
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 <i>EPS</i> in year t+1
Analyst forecast of <i>EPS</i> 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:

$$= \frac{+1}{\text{Stock price 4 months after fiscal year end}} \quad (3.1)$$

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).

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

Where:

r_E	\triangleq	Cost of equity
	\triangleq	Risk free rate
	\triangleq	Beta (measures the systematic risk)
$r_M - r_f$	\triangleq	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

$$= \frac{E_t \text{DIV}_{t+1}}{(1+r_E)} + \frac{E_t \text{DIV}_{t+2}}{(1+r_E)^2} + \frac{E_t \text{DIV}_{t+2} * (1+g)}{(r_E - g) * (1+r_E)^2} \quad (3.3)$$

Discounted Cash Flow Valuation Model²

$$= \frac{E_t \text{FCFE}_{t+1}}{(1+r_E)} + \frac{E_t \text{FCFE}_{t+2}}{(1+r_E)^2} + \frac{E_t \text{FCFE}_{t+2} * (1+g)}{(r_E - g) * (1+r_E)^2} \quad (3.4)$$

Residual Income Valuation Model

$$= V_0 + \frac{E_t \text{RI}_{t+1}}{(1+r_E)} + \frac{E_t \text{RI}_{t+2}}{(1+r_E)^2} + \frac{E_t \text{RI}_{t+2} * (1+g)}{(r_E - g) * (1+r_E)^2} \quad (3.5)$$

Multiple-based Valuation Model

$$V = VD * \frac{1}{\sum_{n=1}^n \frac{\text{Analyst forecast of EPS in year } t+1}{\text{Stock price 4 months after fiscal year end}}} \quad (3.6)$$

Where:

	\triangleq	Equity value at the time of the valuation
V_0	\triangleq	Current book value of equity
$[RI]$	\triangleq	Expected residual income
$[FCFE]$	\triangleq	Expected free cash flows to equity
$[DIV]$	\triangleq	Expected dividends
	\triangleq	Cost of equity
g	\triangleq	Growth rate
n	\triangleq	Time in years
	\triangleq	Value driver of the valued firm ($VD > 0$)
—	\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 Analysis³

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).

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

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

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

$$H_0: \mu = 0$$

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

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:

$$H_0: \mu_1 = \mu_2$$

$$H_1: \text{Mean and Median Valuation Errors}_1 \neq \text{Mean and Median Valuation Errors}_2$$

The explainability shows the extent to which the equity value estimates explain the variations

$$\text{Share Price} = \alpha + \beta * V_{te} + \varepsilon \quad (3.9)$$

$$H_0: \beta_0 = \beta_1 = 0$$

$$H_1: \beta_0 \text{ and / or } \beta_1 \neq 0$$

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.

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 Estimates⁴

	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.

⁴The 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 Errors⁵

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 Deviation	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
	p-Value	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
	p-Value	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 signed 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	Coefficient	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	Coefficient	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	Coefficient	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	Coefficient	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 (DCF and DDM)

Regression Statistics						
N			4,932			
F-Value			201.520			
Prob>F			0.000			
R^2			0.236			
Root MSE			27.736			
Variables	Coefficient	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	Coefficient	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	Coefficient	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 FBM is 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 13⁶.

⁶The 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 signed 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 signed 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).

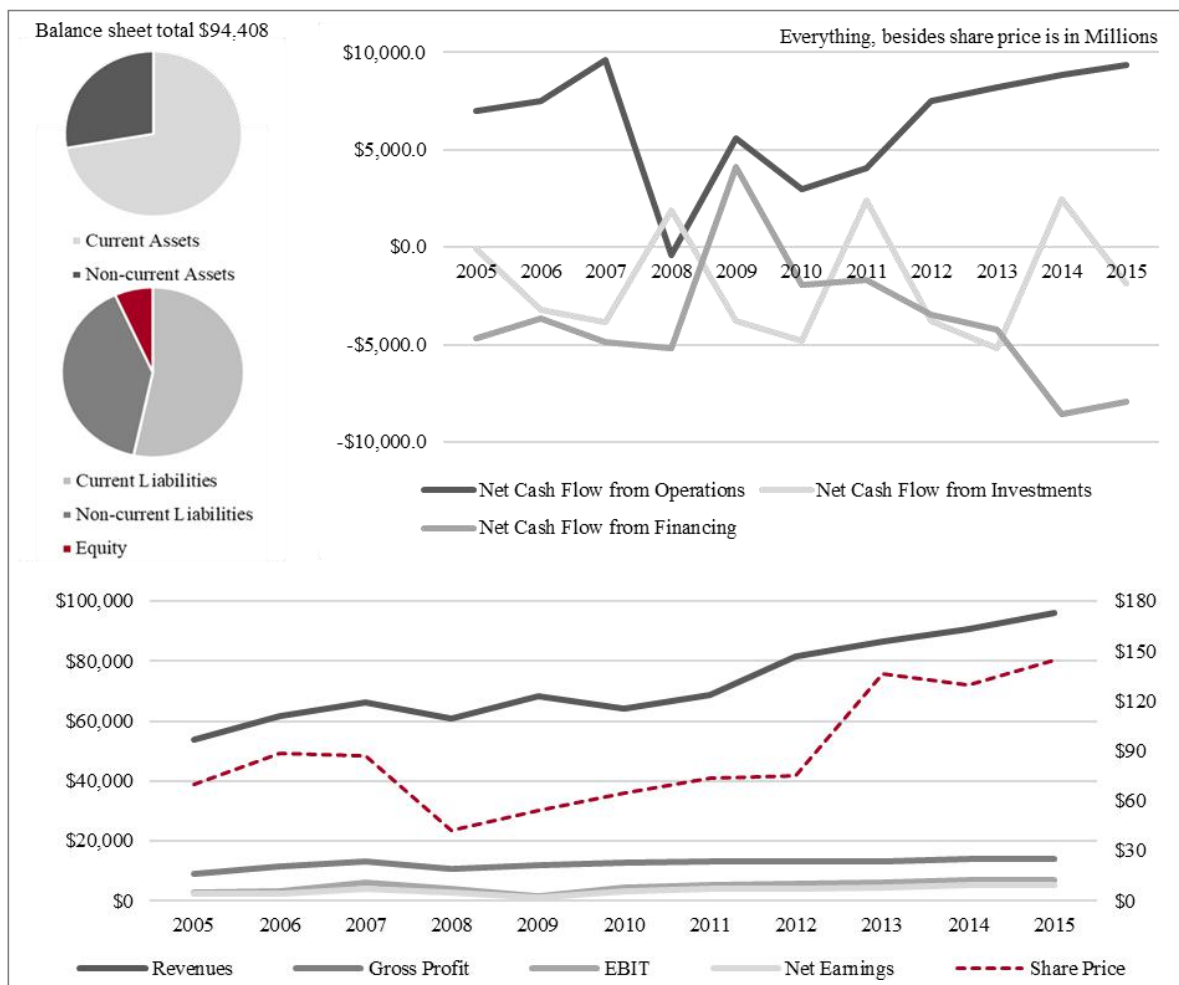


Figure 2- Financial Data of Boeing (2005-2015)⁷

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 ($DCF\text{M} < DDM < RIVM < MBV$) 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 Boeing⁸

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.

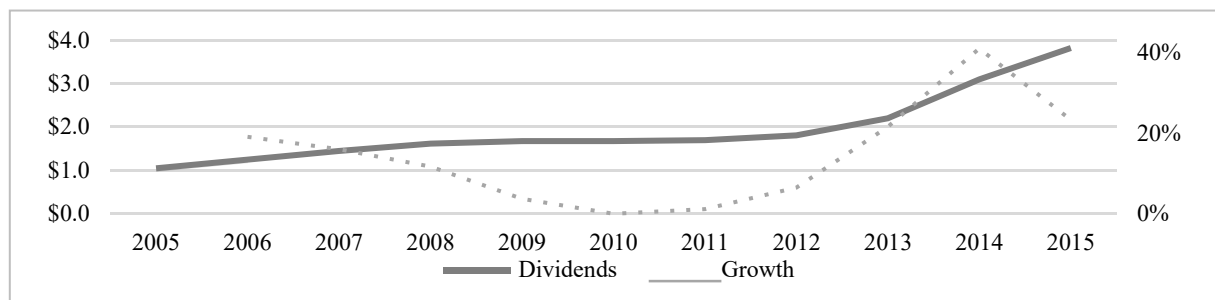


Figure 3- Dividend Development of Boeing

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.

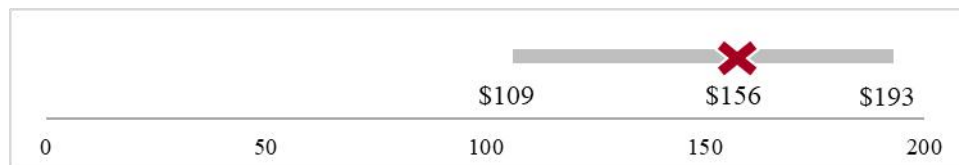


Figure 4- Fair Value Estimates of Boeing

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	Morningstar	Large Sample Analysis	Morningstar	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.