UNIVERSITY OF LJUBLJANA
SCHOOL OF ECONOMICS AND BUSINESS

MASTER'S THESIS

THE USE OF RELATIVE VALUATION MULTIPLES IN IDENTIFYING UNDERVALUED STOCKS

Ljubljana, June 2019

GREGOR HORVAT

AUTHORSHIP STATEMENT

The undersigned Gregor Horvat, a student at the University of Ljubljana, School of Economics and Business, (hereinafter: FELU), author of this written final work of studies with the title The use of relative valuation multiples in identifying undervalued stocks, prepared under supervision of izr. prof. dr. Igor Lončarski

DECLARE

1. this written final work of studies to be based on the results of my own research;
2. the printed form of this written final work of studies to be identical to its electronic form;
3. the text of this written final work of studies to be language-edited and technically in adherence with the FELU's Technical Guidelines for Written Works, which means that I cited and / or quoted works and opinions of other authors in this written final work of studies in accordance with the FELU's Technical Guidelines for Written Works;
4. to be aware of the fact that plagiarism (in written or graphical form) is a criminal offence and can be prosecuted in accordance with the Criminal Code of the Republic of Slovenia;
5. to be aware of the consequences a proven plagiarism charge based on the this written final work could have for my status at the FELU in accordance with the relevant FELU Rules;
6. to have obtained all the necessary permits to use the data and works of other authors which are (in written or graphical form) referred to in this written final work of studies and to have clearly marked them;
7. to have acted in accordance with ethical principles during the preparation of this written final work of studies and to have, where necessary, obtained permission of the Ethics Committee;
8. my consent to use the electronic form of this written final work of studies for the detection of content similarity with other written works, using similarity detection software that is connected with the FELU Study Information System;
9. to transfer to the University of Ljubljana free of charge, non-exclusively, geographically and time-wise unlimited the right of saving this written final work of studies in the electronic form, the right of its reproduction, as well as the right of making this written final work of studies available to the public on the World Wide Web via the Repository of the University of Ljubljana;
10. my consent to publication of my personal data that are included in this written final work of studies and in this declaration, when this written final work of studies is published.

Ljubljana, June 6th, 2019 Author's signature

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIXES

INTRODUCTION

In this thesis I test the potential of relative valuation multiples for identifying undervalued stocks in the market.

The basic idea behind multiples is that similar assets should sell for similar prices. While relative valuation is arguably the most popular approach for estimating firm value, the accounting and financial literature provide little guidance on how the method of multiples should be used in practice. Damodaran (2002, p. 462) and Vernimmen, Quiry, Dallocchio, Le Fur and Salvi (2014, p. 569) argue that approximating firm value based on what the market is paying for comparable firms provides a reasonable valuation accuracy only if those firms share similar growth, risk and cash flow characteristics. A common approach recommended by academics and practitioners is to use industry membership as a proxy for identifying peers. In this thesis I argue that theoretically more sound method is to apply regression models based on the firm fundamentals. Because multiples are interpreted as an application of a dividend discount model with expected growth rate, risk and cash flow characteristics, financial and operating performance measures can be used as explanatory variables in the regression model (Baker & Ruback, 1999, p. 5).

I use a sample of 4722 publicly listed United States firms from 2010 to 2016 to examine the following three multiples: the price-earnings (hereinafter: P/E), the price-to-book-value (hereinafter: P/BV), and the price-sales ratios (hereinafter: P/S). To evaluate the accuracy of regression models I use the comparable firms approach based on industry membership as a benchmark valuation. I then compare both methods by calculating pricing errors, as the estimated firm value less the actual market price expressed as a fraction of the actual price. The method with lower pricing error has higher valuation accuracy.

After examining the hypothesis that regression models improve performance of relative valuation multiples, I investigate if a strategy of investing in a group of undervalued stocks outperforms the return of the Standard and Poor’s market index (hereinafter: S&P 500). I use the ratio of the actual stock price divided by the firm value estimate of the best performing regression model to categorize stocks as either undervalued or overvalued. To validate the effectiveness of this allocation method I evaluate short-term and long-term returns for both portfolios. Finally, I analyse the differences in fundamentals between undervalued and overvalued stocks in the sample to draw conclusions about portfolio characteristics.

The thesis starts with a discussion on principles of firm value and underlying fundamentals that drive value creation. Chapter 2 continues with the review of related literature on the relative valuation multiples and previous research on three implementation challenges: identifying a group of comparable firms, determining value drivers for standardizing prices, and methods for averaging multiples. The next chapter presents the methodology of regression models of multiples and the comparable firms approach, illustrates how the valuation performance of both methods is evaluated and demonstrates the process of allocating stocks to undervalued or overvalued portfolios. Finally, chapter 4 concludes this thesis with a summary of empirical results and implications of findings.

1 FIRM VALUE

1.1 Measuring value

The basic principle of value creation states that the value is created by firms that grow and earn returns exceeding the cost of capital. This implies that the amount of created value is determined by the growth potential of a firm, its returns and the ability to sustain both over time (Koller, Goedhart & Wessels, 2015, p. 17). As value creation gained more importance in the accounting and financial literature several indicators have been proposed in the attempt to accurately measure value. Vernimmen et al. (2014, p. 492) provide a review of commonly used indicators and organize them into four categories: market indicators, accounting based indicators, hybrid indicators, and financial indicators.

Firstly, among market indicators the total returns to shareholders (hereinafter: TRS) has received most attention and it is often used by analysts to evaluate firm performance. The measure corresponds to the amount shareholders gain through price increase over a given period and the sum of paid dividends. Koller et al. (2015, p. 49) argue that over periods shorter than 10 years TRS may not reflect the actual performance of a firm as it creates perverse incentives. Pressured by investors' expectations, managers can for example increase TRS by implementing stock buyback programs at the expense of more solid investments that would yield greater returns over the long-term period. Furthermore, Vernimmen et al. (2014, p. 493) argue that a major limitation of market indicators is the destruction in value because of declining investor expectations about future profits.

Secondly, accounting indicators of value creation include profit and profitability measures, such as net profit, earnings per share (hereinafter: EPS) and return on equity (hereinafter: ROE). Because these indicators are based on accounting rules and practices, they are easy to manipulate. For example, a firm can increase its ROE by raising its debt level. In this case an increase in ROE does not mean that value was created as increase in profitability is cancelled by higher risk that is not captured in the accounting information. By limiting the impact of exception items, indicators such as earnings before interests and taxes, depreciation and amortization (hereinafter: EBITDA), and the return on invested capital (hereinafter: ROIC) try to avoid these accounting biases (Vernimmen et al., 2014, p. 493).

Next, hybrid indicators emerged with the realization that value cannot be estimated without combining profitability with risk. To measure a potential of a firm to create value, returns can be compared to the weighted average cost of capital (hereinafter: WACC). This means that when returns are higher than the WACC, value is created, and when returns are lower than the cost of capital, value is destroyed.

Lastly, the value of any financial security can be measured by the present value of the cash payments that claimholders receive, discounted at an appropriate discount rate. In the equation (1) the present value is calculated as the sum of current cash flows discounted by the discount rate over a number of periods. Since firms pay dividends, the value of a firm is estimated as the present value of the future dividends (Koller et al., 2015, p. 17).

$$PV = \sum_{n=1}^{\infty} \frac{Cash\ flow}{(1+r)^n} \tag{1}$$

In addition, the difference between the present value of future cash flows and the market value is known as the net present value (hereinafter: NPV).

$$NPV = \sum_{n=1}^{\infty} \frac{Cash\ flow}{(1+r)^n} - Market\ value \tag{2}$$

If the NPV of a security is greater than its current market value, then it will be worth more in the future as the market has presently valued it. Vernimmen et al. (2014, p. 275) argue that this measure provides the best indicator of value as it reflects how allocation of the firm's resources creates or destroys value.

1.2 The relationship of growth, returns, and risk

Firms create value by investing cash now to generate more cash in the future. If value in its purest form is measured as the sum of the present value of future cash flows, then value creation is represented by the change in value over time due to firm performance. In order to determine the underlying drivers of firm performance Koller et al. (2015, p. 19) propose disaggregating firm value into measures related to revenue growth, risk and rate of return.

$$\begin{gathered} Cash\ flow = Earnings\ \times\ (1 - Investment\ rate) \\ Cash\ flow = ROIC\ \times\ Investment\ rate) \\ Cash\ flow = Earnings\ \times\ \left(1 - \frac{r}{ROIC}\right) \end{gathered} \tag{3}$$

Under the assumption that the firm's cash flows are growing at a constant rate, the cash flow perpetuity model is used for expressing key value drivers. Substituting the cash flow expression in equation (1) expresses the key value drivers of firm valuation (Koller et al., 2015, p. 31).

$$Firm\ value = \frac{Earnings\ \times \left(1 - \frac{g}{ROIC}\right)}{WACC - g} \quad (4)$$

Equation (4) demonstrates that the amount of value a firm creates depends on its expected cash flows discounted at the WACC. Cash flows are determined by the revenue growth, the ROIC, and firm's ability to sustain both over time. The next sections explore each of these three components in more details.

1.3 Growth

The faster a firm increases revenues and earnings, and deploys more capital at higher rates of return, the more value it creates (Koller et al., 2015, p. 115). In practice, the starting point of estimating future growth is the analysis of historical performance. Arithmetic or geometric averages, regression and time series models of the past growth provide useful information about future performance. However, studies of the relationship between past and future growth rates show that historical growth rates are often associated with significant noise. Damodaran (2002, p. 276) observes that the correlation between growth rates in revenues and earnings in consecutive periods tends to be higher for one-year growth then for three-year or five-year growth. Furthermore, revenues tend to be more persistent and predictable than earnings, and firms with smaller market capitalization have lower value of correlation than the rest of the market.

The growth rate is ultimately determined by how much a firm reinvests into new assets and the quality of these investments. Damodaran (2002, p. 283) states that growth in earnings can be expressed as a product of the retention ratio and the return on equity. Firms that achieve high growth rates create growth by reinvesting equity at returns that are higher than their cost of equity.

The retention ratio or the percentage of earnings retained in the firm is calculated as retained earnings divided by the net income. This means that firms with a high retention ratio and high ROE should have higher growth rates in earnings per share than firms that do not share these characteristics (Damodaran, 2002, p. 284). Furthermore, assuming that the growth in net income is different from the growth in earnings per share, the expected growth rate can be expressed as the product of the equity reinvestment rate and ROE.

1.3.1 Drivers of growth

To maximize value firms should understand what drives growth and what makes it value creating. Baghai, Smit and Viguerie (2007) analyze the granularity of growth and find that the most important source of growth for a firm is the organic growth that stems from expansions in the fast growing segments. Based on their research the next best strategy is the inorganic growth through acquisitions or divestments, and the least important driver is the market share performance.

However, maintaining high growth potential and sustaining future growth is difficult for any firm. Palepu, Healy, and Bernard (2004, p. 6-3) study the challenge of sustaining growth and argue that growth rates of firms tend to be mean-reverting. Firms with above average or below average rates revert to the normal level within three to ten years. In their study of publicly traded United States firms from 1984 to 2001 Palepu et al. show that the group of firms with the initial growth rates of over 60 percent experienced a decline to the average growth rate of about 13 percent within two years.

These results are confirmed by Koller et al. (2015) in an analysis of the persistence of corporate growth. On a sample of United States firms from 1963 to 2013 they find that even for the fastest growing firms growth rates tend to fall to below five percent within the next 10 years. As young firms mature and industries become more competitive, finding high return opportunities becomes increasingly difficult. In addition, most products and markets have life cycles that follow an S-curve relationship from market launch until maximum market penetration. First the product is used only by early adopters who test product quality and review characteristics. Growth then accelerates as more people want to buy the product until the market reaches a state of maturity. Koller et al. (2015, p. 126) argue that the only way a firm can achieve high growth over a long-term period is to replace products that mature and decline in revenues, with a similar sized new products.

1.4 Profitability

Another determinant of value is the profitability of a firm. Profitability is a measure of ROIC which is expressed as a product of operating tax rate and the ratio of operating profit to the capital that had to be invested to generate these profits. A firm that delivers returns that are at least equal to the required rate of return will not experience financing problems in the long-term, as it will always create value for its shareholders.

1.4.1 Drivers of ROIC

The more the firm can increase its profitability, and the longer it can sustain return rates greater than its cost of capital, the more value it creates. Koller et al. (2015, p. 102) argue a firm's ability to sustain a given level of returns depends on several factors. Firstly, a longer business and product life cycle or the existence of a unique resource or a business model translates into better chances of sustaining high levels of profitability. Next, persistence of competitive advantage that arises from brand equity, quality of products and scalability of cost efficiencies tend to have lasting effects on the value. Lastly, firms that are able to find new business opportunities where they can leverage competitive advantage have a better chance of sustaining high ROIC.

To understand what is driving profitability of a firm the definition of ROIC can be further expanded to include the operating tax rate, the operating margin, and the capital turnover.

$$ROIC = (1-T) \times \frac{Operating\ earnings}{Revenues} \times \frac{Revenues}{Invested\ capital} \tag{5}$$

If the net debt of a firm equals zero, ROIC can be substituted by the ROE. This measure is usually computed as the net income to shareholder equity and serves as an indicator of how well a firm is employing invested equity capital.

$$ROE = \frac{Net\ income}{Shareholder\ equity} = \mathrm{ROIC} + [ROIC - (1-T) \times k_d] \times \frac{Debt}{Equity} \tag{6}$$

Equation (5) also helps to understand why firms with competitive advantage can earn higher rates of return. Higher ROIC is generated by charging a price premium or producing products more efficiently at a lower cost or lower capital employed (Koller et al., 2015, p. 94). Over time consistently high returns will attract competition and drive the profitability downwards. In a study of publicly traded United States firms in the period from 1984 to 2001 Palepu et al. (2004, p. 6-5) report a mean-reverting ROE. They find that firms with above and below average rates of return reverted to the normal level within no more than 10 years. Despite these overall tendencies Palepu et al. find examples of firms where ROE remained above average for longer periods of time. Furthermore, Koller et al. (2015, p. 110) report that returns of the best performing firms in their study did not revert to aggregate levels. These firms seem to be capable of sustaining competitive advantage over time by finding new opportunities to continue delivering superior performance.

1.5 Risk and returns

Investors spend money today expecting to earn more money in the future. They face risks because securities rarely produce their expected rate of return, and generally earn more or less than what investors anticipate. This implies that the risk of an investment is related to the probability of returns. The greater the chance of earning low or negative return, the riskier the investment (Brigham & Ehrhardt, 2005, p. 29). To compensate for the perceived level of risk, investors require returns that are at least equal to what they receive on an alternative investment with a comparable level of risk (DePamphilis, 2014).

Damodaran (2003, p. 7) defines risk as the distribution of the actual returns around the expected returns. The measure of the expected return represents the center of location of the distribution and is defined as the average of possible returns r_i weighted by their probability of occurring P_i (Vernimmen et al., 2014, p. 306). The tighter the probability distribution of the expected returns, the more likely it is the actual outcome will be close to the anticipated value, and less likely it is that the actual returns will be below or above the expected return.

$$Expected\ return = \widehat{r_i} = \sum_{i}^{n} r_i \times P_i \tag{7}$$

To effectively measure risk we need to assign a value to the tightness of the probability distribution. Mathematically the volatility of rates of return can be measured by the standard deviation. The measure is computed as the square root of the sum of the squares of the deviations of each return from the expected outcome, weighted by the likelihood of each return occurring (Vernimmen et al., 2014, p. 307). One challenge of using standard deviation for measuring risk mentioned by Damodaran (2003, p. 5) and Vernimmen et al. (2014, p. 303) is that there is no fundamental distinction between risk of asset revaluation and devaluation. For example, a stock that has increased in value in the past is seen as risky as a stock that has lost value.

$$Standard\ deviation = \sigma(r) = \sqrt{\left[\sum (r_i - \widehat{r_i})^2 \times P_i\right]} \tag{8}$$

Risk can be classified into risk that is specific to one or few firms and market risk. Specific or intrinsic risk is independent of market phenomena and is due to factors affecting a firm, such as mismanagement, risk of projects, competitive risks, and industry risk (Vernimmen et al., 2014, p. 308). While firm-specific risk can be diversified, market risk cannot be diversified and is relevant to all investments. Examples of market risk include changes in interest rates, preferences of investors, inflation and economic growth.

When investors invest in only one security they are exposed to both firm-specific and market risk. Brigham and Ehrhardt (2005, p. 39) argue that when an asset is held as part of a portfolio, it is less risky than the same asset held in isolation. In practice, insurance firms, mutual funds, banks, and other financial institutions are holding diversified portfolios. By expanding the portfolio, an individual security represents a smaller percentage and the risk tends to average out between positive or negative effects on the diversified portfolio.

The notion that a portfolio of risky securities has less risk than any individual security is also used in practice. Diversification is seen as a method of reducing risk by forming a portfolio of individual investments. The expected return on a portfolio is then estimated by a weighted average of the expected returns on the individual security r_i, with the weights w_i being the fraction of the total portfolio invested (Brigham & Ehrhardt, 2005, p. 40).

$$Expected\ return\ for\ a\ portfolio = \hat{r_p} = \sum_{i=1}^{n} w_i \times \hat{r_i} \tag{9}$$

Unlike the expected rate of return, the risk of a portfolio is not the weighted average of standard deviations of individual securities. When the stock is part of a portfolio, the risk of the stock is measured by how much it contributes to the portfolio risk. Damodaran (2011, p. 70) and Ho and Lee (2004, p. 28) show that standard deviation of a portfolio of two or more stocks is lower than standard deviations of each individual stock. In practice, diversification can only reduce risk, but it cannot completely eliminate it. Risk that affects assets in the market will persist even in large and diversified portfolios. Because investors can diversify their portfolio of investments, the only risk that needs to be reflected in the required rate of return is the risk that cannot be diversified (Koller et al., 2015, p. 47).

1.5.1 Capital asset pricing model

An important tool used to analyze the relationship between risk and rates of return is the capital asset pricing model (hereinafter: CAPM). The model emphasizes that the relevant risk of an individual security lies in the contribution to the risk of a diversified portfolio (Brigham & Ehrhardt, 2005, p. 47).

$$k = r_f + \beta_i\left[E(R_m) - R_f\right] \tag{10}$$

Equation (10) represents the CAPM for estimating the required rate of return: (1) the rate of a riskless investment r_f, (2) the beta coefficient of the risk that an investment adds to a market portfolio, and (3) the market risk premium $[E(R_m)-r_f]$.

The first component of the model is the riskless rate. Brigham and Ehrhardt (2005, p. 47) define risk-free assets as assets that possess no default risks and no reinvestment risk. Because the actual return of a risk-free investment equals to expected return, the standard deviation equals to zero. In practice this is illustrated by long-term government bond rate of developed countries, which are viewed by investors as risk-free securities. Whereas the risk-free rate and the market risk premium are common, the beta coefficient in CAPM varies across firms. Beta that serves a measure of sensitivity of a security to market risk is defined as the amount of risk that the stock contributes to the market portfolio.

Beta is estimated with a regression of historical returns on the investment R_i against returns on a market index R_m such as the S&P 500. For firms that have been publicly traded for a longer time, the process of estimating returns on investing in the firm's equity over a certain period is relatively straightforward.

$$R_i = a + b \times R_m \tag{11}$$

The slope in the regression equation corresponds to the beta of a stock and measures the riskiness of the stock. For example, the value of beta 1.0 indicates that if the market moves up by 10 percent, the stock will also move up by 10 percent. On the contrary, Damodaran (2002, p. 192) argues that while betas can be computed using regression analysis, a better approach is to rely on their fundamentals. The beta of a firm is ultimately determined by the sensitivity to the market economy, the degree of operating and financial leverage of the firm, and earnings growth. Firstly, cyclical firms and firms in industries that are sensitive to changes in economic conditions have higher perceived risk. This means the greater the effect of the state of the economy, the higher its beta (Vernimmen et al. (2014, p. 311). Next, the degree of operating leverage is defined by the relationship of fixed costs relative to the total costs. Firms with a greater proportion of fixed costs are more exposed to volatility in cash flows, have higher operating leverage and as a result higher betas. In addition, Damodaran (2002, p. 194) observes that a higher ratio of debt-to-equity increases variance in net income and makes equity investment in the firm riskier. The increase in financial leverage means that equity investors need to bear higher amount of market risk in the firm which leads to higher betas. Also, the higher the forecasted earnings growth of a firm, the higher the beta. Because the value of a firm is based on the future performance, any changes to assumptions, such as growth in cash flows, result in higher risk. This alternative approach provides a way of estimating betas in which historical prices and returns on investment in the firm's equity are not required, and can be used for private firms, divisions of firms, and stock that have recently started trading on financial markets (Damodaran, 2002, p. 197).

The final component of the CAPM is the market risk premium. Financial literature points to two different ways of estimating the premium. The first method measures the historical returns on the market index. In its simplest form, the historical market risk premium can be estimated by subtracting the return on government bonds from the return on a large sample of companies over longer period of time. Koller et al. (2015, p. 805) suggest to calculate the market risk premium relative to the long-term government bonds by using the longest historical period possible. In addition, Damodaran (2002, p. 161) argues that the choice of averaging methodology affects the results. The arithmetic average return measures the simple mean of the series of annual returns, whereas geometric mean evaluates the compounded return and provides a better measure for estimating the expected rate of return of the market. Koller et al. (2015, p. 805) conclude that historical approximations are often too high, as the sample is based on the best performing firms over time, and suggest to downward adjust the historical risk premium.

The alternative approach of estimating the premium assumes that the market is correctly priced. The expected return of the market is then calculated based on the relationship between current stock prices and underlying performance factors.

$$Price = \frac{Expected\ dividends\ next\ period}{ROE - Expected\ growth\ rate} \tag{12}$$

The required ROE serves as a proxy for the implied expected market return and can be computed by solving equation (12) using the market capitalization, the expected dividends, and the expected growth rate in earnings. Damodaran (2002, p. 172) describes this approach as a superior method for estimating the market risk premium.

The CAPM provides an appealing and logical framework for estimating the required rate of returns, but over time few concerns were raised about its assumptions. As a result the arbitrage pricing theory (hereinafter: APT) that includes any number of risk factors, and the Fama-French five-factor model that builds on the CAPM by adding the size, value, profitability, and investment patterns in average stock returns as factors, have become widely used in academic literature. However, a detailed discussion on estimating required returns with these models is beyond the scope of the thesis.

1.5.2 Estimating the cost of capital

Risk enters into valuation through the firm's cost of capital, which is the price investors require for the investment. The preceding section laid the groundwork for estimating the cost of capital by examining the concept of risk and analyzing the relationship between risk and rates of returns. This chapter continues by describing the process of determining the cost of capital for an individual firm.

$$WACC = \frac{Debt}{Debt + Equity} \times k_d \times (1 - T) + \frac{Equity}{Debt + Equity} \times k_e \tag{13}$$

Firms raise capital to finance operations and make investments using equity, debt or other types of securities. The costs of these sources of financing are generally very different. If we consider all financing to the firm, the composite cost would be the weighted average of the costs of equity and cost of debt (Damodaran, 2002, p. 207). This rate is described as the WACC and represents returns to all investors in a firm. It is calculated as the sum of the after-tax cost of debt k_d and the cost of equity k_e with weights being the target levels of debt-to-enterprise-value and equity-to-enterprise-value.

The cost of equity represents the rate of return investors require for an equity investment in a firm. It is approximated by the expected return on the entire market portfolio after making adjustments for the firm specific risk (Koller et al., 2015, p. 272).

Koller et al. (2015, p. 290) observe that in practice the cost of debt is calculated using the yield to maturity of the long-term bonds. Because yield to maturity represents a promised rate of return on the firm's debt, it serves as a suitable proxy to the cost of debt for investment-grade firms. However, this approach works well only for liquid, long-term debt. For firms with short term bonds or bonds that are rarely traded, using their bond ratings by rating agencies to determine the yield to maturity is a good alternative. By combining the cost of equity and the after-tax cost of debt, the cost of capital reflects the combined risk of a firm and has strong implications for investors, who make investment decisions based on the expected rate of return, and for managers, who need to deliver returns exceeding the firm's cost of capital (Damodaran, 2002, p. 205).

1.6 Firm valuation

A value of a firm stems from its ability to earn returns exceeding the cost of capital, and its ability to grow over time. Healthy returns and growth produce high cash flows, which are the ultimate source of firm value (Koller et al., 2015, p. 135). The idea behind valuation is then to convert a forecast of a firm's performance into an estimate of value (Palepu et al., 2004, p. 7-1). Because each firm has a different way of generating profits and its own risk profile, the valuation method needs to take into consideration the firm's business model and competitive position. For example, whereas the value of a mining firm is largely based on the value of commodities, the value of a pharmaceutical firm depends on its ability to create new products through research and development.

Valuation literature discusses two broad techniques on how future cash flows are turned into an estimated of firm value. The first approach is a direct method in which firm value is estimated from its expected cash flows without appeal to the current price of other firms. From direct valuations techniques, the enterprise discounted cash flow model (hereinafter: DCF) is the favorite among practitioners. The DCF model relies on future cash flows rather than on accounting-based measures and discounts them at the WACC. This approach is especially useful when applied to a multi-business firm because it allows to value projects, business units, and the entire firm with a consistent methodology. Koller et al. (2015, p. 138) describe valuing a firm using the DCF model as per the following process: (1) free cash flow is discounted at the WACC, (2) non-operating assets, such as excess cash and marketable securities are summarized with the discounted value of operations to gross enterprise value, (3) debt and other non-equity claims are valued, (4) the value of debt and other non-equity claims is subtracted from enterprise value to determine the equity value.

The second approach to firm valuation is a relative method where a market multiple from a group of comparable firms is applied to a target firm's financial or operating performance measures. Multiples appear in reports and recommendations of financial analysts for initial public offerings, leveraged buyouts, and mergers and acquisition. The primary reason for their popularity is simplicity. Contrary to the DCF model that requires detailed forecast for growth, profitability and discount rate, relative valuation multiples rely on the market measures of the required rate of return and growth rates. Even advocates of the DCF model often use multiples when estimating the terminal value or validating the results of their valuation (Baker & Ruback, 1999, p. 1). Because they are easy to use and capture the essence of valuation, multiples often substitute more comprehensive valuation methods.

2 MULTIPLES

2.1 Using relative valuation multiples

The basic idea behind multiples is that similar assets should sell for similar prices. This means that instead of computing the intrinsic value of a firm, estimates are obtained in relation to what the market is paying for comparable firms (Viebig, Poddig & Varmaz, 2008, p. 361). Multiples approach generally involves three steps: (1) finding comparable firms that are priced by the market, (2) selecting a measure of value as the basis for substitutability, (3) applying comparable firms' multiples to the value driver of the target firm under valuation.

$$V_i = \left(\frac{P}{D}\right)_{com} \times D_i + \varepsilon_i \tag{14}$$

If comparable firms are available, then the estimated value V_i of a firm is computed by multiplying the value drive D_i with the corresponding multiple $(P/D)_{com}$ of comparable firms. A value driver is typically a measure of financial or operating performance such as cash flow, EBITDA, sales or book value (DePamphilis, 2014). For example, using the P/E ratio a firm's price per share is estimated as the product of its EPS and the computed averaged multiple of a group of comparable firms.

Based on the type of value drivers, Vernimmen et al. (2014, p. 569) differentiate between three groups of multiples. Firstly, multiples based on the enterprise value of a firm include ratios of operating balances before subtracting interest expense. Examples are ratios with EBITDA and earnings before interests and taxes (hereinafter: EBIT) in the denominator. Secondly, multiples based on the value of equity include ratios of operating balances after interests, such as net income multiples and cash flow multiples. Finally, multiples can be computed based on recent transactions in the same industry, such as the sale of a controlling share, a merger or an acquisition.

2.2 Implementation challenges of multiples

Despite their widespread popularity among analysts and investors, multiples have received little academic attention. With few exceptions, the accounting and financial literature contain mixed guidance on how the method of multiples should be applied in dealing with three implementation challenges: identifying a group of comparable firms, determining value drivers for standardizing prices, and methods for averaging multiples.

2.2.1 Identifying a group of comparable firms

Comparable firms or peers are generally used in finance in at least three situations: (1) when performing fundamental analysis on estimating sales forecasts of earnings growth rates, (2) in multiples valuation for calculating the predicted value, and (3) in research as a device for isolating a variable (Bhojraj & Lee, 2002, p. 410). Damodaran (2002, p. 462) and Vernimmen et al. (2014, p. 569) explain that a peer group consists of firms that have not only similar sector characteristics but also similar operating measures, such as ROE and the expected growth rate. Therefore, a comparable firm is defined as one with cash flows, growth, and risk characteristics that are similar to the firm under valuation. This definition implies that technology firms might be a better comparable group for valuing an automotive firm as long as they are comparable in terms of growth, profitability and risk.

The practice of selecting comparable firms recommended by academics and practitioners is to use industry membership. The assumption here is that because firms in the same industry share similar markets, product offerings, and the degree of financial leverage, they serve as good peers. DePamphilis (2014) suggests validating this assumption by estimating the correlation between the operating income or sales of the firm under valuation and the peer group. Firms are comparable if the correlation is high and positive. To further improve the selection of comparable firms, analysts could apply criteria, such as firm size or choose to focus on a smaller industry segment. But even in narrowly defined segments it is often challenging to identify peers. Some practitioners even suggest that the process of selecting comparable firms is an art form and requires years of practice (Bhojraj & Lee, 2002, p. 410).

To deal with challenges related to identifying a group of comparable firms, Palepu, Healy and Bernard (2004) propose to average multiples across all companies in the industry and thereby compensating for various sources of non-comparability. Another technique is to focus only on those firms in the industry that are most similar based on some performance measures. By examining the choice of comparable firms in calculating the P/E multiples Boatsman and Baskin (1981, p. 45) conclude that the valuation accuracy for firms in the same industry with the most similar 10-year average earnings growth is greater than if peers are randomly selected from the industry. Their findings suggest that controlling for differences can improve valuation accuracy without conducting a rigorous examination of factors affecting the relation between the multiple and firm fundamentals.

A more comprehensive review of the process of selecting comparable firms from industry membership is examined in study by Alford (1992) and Cheng and McNamara (2000). Both analyze the effect of different methods of selecting peer groups on the valuation accuracy. Alford (1992) examines the valuation accuracy of the P/E multiple on a sample of United States firms in years 1978, 1982, and 1986 when comparable firms are selected on the basis of industry membership, firm size, and ROE, both individually and in pairs. By evaluating the firm's predicted stock price to its actual price for different methods, he concludes that the industry membership is relatively effective if the industry is defined by first three digits of the standard industrial classification (hereinafter: SIC). Furthermore, segmenting industry by risk or growth does not improve accuracy, and selecting a comparable firm solely on the basis of risk or growth is not advantageous. This outcome suggests that the cross-sectional variations in the P/E ratio that are explained by measures of risk and earnings growth are also captured by the industry classification.

Similarly, Cheng and McNamara (2000) examine the valuation accuracy of the P/E ratio, the P/BV ratio and a combined price-earnings-and-price-to-book-value method. They use six different techniques of selecting peer groups for evaluating the performance: market, industry defined on the basis of 4-digit SIC codes, total assets, ROE, and combination of the industry membership and total assets and ROE. Their results confirm the same ranks of the six methods as in the study by Alford (1992). However, they find a significantly better valuation performance when industry membership is paired with ROE, whereas Alford (1992) reports no improvements in the accuracy. Their findings support earlier results by Boatsman and Baskin (1981) in that controlling for differences in the industry can improve the valuation accuracy of the P/E and the P/BV valuation methods.

In addition, another group of researchers investigates alternative techniques for identifying comparable firms in multiples. Damodaran (2002, p. 464) argues that because firms differ on more than just one variable it is difficult to control for differences across firms by making subjective adjustments. To account for variations, he suggests using a regression against explanatory variables and computing the predicted value of a multiple by multiplying regression coefficients with the respective firm's values for variables. Since the definition of a comparable firm is not dependent on the industry but is related to cash flows, growth, and risk characteristics, regression analysis can include the entire market.

Bhojraj and Lee (2002) suggest that the comparable firms should be related to financial and operating measures that drive variations in the multiple. Their research uses a regression model based on cross-sectional variations in the enterprise-value-to-sales (hereinafter: EV/S) ratio and the P/BV ratio to estimate a warranted multiple for each firm. Peers are identified as firms with the closest value of the warranted multiple to that of the target firm. This approach to the choice of comparable firms includes simultaneous effect of several variables related to profitability, future growth and risk measures (Bhojraj & Lee, 2002, p. 411). The results show that warranted multiples offer improvements over the traditional method where comparable firms are based on the industry membership.

In conclusion, the review of related literature highlights different approaches to identifying comparable firms. The standard practice of using industry membership delivers mixed results even when paired with additional variables. While the approach is simple to use and explains portion of the cross-sectional variations in multiples finding good peers is not a straightforward exercise and new methods, including regression and warranted multiples, were proposed.

2.2.2 Determining value drivers for standardizing prices

Another issue of multiples valuation discussed in prior literature is related to the selection of value drivers. Damodaran (2002, p. 456) explains that multiples require a measure of financial or operating performance in order to standardize prices and allow comparison. Prices can be standardized relative to generated earnings, to the book value of assets, to the revenues or to measures specific for a sector or industry. One of the key principles in determining multiples is that both a numerator and a denominator are consistently defined. In practice, earnings multiples such as the P/E ratio or the enterprise-value-to-EBITDA ratio are most commonly used by investors and analysts.

Another important distinction among different value drivers is that multiples based on the firm earnings and the book value of assets are affected by accounting principles. Thus, they cannot be reliably computed for firms with negative profits, industries with highly volatile profit margins or young firms (Koller et al., 2015, p. 347).

When earnings or book value ratios provide little guidance, revenue multiples such as the P/S and the EV/S ratios, or the sector specific multiples based on operating measures can serve as indicators of performance (Damodaran, 2002, p. 455). For example, in the late 1990s when investors valued young firms with low revenues and negative profits, they used metrics such as website visits or number of subscribers. However, Koller et al. (2015, p. 350) argue that these non-financial measures need to be related to profitability and growth in order to represent an indicators of value.

Among the prior research on the challenge of selecting value drives Liu, Nissin and Thomas (2002) provide the most comprehensive account of absolute and relative performance. On a sample of United States firm from 1982 to 1999 they examine the valuation accuracy of several value drivers, including historical cash flows and accrual-based measures, intrinsic value, and forward looking estimates. To evaluate performance, Liu et al. (2002) examine measures of dispersion for the pricing error, measured as price minus predicted price divided by price. Their research concludes that multiples based on forward earnings explain stock prices reasonably well. For about a half of the sample the pricing errors lie within the 15 percent margin of stock prices. Historical earnings measures are ranked second, followed by cash flow measures and book value, while revenue multiples perform the worst (Liu et al., 2002, p. 163).

In the study of the valuation accuracy of the P/E and the P/BV ratios Cheng and McNamara (2000, p. 357) observe that for the majority of definitions of comparable firms the P/E method performs better than the P/BV method. Despite not including multiples based on forward looking earning, their results confirm findings of Liu et al. (2002) that historical earnings measures better explain firm value than the book value of firm assets. Similarly, Kim and Ritter (1999, p. 410) report a surprisingly weak performance of the market multiples with historical numbers. In the study of pricing of initial public offerings they use regression models with the P/E, the P/BV and the P/S ratios as dependent variables, and the multiples of comparable firms as explanatory variables. While idiosyncratic factors are not captured by industry multiples using past accounting data, forecasted earnings perform better and overall improve the valuation accuracy.

In another study of the value drivers' performance Baker and Ruback (1999, p. 17) examine a sample of firms from 22 industries and calculate multiples for three value drives: EBITDA, EBIT, and sales. They focus on multiples distribution around the harmonic mean for firms within an industry to indicate a common value driver. Using this approach, the best basis of substitutability is determined by the lowest standard deviation around the mean. Their research suggests that EBITDA is the best performing value driver for 10 out of 22 industries, with EBIT ranked second while the revenue multiples perform the worst (Baker & Ruback, 1999, p. 19).

Findings from the related literature suggest that the earnings and forward-looking multiples are consistently rated as best performing. As reported by Liu et al. (2002), Kim and Ritter (1999) and others the valuation accuracy of the same sample of firms increases when multiples are computing using forward earnings. Koller et al. (2015, p. 334) explain that these results are not surprising as forward-looking multiples are consistent with the fundamental principles of valuations and generally display lower levels of variation across a group of comparable firms.

2.2.3 Methods for averaging multiples

The method of relative valuation multiples assumes a linear relationship between the firm value and the basis of substitutability. As seen in equation (14) the estimated value of a firm is computed by multiplying the selected value driver with the corresponding averaged multiple of comparable firms. Similar to the challenges of identifying the right peers and determining value drivers for standardizing prices, the method for averaging multiples ultimately affects the estimated value of the target firm.

The accounting and financial literature that applies ratios in valuation provide a mixed guidance on the appropriate method. In a study of the valuation accuracy Kim and Ritter (1999, p. 427) apply both the median and the geometric mean to evaluate performance. Koller et al. (2015, p. 332) propose to calculate multiples either by the arithmetic mean or the median, while Alford (1992, p. 104) and Damodaran (2002, p. 458) advocate the use of median as the method that produces the most accurate results for a group of industry peers. In addition, Yoo (2006) uses a weighted average of several multiples, where each weight is calculated by the out-of-sample regression model of stock prices on the valuation outcome. By incorporating incremental information of each multiple this approach improves valuation accuracy on a single historical measure, but the combination of forward multiples with historical data does not improve the overall performance (Yoo, 2006, p. 117). Similarly, Cheng and McNamara (2000, p. 352) use a simple average to combine valuation results of the P/E and the P/BV ratios to the price-earnings-and-price-to-book-value multiple.

To address the challenge of finding the best approach for averaging multiples Agrrawal, Borgman, Clark, and Strong (2010, p. 11) publish a review of methods used in practice for estimating the portfolio average of the P/E multiple. Their work suggests that the less familiar harmonic mean provides the most appropriate measure of central tendency. The harmonic mean of *n* observations is defined as *n* divided by the sum of inverses of all of the observations (Marques de Sa, 2003, p. 240). For example, the harmonic mean of the P/E ratio is computed by averaging the EPS/P ratio and taking the inverse of that average.

$$P/E_{Harmonic\ mean} = \frac{1}{\frac{1}{n}\sum_{i=1}^{N}\frac{EPS_i}{P_i}} \tag{15}$$

Agrrawal et al. (2010, p. 15) observe that the harmonic mean makes an assumption of an equal value investment in each stock in contrast to the arithmetic mean that takes the equal amount for each stock in the sample. By averaging the inverse of the average, the harmonic mean is not biased upwards and is a more appropriate measure when there is a possibility of negative P/E ratios.

Liu et al. (2002) and Bhojraj and Lee (2002) apply the harmonic mean in their research and find that using the harmonic mean improves performance relative to the simple mean or the median. In addition, Baker and Ruback (1999) study econometric issues of measuring multiples and provide empirical evidence that the harmonic mean is close to the minimum variance estimates based on the Monte Carlo simulation.

Despite a common practice of averaging multiples using the arithmetic mean or median, a closer examination suggests that the harmonic mean dominates other measures of central tendency and provides a more appropriate method. Studies by Baker and Ruback (1999), Liu et al. (2002), and Bhojraj and Lee (2002) confirm that the harmonic mean improves valuation performance of multiples.

2.3 Determinants of multiples

Relative valuation multiples substitute some of the benefits of a more complete analysis for a convenient heuristic that produces satisfactory results. Baker and Ruback (1999, p. 5) observe that multiples are interpreted as an application of a growing perpetuity of cash flows valuation model. This implies that a value of an individual multiple can be expressed as a function of three variables: its capacity to generate cash flows, the expected growth rate, and the risk associated with uncertainty of future cash flows (Viebig et al., 2008, p. 363). Firms with greater cash flow potential, higher growth, and lower discount rate should therefore have higher values of multiples.

As in Gordon (1962), Damodaran (2002), and Bhojraj and Lee (2002) the determinants of multiples are examined by analyzing the equation of the dividend discount model. The price of a firm's stock is equal to dividends per share in the next period divided by the required return on common equity minus the expected growth rate.

$$P_t = \frac{DPS_t \times (1+g)}{r-g} = \frac{DPS_{t+1}}{r-g} \tag{16}$$

Re-examining equation (16) by dividing both sides with a measure of value reveals cash flows, growth, and risk fundamentals of the corresponding multiple. In the next section of the thesis I further discuss determinants of each of the three multiples used in the analysis: the P/E, the P/BV, and the P/S ratios.

2.3.1 Price-earnings ratio

The P/E ratio is defined as the value of equity per share divided by the EPS. It indicates the dollar amount each investor expects to invest in a firm in order to receive one dollar of the firm's earnings.

$$P/E = \frac{Market\ price\ per\ share}{EPS} \tag{17}$$

The simplicity of the multiple and the availability of historical information make the P/E ratio an attractive choice for applications in valuation studies. One of the challenges of the multiple is variation in the EPS used for calculating the ratio (Damodaran, 2002, p. 468). The P/E ratio can be calculated using the current, trailing or forward-looking earnings, and using fully diluted or primary EPS. Especially for high-growth firms with volatile earnings different earnings measures can produce very different estimates. Previous studies by Kim and Ritter (1999), Liu et al. (2002) and Koller et al. (2015) examine this issue and demonstrate that the forecasted earnings provide the most reliable valuation. Another limitation of the P/E ratio is that it cannot be calculated for firms with negative earnings and even comparison of firms with relatively low earnings produces unreliable results. Koller et al. (2015, p. 337) state that the P/E ratio provides less reliable estimates of firm value because it mixes capital structure and non-operating items with expectations of operating performance. In addition, the difference in the multiple across firms can stem from different accounting rules and practices or the manipulation of income statement and not the underlying firm performance.

Despite its drawback, the P/E ratio remains one of the most widely used valuation models. Cheng and McNamara (2000, p. 349) argue that the usefulness of the P/E ratio relies on the assumption that it properly captures the risk and growth characteristics of a firm.

To determine the fundamentals of the multiple, I divide both sides of the dividend discount model equation by the EPS. The P/E ratio is articulated by three measures: the dividend payout, the cost of equity and the expected growth in earnings.

$$P/E = \frac{P_t}{EPS_t} = \frac{DP \times (1+g)}{r-g} \tag{18}$$

The dividend payout is further expressed as a function of expected growth rate and ROE.

$$DP = 1 - \frac{g}{ROE}$$

$$P/E = \frac{P_t}{EPS_t} = \frac{\left(1 - \frac{g}{ROE}\right) \times (1+g)}{r-g} \tag{19}$$

This formulation demonstrates that the P/E ratio is an increasing function of the dividend payout and higher dividend payout will lead to higher value of the multiple. The ratio in turn depends on the firms’ dividend policy and tax regulations. Also, the multiple is determined by the expected growth rate of a firm. Assuming that the ROE is higher than the required return, the P/E ratio increases with the higher expected growth rate. Lastly, the P/E ratio is a decreasing function of riskiness of the firm. A firm with higher debt will have a lower P/E ratio because more debt translates to higher level of risk for investors (Damodaran, 2002, p. 472). These findings are similar to Penman (1996, p. 235) who reports that previous studies have linked the multiple fundamentals to growth in earnings, earnings capitalization, risk measures, and ROE.

When computing the P/E ratio a high value of the multiple generally signals that a firm is overvalued. However, it is difficult to draw conclusions about the multiple without looking at its fundamentals. A high value of the P/E ratio indicates that the firm has high return on equity, promising growth potential, and low level of risk. Furthermore, the P/E ratio is sensitive to changes in interest rates, market risk premium, and investors' expectations. Other things remaining equal, a decrease in the interest rate and market risk premium results in a lower cost of equity and a higher P/E ratio. On the contrary, the ratio of a firm for which investors believe cannot sustain future growth is likely to be low.

2.3.2 Price-to-book-value ratio

The P/BV ratio is defined as the value of equity per share divided by the current book value of equity per share. Damodaran (2002, p. 511) argues that the usefulness of the ratio lies in its ability to serve as a good indicator of undervaluation and overvaluation across firms with similar accounting standards. In contrast to the P/E ratio, the P/BV ratio can be calculated for firms with negative earnings. Furthermore, the book value of equity provides a stable measure that can be compared to the market price.

$$P/BV = \frac{Market\ price\ per\ share}{Book\ value\ of\ equity\ per\ share} = \frac{Total\ market\ value}{Book\ value\ of\ equity} \tag{20}$$

One of the challenges of computing the P/BV ratio is ensuring internal consistency of the equity value for different classes of stocks. A common approach to this issue is to calculate the ratio as the total market value of common stocks divided by the total book value of equity. Another limitation of using the multiple is that the book value of equity is affected by accounting principles. This means that the value of the P/BV ratio is not be comparable across firms with different accounting standards. In addition, the book value relies heavily on the value of tangible assets which are becoming less important for high-growing firms in the technology sector. For firms where the value of intellectual capital and other intangible assets is not accounted, the P/BV ratio does not provide reliable estimates.

Determining the fundamentals of the P/BV ratio received little attention in literature until Fama and French (1992, p. 445) demonstrated that the multiple can be related to mean stock returns. As a result the P/BV can serve as a proxy for risk and firms with lower P/BV ratios are viewed as riskier. In addition, Penman (1996, p. 236) argues that the multiple is often interpreted as a function of the expected ROE which is expressed in the standard formula reconciling price to book value.

$$P/BV = \frac{P_t}{BV_t} = 1 + \sum_{i=1}^{\infty} \frac{(ROE_{t+1} - r) \times BV_{t+i-1}}{(1+r)^i \times BV_t} \tag{21}$$

In this thesis I determine the fundamentals of the P/BV ratio by expressing the dividend discount model in terms of the book value of equity (Bhojraj & Lee, 2002, p. 414). The P/BV ratio is an increasing function of the expected ROE and firms with high ROE tend to have high expected growth rate in earnings and the dividend payout. Also, the ratio is determined by future growth in the book value of equity. Lastly, the P/BV ratio is a decreasing function of the riskiness of the firm and the high cost of equity decreases the value of the multiple. This formulation draws similarities to the P/E ratio. Penman (1996, p. 236) provides evidence on the reconciliation where each multiple is a transformation of the other by the ratio of the accounting summary of the income statement and the balance sheet. Both multiples are reconciled by the relation between the current and the expected future return on equity.

Strong influence of ROE on the P/BV ratio has been highlighted by previous studies and it is reasonable to expect that the larger the value of ROE relative to the cost of equity, the greater is the value of the multiple. Damodaran (2002, p. 531) suggests this approach can be used for identifying investment opportunities in the market. Firms with high ROE tend to sell for above their book value and firms with low ROE sell at or below book value. In addition, investors search for undervalued firms that provide a mismatch of the P/BV ratio and the equity return spread, which is calculated as ROE less cost of equity. Another use of the P/BV ratio in investment strategies was provided by Fama and French (1992). Their analysis of returns shows that the P/BV ratio serves as a proxy for risk and firms with low value of the P/BV ratio are viewed by the market as risker than firms with high values of the multiple. The higher return of these firms is therefore a compensation for higher risk.

2.3.3 Price-sales ratio

Revenue multiples measure the value of a firm relative to the revenues that it generates. In contrast to ratios based on the firm earnings and the book value of assets that can become negative, the revenue multiples are available for young or distressed firms. Furthermore, unlike earnings and book values, which are affected by accounting standards and can differ across countries, revenues are relatively simple to compute. In addition, Damodaran (2002, p. 543) argues that ratios based on revenues display lower volatility than earnings ratios.

The P/S ratio is a popular multiple used by practitioners and academics. It is calculated by dividing the market value of firm equity with the total revenues of a firm and indicates the dollar amount investors are willing to pay for one dollar of the firm's revenues.

$$P/S = \frac{Market\ value\ of\ equity}{Revenues} \tag{22}$$

Kim and Ritter (1999), Damodaran (2002) and Liu et al. (2002) study the valuation accuracy of the P/S ratio and report it to be the lowest compared to the P/E and the P/BV ratios. Another drawback is that the multiple is not internally consistent. Because it is defined as equity value divided by the revenues of the firm it yields lower values for highly leveraged firms (Damodaran, 2002, p. 544). Also, the P/S ratio can lead to misleading valuations as increase in revenues does not directly translates to increase in earnings.

$$P_t = \frac{DPS_t \times (1+g)}{r-g} = \frac{EPS_t \times DPS \times (1+g)}{r-g}$$

$$EPS_t = Revenues\ per\ share \times NM \tag{23}$$

$$P/S = \frac{P_t}{S_t} = \frac{NM \times DP \times (1+g)}{r-g}$$

Similarly to the other multiples, I examine the fundamentals of the P/S ratio by using the dividend discount model. In the case of a stable growth firm the multiple is expressed as an increasing function of the net margin, the expected growth rate and the dividend payout, and a decreasing function the riskiness of a firm. This formulation shows that firms with a high value of the P/S ratio have high net profit margins, positive dividend payout, and growth rate higher than the cost of equity. Damodaran (2002, p. 558) argues that net profit margin is the key determinant of the multiple and investors searching for undervalued firms should be attracted to firms with low P/S ratio and high profit margin. While this approach is intuitive historical profit margins may not be highly correlated with expected margins and ignoring other fundamentals such as risk can result in misleading valuation.

3 RESEARCH METHODOLOGY

In this chapter I present theoretical underpinnings of the research methodology, including sampling process, selection of explanatory variables for regression models of multiples, comparison of valuation performance of regression models against the comparable firms approach, and portfolio allocation method for undervalued stocks in the sample.

3.1 Sample selection

The sample includes publicly listed firms on the NYSE and the NASDAQ stock exchanges (excluding ADRs) from 2010 to 2016. I use Datastream to combine accounting numbers, stock prices, analysts' earnings forecasts and industry classification codes.

To be selected in the final sample firms need to satisfy the following criteria: (1) financial statement information is non-missing; (2) price, forecasted EPS and the long-term growth estimates are available; (3) all multiples are positive; (4) ratios of value driver to price lie within the 1st and the 99th percentile; (5) industry classification includes at least five firms; (6) financial firms are excluded from the sample. These conditions are imposed to avoid large pricing errors due to negatively predicted prices and unreasonable small group of peers. The final sample has 4722 firm-years observations. The fraction of firms of the NYSE and the NASDAQ stock exchanges from which the sample is drawn from varies between 20 and 30 percent for the period. This is comparable to a similar study by Liu et al. (2002) that selects on average between 11 and 18 percent of the stock exchange population. However, the proportion of market value of the population is considerably large as firms removed from the sample lack analyst data or have negative value drivers and are likely to be young or distressed.

3.2 Regression models of multiples

Relative valuation multiples substitute a more complete analysis with a simple technique where the firm value is estimated in relation to what the market is paying for comparable firms. While previous research focuses mostly on examining challenges of identifying peer groups, determining value drivers and averaging multiples, there are few examples of how regression models are applied in the context of multiples.

3.2.1 Application of regression in multiples valuation

A regression is simply a statistical model of influence of one or more random variables on another variable. The method is often used in finance to test a theory, forecast values of dependent variables, determine optimal portfolio allocation, examine market behavior, and build trading models (Alexander, 2008, p. 179). Vernimmen et al. (2004, p. 573) observe that analysts and investors apply regression models in the context of multiples valuation to determine the relationship between the multiple and explanatory variables. In addition, Damodaran (2002, p. 464) advocates that this technique is useful for effectively controlling for difference across firms when selecting a group of peers. Since the definition of a comparable firm is not dependent on the industry but is related to cash flows, growth, and risk characteristics, the regression can evaluate the performance of the target firm relative to the entire market.

Whiteck and Manown (1963) provide one of the first accounts of regression analysis in the context of investment decision making. Their study examines the effect of three principal determinants of common stock on firm valuation. By utilizing a sample of 135 firms they express the market relationship between the theoretical P/E ratio and the projected growth rates, the stability of earnings, and the dividend payout of a firm. Furthermore, Whiteck and Manown (1963, p. 58) use the value of a theoretical P/E multiple for computing the ratio between market price of a firm and its theoretical price.

In another study Beaver and Morse (1978) use a portfolio approach for examining behavior of the P/E ratio and evaluating if growth and risk measures explain differences across stocks. They rank a sample of firms on the NYSE stock exchange from 1956 to 1975 in 25 portfolios based on the value of the P/E ratio for each firm. The median value of the P/E ratio of a portfolio is then compared with the median value of the realized growth and the median value of beta. The results of the linear regression model show that differences in the median P/E ratio among portfolios persist over time but the growth and risk variables explain little of this persistency. The P/E ratios correlate negatively with earnings growth in the first year of the formation, but positively with earnings growth in the subsequent year, suggesting that investors are forecasting only short earnings distortions. In addition, Beaver and Morse (1978, p. 65) conclude that the most likely explanation of the evident persistence is not growth or risk, but differences in accounting methods.

Contrary to Whiteck and Manown (1963), and Beaver and Morse (1978) that examine the P/E ratio, Wilcox (1984) develops a model to describe the relationship between the P/BV ratio of a firm and its ROE. In the study the equation of the P/BV ratio is expressed as a simple log-linear function of the estimated investment horizon, the estimated required shareholder returns and historical return on equity. The P/BV-ROE model offers practical application as it appears to be superior to P/E ratio in terms of the means square errors when explaining current stock prices. Furthermore, Wilcox (1984, p. 65) argues the model leads to interesting conclusions about the relations between the stock price, earnings stability, dividend policy, leverage and beta. It suggests that stable earnings growth does not necessarily lead to higher prices, that dividends matter, that leverage can be either good or bad, and the stocks with higher betas do not have higher required returns.

Also, Kim and Ritter (1999) report regression results for a sample of 190 pricings of initial public offerings where they estimate the value of the P/E, the P/BV and the P/S ratios. In their regression model multiples serve as dependent variables and the median values of multiples of comparable firms are used as explanatory variables. Their results show that the valuation accuracy is highest with the P/BV ratio, with the mean prediction error of 33 percent, where the prediction errors are measured as the natural log of the ratio of the predicted multiple to the actual multiple (Kim & Ritter, 1999, p. 424). However, the adjusted R-squared for each of the regression is below 9 percent indicating low explanatory power of the regression.

The study by Ohlson and Juettner-Nauroth (2005) introduces a different approach to the application of regression. They develop a comprehensive econometric model of the P/E ratio and show that a firm's price per share is related to the next year's expected earnings per share, short-term growth rate in EPS, long-term growth rate, and cost-of-equity capital. Their empirical results also suggest that the P/E multiple is an increasing function of the short-term and long-term growth rate, and a decreasing function of the cost of capital.

Yin, Peasnell, Lubberink, and Hunt (2014) follow this approach with the aim to review the techniques sell-side analysts apply to the multiples. They argue that analysts of brokerage firms assign higher value of the P/E ratio to firms with superior earnings growth in the near-term and the long-term, while firms with high levels of riskiness receive lower multiples (Yin et al., 2014, p. 41). To test this hypothesis, they collect P/E multiples from a sample of analysts' reports and perform a cross-sectional regression analysis. The model includes the following independent variables: long-term growth forecast, growth in expected EPS, firm leverage, stock price volatility, firm size, beta, the P/BV ratio, gross margin, five year sales growth rate, earnings volatility, dividend yield, and a vector of 20 industries to control for industry effect (Yin et al., 2014, p. 38). The results of the study confirm the hypothesis and suggest that valuations based on the P/E multiple effectively capture firm fundamentals.

3.2.2 Development of regression models of multiples

For computing the firm value estimates with the regression model of multiples I use the equation (24).

$$V_i^M = \left[\alpha + \sum_{i=1}^{N} \beta \times X_i\right] \times D_i^M + \varepsilon_i \tag{24}$$

The estimated value V_i of a firm is calculated by multiplying a product of regression coefficients β and explanatory variables X_i with the value driver D_i for a multiple M. Independent variables in the equation (24) serve as proxies for cash flow, risk and growth characteristics of a firm. The choice of variables for the P/E, the P/BV and the P/S ratios is guided by valuation equations of a dividend discount model and findings of previous studies.

Out-of-sample review of normal probability plot shows that the residuals of the P/E, the P/BV, and the P/S ratios are not normally distributed. Violation of normality assumption in the model means that the results of the hypothesis testing of coefficients are not valid. To deal with this limitation, I exclude outliers from the sample and transform the dependent variable to be an inverse of the multiple. For example, the dependent variable for the P/E multiple is the ratio of forward EPS and market price per share.

I start the cross-section analysis by running annual regressions in order to estimate values of regression coefficients. Annual period is selected to ensure the same sample of firms is used when comparing predicted firm values of regression models to the estimates of the comparable firms approach. Next, the value of a multiple of a target firm in a given year is computed by multiplying values of statistical significant regression coefficients with the firm's specific values of explanatory variables. The estimated firm value is then calculated by multiplying the inverse of the derived multiple with the corresponding value driver.

3.2.3 Price-earnings ratio

The P/E ratio is related to three measures: the dividend payout, the cost of equity and the growth in earnings. The multiple is expressed as an inverse in the equation (25).

$$E/P_i = \alpha + \beta_1 EPIN_i + \beta_2 DP_i + \beta_3 BETA_i + \beta_4 VOL_i + \beta_5 MV_i + \beta_6 LTG_i + \beta_7 G2_i \quad (25)$$

The dependent variable in the regression model of the P/E multiples is the ratio of forward EPS to stock price. The selection of explanatory variables is based on previous research on determinants of multiples. Following Bhojraj and Lee (2002) the starting estimate of the valuation is the mean industry market ratio of the forward EPS to stock price $EPIN_i$. Industry is defined as a group of firms with the same three digits SIC code. As in Damodaran (2002) and Whiteck and Manown (1963) I add the firm's dividend payout DP_i which is calculated by dividing the dividends per share with the EPS. In order to capture the multidimensional notion of risk, Damodaran (2002) suggests to include beta coefficient of the firm, Whiteck and Manown (1963) rely on the standard deviation is stock prices, and Yin et al. (2014, p. 37) argue that firm size plays an important role in the risk assessment. Younger and smaller firms are associated with higher costs of equity while mature and larger firms are generally perceived as having lower risk. Thus, equation (25) includes $BETA_i$, measure of stock's average annual price movement to a high and low from a mean price VOL_i, and the natural logarithm of a firm market value MV_i. In addition, empirical findings by Ohlson and Juettner-Nauroth (2005) and Yin et al. (2014) suggest that the P/E ratio is determined by the long-term and near-term growth in earnings. The faster a firm increases revenues and earnings, and deploys more capital at higher rates of return, the more value it creates (Koller et al., 2015, p. 115). The final explanatory variables in the regression model are the estimated long-term growth LTG_i, and near-term growth $G2_i$ which is calculated by dividing the difference between earnings per share for two year out period and earnings per share for one year out period divided by earnings per share for one year period.

3.2.4 Price-to-book-value ratio

The P/BV ratio is an increasing function of the expected ROE and the growth rate, and a decreasing function of the riskiness of the firm. Previous studies by Wilcox (1984) and Penman (1996) confirm usefulness of ROE in explaining the value of the multiple. The ratio is expressed as an inverse in the equation (26).

$$BV/P_i = \alpha + \beta_1 BVPIN_i + \beta_2 ROE_i + \beta_3 LTG_i + \beta_4 BETA_i + \beta_5 VOL_i + \beta_6 MV_i \qquad (26)$$

The regression model of the P/BV multiple includes the following variables: the dependent variable BV/P_i, the mean industry market ratio of book value and the otal market value $BVPIN_i$, the current return on equity of the firm ROE_i, the estimated long-term growth LTG_i, the beta coefficient of the firm $BETA_i$, the measure of stock's average annual price movement to a high and low from a mean price VOL_i, and the natural logarithm of a firm market value.

3.2.5 Price-sales ratio

The fundamentals of the P/S ratio are linked to the firm's profitability, the growth rate, the cost of capital and the dividend payout (Damodaran, 2002, p. 543). The multiple is expressed as an inverse in the equation (27).

$$S/P_i = \alpha + \beta_1 SPIN_i + \beta_2 NM_i + \beta_3 LTG_i + \beta_4 BETA_i + \beta_5 VOL_i + \beta_6 MV_i + \beta_7 DP_i \qquad (27)$$

The regression model of the P/S multiple includes the following variables: the dependent variable S/P_i, the mean industry market ratio of firm revenues and the total market value $SPIN_i$, the net margin NM_i, the estimated long-term growth LTG_i, the beta coefficient of the firm $BETA_i$, the measure of stock's average annual price movement to a high and low from a mean price VOL_i, the natural logarithm of a firm market value MV_i, and the dividend payout DP_i.

3.3 The comparable firms approach

To examine the accuracy of regression models of multiples I use the comparable firms approach as a benchmark valuation. This means the predicted firm value of the regression models for the P/E, the P/BV and the P/S ratios are compared to the estimates obtained with the comparable firms approach for a target firm.

I use equation (28) of the comparable firms approach commonly seen in the financial and accounting literature. The estimated value V_i of a firm is computed by multiplying the value drive D_i with the corresponding multiple $(P/D)_{com}$ of a peer group.

$$V_i = \left(\frac{P}{D}\right)_{com} \times D_i + \varepsilon_i \tag{28}$$

I use three multiples in the analysis: (1) the P/E ratio is calculated using forward EPS and market price per share, (2) the P/BV ratio is computed as the book value of equity divided by the total market value, and (3) the P/S ratio uses revenues and the total market value of a target firm. As in Baker and Ruback (1999), Liu et al. (2002) and Agrrawal et al. (2010) the multiple of comparable firms is defined using the harmonic mean.

Table 1 presents an example of calculating the estimated firm value for the P/E, the P/BV, and the P/S ratios for the target firm AMGEN for 2010 using the comparable firms approach. Descriptions of the variables are as follows: *P* stands for the stock price, *MVC* is the total market value of a firm calculated as price per share multiplied by number of shares, *E/P* is the ratio of forward EPS to stock price, *BV/P* is the ratio of book value to the total market value, and *S/P* is the ratio of revenues to the total market value of a firm. I start the analysis by examining the SIC for the target firm AMGEN and selecting a peer group of firms with the same three digits code. Next, I derive the value driver to price ratios, and calculate the estimated firm value using the harmonic mean. The process is then repeated for all 4722 firm-years observations in the sample.

3.4 Valuation accuracy

Following Alford (1992) and Cheng and McNamara (2000) I use the pricing error to test if regression models perform better than the comparable firms approach. The pricing error e_i of a firm is calculated as the estimated firm value V_i of a firm minus the market price per share P_i expressed as a fraction of P_i. I compute pricing errors for the regression models and the comparable firms approach for the P/E, the P/BV and the P/S ratios.

Table 1: Illustration of calculations for the comparable firms approach for the target firm AMGEN for 2010

Firm	SIC	Market		Value driver to price ratio		
		P	MVC	E/P	BV/P	S/P
AMGEN	**283**	**57.31**	**53,412,920**	**0.096**	**0.448**	**0.281**
GILEAD SCIENCES	283	19.86	31.847,341	0.102	0.184	0.250
BIOGEN	283	49.09	11,806,904	0.099	0.457	0.396
MYLAN	283	22.01	9,598,781	0.089	0.375	0.568
IDEXX LABORATORIES	283	33.07	3,790,550	0.038	0.151	0.291
UNITED THERAPEUTICS	283	56.89	3,274,361	0.050	0.270	0.184
ENDO INTERNATIONAL	283	21.90	2,541,670	0.145	0.685	0.675
MYRIAD GENETICS	283	24.00	2,257,104	0.068	0.247	0.161
NEOGEN	283	17.56	595,951	0.034	0.256	0.236
IMPAX LABORATORIES	283	18.10	1,167,034	0.062	0.435	0.754
MERIDIAN BIOSCIENCE	283	19.99	812,673	0.047	0.169	0.176
QUIDEL	283	14.76	420,867	0.049	0.267	0.269
SCICLONE PHARMS.	283	4.19	201,166	0.107	0.409	0.423
JOHNSON & JOHNSON	283	64.30	176,059,637	0.083	0.321	0.350
MERCK & COMPANY	283	35.04	107,997,029	0.112	0.503	0.425
BRISTOL MYERS SQUIBB	283	25.31	43,001,690	0.097	0.365	0.453
ABBOTT LABORATORIES	283	24.48	37,868,157	0.194	0.591	0.929
ELI LILLY	283	34.97	40,295,581	0.135	0.308	0.573
ALLERGAN	283	42.82	5,386,756	0.084	0.609	0.662
PERRIGO	283	61.14	5,606,171	0.050	0.194	0.405
ALERE	283	39.78	3,378,436	0.083	0.515	0.638
LANNETT	283	4.69	116,181	0.096	0.765	1.077
Estimated multiple				**11.517**	**2.599**	**2.122**
Estimated firm value				**59,141,366**	**62,240,863**	**31,849,852**
Pricing error				**0.107**	**0.165**	**0.404**

Source: Datastream; Own work.

*Note.** This table provides an example of estimating the value for the target firm AMGEN for 2010. SIC is the industry classification, *P* stands for the stock price, *MVC* is the total market value of a firm calculated as price per share multiplied by number of shares, *E/P* is the ratio of forward EPS to stock price, *BV/P* is the ratio of book value to the total market value, and *S/P* is the ratio of revenues to the total market value of a firm. Estimated multiple is computed with the harmonic mean of comparable firms' value driver to price ratios. Pricing error is calculated as the estimated firm value minus the market value expressed as a fraction of the market value.

The hypothesis that regression models improve accuracy of relative valuation multiples is confirmed if the method shows a lower median pricing error.

$$e_i = \frac{|V_i - P_i|}{P_i} \tag{29}$$

Table 1 illustrates calculations of the pricing errors for the comparable firms approach for the target firm AMGEN for 2010. The pricing error of the P/E ratio 0.107 means that the estimated firm value, computed with the harmonic mean of comparable firms' value driver to price ratios, deviates from the market value for 10.7 percent. The pricing errors of the P/BV and the P/S ratios are 0.165 and 0.404 respectively. Results suggest that when estimating firm value of the target firm AMGEN using the comparable firms approach, the P/E ratio has the highest valuation accuracy.

3.5 Identifying undervalued stocks

After testing the hypothesis that regression models improve valuation performance of multiples, I investigate if firm values estimates can be used for identifying undervalued stocks in the sample. Following Whiteck and Manown (1963) I calculate the ratio of the actual stock price divided by the estimated firm value of the best performing regression model, to categorize each firm-year observation in the sample.

Based on the value of the ratio stocks are allocated to one of the three portfolios: (1) if the ratio is under 0.85 a stock is labeled as undervalued, (2) if the ratio is between 0.85 and 1.15 the estimated firm value is assumed to be similar to the market, and (3) if the ratio is higher than 1.15 then a stock is added to the overvalued portfolio. In the analysis I assume that investment portfolio holds one stock of each firm.

To evaluate the performance of the portfolio allocation method I consider the short-term return over 12 month period and the long-term return over the period from 2010 to 2016. The method is successful if a group of stocks labeled undervalued in relation to the market outperforms returns of the S&P 500 and at the same time performs better than the group of overvalued stocks.

4 DISCUSSION OF RESULTS

4.1 Summary statistics

Table 2 presents annual summary statistics of the value drivers scaled by the stock prices. Following Liu et al. (2002), Yoo (2006) and others, ratios are calculated as the inverse of multiples to avoid large errors that arise when the value is close to zero. The median value of the forward E/P ratio for the sample for the period 2010 to 2016 is 0.067. This number is deviates from the estimate by Damodaran (2016) who calculates the value of the multiple for United States market at 0.033. Among possible explanations of the difference, the size of the sample is the most relevant. Firstly, in this thesis I introduce sample selection criteria related to the industry size and firm performance, whereas Damodaran (2016) includes the total market. In addition, I use Datastream for financial statement information, market prices, forecasted EPS and growth estimates, and Damodaran (2016) draws upon multiple data sources that complement each other and thereby reduce the percentage of missing information. Finally, I export data in April of each year and Damodaran (2016) performs the analysis in January.

The median value of the BV/P ratio for the period is 0.413 with the lowest value in 2015 and the highest in 2012. For the same period Damodaran (2016) reports the BV/P ratio of 0.418. Due to sample selection, firms included in the sample are likely those with higher total market value which results in higher value of the multiple. The median value of the S/P ratio for the pooled sample is 0.650.

Figure 1 plots the distribution of ratios of forward EPS, book value, and sales to price. For each year in the sample these ratios show positively skewed distribution with mean values greater than median values. Also, the out-of-sample analysis indicated presence of outliers with high values of multiples. Among the three selected multiples the E/P ratio has the lowest standard deviation of 0.026 which indicates that the values tend to be closer to the mean. On the contrary, the S/P ratio has standard deviation of 0.986 and the highest dispersion of values. These statistics are similar to Liu et al. (2002) who report the lowest standard deviation for the ratio of forward EPS to price and the highest standard deviation for the ratio of sales to price.

Table 3 shows summary statistics of the explanatory variables used in annual regressions. Descriptions of the variables are as follows: *EPIN* stands for a mean industry market ratio of forward EPS and market price per share, *BVPIN* is a mean industry market ratio of book value and total market value, *SPIN* is the mean industry market ratio of revenue and total market value, *LTG* is the estimated long-term growth, *G2* is the near-term growth, *BETA* is the beta coefficient of firm stock, *VOL* is a measure of stock's average annual price

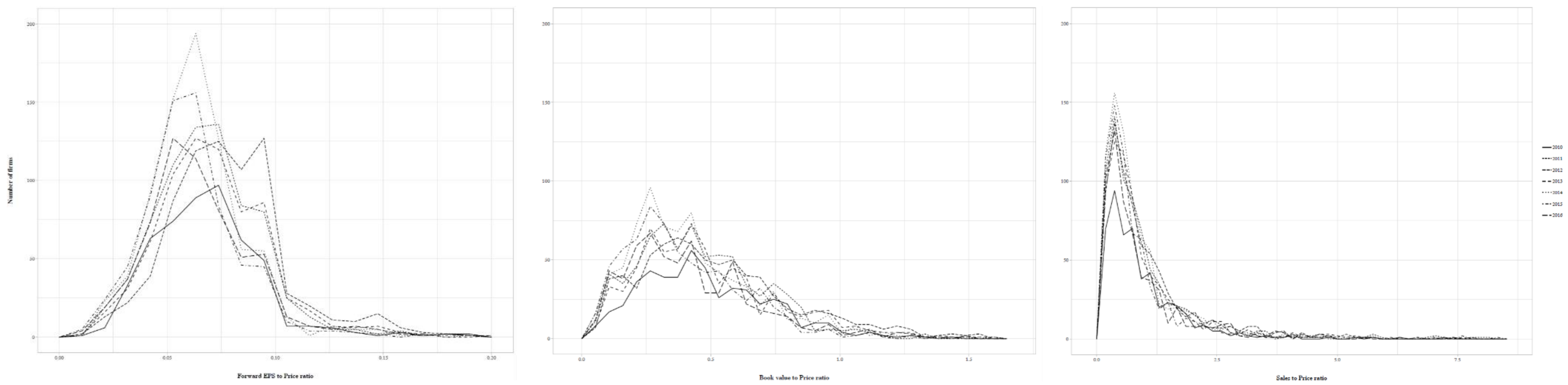
Table 2: Summary statistics of ratios of forward EPS, book value and sales to price by year

Year	Number of observations	E/P				BV/P				S/P			
		Mean	Median	25%	75%	Mean	Median	25%	75%	Mean	Median	25%	75%
2010	506	0.071	0.069	0.054	0.082	0.488	0.449	0.301	0.657	0.954	0.707	0.400	1.208
2011	734	0.072	0.069	0.055	0.085	0.464	0.429	0.286	0.617	1.020	0.683	0.383	1.210
2012	737	0.081	0.077	0.062	0.095	0.525	0.475	0.311	0.678	1.061	0.718	0.408	1.295
2013	695	0.074	0.071	0.057	0.087	0.492	0.439	0.291	0.632	1.007	0.679	0.419	1.215
2014	774	0.067	0.064	0.053	0.076	0.433	0.383	0.250	0.564	0.919	0.618	0.371	1.096
2015	673	0.064	0.061	0.051	0.074	0.398	0.348	0.235	0.533	0.875	0.576	0.336	1.004
2016	603	0.069	0.063	0.051	0.080	0.431	0.380	0.239	0.577	0.942	0.605	0.355	1.149
Mean		**0.071**				**0.461**				**0.970**			
Median		**0.067**				**0.413**				**0.650**			
Standard Deviation		**0.026**				**0.261**				**0.986**			

Source: Datastream; Own work.

Note. * This table provides annual information on the mean, median and standard deviation of the value drivers scaled by the stock prices. *E/P* is the ratio of forward EPS to stock price, *BV/P* is the ratio of book value to the total market value, and *S/P* is the ratio of revenues to the total market value of a firm.

Figure 1: Distribution of the E/P, the BV/P and the S/P ratios by year



Source: Datastream; Own work.

Note. * This figure is derived from annual histograms of the ratio of forward EPS to stock price, the ratio of book value to the total market value, and the ratio of revenues to the total market value of a firm.

Table 3: Summary statistics of explanatory variables in regression by year

Year		EPIN	BVPIN	SPIN	LTG	G2	BETA	VOL	MV	ROE	DP	NM
2010	Mean	0.071	0.488	0.954	0.130	0.224	0.930	0,302	14.906	0.153	0.426	0.096
	Median	0.069	0.449	0.707	0.121	0.122	0.920	0,294	14.782	0.126	0.158	0.079
2011	Mean	0.072	0.464	1.020	0.128	0.454	1.020	0,314	14.748	0.155	0.261	0.088
	Median	0.069	0.429	0.683	0.125	0.150	0.990	0,304	14.623	0.133	0.057	0.077
2012	Mean	0.081	0.525	1.061	0.125	0.284	1.010	0,292	14.685	0.140	0.446	0.084
	Median	0.077	0.475	0.718	0.120	0.147	0.980	0,283	14.618	0.124	0.156	0.074
2013	Mean	0.074	0.492	1.007	0.122	0.233	1.030	0,279	14.919	0.139	0.424	0.822
	Median	0.071	0.439	0.679	0.120	0.144	1.000	0,272	14.868	0.123	0.174	0.075
2014	Mean	0.067	0.433	0.919	0.125	0.301	1.030	0,271	15.008	0.143	0.406	0.086
	Median	0.064	0.383	0.618	0.120	0.152	1.010	0,261	14.990	0.122	0.209	0.073
2015	Mean	0.064	0.398	0.875	0.115	0.252	1.030	0,262	15.216	0.125	0.380	0.053
	Median	0.061	0.348	0.576	0.110	0.128	1.010	0,252	15.191	0.117	0.234	0.070
2016	Mean	0.069	0.431	0.942	0.105	0.231	1.000	0,257	15.197	0.132	0.432	0.085
	Median	0.063	0.380	0.605	0.102	0.118	1.000	0,251	15.124	0.119	0.262	0.074

Source: Datastream; Own work.

Note. * This table includes the mean and median of the explanatory variables used in annual regressions. *EPIN* stands for a mean industry market ratio of forward EPS and market price per share, *BVPIN* is a mean industry market ratio of book value and total market value, *SPIN* is the mean industry market ratio of revenue and total market value, *LTG* is the estimated long-term growth, *G2* is the near-term growth, *BETA* is the beta coefficient of firm stock, *VOL* is a measure of stock's average annual price movement to a high and low from a mean price, *MV* is the natural logarithm of a firm market value, *ROE* is the current return on equity of a firm, *DP* is the dividend payout, and *NM* is the net margin.

movement to a high and low from a mean price, *MV* is the natural logarithm of a firm market value, *ROE* is the current return on equity of a firm, *DP* is the dividend payout, and *NM* is the net margin. Summary statistics in table 3 also reveal trends for the selected measures. Over the period 2010 to 2016, estimated long-term growth and near-term growth are decreasing while market value is increasing. This is consistent with Palepu, Healy and Bernard (2004) and Koller et al. (2015) who analyze corporate growth trends and argue that growth rates of firms tend to be mean-reverting. As firms grow and increase in their size it is becoming increasingly difficult to find new high return opportunities. In addition, BETA, ROE and net margin are relatively stable over the period and DP is increasing as firms return more of their profits as dividends.

4.2 Results of regression models

4.2.1 Price-earnings ratio

Table 4: Correlation between the ratio of forward EPS to price and explanatory variables

	EP	EPIN	DP	BETA	VOL	MV	LTG	G2
EP		0.510***	-0.047***	0.119***	0.170***	-0.020	-0.082***	-0.018
		(0.000)	*(0.001)*	*(0.000)*	*(0.000)*	*(0.161)*	*(0.000)*	*(0.221)*
EPIN	0.509***		-0.045***	0.200***	0.225***	-0.037**	0.050***	0.017
	(0.000)		*(0.002)*	*(0.000)*	*(0.000)*	*(0.012)*	*(0.001)*	*(0.256)*
DP	-0.031**	-0.088***		0.008	-0.109***	0.044***	-0.075***	-0.007
	(0.031)	*(0.000)*		*(0.579)*	*(0.000)*	*(0.003)*	*(0.000)*	*(0.635)*
BETA	0.088***	0.191***	-0.178***		0.262***	0.017	0.164***	0.019
	(0.000)	*(0.000)*	*(0.000)*		*(0.000)*	*(0.236)*	*(0.000)*	*(0.197)*
VOL	0.134***	0.262***	-0.490***	0.274***		-0.524***	0.233***	0.088
	(0.000)	*(0.000)*	*(0.000)*	*(0.000)*		*(0.000)*	*(0.000)*	*(0.000)*
MV	-0.019	-0.059***	0.287***	0.004	-0.523***		-0.027*	-0.063
	(0.185)	*(0.000)*	*(0.000)*	*(0.775)*	*(0.000)*		*(0.068)*	*(0.000)*
LTG	-0.152***	0.041***	-0.347***	0.228***	0.331***	-0.075***		-0.026*
	(0.000)	*(0.004)*	*(0.000)*	*(0.000)*	*(0.000)*	*(0.000)*		*(0.075)*
G2	-0.121***	0.077***	-0.308***	0.221***	0.476***	-0.308***	0.393***	
	(0.000)	*(0.000)*	*(0.000)*	*(0.000)*	*(0.000)*	*(0.000)*	*(0.000)*	

Source: Datastream; Own work.

Note. * This table provides correlation statistics between variables for a pooled sample. The upper triangle shows the Pearson correlation coefficients and the lower triangle reflects the Spearman rank correlation. *EP* is the ratio of the forward EPS to stock price, *EPIN* stands for a mean industry market ratio of forward EPS and market price per share, *DP* is the dividend payout, *BETA* is the beta coefficient of firm stock, *VOL* is a measure of stock's average annual price movement to a high and low from a mean price, *MV* is the natural logarithm of a firm market value, *LTG* is the estimated long-term growth, and *G2* is the near-term growth. P-values are provided in parentheses. All values with the significance at > 0,01 are marked with ***, with the significance at > 0,05 with **, and with the significance at > 0,10 with *.

Table 5: Results of annual regression for the P/E ratio

	2010	2011	2012	2013	2014	2015	2016
Intercept	-0.019	-0.015	-0.019	-0.018	-0.005	-0.018*	0.019
	(-1.386)	*(-1.288)*	*(-1.589)*	*(-1.510)*	*(-0.461)*	*(-1.785)*	*(-1.523)*
EPIN	0.916***	0.944***	0.925)***	0.891***	0.982***	0.969***	0.909***
	(9.083)	*(12.061)*	*(13.379*	*(12.627)*	*(12.699)*	*(15.617)*	*(13.353)*
DP	0.001	-0.001	-0.002)***	-0.001	0.001	0.000	-0.001
	(1.157)	*(-0.597)*	*(-3.004*	*(-1.122)*	*(0.870)*	*(0.174)*	*(-1.045)*
BETA	0.001	0.001	0.002	0.001	0.000	-0.001	0.002
	(0.835)	*(0.635)*	*(1.347)*	*(0.541)*	*(-0.185)*	*(-0.970)*	*(1.346)*
VOL	0.013	0.028**	0.050***	0.052***	0.022*	0.055***	0.049***
	(0.962)	*(2.554)*	*(3.989)*	*(3.934)*	*(1.925)*	*(4.739)*	*(3.127)*
MV	0.002**	0.001	0.001*	0.001**	0.000	0.001	0.001
	(2.388)	*(1.575)*	*(1.783)*	*(2.008)*	*(0.475)*	*(1.536)*	*(1.357)*
LTG	-0.032**	-0.035***	-0.064***	-0.055***	-0.030***	-0.043***	-0.024**
	(-2.487)	*(-3.484)*	*(-6.019)*	*(-4.886)*	*(-3.657)*	*(-5.113)*	*(-2.348)*
G2	-0.012***	0.000***	0.001**	-0.004**	0.000	-0.002**	0.000
	(-4.057)	*(-2.925)*	*(2.022)*	*(-2.482)*	*(-0.048)*	*(-2.419)*	*(-0.603)*
R-square	**22%**	**21%**	**30%**	**29%**	**21%**	**33%**	**31%**
Sample	**506**	**734**	**737**	**695**	**774**	**673**	**603**

Source: Datastream; Own work.

Note. * This table reports the results of annual regressions of equation (25) with the ratio of the forward EPS to stock price as the dependent variable. *EPIN* stands for a mean industry market ratio of forward EPS and market price per share, *DP* is the dividend payout, *BETA* is the beta coefficient of firm stock, *VOL* is a measure of stock's average annual price movement to a high and low from a mean price, *MV* is the natural logarithm of a firm market value, *LTG* is the estimated long-term growth, and *G2* is the near-term growth. P-values are provided in parentheses. All values with the significance at > 0,01 are marked with ***, with the significance at > 0,05 with **, and with the significance at > 0,10 with *.

Table 4 presents correlation coefficients between the ratio of forward EPS to stock price and seven explanatory variables over the period 2010 to 2016. The upper triangle shows Pearson correlation coefficients, which are commonly used for determining the strength of linear association between two variables. However, the out-of-sample review of the distribution suggests that Pearson correlation could lead to misleading interpretations. As an alternative measure I report Spearman rank correlation in the lower triangle in table 4. Results suggest that the E/P ratio is negatively correlated to dividend payout, estimated long-term and near-term growth, while measure of stock's price movement and beta have positive sign of correlation. This means that a firm with promising growth in earnings, higher dividend payout and lower risk is rewarded with a higher P/E multiple. Contrary to expectations, market value has negative correlation and is not statistically significant. In addition, the low levels of correlation between pairs of explanatory variables suggest the absence of multicollinearity in the sample.

Table 5 presents annual regression of the E/P ratio and the explanatory variables. Results suggest that growth and risk factors are incrementally important in explaining variations after controlling for the industry mean. The proportion of cross-sectional variation in the multiple captured by the seven explanatory variables is on average 27 percent over the period and ranges between 21 and 33 percent. The strongest explanatory variables mean industry market multiple and estimated long-term growth are significant at less than 5 percent and have the same direction in each of the annual regressions. Estimated near-term growth and measure of stock's price movement display the expected sign of correlation with the E/P ratio and are significant in five out of seven regressions. Contrary to assumptions, dividend payout and beta are not significant, while market value is included in two out of seven annual regressions.

4.2.2 Price-to-book-value ratio

Table 6: Correlation between the ratio of book value to price and explanatory variables

	BVP	BVPIN	ROE	LTG	BETA	VOL	MV
BVP		0.500***	-0.277***	-0.163***	-0.018	0.126***	-0.321***
		(0.000)	*(0.000)*	*(0.000)*	*(0.211)*	*(0.000)*	*(0.000)*
BVPIN	0.503***		-0.122***	-0.125***	0.027*	0.049***	-0.066***
	(0.000)		*(0.000)*	*(0.000)*	*(0.063)*	*(0.001)*	*(0.000)*
ROE	-0.603***	-0.255***		-0.008	-0.039***	-0.132***	0.203***
	(0.000)	*(0.000)*		*(0.603)*	*(0.008)*	*(0.000)*	*(0.000)*
LTG	-0.225***	-0.164***	0.046***		0.164***	0.233***	-0.027*
	(0.000)	*(0.000)*	*(0.001)*		*(0.000)*	*(0.000)*	*(0.068)*
BETA	-0.043***	0.014	-0.014	0.228***		0.262***	0.017
	(0.003)	*(0.341)*	*(0.320)*	*(0.000)*		*(0.000)*	*(0.236)*
VOL	0.121***	0.067***	-0.180***	0.331***	0.274***		-0.524***
	(0.000)	*(0.000)*	*(0.000)*	*(0.000)*	*(0.000)*		*(0.000)*
MV	-0.320***	-0.076***	0.345***	-0.075***	-0.004	-0.523***	
	(0.000)	*(0.000)*	*(0.000)*	*(0.000)*	*(0.775)*	*(0.000)*	

Source: Datastream; Own work.

Note. * This table provides the correlation between variables for a pooled sample. The upper triangle shows the Pearson correlation coefficients and the lower triangle reflects the Spearman rank correlation. *BVP* is the ratio of the book value to price, *BVPIN* is a mean industry market ratio of book value and total market value, *ROE* is the current return on equity of a firm, *LTG* is the estimated long-term growth, *BETA* is the beta coefficient of firm stock, *VOL* is a measure of stock's average annual price movement to a high and low from a mean price, and *MV* is the natural logarithm of a firm market value. P-values are provided in parentheses. All values with the significance at > 0,01 are marked with ***, with the significance at > 0,05 with **, and with the significance at > 0,10 with *.

Table 6 presents correlation coefficients between the ratio of book value to the total market value and six explanatory variables. The upper triangle shows the Pearson correlation coefficients and the lower triangle reflects the Spearman rank. As expected, ROE and the estimated long-term growth are negatively correlated to the BV/P ratio, and measure of stock's price movement shows a positive correlation. This implies that the P/BV ratio is higher for firms that report strong ROE and estimated growth in earnings, and have low level of risk. Correlations for market value and beta are opposite to the expectations. In addition, coefficients between pairs of explanatory variables suggest the absence of multicollinearity in the sample.

Table 7: Results of annual regression for the P/BV ratio

	2010	2011	2012	2013	2014	2015	2016
Intercept	0.592***	0.789***	0.841***	0.844***	0.842***	0.682***	0.576***
	(5.331)	*(8.373)*	*(7.469)*	*(7.830)*	*(9.294)*	*(7.161)*	*(4.731)*
BVPIN	0.867***	0.836***	0.882***	0.808***	0.901***	0.900***	0.896***
	(13.756)	*(13.907)*	*(13.463)*	*(11.495)*	*(14.700)*	*(14.378)*	*(12.390)*
ROE	-0.460***	-0.254***	-0.406***	-0.505***	-0.280***	-0.104***	-0.037*
	(-9.314)	*(-7.879)*	*(-8.910)*	*(-9.001)*	*(-7.100)*	*(-4.559)*	*(-1.847)*
LTG	-0.165	-0.362***	-0.411***	-0.453***	-0.306***	-0.124	-0.185*
	(-1.591)	*(-4.431)*	*(-4.014)*	*(-4.331)*	*(-4.005)*	*(-1.540)*	*(-1.904)*
BETA	0.006	0.009	0.002	-0.005	-0.002	-0.014	-0.007
	(0.495)	*(0.859)*	*(0.135)*	*(-0.389)*	*(-0.212)*	*(-1.335)*	*(-0.444)*
VOL	-0.170*	-0.217**	-0.107	-0.140	-0.295***	-0.113	0.328**
	(-1.652)	*(-2.468)*	*(-0.920)*	*(-1.175)*	*(-2.890)*	*(-1.055)*	*(2.334)*
MV	-0.026***	-0.038***	-0.044***	-0.039***	-0.043***	-0.038***	-0.038***
	(-4.354)	*(-7.697)*	*(-7.178)*	*(-6.589)*	*(-8.724)*	*(-7.634)*	*(-6.166)*
R-square	**46%**	**40%**	**39%**	**39%**	**39%**	**36%**	**34%**
Sample	**506**	**734**	**737**	**695**	**774**	**673**	**603**

Source: Datastream; Own work.

Note. * This table reports the results of the annual regression of equation (26) with the ratio of the book value to price as the dependent variable. *BVPIN* is a mean industry market ratio of book value and total market value, *ROE* is the current return on equity of a firm, *LTG* is the estimated long-term growth, *BETA* is the beta coefficient of firm stock, *VOL* is a measure of stock's average annual price movement to a high and low from a mean price, and *MV* is the natural logarithm of a firm market value. P-values are provided in parentheses. All values with the significance at > 0,01 are marked with ***, with the significance at > 0,05 with **, and with the significance at > 0,10 with *.

Table 7 presents results of annual regression for the BV/P ratio and the explanatory variables. The R-squares averages 39 percent over the period and ranges from 34 percent in 2016 to 46 percent in 2010. The strongest explanatory variables mean industry market multiple, ROE and market value have the predicted sign of correlation in each regression and are significant at less than one percent. In addition, estimated long-term growth is significant at the 1 percent in four regressions, and measure of stock's price movement is significant at 5 percent in three regressions.

4.2.3 Price-sales ratio

Table 8: Correlation between the ratio of sales to price and explanatory variables

	SP	SPIN	NM	LTG	BETA	VOL	MV	DP
SP		0.660***	-0.233***	-0.062***	0.017	0.186***	-0.245***	0.019
		(0.000)	*(0.000)*	*(0.000)*	*(0.229)*	*(0.000)*	*(0.000)*	*(0.183)*
SPIN	0.640***		-0.145***	0.001	0.011	0.098***	-0.092***	0.000
	(0.000)		*(0.000)*	*(0.938)*	*(0.449)*	*(0.000)*	*(0.000)*	*(0.993)*
NM	-0.677***	-0.405***		0.039***	-0.005	-0.153***	0.205***	-0.004
	(0.000)	*(0.000)*		*(0.008)*	*(0.717)*	*(0.000)*	*(0.000)*	*(0.802)*
LTG	-0.136***	-0.024*	0.001		0.164***	0.233***	-0.027*	-0.075***
	(0.000)	*(0.093)*	*(0.922)*		*(0.000)*	*(0.000)*	*(0.068)*	*(0.000)*
BETA	-0.044***	-0.011	-0.022	0.228***		0.262***	0.017	0.008
	(0.002)	*(0.442)*	*(0.135)*	*(0.000)*		*(0.000)*	*(0.236)*	*(0.579)*
VOL	0.144***	0.114***	-0.244***	0.331***	0.274***		-0.524***	-0.109***
	(0.000)	*(0.000)*	*(0.000)*	*(0.000)*	*(0.000)*		*(0.000)*	*(0.000)*
MV	-0.289***	-0.121***	0.357***	-0.075***	0.004	-0.523***		0.044***
	(0.000)	*(0.000)*	*(0.000)*	*(0.000)*	*(0.775)*	*(0.000)*		*(0.003)*
DP	0.028***	0.071***	0.084***	-0.347***	-0.178***	-0.490	0.287***	
	(0.000)	*(0.000)*	*(0.000)*	*(0.000)*	*(0.000)*	*(0.775)*	*(0.000)*	

Source: Datastream; Own work.

Note. * This table provides the correlation between variables for a pooled sample. The upper triangle shows the Pearson correlation coefficients and the lower triangle reflects the Spearman rank correlation. *SP* is the ratio of sales to price, *SPIN* is a mean industry market ratio of revenue and total market value sales to total market value, *NM* is the net margin, *LTG* is the estimated long-term growth, *BETA* is the beta coefficient of firm stock, *VOL* is a measure of stock's average annual price movement to a high and low from a mean price, *MV* is the natural logarithm of a firm market value, and *DP* is the dividend payout. P-values are provided in parentheses. All values with the significance at > 0,01 are marked with ***, with the significance at > 0,05 with **, and with the significance at > 0,10 with *.

Table 8 presents correlation between the ratio of firm revenues to the total market value and seven explanatory variables. The upper triangle shows the Pearson correlation coefficients and the lower triangle reflects the Spearman rank correlation. As predicted the S/P ratio is negatively correlated to net margin and estimated long-term growth, and has a positive relationship to measure of stock's price movement. This means that firms with high margins, promising future earnings expectations and lower risk levels are rewarded with a higher multiple. Contrary to expectations, market value and beta show negative correlation and dividend payout has positive relationship to the S/P ratio. All selected variables show statistically significant Spearman rank correlations. In addition, coefficients between pairs of explanatory variables suggest the absence of multicollinearity.

Table 9 presents results of annual regression of the S/P ratio and the explanatory variables. The average of annual R-squares is 50 percent, which represents the highest proportion of explained cross-sectional variation of the three regression models. As expected, the strongest explanatory variables mean industry market multiple and net margin are significant at less than 1 percent. Also, market value is significant at the 5 percent for all models and estimated long-term growth is significant in six out of seven regressions. These findings suggest that profitability, growth and risk variables help to explain the variation in the S/P ratio beyond the mean industry market ratio.

Table 9: Results of annual regression for the P/S ratio

	2010	2011	2012	2013	2014	2015	2016
Intercept	0.800**	1.494***	1.376***	1.410***	1.205***	0.701**	0.911**
	(2.302)	*(4.018)*	*(4.091)*	*(3.685)*	*(4.077)*	*(2.172)*	*(2.444)*
SPIN	0.884***	0.956***	0.933***	0.967***	0.885***	0.978***	0.897***
	(16.307)	*(23.957)*	*(23.688)*	*(20.415)*	*(20.943)*	*(25.568)*	*(20.198)*
NM	-1.788***	-0.661***	-1.614***	-0.615***	-2.133***	-0.089	-1.144***
	(-6.432)	*(-3.340)*	*(-6.328)*	*(-2.911)*	*(-7.196)*	*(-0.793)*	*(-4.508)*
LTG	-0.432	-0.894***	-0.745**	-1.259***	-0.588**	-0.979***	-0.671**
	(-1.275)	*(-2.694)*	*(-2.340)*	*(-3.340)*	*(-2.313)*	*(-3.439)*	*(-2.196)*
BETA	0.088**	0.069*	-0.005	-0.014	-0.025	-0.014	0.047
	(2.166)	*(1.648)*	*(-0.129)*	*(-0.334)*	*(-0.706)*	*(-0.366)*	*(1.001)*
VOL	0.309	0.235	0.441	0.640	0.465	1.094***	1.245***
	(0.900)	*(0.631)*	*(1.221)*	*(1.473)*	*(1.359)*	*(2.810)*	*(2.786)*
MV	-0.044**	-0.096***	-0.082***	-0.090***	-0.063***	-0.054***	-0.070***
	(-2.213)	*(-4.680)*	*(-4.366)*	*(-4.263)*	*(-3.853)*	*(-3.112)*	*(-3.489)*
DP	0.042	0.000	0.013	0.003	0.020	-0.021	0.118***
	(1.632)	*(0.002)*	*(0.761)*	*(0.135)*	*(0.840)*	*(-0.577)*	*(3.362)*
R square	**48%**	**50%**	**52%**	**44%**	**49%**	**53%**	**53%**
Sample	**506**	**734**	**737**	**695**	**774**	**673**	**603**

Source: Datastream; Own work.

Note. * This table reports the results of the annual regression of equation (27) with the ratio of sales to price as the dependent variable. *SPIN* is a mean industry market ratio of revenue and total market value sales to total market value, *NM* is the net margin, *LTG* is the estimated long-term growth, *BETA* is the beta coefficient of firm stock, *VOL* is a measure of stock's average annual price movement to a high and low from a mean price, *MV* is the natural logarithm of a firm market value, and *DP* is the dividend payout. P-values are provided in parentheses. All values with the significance at > 0,01 are marked with ***, with the significance at > 0,05 with **, and with the significance at > 0,10 with *.

4.3 Evaluation of pricing errors

To evaluate the potential of regression models for improving performance of multiples, I compare estimated firm values of regression models to estimated firm values of the comparable firms approach using the pricing error. As seen in studies by Alford (1992), and Cheng and McNamara (2000), the pricing error is defined as the predicted firm value less the market price expressed as a fraction of the market price.

Table 10: Summary statistics of pricing errors of the P/E, the P/BV and the P/S ratios for regression and the comparable firms approach

	Regression	Comparable firms approach
Price-earnings ratio		
Median	0.170	0.186
Rank based on median	1	2
Test statistics	-68.702***	
	(0.000)	
Price-to-book-value ratio		
Median	0.279	0.341
Rank based on median	1	2
Test statistics	-15.557***	
	(0.000)	
Price-sales ratio		
Median	0.394	0.417
Rank based on median	1	2
Test statistics	-17.419***	
	(0.000)	

Source: Datastream; Own work.

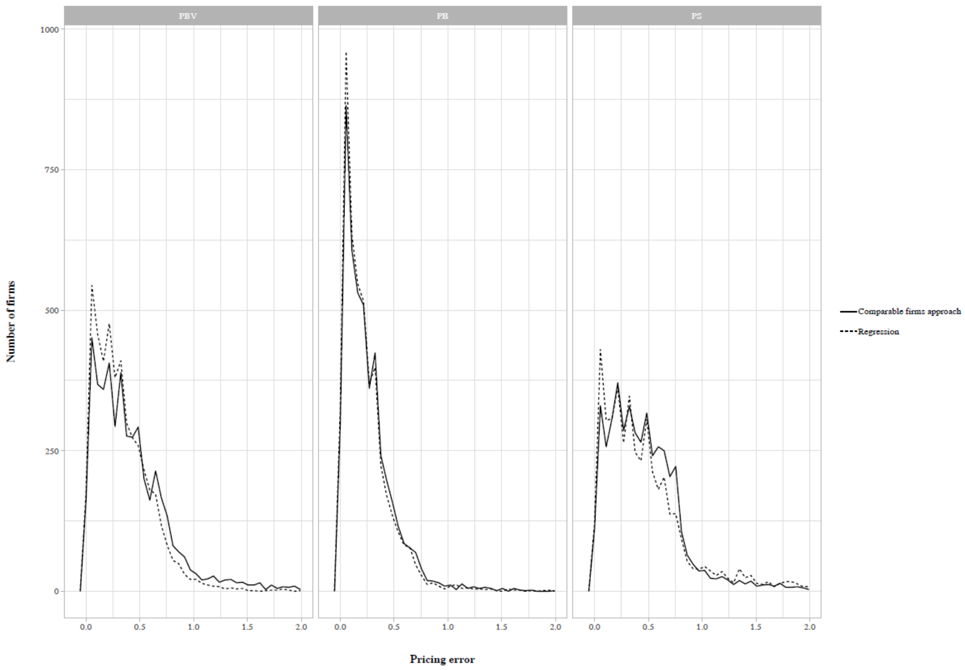
Note. * This table provides the median and rank based on median for regression and the comparable firms approach. The nonparametric test result for two related samples is also reported. P-values are provided in parentheses. All values with the significance at > 0,01 are marked with ***, with the significance at > 0,05 with **, and with the significance at > 0,10 with *.

Table 10 presents the following summary statistics of pricing errors for regression and the comparable firms approach: the median, rank based on the median, and statistics for nonparametric tests for two related samples. Results suggest that regression of the P/E ratio has the lowest dispersion of pricing errors. The median value of P/E regression is 0.170 compared to the median values of 0.279 for the P/BV regression and 0.394 for the P/S regression. Similar results are reported for the comparable firms approach. The median pricing error of 0.186 for the P/E ratio is lower than median pricing errors for the P/BV or the P/S ratios. These findings are similar to Liu et al. (2002) who report forecasted earnings multiples as best performing.

Results of the median pricing errors validate the hypothesis that regression models have the potential to improve valuation performance of multiples. When comparing pricing errors between regression and the comparable firms approach, regression ranks better for the P/E, the P/BV and the P/S ratios. The difference in median pricing errors between both methods is lowest for the P/E ratio based on the forecasted earnings. Nonparametric tests confirm that the difference in ranking of pricing errors is statistically significant.

Figure 2 presents the distribution of pricing errors of multiples by valuation method. For reporting purposes 550 extreme values or 2 percent of the total population are omitted from charts. Distribution of pricing errors for both methods is positively skewed with mean values greater than median values. The plots for regression display a tighter distribution for all ratios, which is a mark of superior performance. This confirms the initial conclusions based on summary statistics that regression improves valuation accuracy.

Figure 2: Distribution of pricing errors of the P/BV, the P/E, and the P/S ratios by the comparable firms approach and regression



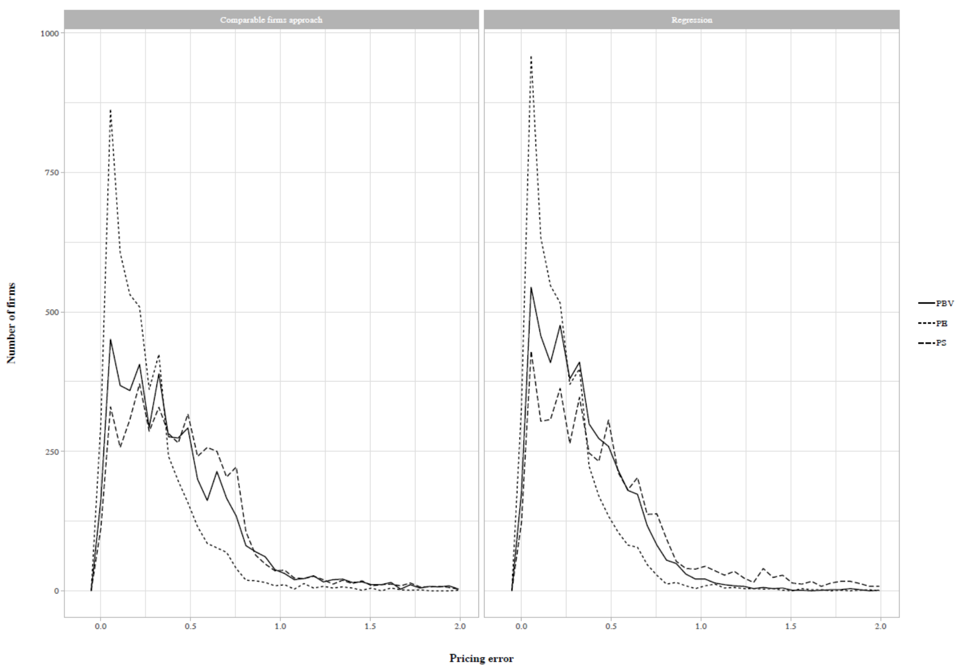
Source: Datastream; Own work.

Note. * This figure presents pooled sample distribution of pricing errors for multiples. The pricing error of a firm is calculated as the estimated firm value minus the market price expressed as a fraction of market price. *P/BV* is the ratio of market value to book value, *P/E* is the ratio of stock price to forward EPS, and the *P/S* is the ratio of market value to revenues.

Figure 3 compares distributions of pricing errors of regression and the comparable firms approach for each multiple. Results indicate that the P/E ratio has the lowest standard deviation of pricing errors. This translates into a tighter inter-quartile range and a shorter tail of the distribution.

Appendix 4 shows a detailed breakdown of median pricing errors by 3-digit SIC codes. On average the lowest pricing error is reported for industries with predominately large firms with low growth estimates, and high ROE and dividend payout. Examples include firms in chemicals, transportation, electric and utility services, and apparel industries. Furthermore, the largest pricing error is reported for industries including grocery and department stores, no-stores retailers, electronic goods, and computer and software services. These firms are on average smaller in size, have high values of beta coefficient and price volatility, and report below average return on equity.

Figure 3: Distribution of pricing errors of the comparable firms approach and regression by the P/BV, the P/E, and the P/S ratios



Source: Datastream; Own work.

Note. * This figure shows pooled sample distribution of pricing errors for the comparable firms approach and regression. The pricing error of a firm is calculated as the estimated firm value minus the market price expressed as a fraction of market price.

4.4 Performance of undervalued stocks

After confirming that regression has the potential to improve valuation performance of multiples, I investigate if the firm value estimates of the best performing ratio can be used for identifying undervalued stocks in the sample. To allocate stocks to the respective investment portfolio, I calculate the ratio of actual stock price divided by the estimated firm value. A stock is allocated to the undervalued portfolio if the ratio is lower than 0.85, and if the ratio is over 1.15, a stock is added to the portfolio of overvalued stocks.

Table 11 presents portfolio performance for the short-term return over a 12 month period and for the long-term return over the period 2010 to 2016. Figure 4 further illustrates the returns over the investment period for portfolios of undervalued and overvalued stocks. To evaluate the portfolio allocation method presented in this thesis I compare results of the portfolio of undervalued stocks to the portfolio of overvalued stocks and the S&P 500. The method is successful if a group of undervalued stocks outperforms the market and at the same time displays higher returns than a group of overvalued stocks.

Table 11: Short-term and long-term returns for undervalued stocks, overvalued stocks and the S&P 500

Year	Undervalued		Overvalued		S&P 500	
	12 month return	Long-term return	12 month return	Long-term return	12 month return	Long-term return
2010	13.90%	103.52%	32.47%	108.69%	11,21%	73,35%
2011	2.74%	99.59%	2.91%	64.47%	4,13%	55,88%
2012	23.15%	91.04%	15.33%	59.31%	13,29%	49,70%
2013	35.59%	52.59%	23.31%	43.32%	18,69%	32,14%
2014	18.47%	11.89%	16.60%	15.37%	12,37%	11,33%
2015	-8.51%	-8.51%	-0.24%	-0.24%	-0,92%	-0,92%

Source: Datastream; Own work.

Note. * This table provides annual short-term return over a 12 month period and long-term returns over the period 2010 to 2016 for undervalued stocks, overvalued stocks and the S&P 500. A stock is undervalued if the ratio of actual stock price divided by the estimated firm value, is under 0.85 and overvalued if the ratio is higher than 1.15.

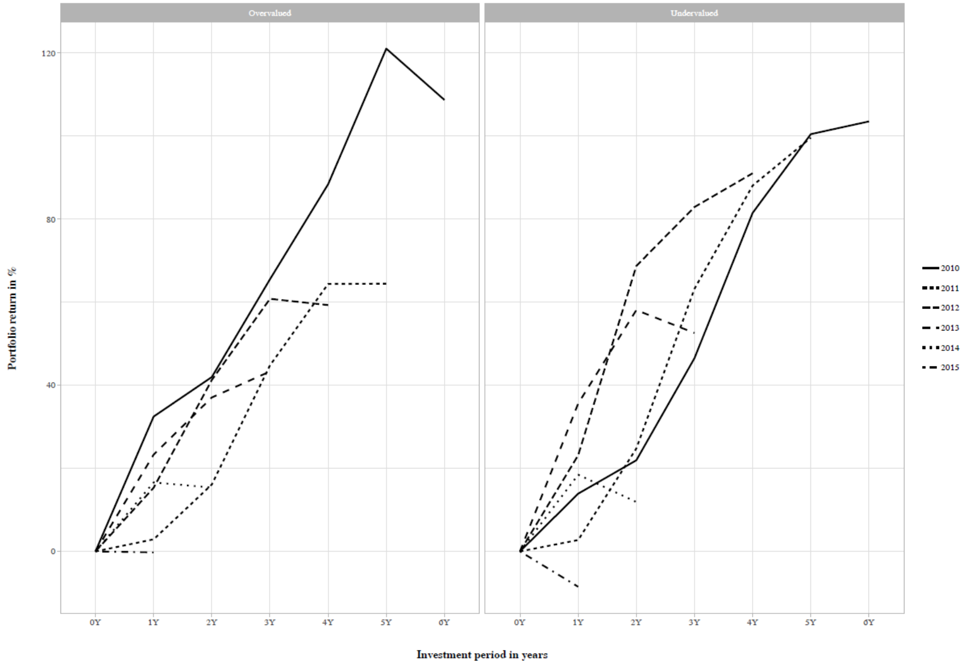
Results show that these criteria are met in three out of six cases for the short-term returns, and in three out of six cases for the long-term returns. For 2010 and 2015 the group of overvalued stocks delivers better returns for both the short-term and long-term period, and for 2011 the S&P 500 has the highest short-term returns. When comparing returns of undervalued stocks directly to the S&P 500, the portfolio outperforms the market in 9 out of 12 possible scenarios. These findings are similar to Whiteck and Manown (1963) who use estimates of the P/E market regression to select undervalued stocks and report that the portfolio outperforms the market in each of the three month periods in the sample.

Figure 5 presents the distribution of explanatory variables for the portfolios of undervalued and overvalued stocks. The plot includes the following adjustments: (1) 912 extreme values or 5.8 percent of data are omitted, (2) market value is not included as it is calculated on a different scale. The comparison on a level of firm fundamentals reveals that on average overvalued stocks have higher growth estimates and higher perceived level of risk.

Table 12 shows test statistics to determine if there is a statistically significant difference in explanatory variables between the portfolios of undervalued and overvalued stocks. Results suggest that estimated long-term and near-term growth, beta, and net margin for the portfolio of overvalued stocks are statistically significantly higher than for the undervalued stocks. This confirms initial conclusions that overvalued firms are riskier, have better near-term and long-term growth prospects, and are more profitable. However, the difference in median between both groups is not significant for measure of stock's price movement, market value, ROE and dividend payout.

Appendix 4 and 5 include a detailed breakdown of median values of explanatory variables for the undervalued and overvalued stocks by three digits SIC codes.

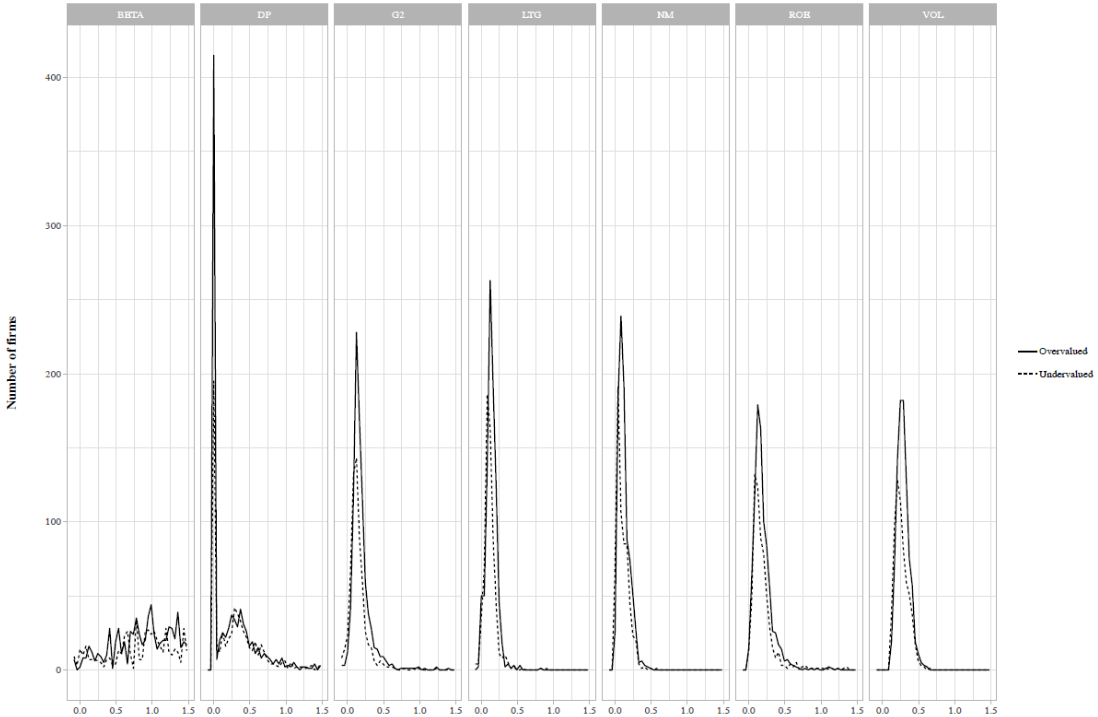
Figure 4: Returns for portfolios of undervalued and overvalued stocks



Source: Datastream; Own work.

Note. * This figure shows returns over the investment period 2010 to 2016 for portfolios of undervalued and overvalued stocks. A stock is undervalued if the ratio of actual stock price divided by the estimated firm value, is under 0.85 and overvalued if the ratio is higher than 1.15.

Figure 5: Distribution of firm fundamentals by undervalued and overvalued stocks



Source: Datastream; Own work.

Note. * This figure shows pooled sample distribution of the explanatory variables used in regression by the portfolios of undervalued and overvalued stocks. A stock is undervalued if the ratio of actual stock price divided by the estimated firm value, is under 0.85 and overvalued if the ratio is higher than 1.15. *BETA* is the beta coefficient of firm stock, *DP* is the dividend payout, *G2* is the near-term growth, *LTG* is the estimated long-term growth, *NM* is the net margin, *ROE* is the current return on equity of a firm, and *VOL* is a measure of stock's average annual price movement to a high and low from a mean price.

Table 12: Test statistics for differences in explanatory variables between portfolio of undervalued and overvalued stocks

	Portfolio of undervalued stocks	Portfolio of overvalued stocks
LTG		
Median	0.110	0.146
Test statistics	11.390***	
	(0.000)	
G2		
Median	0.135	0.184
Test statistics	9.330***	
	(0.000)	
BETA		
Median	0.990	1.060
Test statistics	2.227**	
	(0.023)	
VOL		
Median	0.298	0.291
Test statistics	-1.627	
	(0.104)	
MV		
Median	14.768	14.715
Test statistics	-0.017	
	(0.987)	
ROE		
Median	0.121	0.124
Test statistics	0.142	
	(0.887)	
DP		
Median	0.103	0.000
Test statistics	-0.243	
	(0.808)	
NM		
Median	0.057	0.086
Test statistics	6.657***	
	(0.000)	

Source: Datastream; Own work.

Note. * This table presents the Mann-Whitney U test statistics for differences in explanatory variables between group of undervalued and overvalued stocks. A stock is undervalued if the ratio of actual stock price divided by the estimated firm value, is under 0.85 and overvalued if the ratio is higher than 1.15. *LTG* is the estimated long-term growth, *G2* is the near-term growth, *BETA* is the beta coefficient of firm stock, *VOL* is a measure of stock's average annual price movement to a high and low from a mean price, *MV* is the natural logarithm of a firm market value, *ROE* is the current return on equity of a firm, *DP* is the dividend payout, and *NM* is the net margin. P-values are provided in parentheses. All values with the significance at > 0,01 are marked with ***, with the significance at > 0,05 with **, and with the significance at > 0,10 with *.

CONCLUSION

In thesis I introduce a technique for identifying undervalued stocks in the market based on regression estimates of multiples. Because relative valuation multiples can be interpreted as an application of a dividend discounted model with expected growth rate, risk and cash flow fundamentals, regression provides a useful technique for determining the relationship between the multiples and the explanatory variables.

I start the analysis by evaluating the valuation accuracy of regression models of the P/E, the P/BV and the P/S ratios. Estimated firm values computed using the comparable firms approach based on industry membership provide a benchmark valuation. I examine the performance of regression models and the comparable firms approach with the pricing error, which is calculated as the estimated firm value of a target firm less the market price expressed as a fraction of the market price. Results presented in this thesis validate the hypothesis that regression models are on average performing better than the comparable firms approach. The distribution of pricing errors for regression models has a more peaked shape, and nonparametric tests confirm that the difference in ranking of the pricing errors is statistically significant. Among the selected multiples, the P/E ratio has the lowest median and the standard deviation of pricing errors, which is similar to previous studies on the performance of value drivers in multiples.

After confirming that regression improves valuation performance of multiples, I further investigate if the predicted firm values of the best performing ratio can be used for identifying undervalued stocks. Based on the value of the ratio of the actual price per share divided by the estimated firm value per share, I categorize all firm-year observations in the sample as either undervalued of overvalued. The analysis of return performance shows that the selected portfolio of undervalued stocks outperforms S&P 500 in 9 out of 12 possible scenarios. However, when considering the returns of the overvalued stocks, I find that the portfolio of the undervalued stocks performs only marginally better. Over a short-term period of 12 months the portfolio of undervalued stocks outperforms the S&P 500 and the portfolio of overvalued stocks in three out of six valuations. Similarly, over a long-term period from 2010 to 2016 undervalued stocks perform better in three out of six valuations. Finally, the review of fundamentals for both groups indicates that on average overvalued stocks are riskier, have better near-term and long-term growth prospects, and are more profitable. This indicates that the market tends to undervalue stocks due to unsatisfactory performance and rewards stocks that grow and earn returns exceeding the cost of capital. As a result stocks with excellent prospects are recognized in the market with high prices, which makes them overvalued.

Findings of this thesis have a number of possible applications. As suggested by Whiteck and Manown (1963), Wilcox (1984), Kim and Ritter (1999) and others, I find that the use of regression improves the accuracy of relative valuation multiples. The regression based approach is not limited to the P/E, the P/BV and the P/S ratios, but can be applied to other relative valuation multiples. The technique has potential to improve accuracy of valuation and produce better estimates of firm value. In addition, the ratio of the actual price per share and predicted value of the best performing regression model serves as a useful proxy for selecting the portfolio of undervalued stocks.

Results also present a number of potential areas for future research. Firstly, I examine a sample of publicly listed United States firms for a relatively short period following the financial downturn in 2009 which the S&P 500 generated cumulative returns of over 70 percent. This is likely not sufficient to conclude that an investment strategy based on a portfolio of undervalued firms delivers superior performance. A study over a longer time period would improve the robustness of the model and validate these findings. Another possible area of interest is the selection of independent variables based on findings of previous studies. One of the pitfalls of regression is that it is possible to obtain a good in-sample fit through variables that have no predictive power out-of-sample (Rachev, Mittnik, Fabozzi, Focardi & Jašić, 2007, p. 124). In this thesis undervalued stocks are characterized by similar values of fundamentals, but unless these factors cause firms to be undervalued, we cannot rely on results to predict future returns. Thus, the choice of explanatory variables in regression could be further examined with an alternative method, such as principal component analysis or factor analysis. In addition, the approximation of a linear model to a sample of non-linear observations has limitations. Logarithmic transformations of the dependent variable or robust estimation procedure are possible alternative methods.

In conclusion, empirical evidence presented in this thesis suggests practical applications of regression models of multiples for short-term and long-term investment decisions. The portfolio of undervalued stocks, selected from the sample using the ratio of actual stock prices divided by the regression estimates of value, delivers on average higher returns than the S&P 500 or the portfolio of overvalued stocks.

REFERENCE LIST

1. Agrrawal, P., Borgman, R., Clark, J. M. & Strong, R. (2010). Using the Price-to-Earnings Harmonic Mean to Improve Firm Valuation Estimates. *Journal of Financial Education*, *36*(3), 98–110.

2. Anthony, J. H. & Ramesh, K. (1992). Association between accounting performance measures and stock prices. *Journal of Accounting and Economics*, *15*(2), 203–227.

3. Alford, A. W. (1992). The Effect of the Set of Comparable Firms on the Accuracy of the Price-Earnings Valuation Method. *Journal of Accounting Research*, *30*(1), 94–108.

4. Alexander, C. (2008). *Market Risk Analysis volume 1: Quantitative Methods in Finance*. Chichester, West Sussex: John Wiley & Sons.

5. Amenc, N. & Le Sourd, V. (2005). *Portfolio theory and performance analysis*. Chichester: John Wiley & Sons.

6. Baghai, M., Smit, S. & Viguerie, P. (2007). The Granularity of Growth. *McKinsey on Finance*, 24, 25 - 30

7. Baker, M. & Ruback, R. S. (1999). *Estimating Industry Multiples*. Retrieved May 8, 2016, from http://www.people.hbs.edu/mbaker/cv/papers/estimatingindustry.pdf

8. Beatty, R. P., Riffe, S. M. & Thompson, R. (1999). The Method of Comparables and Tax Court Valuations of Private Firms: An Empirical Investigation. *Accounting Horizons*, *13*, 177–199.

9. Benninga, S. (2014). *Financial Modelling*. England: The MIT Press.

10. Beaver, W. & Morse, D. (1978). What Determines Price-Earnings Ratios. *Financial Analysts Journal*, *34*(4), 65–76.

11. Bhojraj, S. & Lee, C. (2002). Who is my peer? A valuation based approach to the selection of comparable firms. *Journal of Accounting Research*, *40*(2), 407–439.

12. Brief, R. P. & Lawson, R. A. (1992). The Role of the Accounting Rate of Return in Financial Statement Analysis. *The Accounting Review*, *67*(2), 411–426.

13. Boatsman, J. R. & Baskin, E. F. (1981). Asset Valuation with Incomplete Markets. *The Accounting Review*, *56*(1), 38–53.

14. Cheng, C. S. A. & McNamara, R. A. Y. (2000). The Valuation Accuracy of the Price-Earnings and Price-Book Benchmark Valuation Methods. *Review of Quantitative Finance and Accounting*, *15*(4), 349–370.

15. Cragg, J. G. & Malkiel, B. G. (1968). The Consensus and Accuracy of some Predictions of the Growth of Corporate Earnings. *The Journal of Finance*, *23*(1), 67–84.

16. Dodge, Y. (2008). *The Concise Encyclopaedia of Statistics*. New York: Springer.

17. Damodaran, A. (n.d.). Data: History & Sharing. *Damodaran Online*. Retrieved December 3, 2017 from http://people.stern.nyu.edu/adamodar/New_Home_Page/datahistory.html

18. Damodaran, A. (2000). *The Dark Side of Valuation: Firms with no Earnings, no History and no Comparables*. Retrieved April 20, 2016, from http://people.stern.nyu.edu/adamodar/New_Home_Page/papers.html#distr

19. Damodaran, A. (2002). *Investment Valuation: Tools and techniques for determining the value of any asset* (2nd ed.). New York: John Wiley.

20. Damodaran, A. (2009). *Valuing Young, Start-up and Growth Companies: Estimation Issues and Valuation Challenges*. Retrieved April 20, 2016, from http://people.stern.nyu.edu/adamodar/New_Home_Page/papers.html#distr

21. Damodaran, A. (2011). *Applied Corporate Finance (Third edition).* New Jersey: John Wiley.

22. Datastream (n.d). *Thomson Reuters Datastream*. Retrieved September 21, 2017

23. DePamphilis, D. M. (2014). *Mergers, Acquisitions, and Other Restructuring Activities* (7th ed.). San Diego: Elsevier.

24. Fama, E. F. & French, K. R. (1992). The Cross-Section of Expected Stock Returns. *Journal of Finance*, *47*(2), 427–465.

25. Fox, J. (2008). *Applied Regression Analysis and Generalised Linear Models*. United States of America: Sage Publications.

26. Franco, G. D., Hope, O. K. & Larocque, S. (2015). Analyst's' choice of peer companies. *Review of Accounting Studies*, *20*(19), 82–109.

27. Gordon, M. J. (1962). *The Investment, Financing and Valuation of the Corporation.* Homewood: Richard D. Irwin.

28. Goodman, D. A. & Peavy, J. W. (1983). Industry Relative Price-Earnings Ratios as Indicators of Investment Returns. *Financial Analysts Journal*, *39*(4), 60–66.

29. Greene, W. H. (2012). *Econometric Analysis* (7th ed.). United States of America: Pearson Education.

30. Graham, B., & Dodd, D. L. (1951). *Security Analysis* (3rd ed.). United States of America: McGraw-Hill.

31. Graham, B. (2003). *The Intelligent Investor*. United States of America: HarperCollins

32. Kaplan, S. N. & Ruback, R. S. (1995). The Valuation of Cash Flow Forecasts: An Empirical Analysis. *Journal of Finance*, *50*(4), 1059–1093.

33. Kim, M. & Ritter, R. J. (1999). Valuing IPOs. *Journal of Financial Economics*, *53*, 409–437.

34. Koletnik, F. (2010). *Koliko je vredno podjetje: vrednotenje in trženje podjetij*. Ljubljana: Zveza računovodij, finančnikov in revizorjev Slovenije.

35. Koller, T., Goedhart, M. & Wessels, D. (2015). Va*luation: Measuring and managing value of companies* (6th ed.). New Jersey: John Wiley & Sohn.

36. Liu, J., Nissim, D. & Thomas, J. (2002). Equity Valuation Using Multiples. *Journal of Accounting Research*, *40*(1), 135–172.

37. Marinsek, D. (2015). *Multivariatna analiza: Zbirka rešenih primerov s komentarj*i. Ljubljana: Ekonomska Fakulteta.

38. Marques de Sa, J. P. (2003). *Applied Statistics: Using SPSS, Statistica and Matlab*. New York: Springer.

39. Ohlson, J.A. & Juettner-Nauroth, B. E. (2005). Expected EPS and EPS Growth as Determinants of Value. *Review of Accounting Studies*, *10*, 349–365.

40. Palepu, K. G., Healy, P. M. & Bernard V. L. (2004). *Business Analysis & Valuation: Using financial statements* (3rd ed.). Australia: South Western.

41. Penman, S. H. (1996). The Articulation of Price-Earnings Ratios and Market-to-Book Ratios and the Evaluation of Growth. *Journal of Accounting Resear*ch, *34*(2), 235–259.

42. Rachev, S. T., Mittnik, S., Fabozzi, F. J., Focardi, S. M. & Jašić, T. (2007). *Financial Econometrics: From Basics to Advanced Modeling Techniques*. Canada: John Wiley & Sons.

43. Sanders, W. G. & Boivie, S. (2003). Valuation of New Firms in Uncertain Markets. *Strategic Management Journal*, *25*, 167–186.

44. Vernimmen, P., Quiry, P., Dallocchio, M., Le Fur, Y., Salvi, A. (2014). *Corporate finance: theory and practice* (4th ed.). Chichester: John Wiley & Sons.

45. Viebig, J., Poddig, T. & Varmaz, A. (2008). *Equity Valuation: Models from Leading Investment Banks*. Chichester: John Wiley & Sons.

46. Wilcox, J. W. (1984). The P/B-ROE Valuation Model. *Financial Analysts Journal*, *40*(1). 58 - 66.

47. Whitbeck, V. S. & Manown K. J. (1963). A New Tool in Investment Decision-Making. *Financial Analysts Journal*, *19*(3). 55–62.

48. Yin, Y., Peasnell, K., Lubberink, M. & Hunt III, H. G. (2014). Determinants of Analysts' Target P/E Multiples. *The Journal of Investing*, *23*(3), 35–42.

49. Yoo, K. Y. (2006). The valuation accuracy of equity valuation using a combination of multiples. *Review of Accounting and Finance*, *5*(2), 108–123.

APPENDIXES

Appendix 1: Povzetek magistrskege dela

V magistrskem delu predstavim metodo vrednotenja podjetij na podlagi regresijske ocene vrednosti multiplikatorjev, ki ima uporabno vrednost pri oblikovanju portfelja podcenjenih podjetij na trgu.

Osnovna ideja multiplikatorjev se skriva v predpostavki, da imajo na trgu primerljiva sredstva približno podobno vrednost. Čeprav veljajo multiplikatorji oziroma relativni kazalci vrednosti za najpogosteje uporabljeno metodo vrednotenja podjetij, ponuja strokovna literatura zanemarljivo število smernic za praktično uporabo. V delu bom preveril hipotezo, ali uporaba regresije na podlagi izbranih finančnih spremenljivk izboljša natančnost ocen vrednosti multiplikatorjev v primerljavi s klasičnim pristopom, ki temelji na klasifikaciji industrijske dejavnosti. Uporaba regresijske analize omogoča ovrednotenje razmerja med izbranim multiplikatorjem in ključnimi finančnimi podatki o prihodnji rasti, stopnji tveganja podjetja in oceni denarnih tokov.

Pri analizi regresijskega modela multiplikatorjev sem uporabil vzorec 4722 podjetij, ki kotirajo na borzi v Združenih državah Amerike v obdobju od leta 2010 do leta 2016, ter tri izbrane kazalce: P/E, P/BV in P/S. Izbor finančnih spremenljivk v regresijskem modelu multiplikatorjev je narejen na podlagi rezultatov preteklih študij. Pridobljena ocena vrednosti podjetij z regresijskim modelom je ovrednotena v primerjavi z metodo primerljivih podjetij iz podobne industrijske dejavnosti na podlagi odstopanja ocenjene vrednosti od dejanske tržne vrednosti v razmerju do dejanske tržne vrednosti. Rezultati, predstavljeni v magistrskem delu, potrjujejo hipotezo, da regresijski model v povprečju izboljša zanesljivost ocen vrednosti. Skladno z rezultati preteklih študij ima med izbranimi relativnimi kazalci vrednosti najnižjo povprečno vrednost odstopanja od tržne vrednosti P/E multiplikator.

Nadalje, rezultate najbolj zanesljivega multiplikatorja sem uporabil za testiranje hipoteze, da se lahko na podlagi ocen vrednosti oblikuje investicijski portfelij podcenjenih podjetij. Iz analize donosnosti v kratkem obdobju 12 mesecev in dolgoročnem obdobju od leta 2010 do leta 2016 je razvidno, da portfelij podcenjenih podjetij dosega višjo donosnost od tržnega indeksa S&P 500 v 9 od možnih 12 scenarijev. Če v analizi hkrati s tržnim indeksom upoštevamo tudi precenjena podjetja, potem dosega portfelj podcenjenih podjetij boljše rezultate v 3 od možnih 6 scenarijev v kratkem obdobju. Prav tako ima portfelij podcenjenih podjetij najvišjo donosnost v 3 od možnih 6 scenarijev v obdobju od leta 2010 do leta 2016. Pregled podjetij v portfelju podcenjenih in precenjenih podjetij na nivoju ključnih finančnih spremenljivk razkriva, da imajo precenjena podjetja v povprečju višje ocene prihodnje rasti, nižje kazalnike stopnje tveganja ter višjo dobičkonostnost. Na podlagi tega lahko zaključimo, da so investitorji v izbranem obdobju nagradili rastoča podjetja z visoko stopnjo dobičkonostnosti, kar se odraža v relativno visoki tržni ceni in nižjem potencialu prihodnje donostnosti.

Empirični podatki, predstavljeni v magistrskem delu, potrjujejo hipotezo, da metoda vrednotenja podjetij na podlagi regresijskih ocen multiplikatorjev v povprečju izboljša zanesljivost ocen vrednosti ter ima praktično uporabnost pri oblikovanju investicijskega portfelja podcenjenih podjetij. Rezultati dela prav tako odpirajo nova vprašanja za prihodnje študije: obnašanje regresijskega modela multiplikatorjev v času recesije, ovrednotenje pravilnosti izbora ključnih finančnih spremenljivk s pomočjo faktorske metode ter uporaba nelinearnega regresijskega modela. Tovrstne raziskave bi povečale robustnost modela vrednotenja ter potrdile zaključke magistrskega dela.

Appendix 2: Median of explanatory variables by SIC

SIC	EPIN	BVPIN	SPIN	LTG	G2	BETA	VOL	MV	ROE	DP	NM
131	0.067	0.495	0.356	0.117	0.251	1.260	0.336	15.671	0.075	0.000	0.135
138	0.086	0.596	0.556	0.148	0.254	1.350	0.327	15.290	0.081	0.181	0.106
153	0.084	0.755	1.043	0.116	0.279	1.150	0.322	15.119	0.098	0.000	0.067
162	0.072	0.586	1.801	0.142	0.197	1.290	0.337	13.673	0.085	0.000	0.030
203	0.073	0.388	0.898	0.095	0.094	0.120	0.191	14.595	0.147	0.429	0.063
204	0.074	0.459	1.645	0.083	0.105	0.430	0.238	16.721	0.163	0.310	0.063
208	0.058	0.310	0.724	0.081	0.100	0.600	0.208	15.948	0.254	0.359	0.114
232	0.067	0.450	1.166	0.129	0.144	0.510	0.321	15.097	0.140	0.301	0.060
251	0.065	0.474	1.257	0.125	0.220	0.980	0.330	13.413	0.119	0.282	0.047
262	0.094	0.654	1.656	0.109	0.131	1.420	0.288	14.472	0.123	0.324	0.040
281	0.082	0.558	1.016	0.089	0.119	1.420	0.227	14.441	0.136	0.336	0.081
282	0.085	0.458	1.375	0.120	0.166	1.620	0.280	15.021	0.147	0.263	0.065
283	0.074	0.346	0.377	0.132	0.150	1.060	0.268	15.060	0.176	0.000	0.133
284	0.068	0.291	0.676	0.107	0.107	0.650	0.176	16.383	0.183	0.457	0.093
286	0.081	0.321	1.101	0.089	0.122	0.780	0.319	14.913	0.238	0.328	0.090
287	0.077	0.373	0.617	0.108	0.156	1.415	0.309	15.586	0.170	0.205	0.076
291	0.109	0.672	1.893	0.062	0.095	1.245	0.285	16.911	0.138	0.326	0.060
308	0.072	0.331	0.804	0.100	0.128	1.320	0.272	14.633	0.142	0.321	0.073
331	0.079	0.570	1.655	0.138	0.498	1.450	0.331	14.343	0.064	0.439	0.027
344	0.062	0.533	1.101	0.140	0.295	1.240	0.316	14.087	0.072	0.000	0.054
349	0.069	0.451	0.901	0.112	0.157	1.320	0.250	14.557	0.116	0.322	0.060
352	0.057	0.448	1.101	0.080	0.121	0.610	0.244	13.704	0.122	0.246	0.049
353	0.077	0.606	1.011	0.135	0.190	0.940	0.305	14.826	0.105	0.139	0.068
355	0.082	0.604	0.946	0.120	0.235	1.300	0.310	13.038	0.120	0.000	0.056
356	0.061	0.370	0.693	0.140	0.147	1.150	0.280	14.969	0.131	0.242	0.089
357	0.071	0.472	0.854	0.150	0.157	1.250	0.345	14.434	0.087	0.000	0.062
362	0.066	0.342	0.624	0.113	0.120	1.310	0.246	14.963	0.149	0.159	0.083
364	0.050	0.453	0.804	0.139	0.270	1.390	0.279	13.920	0.150	0.241	0.073
366	0.074	0.494	0.608	0.115	0.136	1.290	0.292	14.670	0.103	0.000	0.077
367	0.075	0.477	0.705	0.128	0.187	1.190	0.333	14.484	0.098	0.000	0.088
371	0.083	0.417	1.468	0.135	0.162	1.300	0.311	15.125	0.175	0.200	0.055
372	0.075	0.423	1.035	0.110	0.139	1.100	0.244	15.296	0.154	0.077	0.077
381	0.076	0.460	0.870	0.081	0.090	0.760	0.212	16.160	0.174	0.345	0.089
382	0.065	0.432	0.522	0.120	0.147	1.070	0.263	14.907	0.112	0.000	0.096
384	0.062	0.423	0.516	0.117	0.123	0.860	0.216	14.817	0.124	0.078	0.110
394	0.057	0.395	0.743	0.136	0.173	0.710	0.265	13.446	0.174	0.348	0.077
401	0.065	0.392	0.364	0.136	0.148	1.360	0.230	16.940	0.147	0.329	0.159
421	0.063	0.415	1.424	0.128	0.174	1.150	0.244	14.444	0.142	0.117	0.046
441	0.096	0.820	0.560	0.050	0.218	0.820	0.319	13.823	0.082	0.531	0.139
451	0.105	0.454	1.615	0.144	0.164	1.110	0.305	15.259	0.168	0.079	0.063
461	0.057	0.407	1.061	0.059	0.096	1.010	0.210	15.680	0.101	1.542	0.042
473	0.056	0.345	1.612	0.128	0.146	1.560	0.211	14.207	0.128	0.240	0.030
481	0.071	0.554	1.388	0.058	0.097	0.550	0.250	15.240	0.074	0.407	0.040

(table continues)

(continued)

SIC	EPIN	BVPIN	SPIN	LTG	G2	BETA	VOL	MV	ROE	DP	NM
483	0.074	0.463	0.820	0.060	0.143	1.390	0.433	13.774	0.143	0.216	0.096
484	0.066	0.360	0.588	0.144	0.152	1.590	0.250	16.462	0.259	0.000	0.121
491	0.064	0.612	0.739	0.050	0.059	0.150	0.156	15.938	0.092	0.613	0.093
492	0.056	0.486	0.746	0.055	0.080	0.780	0.201	15.281	0.095	0.687	0.069
493	0.067	0.661	0.738	0.050	0.057	0.090	0.148	15.942	0.096	0.634	0.089
494	0.054	0.537	0.410	0.054	0.065	0.040	0.146	13.559	0.095	0.610	0.132
495	0.054	0.358	0.702	0.100	0.111	0.570	0.195	14.971	0.095	0.413	0.064
504	0.069	0.473	2.707	0.100	0.104	0.870	0.192	14.697	0.124	0.075	0.022
506	0.081	0.572	2.893	0.133	0.133	1.130	0.280	14.982	0.128	0.075	0.025
514	0.066	0.479	4.046	0.094	0.111	1.120	0.257	14.128	0.104	0.333	0.016
517	0.056	0.460	3.781	0.070	0.103	1.420	0.283	14.288	0.055	1.452	0.009
531	0.061	0.804	2.935	0.100	0.117	0.720	0.353	16.020	0.086	0.199	0.029
533	0.068	0.351	1.766	0.125	0.140	0.510	0.226	16.620	0.185	0.276	0.034
551	0.085	0.494	4.933	0.193	0.116	1.300	0.332	14.381	0.173	0.119	0.017
565	0.070	0.379	1.304	0.122	0.134	0.420	0.289	15.059	0.191	0.331	0.059
566	0.086	0.567	1.819	0.104	0.135	0.770	0.332	13.937	0.132	0.226	0.042
571	0.073	0.358	1.152	0.149	0.202	0.910	0.281	14.405	0.239	0.218	0.061
581	0.056	0.341	0.999	0.132	0.168	0.410	0.277	14.250	0.173	0.125	0.051
591	0.069	0.408	2.012	0.136	0.129	0.600	0.237	17.221	0.131	0.235	0.031
594	0.069	0.414	1.449	0.140	0.142	0.020	0.322	15.056	0.149	0.189	0.055
596	0.053	0.343	2.111	0.186	0.243	0.775	0.390	12.822	0.119	0.000	0.024
701	0.062	0.500	0.601	0.150	0.176	1.110	0.315	14.782	0.105	0.000	0.100
735	0.097	0.588	0.748	0.101	0.122	1.360	0.331	14.226	0.124	0.282	0.109
736	0.065	0.497	1.966	0.140	0.198	1.070	0.304	13.593	0.106	0.095	0.026
737	0.065	0.324	0.482	0.140	0.148	0.990	0.283	14.822	0.134	0.000	0.110
738	0.066	0.367	0.570	0.148	0.159	1.200	0.285	15.061	0.146	0.000	0.101
806	0.074	0.498	1.847	0.117	0.114	0.460	0.256	14.952	0.137	0.000	0.054
822	0.084	0.552	0.957	0.142	0.128	1.390	0.312	13.564	0.169	0.000	0.074
871	0.075	0.531	2.055	0.115	0.138	1.690	0.267	14.205	0.105	0.000	0.025
874	0.064	0.471	0.961	0.135	0.138	0.570	0.270	13.603	0.107	0.000	0.054

Source: Datastream; Own work.

Note. * This table includes the median of the explanatory variables used in annual regressions by three digits SIC code. *EPIN* stands for a mean industry market ratio of forward EPS and market price per share, *BVPIN* is a mean industry market ratio of book value and total market value, *SPIN* is the mean industry market ratio of revenue and total market value, *LTG* is the estimated long-term growth, *G2* is the near-term growth, *BETA* is the beta coefficient of firm stock, *VOL* is a measure of stock's average annual price movement to a high and low from a mean price, *MV* is the natural logarithm of a firm market value, *ROE* is the current return on equity of a firm, *DP* is the dividend payout, and *NM* is the net margin.

Appendix 3: Median pricing errors of regression models and the comparable firms approach for the P/E, the P/BV and the P/S ratios by SIC

SIC	Regression			Comparable firms approach		
	P/E	P/BV	P/S	P/E	P/BV	P/S
131	0.267	0.258	1.369	0.275	0.311	0.356
138	0.223	0.315	0.542	0.242	0.424	0.408
153	0.122	0.156	0.307	0.135	0.192	0.354
162	0.141	0.202	0.197	0.165	0.288	0.219
203	0.120	0.370	0.247	0.140	0.469	0.401
204	0.171	0.537	0.655	0.224	0.767	0.772
208	0.201	0.428	0.413	0.222	0.481	0.609
232	0.182	0.284	0.198	0.215	0.401	0.305
251	0.144	0.226	0.191	0.186	0.584	0.266
262	0.074	0.290	0.298	0.094	0.412	0.277
281	0.110	0.158	0.217	0.131	0.270	0.334
282	0.196	0.232	0.483	0.219	0.326	0.537
283	0.258	0.339	1.013	0.266	0.321	0.390
284	0.141	0.356	0.404	0.160	0.455	0.285
286	0.163	0.339	0.328	0.190	0.585	0.460
287	0.109	0.437	0.307	0.133	0.447	0.268
291	0.155	0.239	0.544	0.172	0.238	0.637
308	0.128	0.255	0.148	0.146	0.416	0.272
331	0.174	0.163	0.464	0.198	0.195	0.478
344	0.144	0.292	0.464	0.186	0.416	0.474
349	0.113	0.187	0.182	0.127	0.245	0.210
352	0.177	0.313	0.293	0.204	0.432	0.321
353	0.251	0.380	0.400	0.277	0.451	0.418
355	0.171	0.185	0.383	0.188	0.308	0.519
356	0.146	0.252	0.340	0.157	0.340	0.474
357	0.275	0.332	0.402	0.295	0.391	0.506
362	0.167	0.190	0.293	0.197	0.295	0.315
364	0.178	0.300	0.346	0.213	0.574	0.447
366	0.227	0.291	0.397	0.243	0.391	0.436
367	0.220	0.295	0.445	0.224	0.355	0.579
371	0.221	0.250	0.468	0.232	0.299	0.573
372	0.103	0.346	0.392	0.113	0.460	0.420
381	0.184	0.129	0.506	0.223	0.176	0.477
382	0.194	0.353	0.360	0.203	0.428	0.334
384	0.161	0.272	0.372	0.168	0.348	0.337
394	0.122	0.443	0.298	0.148	0.528	0.151
401	0.131	0.156	3.052	0.169	0.163	0.213
421	0.120	0.300	0.377	0.137	0.416	0.494
441	0.306	0.360	0.675	0.331	0.427	0.769
451	0.214	0.267	0.328	0.244	0.346	0.379
461	0.080	0.219	0.688	0.094	0.314	0.815

(table continues)

(continued)

SIC	Regression			Comparable firms approach		
	P/E	P/BV	P/S	P/E	P/BV	P/S
473	0.067	0.171	0.459	0.080	0.375	0.589
481	0.270	0.362	0.431	0.304	0.442	0.477
483	0.140	0.310	0.241	0.159	0.405	0.389
484	0.145	0.300	0.582	0.175	0.557	0.271
491	0.081	0.144	0.272	0.085	0.173	0.243
492	0.155	0.207	0.489	0.166	0.282	0.548
493	0.054	0.128	0.199	0.057	0.115	0.213
494	0.065	0.158	0.352	0.079	0.167	0.437
495	0.132	0.420	0.318	0.162	0.317	0.379
504	0.223	0.261	0.614	0.276	0.350	0.687
506	0.175	0.278	0.531	0.209	0.343	0.578
514	0.267	0.462	0.517	0.323	0.546	0.602
517	0.268	0.229	0.769	0.314	0.406	0.814
531	0.314	0.296	0.297	0.364	0.349	0.317
533	0.179	0.197	0.428	0.215	0.246	0.394
551	0.107	0.153	0.252	0.126	0.219	0.313
565	0.083	0.315	0.292	0.093	0.531	0.374
566	0.077	0.119	0.221	0.098	0.228	0.423
571	0.101	0.206	0.106	0.124	0.462	0.258
581	0.187	0.357	0.296	0.203	0.450	0.404
591	0.098	0.420	0.346	0.118	0.330	0.360
594	0.154	0.268	0.365	0.179	0.340	0.472
596	0.547	0.533	0.706	0.592	0.762	0.793
701	0.147	0.354	0.348	0.191	0.686	0.545
735	0.218	0.248	0.379	0.255	0.307	0.428
736	0.175	0.298	0.391	0.191	0.358	0.452
737	0.280	0.346	0.485	0.284	0.338	0.471
738	0.214	0.364	0.392	0.222	0.487	0.393
806	0.117	0.218	0.541	0.137	0.322	0.637
822	0.126	0.340	0.363	0.146	0.632	0.598
871	0.244	0.260	0.346	0.274	0.343	0.426
874	0.214	0.339	0.363	0.238	0.449	0.460

Source: Datastream; Own work.

Note. * This table includes the median of pricing errors of regression models and the comparable firms approach for the P/E, the P/BV and the P/S ratios by three digits SIC code. The pricing error of a firm is calculated as the estimated firm value minus the market price expressed as a fraction of market price. *P/E* is the ratio of stock price to forward EPS, *P/BV* is the ratio of market value to book value, and the *P/S* is the ratio of market value to revenues.

Appendix 4: Median of explanatory variables for undervalued stocks by SIC

SIC	EPIN	BVPIN	SPIN	LTG	G2	BETA	VOL	MV	ROE	DP	NM
131	0.067	0.495	0.356	0.076	0.230	1.300	0.362	15.396	0.095	0.000	0.135
138	0.086	0.596	0.556	0.156	0.221	2.110	0.318	15.343	0.059	0.000	0.141
153	0.056	0.652	0.771	0.121	0.395	0.960	0.348	15.152	0.111	0.000	0.056
162	0.077	0.586	1.801	0.120	0.187	1.460	0.338	13.812	0.075	0.060	0.031
203	0.073	0.388	0.899	0.104	0.128	0.010	0.173	15.895	0.160	0.606	0.055
204	0.074	0.459	1.645	0.100	0.153	0.450	0.250	15.430	0.062	0.156	0.017
208	0.062	0.329	0.766	0.075	0.100	0.480	0.202	15.854	0.151	0.375	0.119
232	0.067	0.473	1.199	0.129	0.132	0.320	0.336	14.829	0.151	0.058	0.051
251	0.066	0.524	1.299	0.000	0.229	0.565	0.266	12.208	0.094	0.439	0.048
262	0.108	0.745	1.659	0.000	0.339	0.690	0.435	14.769	0.012	0.000	0.009
281	0.079	0.458	1.028	0.150	0.098	2.590	0.427	14.828	0.206	0.216	0.111
282	0.084	0.458	1.346	0.089	0.186	1.750	0.293	15.282	0.124	0.668	0.030
283	0.060	0.360	0.406	0.092	0.123	1.120	0.250	16.179	0.200	0.000	0.129
284	0.068	0.291	0.676	0.096	0.095	0.650	0.240	15.312	0.166	0.370	0.080
286	0.086	0.321	1.101	0.110	0.215	1.075	0.347	14.773	0.225	0.101	0.082
287	0.084	0.363	0.616	0.117	0.173	0.980	0.335	16.159	0.173	0.074	0.162
291	0.109	0.670	1.815	0.080	0.073	1.260	0.294	16.955	0.172	0.368	0.054
308	0.072	0.331	0.804	0.096	0.118	1.270	0.272	13.974	0.120	0.000	0.055
331	0.078	0.562	1.526	0.139	0.451	1.450	0.338	14.550	0.080	0.450	0.023
344	0.062	0.533	1.101	0.124	0.382	1.180	0.432	14.745	0.109	0.000	0.057
349	0.074	0.495	0.901	0.138	0.175	2.280	0.364	14.073	0.164	0.000	0.056
352	0.073	0.464	1.134	0.097	0.121	0.580	0.286	13.461	0.119	0.076	0.042
353	0.088	0.634	0.941	0.131	0.153	1.155	0.305	15.658	0.113	0.136	0.095
355	0.082	0.536	0.946	0.275	0.280	1.300	0.451	12.090	0.114	0.000	0.056
356	0.063	0.370	0.695	0.145	0.176	1.465	0.313	13.828	0.112	0.304	0.048
357	0.066	0.494	0.854	0.120	0.123	1.420	0.355	16.043	0.165	0.000	0.076
362	0.068	0.342	0.624	0.127	0.194	0.600	0.183	14.792	0.099	0.185	0.054
364	0.050	0.453	0.804	0.139	0.270	1.390	0.279	13.920	0.159	0.241	0.079
366	0.071	0.494	0.619	0.086	0.100	1.445	0.238	15.543	0.106	0.233	0.061
367	0.082	0.494	0.879	0.135	0.211	1.220	0.413	14.322	0.080	0.000	0.038
371	0.083	0.433	1.468	0.150	0.186	1.410	0.410	14.990	0.218	0.125	0.036
372	0.075	0.431	1.023	0.110	0.196	1.460	0.321	14.887	0.096	0.036	0.052
381	0.087	0.489	0.949	0.081	0.070	0.770	0.186	16.701	0.205	0.355	0.078
382	0.071	0.453	0.616	0.100	0.190	0.800	0.292	13.964	0.096	0.000	0.074
384	0.062	0.423	0.516	0.094	0.094	0.740	0.206	16.231	0.116	0.181	0.104
401	0.069	0.396	0.386	0.106	0.143	1.360	0.228	16.965	0.179	0.332	0.157
421	0.063	0.415	1.424	0.106	0.280	1.600	0.380	12.970	0.077	0.029	0.018
441	0.100	0.820	0.557	0.050	0.319	0.660	0.424	13.367	0.034	0.161	0.057
451	0.101	0.649	2.068	0.149	0.197	1.025	0.366	14.697	0.215	0.000	0.068
461	0.044	0.334	0.964	0.081	0.103	1.150	0.198	15.777	0.074	1.765	0.038
473	0.056	0.350	1.578	0.157	0.183	1.240	0.253	13.907	0.087	0.108	0.022
481	0.071	0.554	1.101	0.047	0.064	0.520	0.260	15.204	0.102	0.856	0.036
483	0.087	0.585	0.902	0.020	1.172	1.525	0.483	12.722	0.089	0.000	0.059

(table continues)

(continued)

SIC	EPIN	BVPIN	SPIN	LTG	G2	BETA	VOL	MV	ROE	DP	NM
484	0.066	0.360	0.588	0.147	0.151	1.820	0.233	16.973	0.266	0.261	0.145
491	0.070	0.741	0.827	0.037	0.039	0.480	0.184	16.470	0.097	0.585	0.084
492	0.047	0.480	0.563	0.047	0.062	0.180	0.162	14.894	0.092	0.521	0.061
493	0.067	0.661	0.738	0.078	0.072	-0.150	0.167	15.147	0.089	1.517	0.082
494	0.053	0.553	0.410	0.060	0.057	-0.270	0.145	13.394	0.111	0.621	0.109
495	0.043	0.306	0.474	0.048	0.095	0.670	0.143	16.458	0.096	0.557	0.058
504	0.074	0.458	3.218	0.105	0.106	0.510	0.263	14.464	0.115	0.075	0.015
506	0.087	0.562	2.943	0.102	0.087	0.850	0.258	15.453	0.122	0.000	0.021
514	0.076	0.504	3.542	0.024	0.098	1.275	0.446	11.599	0.071	0.185	0.009
517	0.056	0.460	3.781	0.139	0.225	1.820	0.437	14.019	0.055	0.069	0.006
531	0.061	0.804	2.935	0.120	0.130	0.840	0.301	16.344	0.148	0.120	0.047
533	0.071	0.379	2.102	0.103	0.122	0.350	0.210	17.372	0.192	0.323	0.034
551	0.085	0.513	5.367	0.194	0.154	1.540	0.360	13.900	0.145	0.058	0.010
565	0.069	0.407	1.400	0.117	0.135	0.310	0.307	14.732	0.163	0.332	0.058
566	0.086	0.651	2.393	0.000	0.180	0.770	0.427	13.182	0.061	0.338	0.010
571	0.073	0.358	1.152	0.093	0.085	0.910	0.222	16.362	0.259	0.000	0.089
581	0.067	0.368	1.301	0.120	0.161	0.350	0.263	14.396	0.220	0.300	0.049
591	0.072	0.529	2.012	0.142	0.108	0.600	0.230	17.666	0.091	0.000	0.020
594	0.070	0.453	1.556	0.125	0.140	-0.900	0.386	13.425	0.115	0.164	0.033
596	0.053	0.343	2.111	0.165	0.097	0.900	0.370	12.957	0.168	0.000	0.029
701	0.061	0.455	0.568	0.145	0.289	0.730	0.341	12.195	0.089	0.000	0.082
735	0.097	0.582	0.737	0.100	0.108	1.210	0.375	14.152	0.121	0.000	0.191
736	0.065	0.517	2.146	0.141	0.193	0.690	0.305	13.584	0.071	0.000	0.023
737	0.067	0.345	0.512	0.108	0.105	0.900	0.262	14.594	0.147	0.000	0.107
738	0.066	0.367	0.570	0.125	0.127	1.020	0.263	15.887	0.107	0.000	0.076
806	0.080	0.579	1.880	0.137	0.109	1.400	0.322	14.815	0.125	0.000	0.018
822	0.085	0.499	0.934	0.110	0.097	1.505	0.323	14.509	0.137	0.115	0.074
871	0.073	0.531	2.055	0.076	0.105	1.800	0.309	13.431	0.124	0.000	0.030
874	0.066	0.532	0.927	0.129	0.128	0.790	0.266	13.571	0.085	0.000	0.042

Source: Datastream; Own work.

Note. * This table includes the median of the explanatory variables used in annual regressions by three digits SIC code for undervalued stocks. A stock is undervalued if the ratio of actual stock price divided by the estimated firm value, is under 0.85 and overvalued if the ratio is higher than 1.15. *EPIN* stands for a mean industry market ratio of forward EPS and market price per share, *BVPIN* is a mean industry market ratio of book value and total market value, *SPIN* is the mean industry market ratio of revenue and total market value, *LTG* is the estimated long-term growth, *G2* is the near-term growth, *BETA* is the beta coefficient of firm stock, *VOL* is a measure of stock's average annual price movement to a high and low from a mean price, *MV* is the natural logarithm of a firm market value, *ROE* is the current return on equity of a firm, *DP* is the dividend payout, and *NM* is the net margin.

Appendix 5: Median of explanatory variables for overvalued stocks by SIC

SIC	EPIN	BVPIN	SPIN	LTG	G2	BETA	VOL	MV	ROE	DP	NM
131	0.067	0.495	0.356	0.159	0.372	1.340	0.333	15.448	0.031	0.017	0.053
138	0.083	0.596	0.556	0.130	0.230	1.240	0.326	15.274	0.075	0.291	0.106
153	0.070	0.704	0.939	0.179	0.409	1.380	0.272	15.260	0.046	0.000	0.069
162	0.077	0.578	1.745	0.143	0.422	1.370	0.340	13.235	0.082	0.000	0.024
203	0.064	0.344	0.898	0.101	0.100	0.120	0.226	14.392	0.138	0.000	0.048
204	0.077	0.508	1.939	0.120	0.109	1.100	0.235	14.463	0.167	0.310	0.122
208	0.062	0.329	0.766	0.130	0.140	0.695	0.321	15.764	0.276	0.000	0.158
232	0.067	0.450	1.166	0.202	0.173	0.100	0.322	14.801	0.137	0.000	0.065
251	0.070	0.574	1.428	0.160	0.289	0.990	0.342	13.413	0.115	0.179	0.047
262	0.107	0.700	1.656	0.119	0.120	1.120	0.326	13.621	0.141	0.195	0.049
281	0.082	0.558	1.016	0.070	0.120	2.340	0.212	14.149	0.105	0.097	0.084
282	0.085	0.458	1.346	0.121	0.160	1.150	0.280	14.570	0.126	0.000	0.071
283	0.078	0.360	0.406	0.170	0.177	0.980	0.296	14.351	0.145	0.000	0.131
284	0.068	0.291	0.676	0.119	0.139	0.640	0.192	16.314	0.233	0.371	0.094
286	0.090	0.321	1.101	0.076	0.095	1.260	0.183	15.453	0.262	0.347	0.108
287	0.084	0.363	0.616	0.111	0.144	0.850	0.238	14.916	0.202	0.502	0.058
291	0.115	0.670	1.815	0.043	0.113	1.230	0.246	17.718	0.162	0.289	0.067
308	0.072	0.331	0.804	0.096	0.125	0.790	0.180	15.075	0.157	0.368	0.081
331	0.079	0.570	1.655	0.150	0.581	1.250	0.297	14.273	0.053	0.598	0.042
344	0.066	0.626	1.133	0.179	0.365	1.870	0.310	14.020	0.047	0.000	0.070
349	0.069	0.451	0.977	0.136	0.187	1.520	0.292	14.177	0.105	0.361	0.047
352	0.073	0.464	1.134	0.092	0.136	0.515	0.240	13.806	0.181	0.321	0.082
353	0.077	0.570	0.871	0.136	0.276	0.940	0.339	13.728	0.112	0.000	0.067
355	0.082	0.604	0.946	0.150	0.256	1.010	0.378	12.791	0.025	0.000	0.019
356	0.063	0.370	0.698	0.140	0.153	1.060	0.252	14.991	0.130	0.201	0.105
357	0.071	0.494	0.854	0.170	0.193	1.250	0.321	13.763	0.073	0.000	0.072
362	0.068	0.342	0.646	0.111	0.104	1.275	0.235	14.899	0.150	0.155	0.086
364	0.050	0.453	0.804	0.190	0.994	1.265	0.360	13.569	0.035	0.074	0.001
366	0.074	0.494	0.642	0.129	0.219	0.760	0.310	14.785	0.094	0.000	0.089
367	0.082	0.477	0.879	0.150	0.174	1.250	0.313	14.726	0.120	0.021	0.133
371	0.083	0.429	1.404	0.140	0.180	1.300	0.281	15.304	0.178	0.323	0.079
372	0.075	0.427	1.043	0.156	0.149	0.580	0.262	14.892	0.167	0.077	0.098
381	0.085	0.489	0.949	0.079	0.174	0.750	0.317	15.386	0.116	0.080	0.129
382	0.071	0.432	0.522	0.131	0.177	1.250	0.286	14.907	0.126	0.000	0.105
384	0.062	0.423	0.516	0.150	0.177	0.940	0.258	14.202	0.106	0.000	0.092
401	0.065	0.396	0.395	0.168	0.218	1.280	0.268	15.366	0.108	0.019	0.146
421	0.063	0.467	1.454	0.148	0.169	1.120	0.229	14.771	0.205	0.254	0.059
441	0.096	0.820	0.558	0.050	0.087	1.135	0.293	13.874	0.090	1.228	0.253
451	0.101	0.649	2.068	0.153	0.211	1.180	0.248	16.021	0.113	0.124	0.046
461	0.049	0.401	1.061	0.121	0.111	1.360	0.216	16.053	0.019	1.713	0.006
473	0.052	0.285	1.388	0.198	0.200	1.325	0.224	14.961	0.142	0.157	0.028
481	0.071	0.554	1.388	0.050	0.140	0.520	0.277	13.819	0.048	0.000	0.039
483	0.086	0.576	0.820	0.137	0.146	1.350	0.390	16.754	0.148	0.232	0.118

(table continues)

(continued)

SIC	EPIN	BVPIN	SPIN	LTG	G2	BETA	VOL	MV	ROE	DP	NM
484	0.066	0.360	0.588	0.178	0.177	1.470	0.257	16.556	0.216	0.000	0.131
491	0.064	0.612	0.739	0.064	0.151	1.150	0.246	15.779	0.062	0.191	0.056
492	0.051	0.480	0.746	0.143	0.161	1.340	0.243	16.133	0.090	1.586	0.079
493	0.067	0.661	0.738	0.054	0.045	0.100	0.155	16.133	0.103	0.622	0.105
494	0.053	0.537	0.410	0.030	0.057	-0.220	0.165	14.153	0.129	0.539	0.131
495	0.061	0.358	0.702	0.160	0.123	0.290	0.238	13.781	0.152	0.000	0.085
504	0.074	0.469	3.218	0.110	0.107	1.055	0.170	15.559	0.152	0.133	0.047
506	0.081	0.562	2.893	0.136	0.144	0.380	0.198	15.853	0.224	0.379	0.070
514	0.076	0.504	3.542	0.155	0.136	1.310	0.258	14.543	0.088	0.000	0.017
517	0.062	0.396	2.811	0.095	0.143	1.420	0.265	14.506	0.077	2.211	0.013
531	0.061	0.804	2.935	0.078	-0.035	0.870	0.458	15.179	0.051	0.100	0.016
533	0.068	0.351	1.835	0.133	0.146	0.915	0.239	15.566	0.165	0.293	0.026
551	0.085	0.494	4.933	0.198	0.115	0.980	0.290	15.246	0.187	0.000	0.021
565	0.077	0.381	1.309	0.150	0.177	0.430	0.340	15.331	0.174	0.000	0.074
566	0.086	0.609	2.106	0.142	0.145	0.855	0.330	14.909	0.144	0.376	0.051
571	0.073	0.358	1.152	0.132	0.136	0.800	0.281	15.569	0.252	0.485	0.066
581	0.067	0.368	1.301	0.193	0.221	0.565	0.304	14.320	0.152	0.000	0.050
591	0.072	0.478	1.957	0.152	0.179	0.420	0.342	13.449	0.171	0.353	0.055
594	0.069	0.414	1.449	0.147	0.141	0.290	0.305	15.665	0.166	0.242	0.075
596	0.053	0.343	2.111	0.200	0.389	0.650	0.410	12.687	0.040	0.000	0.013
701	0.061	0.500	0.613	0.175	0.309	1.070	0.271	15.271	0.093	0.112	0.094
735	0.092	0.588	0.737	0.111	0.144	1.360	0.267	13.652	0.120	0.533	0.083
736	0.065	0.537	1.966	0.150	0.272	1.310	0.330	13.565	0.101	0.354	0.032
737	0.065	0.324	0.482	0.165	0.198	1.010	0.305	14.562	0.117	0.000	0.101
738	0.066	0.367	0.570	0.191	0.228	1.200	0.311	15.133	0.130	0.000	0.119
806	0.080	0.556	1.914	0.131	0.121	0.120	0.337	14.926	0.138	0.000	0.091
822	0.086	0.447	0.952	0.191	0.218	0.820	0.307	13.979	0.257	0.053	0.146
871	0.091	0.714	2.426	0.122	0.189	1.290	0.267	13.379	0.093	0.000	0.025
874	0.066	0.532	0.927	0.175	0.162	1.070	0.276	13.996	0.164	0.000	0.093

Source: Datastream; Own work.

Note. * This table includes the median of the explanatory variables used in annual regressions by three digits SIC code for overvalued stocks. A stock is undervalued if the ratio of actual stock price divided by the estimated firm value, is under 0.85 and overvalued if the ratio is higher than 1.15. *EPIN* stands for a mean industry market ratio of forward EPS and market price per share, *BVPIN* is a mean industry market ratio of book value and total market value, *SPIN* is the mean industry market ratio of revenue and total market value, *LTG* is the estimated long-term growth, *G2* is the near-term growth, *BETA* is the beta coefficient of firm stock, *VOL* is a measure of stock's average annual price movement to a high and low from a mean price, *MV* is the natural logarithm of a firm market value, *ROE* is the current return on equity of a firm, *DP* is the dividend payout, and *NM* is the net margin.

Appendix 6: Definition of variables

Beta	A measure of the sensitivity of a stock's price to the movement of the S&P 500. Calculated as the slope of a straight line fitted to 156 observations of weekly relative price changes.
BV/P	Inverse of the P/BV multiple.
BVPIN	Mean industry market ratio of book value and total market value
Common equity	Common shareholders' investment in a firm (in million USD)
Common shares	The current number of common shares outstanding for an issue (in million shares).
DP	Dividend payout calculated as dividends per share divided by earnings per share.
E/P	Inverse of the P/E multiple.
EPIN	Mean industry market ratio of forward EPS and market price per share.
G2	Near-term earnings growth rate calculated by dividing the difference between earnings per share for two year out period and earnings per share for one year out period divided by earnings per share for one year period.
LTG	Estimated growth rate for the next 5-year period.
Market value	Market capitalization (in million USD) calculated as price per share multiplied by the number of common shares outstanding.
NM	Net margin calculated as net income less preferred dividends divided by sales.
MV	Natural logarithm of the market value of a firm that serves as an indicator of firm size.
P/BV	Price-to-book-value multiple calculated as market value of a firm divided by the common equity.
P/E	Price-earnings multiple calculated as the current market price per share divided by estimated earnings per share for two year out period.
P/S	Price-sales multiple calculated as market value of a firm divided by sales.
Price	The last price an issue is traded at for that day (in USD).
ROE	Current return on equity calculated as net income divided by common equity.
Sales	The gross sales and other operating revenue less discounts, returns and allowances (in million USD).
S/P	Inverse of the P/S multiple.
SPIN	Mean industry market ratio of revenue and total market value sales to total market value.

VOL	A measure of stock's average annual price movement to a high and low from a mean price.
WACC	Weighted average cost of capital calculated as the sum of the after-tax cost of debt and the cost of equity with weights being the target levels of debt-to-enterprise-value and equity-to-enterprise-value.