

3.2 Findings of the Analysis for the entire Sample

To assess the advantageousness of the valuation models, the equity values per-share are examined to see to what extent they differ from the actual share price. However, it should be noted that the share price is an actual market observation, and the valuation methods assume an efficient market that does not reflect all the characteristics of a real market. Bias, accuracy and explainability are tested below using t-tests, Wilcoxon tests and OLS regressions.

3.2.1 Descriptive Statistics

The results of the equity value estimates are summarised in Table 6. The table shows the statistical data for all observations and gives an overview of all firms in the sample.

The average share price of all companies is \$46.32, and the median share price is \$39.03, indicating a right-skewed distribution. The same skewness applies also to all valuation models. Subsequently, a first overview is given whereby the results are statistically analysed in the following chapters.

Compared to the stock valuations, the MBVs, in particular, perform best, deviating only 5.55% (-\$2.57) from the share price, which may be related to the use of the harmonic mean. The RIVM also performs well, deviating by only 10.0% (+$4.61). Especially the DCFM performs poorly and deviates by 65.8% ($30.48), while the DDM performs slightly better at 47.6% (-$22.05). The poor performance of the DCFM can also be seen in the very high standard deviation.

However, when analysing the median, the ranking is different. The RIVM performs best by deviating from the share price by only 3.56% (-$1.39), while the DCFM, which is worst with the mean, now performs better than the MBV (9.94% (-$3.88)) and the DDM (6.23% (-24.31)) by deviating by only 6.04% ($2.36). This may be because, despite winsorizing, still some outliers exist that no longer influence by using the median.

No meaningful conclusion can be drawn based on these results, so the data are subsequently analysed for bias, accuracy and explainability.

Table 6- Equity Value Estimates[4]

	Stock price 4 months after fiscal year-end	Discounted Dividend Valuation	Discounted Cash Flow Valuation	Residual Income Valuation	Multiple-based Valuation
N	4,932	4,932	4,932	4,932	4,932
Mean	46.320	24.268	76.799	50.934	43.746
Standard Deviation	31.715	29.901	117.505	48.459	34.122
Min	1.730	0.001	0.005	-6.288	0.430
Max	161.500	380.364	2276.896	1173.305	232.961
1st percentile	4.680	0.569	0.771	3.337	2.674
1st quartile	23.370	6.601	17.220	20.555	20.304
Median	39.030	14.721	41.389	37.642	35.149
4th quartile	61.560	30.114	90.301	65.399	57.124
99th percentile	161.500	150.512	583.641	222.645	172.199

The table shows the equity value estimates of the individual valuation methods (outlined in section 2.3) and the share price with their central tendency and dispersion. Considering the mean, the MBV performs best and considering the median, the RIVM is best. Especially the DCFM performs poorly, which can also be seen in the high standard deviation. As the data are given without any relation, further analyses in terms of accuracy, bias and explainability are conducted below.

[4] The negative Min value of the RIVM occurs if the required return is higher than the actual earnings.

3.2.2 Statistical Significance

3.2.2.1 Valuation Errors

Table 7 shows the statistical data for the absolute and signed valuation errors. Both error types are tested with a t-test and the Wilcoxon test. The signed error indicates the bias, and the absolute error the accuracy and thus the closeness of the share price and the equity value.

The aforementioned H_0 can be rejected at any significance level for all models and for both the signed and absolute errors as the tests have a p-value of zero for both the mean and median. The valuation errors seem to be different from zero at a 99% confidence level. The only exception is the signed error of the MBV when using a t-test. Since it has a p-value of 0.43, H_0 cannot be rejected at any significance level.

The MBV shows the lowest mean absolute valuation error and therefore performs best in terms of accuracy, while the DCFM performs worst. It also performs best in terms of bias, but as the value is not significant the RIVM performs best. For median values, the RIVM performs best for bias and the MBV performs best for accuracy. The negative signed valuation errors show that DDM and MBV (only median) are positively biased as the equity value is greater than the share price, vice versa.

Table 7- Valuation Errors[5]

Valuation Error		Discounted Dividend Model		Discounted Cash Flow Model		Residual Income Valuation Model		Multiples-based Model	
		Absolute	Signed	Absolute	Signed	Absolute	Signed	Absolute	Signed
N		4,932	4,932	4,932	4,932	4,932	4,932	4,932	4,932
Mean		0.665	-0.368	1.353	0.887	0.522	0.201	0.352	0.008
Standard Devi-ation		0.951	1.101	2.812	2.992	1.282	1.370	0.579	0.677
Median		0.640	-0.593	0.641	0.090	0.316	0.006	0.245	-0.069
Mean	t-Value	49.104	-23.463	33.801	20.814	28.576	10.281	42.698	0.798
	p-Value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.425
Median	z-Value	60.822	-44.403	60.822	17.222	60.822	5.451	60.822	-9.984
	p-Value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

This table shows the central tendency and the statistical significance of the mean as well as the median absolute and signed valuation errors (outlined in section 3.1.4). The significance is tested with single-sample t-tests (mean) and Wilcoxon tests (median). The p-values allow determining whether the mean and median valuation errors are significantly different from zero. All errors besides the singed valuation error of the MBV are significant. The MBV has the best accuracy and the RIVM the best bias for the mean values. For the median values, the RIVM performs best for bias and the MBV performs best for accuracy.

[5] The results of the t-test are listed under the column "Mean" and the results of the Wilcoxon test under the column "Median".

Later, a multivariate regression is used to analyse the relationship between two valuation methods. To test the two methods for the valuation error, a paired t-test is performed. In all cases, the p-value is zero and all H_0 can be rejected at any significance level, which means a difference between the errors exists. The paired t-test shows that the DDM, RIVM and MBV in the respective test are better in terms of accuracy and bias than the comparison method.

Table 8- Paired t-Test

Valuation	Error	DDM	DCFM	DCFM	RIVM	RIVM	MBV
Absolute Valuation Error	Mean	0.665	1.353	1.353	0.522	0.522	0.352
	Difference	-0.689		0.832		0.170	
	p-Value	0.000		0.000		0.000	
Signed Valuation Error	Mean	-0.368	0.887	0.887	0.201	0.201	0.008
	Difference	-1.254		0.686		0.193	
	p-Value	0.000		0.000		0.000	

Two valuation results each are analysed with the paired t-test, whereby all values are significant (outlined in section 3.1.4). The test shows that DDM, RIVM and MBV are better in terms of accuracy in the respective test than the comparison method.

3.2.2.2 Regression

The explanatory power is tested using an OLS regression. All regressions in Table 9 provide an explanatory contribution based on the F-value and the Prob > F. Striking is that the R^2 of the DDM and DCFM are quite low at about 15%, while the RIVM and MBV have a much better explanatory power at 39.3% and 62.5%, respectively. This means that by using MBV 62.5% of the variance of the share price can be explained by the variance of the MBV estimates. The MBV is thus able to explain more than 4 times more of the variance than DCFM and DDM.

All p-values are zero and show that all coefficients are statistically significant at a 99% confidence level. Therefore, the H_0 can be rejected, which makes it probable that the coefficients are positively linked to the share price or that the equity value estimates are linked to higher share prices.

Remarkably, the constant is very high in all models. It captures all distortions that are not considered by the terms used in the models. It can, therefore, be assumed that other influences on the share price exist that are not reflected in the models. All coefficients are positive, indicating that equity values undervalue the share prices. The MBV has the highest impact as with an increase of 1% of the estimated equity value, the share price increases by 0.74%. The impacts of the other models are smaller.

Table 9- Bivariate Regression Results

Regression Statistics							
	DDM		DCF		RIVM		MBV
N	4,932		4,932		4,932		4,932
F-Value	312.590		149.070		66.320		3,230.270
Prob>F	0.000		0.000		0.000		0.000
R^2	0.159		0.152		0.393		0.625
Root MSE	29.081		29.212		24.721		19.429
Valuation	**Coefficient**		**Stand. Error**	**t-Value**	**p-Value**	**95% Confidence Interval**	
Discounted Dividend Valuation	**Coeffi-cient**	0.423	0.024	17.680	0.000	0.376	0.470
	Constant	36.044	0.615	58.590	0.000	34.838	37.250
Discounted Cash Flow Valuation	**Coeffi-cient**	0.105	0.009	12.210	0.000	0.088	0.122
	Constant	38.246	0.672	56.930	0.000	36.929	39.563
Residual Income Valuation	**Coeffi-cient**	0.410	0.050	8.140	0.000	0.311	0.509
	Constant	25.435	2.442	10.410	0.000	20.648	30.223
Multiple-based Valuation	**Coeffi-cient**	0.735	0.013	56.840	0.000	0.709	0.760
	Constant	14.183	0.503	28.190	0.000	13.196	15.169

This table provides the regression results for the reported share price, which is regressed against the equity value estimates generated by the various models (outlined in section 2.3). Statistical significance is tested using t-tests, whereby all values are highly significant (outlined in section 3.1.4). The MBV performs best in explainability and is linked to the share price to a much greater extent than the other models.

An analysis using two valuation models in a multivariate regression is applied in the following.

3.2.3 Hypothesis Evaluation

To answer the hypotheses set up, an analysis is carried out which involves two valuation models in a multiple regression analysis. All regressions provide an explanatory contribution based on the F-value and the Prob > F.

All p-values are equal to zero or below 1% and show that all coefficients are statistically significant at a 99% confidence level. Therefore, H_0 can be rejected, which makes it probable that the coefficients are positively linked to the share price or that the equity value estimates are linked to higher share prices.

3.2.3.1 Hypothesis I

The discounted cash flow valuation model outperforms the discounted dividend model in terms of reliability and accuracy.

The R^2 is 0.236 which means that 23.6% of the variance of the share price can be explained by the variance of the combination of the DCFM and the DDM equity value estimates.

As with the bivariate regressions, the constant is very high and covers all distortions that are not considered by the terms in the model. While the DCFM coefficient is very low, the DDM coefficient shows that a 1% increase in the equity value estimate is connected to a 0.32% increase in share price.

Table 10- Regression Results (DCFM and DDM)

Regression Statistics	
N	4,932
F-Value	201.520
Prob>F	0.000
R^2	0.236
Root MSE	27.736

Variables	Coeffi-cient	Standard Error	t-Value	p-Value	95% Confidence Interval	
DCF Coefficient	0.079	0.008	9.310	0.000	0.062	0.095
DDM Coefficient	0.324	0.023	14.240	0.000	0.280	0.369
Constant	32.415	0.693	46.770	0.000	31.057	33.774

This table provides the regression results for the reported share price, which is regressed against the equity value estimates generated by DCFM and DDM. Statistical significance is tested using t-tests, whereby all values are highly significant (outlined in section 3.1.4). The DDM performs better in explainability and is linked to the share price to a higher extent than the DCFM.

All tests performed show that the DDM performs better than the DCFM, which is consistent with the results of the bivariate regression but contradicts the findings of many discussed papers like Francis et al. (2000). Both models are based solely on assumptions and are therefore among the rather worse off methods. The superiority of the DDM is possible as dividends are more predictable since they are usually quite stable and can thus be forecasted at least in the short term. Furthermore, analysts do not usually forecast cash flows, so the cash flows for this model are made up of many small components. Previously, the large standard deviation of the DCFM was striking, which also contributes to the poor performance. This result contradicts the findings of Francis et al. (2000) as they find that the DCFM performs better than the DDM.

The first hypothesis is not true.

3.2.3.2 Hypothesis II

The residual income valuation model outperforms the discounted cash flow model in terms of reliability and accuracy.

The R^2 is 40.9% and therefore reasonably higher than the prior bivariate model, which means that more of the variance of the share price can be explained by this model combination.

With this combination, the constant is lower, but still high, which means that the model can capture more than the model before, but it still has unobserved distortions. While the DCFM coefficient is very low, the RIVM coefficient shows that a 1% increase in equity value is connected to a 0.37% increase in share price, which is higher than the increase due to the DDM.

Table 11- Regression Results (RIVM and DCFM)

Regression Statistics	
N	4,932
F-Value	200.100
Prob>F	0.000
R^2	0.409
Root MSE	24.386

Variables	Coeffi-cient	Standard Error	t-Value	p-Value	95% Confidence Interval	
RIVM Coefficient	0.369	0.056	6.600	0.000	0.259	0.479
DCF Coefficient	0.038	0.011	3.470	0.001	0.017	0.060
Constant	24.560	2.032	12.080	0.000	20.575	28.545

This table provides the regression results for the reported share price, which is regressed against the equity value estimates generated by RIVM and DCFM. Statistical significance is tested using t-tests, whereby all values are highly significant (outlined in section 3.1.4). The RIVM performs better in explainability and is linked to the share price to a much greater extent than the DCFM.

All the tests carried out indicate that the RIVM performs better than the DCFM, which is consistent with the results of bivariate regressions and tests. With RIVM, not the entire equity value is based on assumptions, since a part consists of the book value to equity, which can be taken from the balance sheet. The DCFM, on the other hand, has only forecasted assumptions and considers investments (CAPEX) negatively, even though they will be profitable in the future. This information could also be included in the constant, as the forecast period is too short to reflect investments. This confirms the results of Francis et al. (2000), who state that the RIVM performs better than the DCFM but contradicts the opinion of Courteau et al. (2001), who assume that both perform almost equally well.

The second hypothesis is true.

3.2.3.3 Hypothesis III

The multiple-based model is more reliable and accurate than the residual income valuation model.

The R^2 is 63.0%, which means that this combination can explain more than 2.5 times more of the variance of the share price than with the combination of DCFM and DDM.

Besides the constant is even lower than with the other models, indicating that the coefficients can capture more. Whilst the RIVM coefficient is very small, the MBV coefficient shows that a 1% increase in equity value is associated with a 0.66% increase in share price, which is much higher than with the other models.

Table 12- Regression Results (RIVM and MBV)

Regression Statistics	
N	4,932
F-Value	200.100
Prob>F	0.000
R^2	0.409
Root MSE	24.386

Variables	Coeffi-cient	Standard Error	t-Value	p-Value	95% Confidence Interval	
RIVM Coefficient	0.369	0.056	6.600	0.000	0.259	0.479
DCF Coefficient	0.038	0.011	3.470	0.001	0.017	0.060
Constant	24.560	2.032	12.080	0.000	20.575	28.545

This table provides the regression results for the reported share price, which is regressed against the equity value estimates generated by MBV and RIVM. Statistical significance is tested using t-tests, whereby all values are highly significant (outlined in section 3.1.4). The MBV performs much better in terms of explainability and is much more strongly linked to the share price than the RIVM.

All the tests performed show that the MBV performs better than the RIVM, which is consistent with the results of bivariate regression. The superiority may be since only a few assumptions need to be made for implementation and the earnings forecasts of the analysts are unbiased. Moreover, the market opinion is reflected in the MBV, as it is based on peer companies. This result contradicts the findings of Courteau et al. (2001) and Frankel and Lee (1998) that the FBMs are more accurate than MBV. Of all evaluation methods, the MBV is considered to be the best valuation method in terms of bias, accuracy and explainability.

The third hypothesis is true.

3.2.4 Sensitivity Analysis

A sensitivity analysis is performed to determine the impact of changes in key assumptions and thus assess the vulnerability of the results to variable and alternative specifications.

The assumptions that are considered controversial in literature and that have a strong influence on the estimates are examined. As the MBV is not based on such assumptions, the analysis is conducted only on the FBMs. All valuation errors in the following analysis are significant.

3.2.4.1 Change of the Growth Rate

All flow-based models include a TV in their calculation, which depends strongly on the growth rate. A sensitivity analysis is performed with 0%, 2% and 5% growth.

Accuracy and bias are best at a growth rate of 2% for all models, while lower growth usually leads to the highest valuation error. Remarkably the R^2 for RIVM and DCFM is highest at 2%, while for the DDM it is lowest at this point. The coefficients behave in the same way. Apart from the DDM, the 2% used for the original sample leads to the best results. For the DDM model, the 0% growth leads to the highest explanatory power.

The deterioration on an increase is probably because some companies have lower *COE* than the growth rate. As a result, the TV's denominator and therefore its total value becomes negative, which significantly reduces the equity value. The 2% growth rate is based on the inflation rate according to Francis et al. (2000) and almost always leads to the best possible result.

3.2.4.2 Change of the Market Risk Premium

The *MRP* is part of the *COE* and provides strong leverage for its value as it is multiplied by the *beta*, that is assumed to be stable, as it only changes if a firm alters its fundamentals, which is rare (Bodie et al., 2005). A sensitivity analysis is performed with 2%, 5% and 7% *MRP*.

Accuracy and bias are best at an *MRP* of 5% for the DDM and RIVM, while a lower *MRP* typically results in the highest valuation error. The DCFM performs best in accuracy and bias at an *MRP* of 7%, while bias is best at 5%. The R^2 increases for each model with an increase in the *MRP* and thus with an increase in *COE*. Therefore, the variance of the share price can be better explained by the variance of the estimates with a higher *MRP*. Especially noticeable is that the R^2 as well as the coefficients of all models are very low at 2% and then rise rapidly at 5%, while at 7% they rise only slightly.

Given the leverage effect of the *MRP* on the *COE*, increased values have a strong impact on the equity value, as it decreases with an increase in the discount factor *COE*. All values deteriorate especially when they are reduced and thus a higher *COE* seems to provide more realistic results.

3.2.4.3 Change of the Forecast Period

Due to the limitations of observations in the longer term, only one change is made, and the analysis is conducted for a two and three-year forecast. To ensure an equal basis for comparison, the observations are reduced to 3,072 to have an equal amount of observations for both periods.

In terms of accuracy and bias no tendency occurs, because for every model exists a valuation error that breaks the mould. In general, it appears that DDM and DCFM perform best for the 3-year forecast and RIVM for the 2-year forecast. The R^2 is higher for the 2-year forecast for DDM and RIVM, while it is higher for the 3-year forecast for DCFM. The difference for the DCFM and the DDM is very small, whereas the R^2 of the RIVM increases by more than 10%. The coefficients capture more for the DCFM and the DDM for the 3-year forecast.

The results largely reflect the findings of the literature review. DCFM and DDM tend to be designed for longer forecast periods as the DDM takes an on-going business approach and the DCFM does not consider short-term *CAPEX*, which may lead to a discrepancy between value gained and value given up. The RIVM, however, is based on accruals and solves the mismatch and timing problems of the other models, so a shorter forecast period seems to be sufficient.

3.2.4.4 Sensitivity Evaluation

Overall the best results are achieved under the initial assumptions, whereas the *MRP* achieves the best results with a higher value. The RIVM is particularly sensitive to changes, as it shows very strong variations especially concerning explainability. Similarly, there is a wide variance in the DCFM for the valuation errors, which generally reflects the poor performance of the DCFM, but gets even worse when the original assumptions are changed. The DDM is the most constant and has only slight deviations. Overall, particularly a decrease in assumptions leads to a deterioration in bias, accuracy and explainability. The results are shown in Table 13[6].

[6] The assumptions used for the original LSA are in bold.

Table 13- Sensitivity Analysis for Growth, Market Risk Premium and Forecast Periods

Valuation	Assump-tions	N	Signed Valuation Error				Absolute Valuation Error				Regression Statistic		
			Mean	p-Value	Median	p-Value	Mean	p-Value	Median	p-Value	R^2	Coeffienc.	Constant
Discounted Dividend Valuation	g=0%	4,932	-0.660	0.000	-0.774	0.000	0.734	0.000	0.777	0.000	0.173	0.885	34.911
	g=2%		**-0.368**	**0.000**	**-0.593**	**0.000**	**0.665**	**0.000**	**0.640**	**0.000**	**0.159**	**0.423**	**36.044**
	g=5%		-0.531	0.000	-0.688	0.000	0.677	0.000	0.701	0.000	0.172	0.634	35.040
Discounted Cash Flow Valuation	g=0%	4,932	-56.344	0.002	-0.379	0.000	93.810	0.000	7.255	0.000	0.003	0.000	46.276
	g=2%		**0.887**	**0.000**	**0.090**	**0.000**	**1.353**	**0.000**	**0.641**	**0.000**	**0.152**	**0.105**	**38.246**
	g=5%		3.217	0.000	1.280	0.000	4.324	0.000	1.627	0.000	0.069	0.023	42.601
Residual Income Valuation	g=0%	4,932	-23.683	0.000	-0.508	0.000	35.928	0.000	3.905	0.000	0.004	0.000	46.243
	g=2%		**0.201**	**0.000**	**0.006**	**0.000**	**0.522**	**0.000**	**0.316**	**0.000**	**0.393**	**0.410**	**25.435**
	g=5%		1.002	0.000	0.675	0.000	1.755	0.000	0.897	0.000	0.151	0.085	39.015
Discounted Dividend Valuation	MRP=2%	4,932	1.947	0.000	0.916	0.000	3.246	0.000	1.199	0.000	0.041	0.025	43.629
	MRP=5%		**-0.368**	**0.000**	**-0.593**	**0.000**	**0.665**	**0.000**	**0.640**	**0.000**	**0.159**	**0.423**	**36.044**
	MRP=7%		-0.594	0.000	-0.735	0.000	0.704	0.000	0.743	0.000	0.166	0.696	35.517
Discounted Cash Flow Valuation	MRP=2%	4,932	7.709	0.000	3.966	0.000	10.382	0.000	4.736	0.000	0.057	0.009	43.403
	MRP=5%		**0.887**	**0.000**	**0.090**	**0.000**	**1.353**	**0.000**	**0.641**	**0.000**	**0.152**	**0.105**	**38.246**
	MRP=7%		0.221	0.000	-0.278	0.000	0.903	0.000	0.594	0.000	0.158	0.171	37.855
Residual Income Valuation	MRP=2%	4,932	2.799	0.000	2.375	0.000	4.621	0.000	2.821	0.000	0.102	0.028	41.758
	MRP=5%		**0.201**	**0.000**	**0.006**	**0.000**	**0.522**	**0.000**	**0.316**	**0.000**	**0.393**	**0.410**	**25.435**
	MRP=7%		-0.466	0.000	-0.547	0.000	0.540	0.000	0.556	0.000	0.405	1.372	18.040
Discounted Dividend Valuation	**FP=2 years**	3,072	**-0.358**	**0.000**	**-0.594**	**0.000**	**0.674**	**0.000**	**0.639**	**0.000**	**0.131**	**0.381**	**40.302**
	FP=3 years		-0.317	0.000	-0.559	0.000	0.669	0.000	0.618	0.000	0.129	0.383	41.347
Discounted Cash Flow Valuation	**FP=2 years**	3,072	**0.943**	**0.000**	**0.154**	**0.000**	**1.375**	**0.000**	**0.634**	**0.000**	**0.142**	**0.099**	**41.992**
	FP=3 years		0.923	0.000	0.162	0.000	1.351	0.000	0.631	0.000	0.151	0.104	43.240
Residual Income Valuation	**FP=2 years**	3,072	**0.219**	**0.000**	**0.025**	**0.000**	**0.519**	**0.000**	**0.312**	**0.000**	**0.422**	**0.448**	**25.364**
	FP=3 years		0.273	0.000	0.053	0.000	0.546	0.000	0.304	0.000	0.314	0.353	31.398

This table presents the sensitivity to changes in the growth rate, market risk premium and forecast period. It shows the mean and median signed and absolute valuation errors as well as the regression results (outlined in section 3.1.4). Statistical significance is tested using t-tests, where the p-values indicate whether the valuation error is significantly different from zero, which is the case for every test. RIVM and DCFM particularly show high variations when assumptions are changed. Overall, the values deteriorate when the assumptions are reduced and perform best with the original assumptions, except for the MRP.

3.3 Findings of the Analysis for the R&D Samples

To evaluate the appropriateness of the valuation models for different R&D expenditures, the equity values per-share are examined to see to what extent they differ from the actual share price. In addition, bias, accuracy and explainability are analysed.

3.3.1 Descriptive Statistics

The firms in the low R&D sample spend less than 0.2% on average of their total assets on R&D, while the firms in the high R&D sample spend almost 10% and therefore nearly 50 times more. The mean share price of $46.93 of the low R&D sample is closer to that of the entire sample than the other sample at $45.32. The low R&D sample has higher share prices, which is in line with Schreiner and Spremann (2007), who conclude that a high R&D spending is penalised by a lower equity value. Both, the share prices and the estimates show a right-skewed distribution.

In the low R&D sample, the MBV performed best, followed by RIVM, DDM and finally the DCFM. In the high R&D sample, the order is different; RIVM performed best, followed by MBV, DCFM and DDM. Noticeable is that only the low R&D sample corresponds to the order of the entire sample. Considering all estimates of all samples, the RIVM is closest to the share price with a deviation of only 1.5% for the large R&D sample. Given the median values, the MBV performed best in both R&D samples. Considering the mean deviations of all models, the high R&D sample is in total slightly closer to the share price.

Table 13- Descriptive Data of the R&D Samples

	HIGH R&D SAMPLE					LOW R&D SAMPLE				
	Share price	DDM	DCFM	RIVM	MBV	Share price	DDM	DCFM	RIVM	MBV
Mean	45.324	21.381	55.816	44.649	43.306	46.927	32.560	83.631	60.705	48.135
Median	37.270	14.199	32.198	31.701	34.699	38.600	16.983	46.161	43.972	37.772
Average spending	0.185%					9.237%				

The table shows the most important descriptive data of the high and low R&D sub-samples as well as their average expenditure. The low R&D sub-sample has a higher mean and median share price and higher estimates. For the means, the RIVM performs best in the high R&D sample and the MBV in the low R&D sample. For the median, MBV performs best in both. The firms in the low R&D sample spend less than 0.2% on average, while the firms in the high R&D sample spend almost 10% of their total assets.

Since no meaningful conclusions can be drawn from these results, the data are subsequently analysed for bias, accuracy and explainability, whereby both the individual values and the differences between the two R&D subsamples are analysed according to the approach of Francis et al. (2000).

3.3.2 Statistical Significance

3.3.2.1 Valuation Errors

In order to adapt to the structure of Francis et al. (2000), the valuation errors are calculated using two different growth rates. Like with the original sample 2% is used and 0% is set as a comparison like Francis et al. (2000) did in their paper. As in the sensitivity analysis, the models perform badly with a 0% growth rate as the mean values are far from the share price. All errors besides the singed valuation error of the MBV (for 2% and 0%) and RIVM are significant at a 5% level and H_0 can be rejected, which means a difference between the errors exists.

A negative difference between the samples represents a superiority of the high R&D sample for the errors. The errors are in general higher for all models in the 0% growth scenario. Like in the original sample the accuracy is mostly better for the high R&D sample although the superiority is not as clear anymore. The accuracy is higher for the DCFM and RIVM of the high R&D sample and for the MBV and DDM of the low R&D sample. However, the differences for MBV and DDM are very small, while they are very high for the other methods, so the accuracy seems to be better overall in the high R&D sample. In terms of bias, the result is clearer as the high R&D sample with the 2% growth rate performs always better. This is partly contradicted by the 0% growth scenario as only for the DDM and MBV the high R&D sample performs better. As the 0% growth rate scenario performed badly in the prior analysis, the superiority can be neglected, and the high R&D performs also best in terms of bias. Considering the single valuation errors, the accuracy is best for the MBV in the low R&D sample and the bias is best for the RIVM in the high R&D sample, as the MBV's signed error is not significant.

In contrast to the findings of Francis et al. (2000), a difference in bias and accuracy exists for equity values of companies with high and low R&D spending. As in their findings, I conclude that the RIVM is more accurate than DDM or DCFM, but unlike them, I find a difference between the high and low R&D samples in terms of accuracy. Combined with bias, the high R&D sample performs best overall. Considering the individual methods, the MBV is best in accuracy and the RIVM in bias.

Table 14- Valuation Errors for the R&D Sample

Valuation	High R&D			Low R&D			Difference			p-Value	
	Absolute Equity Value	Absolute Valuation Error	Signed Valuation Error	Absolute Equity Value	Absolute Valuation Error	Signed Valuation Error	Absolute Equity Value	Absolute Valuation Error	Signed Valuation Error	Absolute Valuation Error	Signed Valuation Error
Discounted Dividend Valuation	21.381	0.658	-0.394	32.560	0.610	-0.295	-11.179	0.048	-0.100	0.000	0.000
Discounted Cash Flow Valuation	55.816	0.881	0.335	83.631	1.345	0.949	-27.815	-0.463	-0.615	0.002	0.000
Residual Income Valuation	44.649	0.436	0.050	60.705	0.530	0.318	-16.056	-0.094	-0.268	0.000	0.199
Multiple-based Valuation	43.306	0.354	0.022	48.135	0.304	0.056	-4.829	0.050	-0.033	0.000	0.438
Discounted Dividend Valuation (0% growth)	11.989	0.757	-0.658	16.629	0.671	-0.632	-4.640	0.086	-0.025	0.000	0.001
Discounted Cash Flow Valuation (0% growth)	-104.194	21.091	4.763	-3803.190	75.381	-57.456	3698.996	-54.290	62.219	0.000	0.000
Residual Income Valuation (0% growth)	-59.595	12.827	0.552	-2312.060	35.639	-26.894	2252.465	-22.812	27.446	0.050	0.000
Multiple-based Valuation (0% growth)	43.306	0.354	0.022	48.135	0.304	0.056	-4.829	0.050	-0.033	0.000	0.438

This table shows the equity value estimates with a high and low R&D spending as well as the statistical significance of the mean absolute and signed valuation errors (outlined in section 3.1.4). The significance is tested with t-tests. The p-values allow determining whether the mean valuation errors are significantly different from each other. All errors besides the singed valuation error of the MBV (2% and 0%) and RIVM are significant at a 5% level. The errors are higher for all methods for the 0% scenario. Overall the high R&D sample performs best in terms of accuracy and bias as the valuation errors are mostly smaller. The accuracy is best for the MBV in the low R&D subsample and the bias is best for the RIVM in the high R&D sample, as the MBV's signed error is not significant. Like in all analyses before the DCFM is worse.

3.3.2.2 Regression

The explainability is tested using OLS regressions. All regressions provide an explanatory contribution based on the F-value and the Prob > F. The R^2 of all models besides the MBV are higher in the high R&D sample than in the low R&D sample, which is consistent with previous results. As in the original sample, the MBV provides the highest explainability, followed by RIVM, DDM and DCFM for the low R&D sample. For the high R&D sample, it is followed by RIVM, DCFM and DDM. Both samples provide a better R^2 compared to the original sample, which is possibly due to less variation. The results of Francis et al. (2000) are reflected as the RIVM has a higher explainability in the high R&D sample than in the low R&D sample. The variance of both MBV estimates can explain more than 70% of the variance of the stock price.

All p-values are zero and show that all coefficients are statistically significant at a confidence level of 99%, making it likely that the coefficients are positively related to share price or that the estimates are related to higher share prices. The constants are still very high, but much lower than the constants of the original sample, which means that more distortions are captured. All coefficients are positive, indicating that equity values understate share prices. The coefficients of the high R&D sample are always higher. The MBV captures the most in the low R&D sample, meaning that if the equity value increases by 1%, the share price increases by 0.73%.

Table 15- Regression Results for the R&D Samples

LOW R&D SAMPLE							
	DDM		**DCF**		**RIVM**		**MBV**
N	809		809		809		809
F-Value	113.150		16.250		319.630		1,106.840
Prob>F	0.000		0.000		0.000		0.000
R^2	0.242		0.165		0.532		0.731
Valuation	**Coefficient**		**Stand. Error**	**t-Value**	**p-Value**	**95% Confidence Interval**	
Discounted Dividend Valuation	**Coefficient**	0.381	0.036	10.640	0.000	0.310	0.451
	Constant	34.537	1.336	25.860	0.000	31.915	37.158
Discounted Cash Flow Valuation	**Coefficient**	0.096	0.024	4.030	0.000	0.049	0.143
	Constant	38.908	1.922	20.240	0.000	35.135	42.681
Residual Income Valuation	**Coefficient**	0.443	0.025	17.880	0.000	0.395	0.492
	Constant	20.016	1.225	16.340	0.000	17.612	22.420
Multiple-based Valuation	**Coefficient**	0.767	0.023	33.270	0.000	0.722	0.812
	Constant	10.245	0.952	10.770	0.000	8.377	12.113

HIGH R&D SAMPLE						
	DDM		DCF		RIVM	MBV
N	808		808		808	808
F-Value	54.440		178.260		62.900	840.430
Prob>F	0.000		0.000		0.000	0.000
R^2	0.257		0.320		0.609	0.725
Valuation	**Coefficient**		**Stand. Error**	**t-Value**	**p-Value**	**95% Confidence Interval**	
Discounted Dividend Valuation	**Coefficient**	0.709	0.096	7.380	0.000	0.521	0.898
	Constant	30.159	1.906	15.820	0.000	26.417	33.902
Discounted Cash Flow Valuation	**Coefficient**	0.250	0.019	13.350	0.000	0.213	0.287
	Constant	31.380	1.171	26.800	0.000	29.082	33.679
Residual Income Valuation	**Coefficient**	0.600	0.076	7.930	0.000	0.451	0.748
	Constant	18.551	3.080	6.020	0.000	12.505	24.597
Multiple-based Valuation	**Coefficient**	0.800	0.028	28.990	0.000	0.745	0.854
	Constant	10.590	1.001	10.580	0.000	8.625	12.556

This table provides the regression results for the reported share price, which is regressed against the equity value estimates generated by the various models for the high and low R&D subsample (outlined in section 2.3). Statistical significance is tested using t-tests, whereby all values are highly significant (outlined in section 3.1.4). All flow-based models have a higher explainability in the high R&D sample, while the MBV only performs best in the low R&D sample and is linked to the share price to a much greater extent than the other models. The same pattern is noticeable for the constants that can capture more than in the original sample. Overall the high R&D sample is better, but the MBV is an exception as it has a higher explanatory power and constant in the low R&D sample.

Overall, all FBMs have a higher explainability in the high R&D sample, while the MBV is better in the low R&D sample and is more strongly linked to stock price than the other models.

3.3.3 Hypothesis Evaluation

3.3.3.1 Hypothesis IV

Firms with lower R&D expenditures are valued more accurate than firms with high R&D expenditures, whereby the order of superiority of the models does not change.

The above results generally draw a clear conclusion for the flow-based models, as the accuracy and bias are almost constantly best for the high R&D sample. For the MBV, which is so far the best performing method in the prior analysis, the best performance is achieved in a low R&D environment. However, if all models are considered, the high R&D sample performs best overall. The superiority of the models is also reflected in the explainability; the flow-based models can explain more in the high R&D sample, while the MBV is best in both samples, but the explainability is highest in the low R&D sample. In general, it is noticeable that both subsamples have a higher explainability compared to the original sample.

Francis et al. (2000) also analysed flow-based models in terms of R&D spending. Like them, I conclude that the RIVM is better than DCFM and DDM in terms of accuracy and explainability. However, contrary to their results, I find a difference between the accuracy of the high and low R&D spending and see a higher accuracy for the high R&D sample for the FBMs. The findings of Schreiner and Spremann (2007) are also reflected. They find that high R&D spending is penalised, which is in line with this analysis, as the equity values of the high R&D sample are lower. The increased accuracy that Sougiannis and Yaekura (2001) find for low R&D firms is contradicted as the absolute valuation error is lower for the high R&D sample.

Overall, this analysis suggests that the MBV achieves the best result in an environment of low R&D spending across the sample. However, the flow-based models benefit from a high R&D spending and demonstrate better results than with a low R&D spending.

This hypothesis is only true if the flow-based models are excluded and thus only the MBV is considered. For the flow-based models, high R&D expenditures lead to better results in terms of bias and accuracy. Furthermore, the hypothesis concerning the order of the models can only be considered true for the low R&D sample.

The fourth hypothesis is partly not true.

3.4 Interim Conclusion

The MBV always performs best in terms of explainability and often also in terms of bias and accuracy. RIVM, DDM and DCFM follow, although the latter two sometimes change their superiority. The sensitivity analysis concludes that under the initial assumptions the best results are achieved, whereas the MRP achieves better results with a higher value. The RIVM is particularly sensitive in terms of explainability and the DCFM in terms of valuation errors, while the DDM is the least sensitive. Overall, a decrease in assumptions leads to a deterioration of bias, accuracy and explainability. Besides, both low and high R&D expenditures have a positive effect on bias, accuracy and explainability compared to the original sample. The high R&D sample is best for the FBMs as the bias and accuracy are best with a high R&D spending. However, the MBV, which is the best performing model in LSA, is best in all aspects in a low R&D environment. It is therefore recommended that firms with a high R&D spending use the RIVM for their valuation and firms with a low R&D spending the MBV.

4 Case Study

Although the large sample analysis (LSA) has advantages, the valuation process actually applied by the analysts is not reflected as it cannot be observed. Thus, in the following case study, only one company is examined in detail. To this end, analysts' reports, media articles and annual reports are analysed to provide a broad overview of the company and its valuations. The results of the analyst reports are linked to the results of the previous analysis. The subsequent discussion addresses the following questions:

- Which valuation models are typically used by analysts to value the specific company?
- Does it seem conclusive that analysts may not apply all models?
- Do the analyst reports correspond to the results of the previous analysis?
- Is the theory reflected in reality?

At the beginning, the selection criteria for the company are defined and the case company is presented. The focus is primarily on the business model, strategy and finance. Everything except the financial part refers to the current situation of the company, while the financial part covers the observation period to relate the results to the same period. Afterwards, the computed estimates and the assumptions are compared to analyst reports.

4.1 Criteria for the Selection of a Company

Francis et al. (2000) suggest that any firm can be selected from any industry as industry affiliation does not influence the valuation model's performance. Demirakos et al. (2004) assume, however, that analysts use MBVs more commonly when valuing stable than unstable industries. As the MBV performed best in the previous analysis and thus represents an important element of comparison, a company from a stable industry is used in this small sample analysis. The manufacturing industry is particularly suitable for this. Another criterion is that the firm should be large, as this makes it more likely that sufficient analyst reports are available. After reviewing the valuation results from the large sample analysis and considering the size of the firms, the Boeing Company appears to be the best firm for the small sample analysis.

4.2 Company

Boeing is the biggest aerospace company in the world and a major manufacturer of commercial aircraft and systems for defence, space and security, based in Chicago. Boeing's product range includes civil and military aircraft, weapons, satellites, defence and electronic systems, launchers, as well as communication and information systems. Boeing is divided into three operational business units; Defense, Space & Security, Commercial Airplanes and Boeing Global Services. They are supported by Boeing Capital Corporation, Boeing Engineering and the Shared Services Group. Boeing has customers in 150 countries and supports especially airlines and governments. As the biggest US manufacturing exporter, approximately 70% of the current orders for passenger aircraft were placed by customers outside the USA. Today, Boeing employs around 153,000 people in over 65 countries worldwide (Boeing, 2020).

James McNerney was CEO on Boeing for most of the observation period and was named “CEO 2015” due to numerous acquisitions and reputation improvements. He was followed by Dennis Muilenburg, who left Boeing in 2019 after two aeroplane crashes. Now, Dave Calhoun is CEO, who was formerly Chairman. This position was filled by Lawrence Kellner (Boeing, 2020).

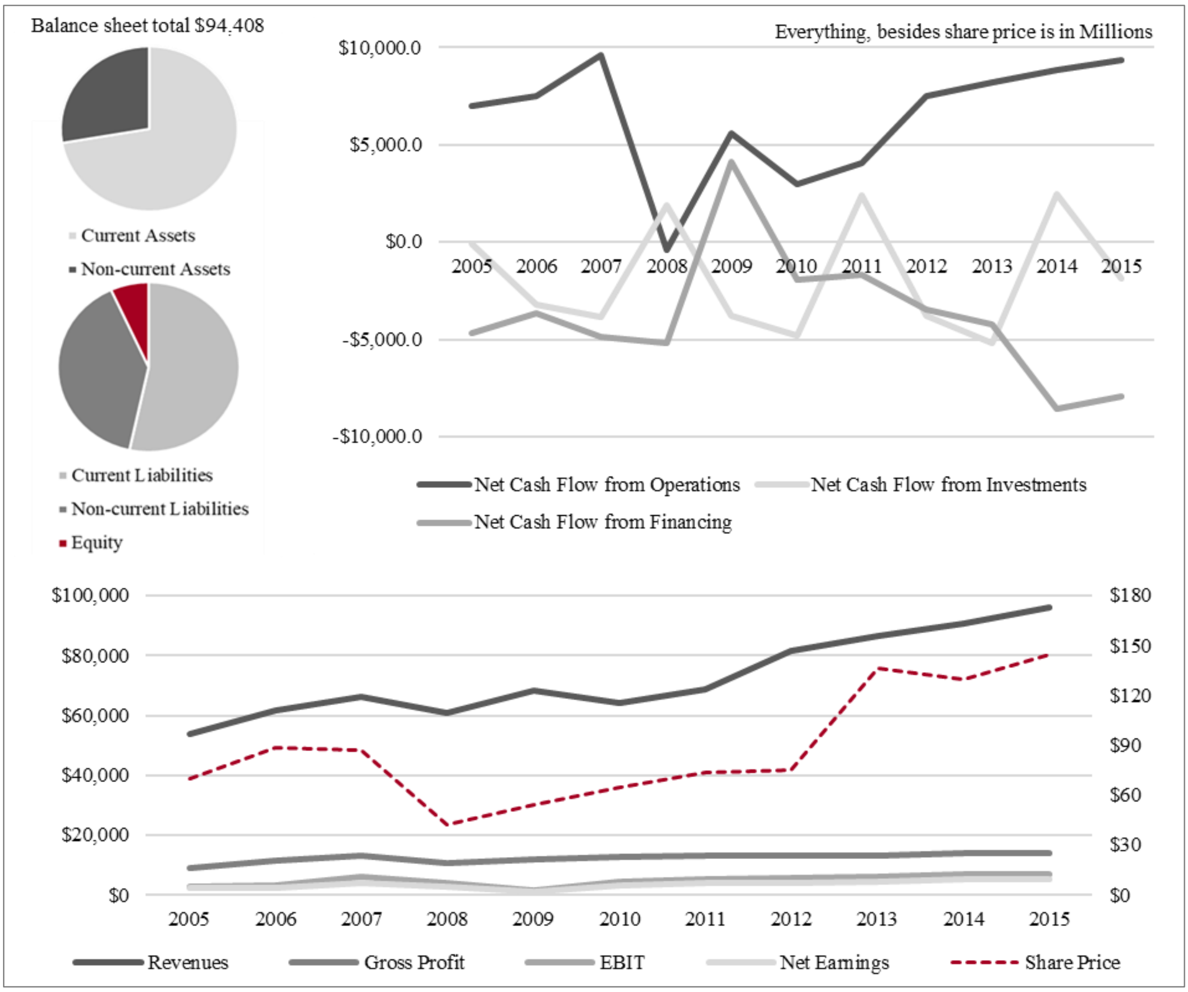

Figure 2- Financial Data of Boeing (2005-2015)[7]

Graphic is self-created (Eikon, 2020)

The chart shows that Boeing is largely debt-financed and has only about one-quarter of non-current assets. The various cash flows develop unsteadily, with only the operating cash flow remaining consistently in a positive range. The development of revenue is at least partially reflected in the share price, with the remaining performance figures showing a disproportionately low development.

[7] The balance sheet data refer to the year 2015. The performance figures and the share prices are shown yearly for the entire observation period.

The above chart reveals that most assets are non-current and are thus fixed for the long term. More than a quarter of this amount is invested in property and equipment. At just 6.7%, Boeing finances only a very small part by equity ($6,397 million); most is financed by liabilities in the form of advances and billings in excess of related costs ($24,364), which come from long-term contracts. While Boeing has maintained a net cash position in the past, in 2009 they issued $5.9 billion debt to meet advanced payments to suppliers under a new program (Morningstar, 2015).

The development of cash flows is very volatile; while the operating cash flow is negative only once during the financial crisis, the financing and investment cash flows are more often negative than positive due to high *CAPEX* and dividend payments. Looking at the development of financial performance over the observation period; revenues increased almost continuously, while gross profit, *EBIT* and net earnings show only slight fluctuations but hardly any growth. Especially the cost of products and R&D expenses rose constantly, while the admin costs mostly declined (Eikon, 2020).

The share price only partially follows Boeing's development - it collapsed mainly during the financial crisis of 2008/2009 and then recovered only slowly until 2012 and then strongly further when several large orders were won from Philippine Air and United Airlines (Reuters, 2012; CNNMoney, 2012). Shortly before the peak in 2015 China Southern Airlines enters into a big deal with Boeing, after which the share price eventually reaches $144.59 (Bloomberg, 2015). In 2015, analysts rate Boeing as a good long-term investment, as its strategy is well prepared for the future (Nasdaq, 2015; Fool, 2015).

4.3 Analyst Report Analysis

To compare the results of the large sample analysis with the results of the analysts' report, an overview of the equity value estimates for each year of the observation period is provided to check which model performs best. In the following, some of the analyst reports from December 2015 are analysed, which results are related to the findings.

4.3.1 Results of the Large Sample Analysis for Boeing

Table 16 shows the estimated equity values for Boeing and their percentage deviation from the share price. All valuation models, except DCFM, perform best for at least two years; DDM is the best method for 2 years during the financial crisis, RIVM for 3 years and MBV for 5 years. The MBV, in particular, performs best in the later years of the observation period. The obtained findings (DCFM<DDM<RIVM<MBV) can be found in the years 2006, 2013 and 2014. In the

other two years, in which the MBV performs best, the subsequent ranking of superiority is different.

Overall, the superiority of the MBV and the failure of the DCFM (far above/below the share price) are also reflected in the valuation of Boeing and the findings of the LSA are partially reflected. In 2015 all estimates, besides the MBV are lower than the share price.

Table 16- Results of the Large Sample Analysis for Boeing[8]

Year	Share price	Equity Values							
		DDM	Δ	**DCFM**	Δ	**RIVM**	Δ	**MBV**	Δ
2006	93.000	23.967	74.2%	7.272	92.2%	42.024	54.8%	**84.146**	9.5%
2007	84.860	26.232	*69.1%*	47.258	*44.3%*	**76.044**	*10.4%*	94.848	*11.8%*
2008	40.050	**33.004**	*17.6%*	215.864	*439.0%*	62.500	*56.1%*	69.296	*73.0%*
2009	72.430	**70.832**	*2.2%*	27.606	*61.9%*	65.101	*10.1%*	69.090	*4.6%*
2010	79.780	32.797	*58.9%*	105.452	*32.2%*	**72.773**	*8.8%*	67.928	*14.9%*
2011	76.800	29.600	*61.5%*	124.693	*62.4%*	**78.219**	*1.8%*	64.171	*16.4%*
2012	91.410	42.198	*53.8%*	76.188	*16.7%*	100.113	*9.5%*	**96.174**	*5.2%*
2013	129.020	50.049	*61.2%*	24.814	*80.8%*	113.996	*11.6%*	**125.380**	*2.8%*
2014	143.340	63.765	*55.5%*	355.760	*148.2%*	130.080	*9.3%*	**144.066**	*0.5%*
2015	134.800	75.935	*43.7%*	122.686	*9.0%*	127.250	*5.6%*	**134.878**	*0.1%*

The table shows the share price and the respective equity value estimates for the individual years of the observation period as well as the percentage deviation from the share price. The MBV performs best most often, but RIVM and DDM also perform best several times, with the latter providing the best estimates during the financial crisis.

As the MBV performs best overall, a recommended target price of $134.88 is recommended, indicating that the share has a nearly fair price. Subsequently, the findings of Boeing are compared to the results of the analyst reports.

4.3.2 Results of the Analysis of the Analyst Reports

Analyst reports for 2015 are available from Credit Suisse, Barclays and Morningstar and thus from a sell-side perspective (Morningstar, 2015; Credit-Suisse, 2015; Barclays, 2015). After reviewing all the reports, it turns out that no analyst report covers all the valuation methods mentioned; only the MBV is done in each analyst report, while Morningstar also covers DCFM. Here too, the MBV can be assumed to be superior. This is consistent with the findings of Demirakos et al. (2004) and Asquith et al. (2005), who state that most analysts use the MBV for valuation, but also that the DCFM is still very common. Barker (1999), on the other hand, sees the MBV more as a kind of basis on which further fundamental analyses must be carried

[8] The best performance for each year is highlighted in red. The years that support the findings are framed.

out. It is striking that theory and practice are not linked; the literature review concludes that the RIVM is the best FBM, while the model is not used in any of Boeings' analyst reports. Only the MBV has its justification in both theory and practice, while the DCFM is considered poor in theory but is at least partially used in practice. One reason for not using the DDM could be that the dividend development does not follow a clear direction and therefore a valuation based on the DDM would not be appropriate.

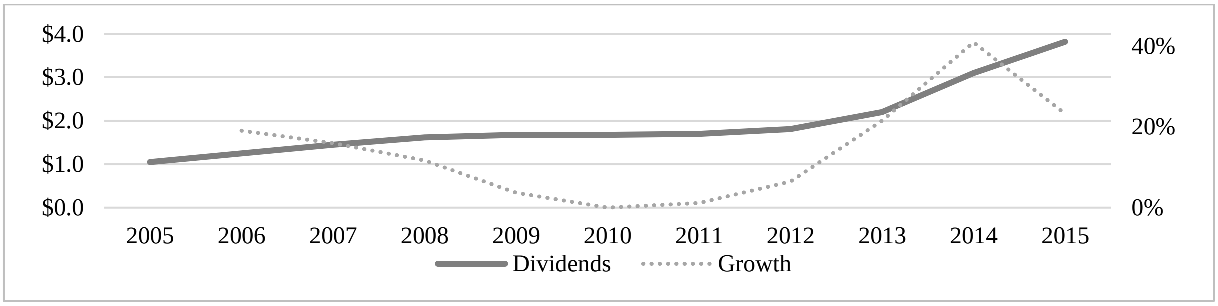

Figure 3- Dividend Development of Boeing

The graph shows that the dividend is rising moderately, but the share price is not developing in any comprehensible correlation.

The following examines Morningstar's most recent 2015 report (23.11.2015) and links it to the other two reports as appropriate.

The analyst report assesses the future of Boeing as good, as production rates are expected to rise, and a new line is introduced. They expect Boeing to deliver more than 1000 commercial aircraft by 2019, which they also see as a major challenge. On the other hand, the defence business is not expected to grow in the coming years, as the US does not intend to increase defence spending due to a tight budget situation. They, therefore, expect that Boeing's future earnings will come mainly from the commercial line and that they will continue to maintain operating and maintenance margins above 9%. Morningstar estimates Boeing's fair value at $156 per-share and expects a fair return. Besides, they expect the return on invested capital to be higher than the cost of capital with around 20%.

For their valuation, they expect an average revenue growth of 5.5% over the next 5 years, combining high growth for the commercial line and no growth for the defence line. This is well above the 2% growth rate (inflation rate) assumed in the LSA and the forecast period was only 2 years. To examine both upside potential and downside risk, they conducted a scenario analysis that includes aircraft deliveries, margins and growth in the defence sector, as well as some ongoing projects. As Boeing was only analysed as part of the LSA, such specific impacts were not considered. Furthermore, forecasts were not made for individual accounting figures such as *CAPEX*, intangible assets or operating cash flow, as Morningstar did, but only for the accounting flows needed for the valuation. Besides, no specific changes during the forecast period in terms of production rates or reductions in supply were considered in the LSA.

After weighing the different scenarios, they come to an upside fair value of $193 and a downside of $109, where the actual fair value of $156 lays closer to the upside.

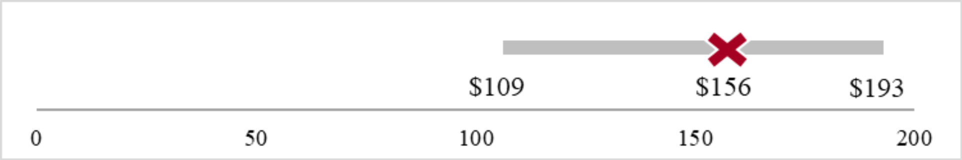

Figure 4- Fair Value Estimates of Boeing

The chart shows the classification of the fair value of equity by Morningstar. They set a range between $109 and $193, with their actual fair value of $156 being closer to the upper end.

They believe that the intrinsic value of Boeing is worth the future cash flows. Morningstar values its companies based on their understanding of the company's economic moat, their estimation of the fair value of the share, their uncertainty about the estimate of fair value, and the current price in the market. Based on these points the DCFM is based on three steps.

In the first stage, the forecast is between 5 and 10 years long and is based on detailed assumptions; in the second stage, the company's return on reinvested capital and the growth rate fades gradually until the year of perpetuity and from then on a return on reinvested capital equal to the weighted cost of capital is assumed. This approach is very different from the approach adopted in the LSA and the results are therefore difficult to compare. Since the whole enterprise is valued in their analysis and not just equity, they do not consider the *COE* for discounting purposes. However, instead of using the cost of capital, they consider expectations for real market returns, inflation, corporate credit spreads, country risk premiums, and any added systematic risk.

Based on their assumptions, they arrive at an enterprise value of $120,354 million after all stages, which corresponds to a share price of $174.50. After deducting net debt, the equity value is $101,656 million and $147.39 per-share. Due to the different approach, this value can only partly be compared to the $122.69 calculated using the DCFM in the LSA (deviation of 16.8%). Remarkably, the actual share price of $143.34 is between Morningstar's and LSA's results, but closer to Morningstar. While Morningstar considers the shares to be undervalued (*buy*), the LSA indicates that they are overvalued (*sell*).

Morningstar expects the current dividends of $3.64 to increase in the future, while the forecast dividends of $4.21, calculated for the DDM in the LSA, are much higher. Therefore, the DDM valuation for Boeing would also be very far from Morningstar's estimate if they had carried out a valuation based on DDM.

Moreover, to the DCFM, Morningstar also provides multiples, but these are not further substantiated. Besides multiples from Barclays and Credit Suisse are shown in a table below.

Table 17- Multiples for Boeing

Multiple	Large Sample Analysis	Morningstar	Barclays	Credit Suisse
Price/Earnings	15.9x	16.7x	16.3x	15.6x
EV/Sales	0.65x	-	1.1x	-
EV/EBITDA	6.6x	9.2x	9.2x	9.5x
EV/EBIT	8.1x	11.4x	-	-
Recommendation	Sell	Buy	Buy	Buy

The table shows the multiples determined by the investment banks alongside the multiples calculated for the analysis. Components such as net debt, EBIT, EBITDA and enterprise value were determined provisionally using the data set. Overall, the multiples of the banks are higher, and all recommend buy, while the recommendation based on this paper is sell.

Remarkably all analysts suggest *buy*, whereas LSA valuation concludes *sell*. While the estimates of the analyst are reasonably close to each other, the results of the case study are always below, which indicates some valuation errors in the calculation of the multiples. No report describes any kind of valuation error or how they try to eliminate it, which is why the errors are calculated and shown below.

Table 18- Valuation Errors of the Analyst Reports

	Discounted Cash Flow Method		Multiple-Based Valuation Method			
Error Type	**Large Sample Analysis**	**Morn-ingstar**	**Large Sample Analysis**	**Morn-ingstar**	**Barclays**	**Credit Suisse**
Absolute Valuation Error	0.437	0.062	0.001	0.065	0.027	0.116
Signed Valuation Error	-0.437	0.062	0.001	-0.065	-0.027	-0.116

The table shows the absolute and signed valuation errors of the investment banks and this analysis (calculation outlined in section 3.1.4). The errors of the LSA of the DCFM are much higher than those of the banks, while those of the MBV are much lower.

Clearly, the DCFM valuation errors are much larger than those of Morningstar. Conversely, the MBV valuation errors are much better than those of all investment banks. The accuracy is really good for the MBV and it is slightly positively biased, while DCFM is poorly accurate and highly negatively biased.

A likely solution to the poor performance of the DCFM estimates in the case study could be that there is no customised valuation approach for Boeing. All companies in the LSA were valued using more or less the same assumptions, with only adjustments within the industry groups. Besides, a constant *MRP* and constant growth were assumed for the FBMs, which showed a high sensitivity in the LSA. Especially growth is different for each company, which was not considered in the LSA. Besides, the peer group probably does not fit to the highest degree, since the industry is based on a 2-digit SIC code only, while the analysts probably did a lot of research to find a suitable peer group. However, under the very general assumptions, Boeing is valued quite close using the MBV. A major mispricing by the market in the case of DCFM can almost be ruled out, as the MBV is close to the share price.

4.4 Interim Conclusion

The general valuation results of the companies valued in the LSA are largely reflected in the individual valuation of Boeing. Of all analyst reports published in 2015, none shows the RIVM or DDM, only one shows the DCFM but all show the MBV, which partly contradicts the theory of the literature. The MBV is, therefore, the predominant choice for Boeing. While the DCFM is conducted differently, as in the LSA, the DCFM and its assumptions are described very precisely in the reports, whereas the MBV is presented without any detailed explanations. The results of the reports show different equity values but are also adjusted to the company, which is why specific events were considered. The valuation errors of the MBV in the case study are better than those of all analyst reports, whereas the opposite is true for the DCFM. Overall, the recommendation is *sell*, while all analysts suggest the opposite. The MBV arrives at a fair value of $134.88, which is only slightly above the share price of $134.80 and superiority is therefore also found in the case study.