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Ville Karell

ESSAYS ON STOCK MARKET ANOMALIES

LUT University

Ville Karell

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The objective of this doctoral thesis is to examine the efficacy of anomaly-based equity trading strategies in the Finnish and the U.S stock markets. The main focus in the papers included in this thesis is on different manifestations of value anomalies, but the momentum, size, profitability, and investment anomalies are also examined. In addition, the value indicators are combined with each other, as well as with a momentum indicator, by employing multicriteria decision-making (MCDM) methods.

The thesis consists of four publications, each of them having a distinct focus and contribution. Publication I introduces a new methodology for value portfolio selection employing Finnish data. The results show that adjusting conventional valuation ratios for firm size, industry classification, and financial leverage, and combining them as composite selection criteria can add value to equity investors. The remaining three publications employ U.S. data. Publication II compares the discriminatory power of a larger number of individual valuation ratios than any earlier study. Publication III serves as a sequel to Publication II by examining the combination strategies with four different MCDM methods. Finally, Publication IV shows new evidence on anomaly interactions and the cross-section of stock returns by employing 5x5 conditional double sorts and Fama and MacBeth (1973) style regressions.

The findings of this thesis are useful for both academics and portfolio practitioners who are interested in enhancing performance of their equity portfolios in terms of raw returns and/or risk-adjusted returns. The overall results give interesting insights to trading opportunities in two different national stock markets and provide many useful implications for both unidimensional, as well as for multidimensional portfolio management.

Keywords: Stock market, anomaly, investment strategies, valuation ratios, momentum, asset growth, profitability, equity investing, multicriteria decision-making methods

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Ville Karell

November 2018

Helsinki, Finland

To my son

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PART B: PUBLICATIONS

PART A: OVERVIEW OF THE DISSERTATION

List of publications

This thesis includes the following publications:

I. Pätäri, E. J., Karell, V., and Luukka, P. (2016). Can size-, industry-, and leverage-adjustment of valuation ratios benefit the value investor? *International Journal of Business Innovation and Research*, 11, pp. 76-109.
II. Pätäri, E. J., Karell, V., Luukka, P., and Yeomans, J. S. (2018). The dirty dozen of valuation ratios: Is one better than another? *Journal of Investment Management*, 16, pp. 1-34.
III. Pätäri, E. J., Karell, V., Luukka, P., and Yeomans, J. S. (2018). Comparison of the multicriteria decision-making methods for equity portfolio selection: The U.S. evidence. *European Journal of Operational Research*, 265, pp. 655-672.
IV. Karell, V., and Yeomans, J. S. (2018). Anomaly interactions and the cross-section of stock returns. *Fuzzy Economic Review*, 23, pp. 33-61.

The contribution of Ville Karell to the publications:

The second author in Publications I–III (estimated proportion of total workload of 45 % in Publications I and II, and 50 % in Publication III). The author was responsible for gathering, processing, and managing the research data. The author executed most of the data analysis and participated in the writing process. The author presented the manuscript of the paper in the seminar, based on which the manuscript was heavily revised resulting in two separate publications (II and III). Publication IV is executed and written solely by the author (based on raw data provided by the second author). The author presented the manuscript of the paper in the seminar.

1 Introduction

1.1 Background

The famous review article by Fama (1970) recapitulated the work on the efficiency of capital markets. At the time, financial economists widely believed that the capital markets were efficient, at least according to the semi-strong form in which security prices fully reflect all publicly available information. That is, investors could not "beat the market" by analyzing any public information available to them, such as companies' financial statements (i.e., fundamental analysis), not to speak of studying historical price data (i.e., technical analysis), which would confront even the weak form of the efficient market hypothesis (EMH).

The EMH paradigm has been challenged many times since the 1970s. An early attempt was Basu (1977) who interpreted the abnormal returns generated by low price-to-earnings (P/E) stocks as evidence of market inefficiency. More generally, the value anomalies, which typically refers to the tendency of stocks with high fundamentals-to-price ratio outperform stocks with low fundamentals-to-price ratio, can be considered to contradict the semi-strong form of the EMH. Moreover, there are well-documented return patterns that seem to challenge even the weak form of the EMH. For example, the momentum anomaly states that stocks with low returns over the last three to twelve months tend to have low returns for the next few months, while past winner stocks continue to perform well in the near future (see, e.g. Jegadeesh and Titman 1993, 2001).

However, market efficiency cannot be tested without a model of equilibrium, or in other words, an asset-pricing model in which the asset prices are such that the aggregate demand equals the aggregate supply of each asset. Since market efficiency and an equilibrium-pricing model are inseparable, the test for the EMH is actually a joint test of them both. Anomalous return patterns indicate that markets are inefficient or an equilibrium-pricing model fails in describing the true relation of risk and return.

The Capital Asset Pricing Model (CAPM) developed independently by Sharpe (1964), Lintner (1965), and Mossin (1966) has served as a benchmark equilibrium-pricing model for decades. However, early studies showed that much of the variation in expected returns is unrelated to the predictions of the CAPM market beta (see, e.g., Basu 1977; Stattman 1980; Banz 1981; Rosenberg, Reid, and Lanstein 1985; Bhandari 1988). In fact, Lintner

(1965) already found that the security market line was too flat in comparison with the predictions. The empirical failure of the CAPM induced Fama and French (1993) to introduce the three-factor asset pricing model (with a market factor, a size factor, and a value factor) which better explains the cross-section of average returns. Since then, a spectrum of other multi-factor models has been proposed, many of which extends the Fama-French three-factor model by adding a new factor, for example a momentum factor (Carhart 1997) or a liquidity factor (Pastor and Stambaugh 2003). More recently, Fama and French (2015) augmented their three-factor model with profitability and investment factors, while Hou, Xue, and Zhang (2015) introduced a closely related *q*-factor model consisting of market, size, investment, and profitability factors. Despite the development of asset pricing models, the line of demarcation between market inefficiency and an inadequate equilibrium-pricing model remains ambiguous because the joint-hypothesis problem in testing the EMH has not vanished.

There are basically two major views for anomalous return patterns to exist: one is rational pricing (risk-based view) and the other is irrational pricing (behavioral view). Proponents of the rational pricing believe that investors are rational according to classical finance theory, and that the observed return patterns reflect a compensation for systematic risk (see, e.g., Fama and French 1996). Instead, behaviorists believe that investors have cognitive biases, which cause deviations from a rational decision-making process. For example, investors incorrectly extrapolate past firm performance, which leads to irrational pricing of stocks (see, e.g., Lakonishok, Shleifer, and Vishny 1994). A third and probably the most criticized group says that the anomalous return pattern is a result of survivorship bias (see, e.g., Kothari, Shanken, and Sloan 1995) or data snooping (see, e.g., Lo and MacKinlay 1988; Black 1993; MacKinlay 1995; Conrad, Cooper, and Kaul 2003).

1.2 Objectives and Contribution

The objective of this doctoral thesis is to examine the efficacy of anomaly-based equity trading strategies in the Finnish and the U.S stock markets. Many branches of anomaly literature are covered, but the value anomalies are at the core of this dissertation. Both traditional and less frequently-used valuation ratios are applied to equity portfolio investing.[1]

[1] By definition, value stocks have high fundamentals-to-price ratios and/or high fundamentals-to-enterprise value ratios, whereas the corresponding ratios for the growth stocks are low. In this dissertation, *book*-to-*price* (B/P), four variants of *cash flow*-to-*price* (CF1/P, CF2/P, CF3/P, and CFO/P), *dividend*-to-*price*

The other anomaly dimensions covered besides value are momentum, size, profitability, and investment. In addition, the value indicators are combined with each other, as well as with the momentum indicator, by employing multicriteria decision-making (MCDM) methods.[2] Since this approach merges anomaly variables into single efficiency scores, unidimensional and multidimensional portfolios contain an equal number of stocks, which makes the inference of potential combination benefits more reliable and transparent. In sum, this dissertation empirically compares the discriminatory power of different stock market anomalies from a practical portfolio management perspective. The main objective is not to argue about market efficiency, but rather to show that there are anomalies in the stock market, and further, to examine to what extent an equity investor can benefit from applying different methodologies introduced in this dissertation.

The dissertation consists of four publications, and each of them has a clear focus and contribution. Publication I introduces a new methodology for value portfolio selection employing the Finnish data. The results show that adjusting conventional valuation ratios for firm size, industry classification, and financial leverage, and combining them as single selection criteria can add value to an equity investor. The introduced methodology offers an interesting alternative for identifying undervalued stocks by capturing both several dimensions of relative value and several peer-group comparisons at the same time. The use of multidimensional selection criteria seems to offer better downside protection against stock market declines than one-dimensional valuation criteria or traditional valuation ratios.

The remaining three publications employ U.S. data. Publication II tests and compares the discriminatory power of a larger number of individual valuation ratios than any earlier study. In addition to eight price-based valuation ratios, the analysis includes four multiples based on enterprise value (EV). Interestingly, three EV multiples (EBIT/EV, EBITDA/EV, and S/EV) seem to be particularly useful for value portfolio selection. The essay also combines the 12 valuation criteria into combination criteria using median-scaled (MS) composite measures analogous to Dhatt, Kim, and Mukherji (2004).

Publication III serves as a sequel to Publication II. This paper examines the combination strategies further including four different MCDM methods: median-scaling (MS), the

(D/P), *earnings*-to-*price* (E/P), *sales*-to-*price* (S/P), *earnings before interest and taxes*-to-*enterprise value* (EBIT/EV), *earnings before interest, taxes, depreciation, and amortization*-to-*enterprise value* (EBITDA/EV), *free cash flow*-to-*enterprise value* (FCF/EV), and *sales*-to-*enterprise value* (S/EV) are used as valuation ratios.

[2] The MCDM methods used in this dissertation are median-scaling (MS), the Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS), the Analytic Hierarchy Process (AHP), and the additive Data Envelopment Analysis (additive DEA).

Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS), the Analytic Hierarchy Process (AHP), and the additive Data Envelopment Analysis (additive DEA). The 12 valuation ratios examined in the preceding publication are supplemented with a price momentum indicator. The results show that the MCDM methods can successfully be applied to equity portfolio selection, since the benefits of combining increase with the number of variables included in the combination strategies in most of the cases and at the aggregate level. Moreover, an equity investor following a certain investing style could take advantage of the different style exposures of stock portfolios provided by the MCDM methods.

Publication IV shows new evidence on anomaly interactions and the cross-section of stock returns. The purpose is to examine five distinct anomalies (i.e., size, value, profitability, investment/asset growth, and momentum) that are well documented, yet lacking of unified frame to evaluate, which of them is the most influential after controlling for the others. In general, investment/asset growth and momentum dimensions capture the cross-sectional return patterns better than size, value, or profitability. The conclusion is similar based on 5x5 conditional double sorts and Fama and MacBeth (1973) style regressions. In addition, the results shed light on the current literature on the anomaly interactions, especially explaining the relative weakness of the return-on-assets anomaly.

2 Related Literature on Stock Market Anomalies

The literature on stock market anomalies is extensive. But what is a stock market anomaly? What is exactly meant by “beating the market”? In this thesis, it refers to an equity investing strategy that consistently earns abnormal returns on a risk-adjusted basis. The question concerning proper risk-adjustment is under discussion in the literature. This section reviews the value, momentum, size, profitability, and investment anomalies and omits all the other anomalies because they are not directly related to the scope of this thesis.

Harvey, Liu, and Zhu (2016) catalogue 316 different factors explaining the cross-section of expected returns since the first empirical tests in 1967. They present a taxonomy of the factors starting with two broad categories. The first category, common factors, can be viewed as a proxy for a common source of risk at the aggregate level, for example inflation. The aim of this dissertation, however, is to examine firm-level characteristics of stocks, and therefore, common factors are not discussed in this thesis. In the second broad category, individual firm characteristics, it is assumed that the factor is specific to a security or portfolio, and hence, the factor reflects an idiosyncratic characteristic. According to Harvey et al. (2016), individual firm characteristics are divided into five subcategories including proxies for firm-level characteristics in 1) financial risks (e.g., volatility and extreme returns), 2) financial market frictions (e.g., short sale restrictions and transaction costs), 3) behavioral biases (e.g., analyst dispersion and media coverage), 4) accounting variables (e.g., E/P ratio and debt-to-equity ratio), and 5) other (e.g., political campaign contributions).

Although the above-presented subcategories are partially overlapping due to the interactions of the factors, the most central one of them from the viewpoint of this thesis is accounting variables, from which value anomalies are traced. The profitability and investment/asset growth anomalies would also fall into the same subcategory as these variables are based on accounting items reflecting business operations. According to Harvey et al. (2016), the momentum anomaly would most likely belong to the “other” subcategory, although behavioral explanations are also represented in the literature (see, e.g., Jegadeesh and Titman 2001). The reasons behind the small-cap effect are ambiguous, and placing the size anomaly into any individual subcategory would not do it justice. For example, the size anomaly would fall into “financial market frictions” subcategory according to limits of arbitrage. Next, I will review the literature on anomalies that are related to the topics of the articles included in Part B of this thesis. I will first introduce the value anomalies and then the rest of the related anomalies in chronological order determined on the basis of the publication date of each anomaly.

2.1 Value anomalies

The value anomaly is well documented in the empirical literature. The phenomenon refers to the tendency of stocks with high fundamentals-to-price ratio to outperform stocks with low fundamentals-to-price ratio, on average. Alternatively, firm fundamentals can be proportioned to the enterprise value (EV). In the following review, the origin and the current state-of-art of each manifestation of value anomaly are introduced.

2.1.1 Earnings-to-Price (E/P) anomaly

Although the use of earnings yield as a basis for value investing strategy can be traced back to the 1930s (see, e.g., Graham and Dodd 1934), the first scientific evidence of the E/P anomaly was reported by Nicholson (1960). However, Nicholson did not report any risk or risk-adjusted performance statistics for the portfolios that consisted of the U.S. common stocks of industrial companies (During the 1960s, similar type of raw return - based studies were also published by some other authors, such as McWilliams, 1966, and Breen, 1968, for example). To the best of my knowledge, Basu (1977) was the first to document that the high E/P firms earn higher risk-adjusted returns than the low E/P firms, on average. His results were challenged by Banz (1981) and Reinganum (1981), who both argued that the E/P anomaly is actually another manifestation of the size anomaly, and in addition, that the E/P anomaly is subsumed by the size anomaly. However, in his further study, Basu (1983) proved that the E/P anomaly remained after controlling for size differences of sample firms, but that the size effect was virtually non-existent after controlling for risk and E/P ratios. By contrast, Cook and Rozeff (1984) reported approximately equal E/P and size effects. Consistently with these two authors, Jaffe, Keim, and Westerfield (1989) also found significant E/P and size effects, but with the difference that the former was significant in all months, whereas the latter seemed to be significant only in January, and hence, related to a calendar anomaly, according to which the average monthly stock return in January is outstandingly higher than it is in other months.

Earnings yield (E/P) has been among the two most frequently examined individual valuation ratios in the literature on value investing (see, e.g., Pätäri and Leivo 2017 for a comprehensive literature review on value anomalies). However, its relative efficacy as portfolio-formation criteria varies a lot across the studies, as well across the sample periods: For example, within the U.S. markets, Davis (1994) reported the highest value quintile return and the highest value premium for the E/P criterion for the 1940–1963 period, when comparing the equal-weight quintile portfolios formed on beta, B/P, market value, E/P, CF/P, sales growth and stock price. In a comparison of B/P, CF/P and E/P-based equally-weight decile portfolios over the period 1968–1990, Lakonishok et al. (1994) found that the CF/P criterion resulted in both the highest value portfolio return and the highest value premium for the period. Desai, Rajgopal, and Venkatachalam (2004) also reported the highest value decile return for the same criterion, but found that the highest value premium was generated by the B/P criterion in their comparison of the efficacy of four individual valuation ratios (i.e., B/P, CF/P, E/P, and *operating cash flow*-to-*price* (CFO/P)) for the 1973–1997 period. According to their results, the value premium generated by the E/P criterion was the lowest, whereas Li, Brooks, and Miffre (2009) documented the highest decile return and the highest value premium for the E/P criterion over the period 1963–2006 in an efficacy comparison of B/P, CF/P, and E/P. By contrast, according to Loughran and Wellman (2011), the E/P criterion was the second worst in the corresponding comparison of B/P, D/P, E/P, and *earnings before interest, taxes, depreciation and amortization*-to-*enterprise value* (EBITDA/EV), and market leverage (defined as total assets-to-market value of equity) in the 1963–2009 sample period. Moreover, Israel and Moskowitz (2013) reported the second highest value premium for the E/P criterion, whereas in terms of value premium, E/P was the second worst (The other portfolio-formation criteria included in their study were B/P, CF/P, D/P, and past 5-year return).

Based on the results of Publication II of Part B in this thesis, E/P was, in comparison with 11 other value measures in terms of raw and risk-adjusted returns over the period from 1971–2013, among the worst portfolio-formation criterion for implementing value investing strategies (Pätäri, Karell, Luukka, and Yeomans 2018b). Overall empirical findings on the relative efficacy of E/P for portfolio-formation are mixed for the U.S. markets for many reasons: For example, the different treatment practices of firms with negative earnings is one potential explanation, as in the majority of the related studies, such firms have been excluded from the sample firms when using E/P as a portfolio-formation criterion, but included when using some other criterion (most often in the case of the B/P criterion, as in Dhatt, Kim, and Mukherji, 1999, and Israel and Moskowitz, 2013, for example). However, such an inconsistent exclusion policy can create a sample selection bias since negative earnings’ firms include many potential turnaround cases that could be among the best-performing stocks in the future. For example, when following such an exclusion policy, a higher value premium or better value quantile portfolio performance based on B/P ratios than based on E/P ratios could be explained by the fact that high (low) B/P firms with negative earnings have, on average, performed well (badly) enough to make the performance of the highest-B/P portfolio to look superior to that of the highest-E/P portfolio.[3] In addition, the relative efficacy of valuation ratios is also dependent on the sample period employed. For example, Leshem, Goldberg, and Cummings (2016) reported that better relative efficacy of B/P in comparison with E/P has existed during the period 1963–1990, but during the subsequent period from 1991 to 2013, E/P would have been a better value portfolio criterion than B/P. Also for the longer sample period from 1951 to 2013, E/P has dominated B/P in the same purpose in terms of both absolute and risk-adjusted returns.[4] A meta-analysis provided by Pätäri and Leivo (2017) includes 14 such U.S. studies that have compared the efficacy of B/P and E/P. In terms of value portfolio returns, both of these two valuation ratios have outperformed each other in seven out of 14 cases.

The same meta-analysis also introduces 19 such papers employing non-US sample data, which have compared at least three alternative portfolio-formation criteria to each other in terms of either value premiums or value portfolio returns, and also included E/P as one of those criteria (for details, see Pätäri and Leivo, 2017). Based on international evidence outside the U.S. stock markets, the relative efficacy of E/P has been somewhat weaker than in the U.S. markets, as in only three out of 18 of them,[5] the greatest value premium has been generated by E/P, whereas the highest value portfolio return has been based on E/P in only 1 out 17 comparable studies.[6] By contrast, the use of E/P has resulted in the lowest value premium in 6 out of 18 comparable cases[7] and in the lowest value portfolio

[3] Penman and Reggiani (2013) reported high average book-to-price (B/P 0.98) for the lowest-E/P decile portfolio, which, on average, consisted of negative earnings stocks over the 1963–2006 sample period.

[4] Similar evidence for the period 1951-2014 has also been provided by Asness, Frazzini, Israel, and Moskowitz (2015).

[5] In Doeswijk (1997) for the Dutch data, in van der Hart, Slagter, and van Dijk (2003) for the pooled emerging markets data, and in Hou et al. (2011) for the global data. In addition, Fama and French (1998) reported the highest value premiums based on E/P in 2 of 13 developed national stock markets (in Netherlands and Sweden).

[6] In van der Hart et al. (2003). The difference in the number of comparable studies stems from the fact that Dissanaike and Lim (2010) and Hou et al. (2011) report only the value premiums, but not the returns of value portfolios, whereas the reverse holds in Suzuki (1998).

[7] In Chan, Hamao, and Lakonishok (1991) and Cai (1997) for Japanese data, Mukherji et al. (1997) for Korean data, Yen et al. (2004) for Singaporean data, Bird and Casavecchia (2007) for pan-European data, and in Gharghori, Stryjkowski, and Veeraraghavan (2013) for Australian data. In addition, Fama and French (1998) reported the lowest value premium on E/P in 3 of 13 developed national stock markets (in U.K., Belgium and Switzerland).

return in 6 out of 17 corresponding cases[8]. The Finnish evidence on relative efficacy of E/P is rather consistent in that E/P has neither been the best nor the worst single selection criterion in the related studies (see, e.g., Leivo and Pätäri 2011; Davydov, Tikkanen, and Äijö 2016). The results obtained in Publication I of Part B in this thesis are also in line with the existing Finnish evidence, but contribute to the existing literature by showing that the discriminatory power of E/P criterion can be somewhat improved by adjusting E/Ps by firm size, financial leverage, or industry classification (Pätäri, Karell, and Luukka 2016).

2.1.2 Book-to-Price (B/P) anomaly

The B/P ratio is the most frequently examined valuation ratio in the existing anomaly literature, and it has established its position as a proxy for value in many asset pricing models. The book value of equity provides a relatively stable and intuitive measure of a company's value. It is sometimes considered as a "floor" below which the market price will not fall. Although this is not always the case as book values are not necessarily reliable indicators of the assets' fair value or liquidation value, a high B/P ratio can be seen to provide a some kind of "margin of safety". (Bodie, Kane, and Marcus 2014, 652) The cornerstone study of Fama and French (1992) has had a huge influence on related literature. The authors found that the B/P ratio has the best explanatory power on expected returns in the U.S. markets over the 1963–1990 period. They further demonstrated that together with market value of equity (i.e., firm size), these two variables captured the cross-sectional explanatory power of the E/P ratio. Moreover, this dramatic dependence of returns on the B/P ratio was independent of beta, thereby indicating either that high B/P firms are relatively underpriced, or that the B/P ratio is serving as a proxy for a risk factor that affects equilibrium expected returns. After controlling for the size and B/P effects, Fama and French (1992) found that beta has no explanatory power on average security returns indicating that systematic risk seems not to matter, while the B/P ratio seems to be capable of predicting future returns.

However, Fama and French (1992) were not the first to discover the B/P anomaly. To the best of my knowledge, Stattman (1980) was the first to report a significant B/P effect in the U.S. stock market, although his results are both survivorship- and look-ahead -biased due to the employed sample-selection criteria. A few years later, Rosenberg et al. (1985)

[8] In the same five first-mentioned studies as in footnote 7, added with Suzuki (1998) for Japanese data.

found that over the sample period from 1973 to 1984, the strategy of picking high-B/P stocks would have yielded an excess return of 0.36% per month. Before the publication of the seminal paper of Fama and French, evidence of the B/P anomaly was also documented from the Japanese stocks markets by Chan, Hamao, and Lakonishok (1991), who compared four portfolio formation criteria (i.e., the CF/P, E/P, B/P, and size criteria) during the 1971–1988 period and concluded that the B/P ratio generated both the highest value premium and the highest raw return, as well as the best risk-adjusted quartile-portfolio performance.

In line with the seminal paper of Fama and French (1992), Capaul, Rowley, and Sharpe (1993) also documented the inverse relationship of return and beta in most of the major stock markets when comparing the value premia and their betas in the six developed national markets. They further showed that the B/P anomaly was a global phenomenon, being even stronger outside the USA. A recent meta-analysis of Pätäri and Leivo (2017) reinforces that this conclusion is also true at more general level. Their literature survey covers 12 U.S. and 19 non-US studies in which at least three alternative portfolio formation criteria based on single valuation ratios, including B/P, have been compared to each other. For the aggregate U.S. sample data, in four out of the 12 such studies, the greatest value premium has been generated by B/P, whereas the value portfolio return has been the highest in three comparable cases[9]. For the aggregate non-US sample data, the corresponding proportions are ten out of 18[10] and ten out of 17[11], respectively. At the other end, in two out of 11 U.S. studies[12], the lowest value premium has been generated by B/P rankings that also have resulted in the lowest value portfolio return in four of 11 cases[13]. For the non-US aggregate sample data, in five out of 18 studies[14], the lowest value premium has been reported for the B/P criterion, while the lowest value portfolio return

[9] Fama and French (1998), Desai et al. (2004), Loughran and Wellman (2011), and Hou et al. (2015) reported the highest value premium based on B/P ratios, whereas the highest value portfolio return based on the same criterion has been documented in Fama and French (1998), Loughran and Wellman (2011), and Israel and Moskowitz (2013).

[10] In Chan et al. (1991) and Cai (1997) for Japanese data, Miles and Timmermann (1996) and Gregory et al. (2001) for U.K. data, Mukherji et al. (1997) for Korean data, Bauman, Conover, and Miller (1998) for EAFE and Canadian data, Bird and Whitaker (2003) for pan-European data from developed markets, Yen et al. (2004) for Singaporean data, Leivo, Pätäri, and Kilpiä (2009) for Finnish data, and in Gharghori et al. (2013) for Australian data.

[11] In the same studies that are listed in the previous footnote, except in Mukherji et al. (1997), and added with Suzuki (1998) for Japanese evidence.

[12] In Davis (1994) and in Dhatt et al. (2004).

[13] In Davis (1994), Dhatt et al. (1999), Desai et al. (2004), and in Gray and Vogel (2012).

[14] In Doeswijk (1997) for Dutch data, Kyriazis and Diacogiannis (2007) for Greek data, Dissanaike and Lim (2010) for U.K. data, Hou et al. (2011) for global data, and in Leivo and Pätäri (2011) for Finnish data.

has been generated by the same criterion in only two out of 17 cases[15]. Based on these rough statistics, Pätäri and Leivo (2017) conclude that the relative efficacy of B/P criterion has been somewhat stronger in the studies based on the non-US sample data than documented in the U.S. stock markets. However, the authors note that the differences in sample-selection practices followed in the studies weaken the cross-study comparability of the results, as quantile-division principles do vary across the studies. For example, in many studies, negative earnings' stocks have been excluded from the E/P-based division while they have been included in the B/P-based division unless their book values have also been negative (see, e.g., Fama and French 1992; Dhatt et al. 1999; Israel and Moskowitz 2013).

In the Finnish stock market, overall evidence of the B/P anomaly is relatively weak, although Leivo, Pätäri, and Kilpiä (2009) documented somewhat significant B/P effect based on the performance of quintile portfolios reformed at 3-year frequency for the period 1991–2006. By contrast, Leivo and Pätäri (2009, 2011) found no evidence of B/P anomaly for either tertile or quintile portfolios reformed at 1-year frequency for the period 1993–2008. The same conclusion was also drawn by Leivo (2012) for the period 1993–2009. Leivo and Pätäri (2009) showed further that the main findings of B/P effect in Finland were neither dependent on the portfolio formation frequency within range from one year up to five years. For most of the holding period lengths, the best performance were documented for the middle-tertile B/P portfolios and the performance difference between value and glamour B/P portfolios were not significant for any of the reformation frequencies. More recently, Davydov et al. (2016) compared four single value-portfolio-selection criteria in the same stock market over the 23-year period from July 1996 to June 2013 and found the performance of the B/P value portfolio worst among the comparable top-30% portfolios with the lowest return and the highest volatility. The results of Publication I of Part B in this thesis over the period from May 1996 to June 2013 are also mostly in line with the existing Finnish evidence of the B/P anomaly, but show further that using size-, leverage- or industry-adjustment in B/P value portfolio selection would not have significantly improved the efficacy of the B/P criterion, unlike in the case of the E/P criterion, in which the added-value of adjustments was documented (Pätäri et al. 2016).

[15] In Bird and Casavecchia (2007) for pan-European data from developed markets, and in Kyriazis and Diacogiannis (2007).

2.1.3 Dividend yield (D/P) anomaly

The prediction power of dividend yield (D/P) on stock returns has both theoretical and empirical foundations, and at least three competing hypotheses have been suggested. First, the tax-effect hypothesis by Brennan (1970) states that investors receive higher before-tax, risk-adjusted returns on stocks with higher anticipated dividend yields to compensate for the historically higher taxation of dividend income relative to capital gain income. Second, the dividend-neutrality hypothesis by Black and Scholes (1974) states that if investors required higher (lower) returns for holding higher dividend-yield stocks, value-maximizing firms would adjust their dividend policy to restrict (increase) the quantity of dividends paid, lower their cost of capital, and thus increase their stock price. In an equilibrium, value-maximizing behavior would result in an aggregate supply of dividends that meets the aggregate demand for dividend income from investors that prefer dividends at least as much as capital gains. As a consequence, the relation between anticipated D/P ratios and risk-adjusted returns would be unpredictable. Third, the signaling hypothesis states that dividend yields and their changes reflect the managements' beliefs about the future prospects of the firm, and hence, higher propensity to pay dividends can be interpreted to signal the managements' trust in the ability to pay dividends also in the future (see, e.g., Dielman and Oppenheimer 1984; Denis, Denis, and Sarin 1994; Sant and Cowan 1994). Dividends may also reduce agency problems between managers and shareholders by lowering the possibility of managers' empire-building tendency caused by free cash flow problem (see, e.g., Jensen and Meckling 1976, Easterbrouck 1984; Jensen 1986).

The results of the prediction power of D/P on stock returns have been mixed since the earliest related studies: A major seminal US study of Black and Scholes (1974) did not find evidence that higher dividend yields would have generated higher returns, but their study has later been criticized on statistical grounds. For example, Litzenberger and Ramaswamy (1979) strongly challenged the results of Black and Scholes and criticized their methods, suggesting that there was a strong positive relationship between dividend yield and expected returns for NYSE stocks. The same conclusion was also drawn by Elton, Gruber, and Rentzler (1983), who demonstrated that dividend yield had a large and statistically significant impact on return above and beyond that explained by the zero-beta form of the CAPM (introduced by Black, Jensen, and Scholes 1972). Moreover, Litzenberger and Ramaswamy (1982) documented a positive but non-linear relation between U.S. stock returns and dividend yields for a 40-year sample period from 1940 to 1980. Rozeff (1984) and Fama and French (1988) also reported the feasibility of dividend yields in predicting stock returns, whereas according to Blume (1980) and Keim (1985), the relation between risk-adjusted returns and D/P was U-shaped with respect that low-yield stocks were outperformed by zero- and high-dividend stocks. A few years later, Christie (1990) showed that the abnormally high returns of zero-dividend stocks were largely caused by the overperformance of stocks with a price of less than $2 during the 1930s. By comparing the returns of zero-dividend stocks during the period 1945–1986 with those of dividend-paying stocks with equal market capitalization, he found the size-adjusted returns of zero-dividend stocks significantly lower than those of dividend-paying stocks. Though his evidence indicated a positive relationship between dividend yields and returns, Christie stated that the magnitude of the effect was too large to have been explained by a tax effect and might have been better explained by the market overestimating the prospects of zero-dividend stocks. Naranjo, Nimalendran, and Ryngaert (1998) found that both absolute and risk-adjusted returns for NYSE stocks were positively related to dividend yield during the period 1963–1994. Consistently with Blume (1980) and Keim (1985), Naranjo et al. reported higher absolute returns for zero-dividend stocks than for low-dividend stocks, but in terms of the Fama-French 3-factor alphas, zero-dividend stocks performed worse than any portfolio of dividend-paying stocks. The authors showed further that their findings could not be explained by tax effects.

Although the literature on return-relation of D/P is abundant, such studies, in which at least three single valuation ratios, including D/P, have been compared to each other based on U.S. sample data, are rather rare. By updating the meta-analysis of Pätäri and Leivo (2017) with recent related evidence, in all seven such studies, the value premium has been the lowest based on D/P.[16] The same also holds for the comparisons of value portfolio returns in all those four studies, where such returns have been reported.[17] Interestingly, Publication II of Part B in this thesis reveals that the relative efficacy of D/P in the U.S. stock markets is not necessarily as weak as indicated by cross-ratio comparisons of raw returns or value premiums, as in total-risk adjusted comparisons, the D/P value portfolio has generated the highest Sharpe ratio among all the 120 decile portfolio formed on 12 different valuation ratios (Pätäri et al. 2018b). The dramatic difference between the rankings based on raw and risk-adjusted returns stems from the fact that the highest-D/P portfolio is outstandingly less risky than any other decile portfolio among the examined 120 decile portfolios. With respect to low-volatility characteristic of the highest-D/P portfolio, our results are generally consistent with Naranjo et al. (1998) and Fong and Ong (2016), who also reported the lowest volatility for the highest-D/P portfolios.

[16] In Fama and French (1998), Loughran and Wellman (2011), Israel and Moskowitz (2013), Asness et al. (2015), Hou et al. (2015, 2017a), and Pätäri et al. (2018b).
[17] In Fama and French (1998), Loughran and Wellman (2011), Israel and Moskowitz (2013), and Pätäri et al. (2018b).

International evidence on the relative efficacy of D/P criterion is more mixed than the U.S. evidence: In 13 major developed national stock markets, Fama and French (1998) compared the value premiums and value portfolio returns based on country-specific portfolios formed on four different portfolio-formation criteria (i.e., B/P, CF/P, E/P, and D/P). The authors found that the D/P criterion resulted in the greatest value premium in only one out of 12 non-US national stock markets during the period 1975–1995 (i.e., in France), whereas the value portfolio return based on D/P was not the highest in any of the same 12 markets. Based on the same criterion, the value premium was statistically significant in two of these markets (i.e., in Japan and France), whereas it was even negative in three countries (i.e., in Germany, Italy, and Singapore). By contrast, a comparison of the same four valuation ratios over the period 1985–1996 by Bauman et al. (1998) documented the greatest value premium based on the D/P ratio for a large pooled sample of international firms, whose fiscal-year-end was in March. However, the Sharpe ratios of value quartile portfolios formed on the basis of the CF/P and B/P ratios were slightly higher than that of the D/P value portfolio for this subsample, whereas for the subsample of the stocks with December fiscal-year-end, the highest Sharpe ratio was shared with the E/P and D/P value quartile portfolios. Based on these results, the relative efficacy valuation ratios also seems to have depended on the time of the fiscal year-ends of sample firms, although the dependence may also be at least partially explained by "country-biased" fiscal year-end subsamples.[18] Nevertheless, overall international evidence on the relative efficacy comparison of valuation ratios is slightly more favorable to D/P than the corresponding U.S. evidence.[19] In two out of nine such studies included in the meta-analysis of Pätäri and Leivo (2017), in which at least three single valuation ratios, including D/P, have been compared to each other, the highest value premium has been generated by D/P, [20] while the highest value portfolio return has been documented for the same criterion in three studies.[21] However, as noted by Pätäri and Leivo (2017), all the evidence for the superiority of D/P is from the small European national stock markets. According to the same literature review, the lowest value premium, as well as

[18] For example, the most common fiscal year-end for the Japanese firms is in the end of the calendar year, whereas for the Australian firms, it is in the end of the third quarter, while for the majority US firms, the fiscal year equals the calendar year.

[19] As noted by Pätäri and Leivo (2017), taxation differences between dividend incomes and capital gains must also be taken into account in the cross-market comparisons of the relative efficacy of the D/P criterion. Historically, U.S. tax law has treated capital gains more favorably than dividends, and therefore, taxable investors may have demanded a higher pre-tax return on higher-D/P stocks to compensate for the increased tax liability. By contrast, in some other countries, such as UK, for example, the tax rates have been lower for dividend incomes than for capital gains.

[20] In Kyriazis and Diacogiannis (2007) for Greek data, and in Leivo and Pätäri (2011) for Finnish data. In addition, Fama and French (1998) documented the greatest value premium based on the D/P criterion in the French stock markets.

[21] In Doeswijk (1997) for Dutch data, Kyriazis and Diacogiannis (2007), and in Leivo and Pätäri (2011).

the lowest value portfolio return based on D/P have been documented in three out of nine related non-US studies.[22]

It is also worth noting in comparisons of D/P and other value anomalies that many different methodologies have been employed in the calculation of dividend yields (see, e.g., Christie 1990; Fama and French 1993; Naranjo et al. 1998). Moreover, as noted by Hou, Karolyi, and Koh (2011), the calculation practices of dividend yields also vary across the countries in the same databases. For example, Worldscope presents all price and per share data (including dividends) on a calendar year-end basis for U.S. firms, but on a fiscal year-end basis for non-U.S. firms. In addition, the group of zero-dividend stocks makes occasionally the sizes of D/P portfolios very unequal compared to the quantile portfolios formed on some other valuation ratios.[23] Besides the weak evidence of the relative efficacy of the D/P criterion, a relatively high proportion of zero-dividend paying stocks may most likely have reduced the number of such studies, in which the efficacy of D/P as a portfolio-formation criterion has been compared to that of other valuation ratios. Particularly, this kind of reason may have limited the number of comparative studies based on the U.S. data, as proportion of zero-dividend paying stocks have historically been much higher in the U.S. than elsewhere in the world.[24]

2.1.4 Sales-to-Price (S/P) anomaly

Influenced by Fisher (1984), the use of sales multiples became popular in the change of the millennium when analysts found it hard to justify their recommendations on the basis of negative earnings and book value multiples that frequently appeared in the ICT industry. Sales multiples could be calculated even for the most distressed and for newly established firms. Although widely adopted among practitioners, the academic research on the usefulness of the sales multiples for value stock selection is relatively scant, particularly in the U.S. stock markets, although the relative efficacy of S/P has been strong in few studies, in which it has been compared with other value multiples: Dhatt et al.

[22] In case of value premium by Miles and Timmermann (1996) for UK data, Bird and Whitaker (2003) for pan-European data from developed markets, and van der Hart et al. (2003) for emerging markets data, whereas in case of the highest value portfolio return by Bauman et al. (1998) for EAFE and Canadian data, Bird and Whitaker (2003), and van der Hart et al. (2003).

[23] For evidence of huge variability in the proportion of dividend-paying stocks in USA over time, see Christie (1990) and Fama and French (2001), for example.

[24] In addition to studies on D/P anomaly, many papers have reported the outperformance of the so-called "Dogs of the Dow" –strategies or their variants in different regional markets (see Filbeck, Holzhauer, and Zhao, 2017, for recent U.S. evidence, and Rinne and Vähämaa, 2011, for Finnish evidence).

(1999, 2004), Barbee, Jeong, Mukherji (2008), and Pätäri et al. (2018b) have all reported higher value premium based on S/P compared to those generated by more frequently used valuation ratios. Although neither the financial literature nor the investment community is unanimous in the applicability of sales multiples for valuation purposes, their use is often motivated by their stability when compared to other valuation multiples, or by the fact that sales are relatively difficult to manipulate, at least in comparison with earnings and book values (see, e.g., Damodaran 2012).

To the best of my knowledge, Senchack and Martin (1987) were the first to analyze the relative efficacy of S/P for value portfolio selection. In the comparison of the relative performance of high S/P and high E/P strategies among NYSE and AMEX stocks over the period 1975–1984, they found that the top-quintile S/P portfolio generated abnormal risk-adjusted returns compared to both its bottom-quintile counterpart and the market portfolio. However, high E/P stocks dominated high S/P stocks in terms of both absolute and risk-adjusted returns, as the relative performance of the top-quintile E/P portfolio was more consistent than that of the top-quintile S/P portfolio. A few years later, Barbee, Mukherji, and Raines (1996) found that over the period 1979–1991, S/P explained U.S. stock returns better than B/P or firm size. The authors stated further that S/P subsumed the role of the debt/equity ratio in explaining the returns. According to the results of Dhatt et al. (1999) for the small-cap sample of U.S. stocks over the period from July 1979 to June 1997, S/P also appeared to be a better indicator of value than B/P, which in turn was superior to E/P. Five years later, the same authors also reported the superiority of S/P over B/P, E/P, as well as over CF/P in terms of both value premium and value portfolio returns for the sample of larger-cap U.S. stocks, although the composite value measure based on combining the S/P and E/P criteria generated marginally higher quintile portfolio returns than S/P on stand-alone basis (Dhatt et al. 2004). The superiority of S/P over the same value multiples as employed in Dhatt et al. (2004) was also documented by Barbee et al. (2008), who reported the greatest explanatory power in cross-sectional regression tests, as well as the highest value premium for S/P. Moreover, they found the highest quintile portfolio return for the top-quintile S/P portfolio. Publication II of Part B in this thesis provides more recent U.S. evidence for the relative efficacy of S/P (see also Hou et al. 2017a,b for parallel evidence). Over the period from July 1971 to June 2013, S/P has outperformed all other seven price-based valuation ratios being compared with respect that the top-decile S/P portfolio has generated the highest decile return among all the 80 decile portfolios formed on the basis of eight price-based valuation ratios. However, in the same terms, it has been slightly outperformed by the three top-decile portfolios formed on three enterprise value –based multiples (i.e., EBIT/EV, EBITDA/EV, and S/EV).

The meta-analysis of Pätäri and Leivo (2017) includes eight such comparative studies, in which the relative efficacy of at least three different value multiples, including S/P, have been compared on the basis of non-U.S. sample data. In two out of seven of them, the highest value premium has been generated by S/P[25], whereas the highest value portfolio return is based on the same criterion in three out of eight cases.[26] By contrast, the S/P-based value premium has been the lowest in two out of seven comparable studies, whereas the corresponding value portfolio return has been the lowest in three out of eight comparable cases. However, it is worth noting that all this evidence is from the Finnish stock market and based on overlapping sample periods (see Leivo et al. 2009; Leivo and Pätäri 2011; Pätäri et al. 2016). In Publication I of Part B in this thesis, which is also included in the meta-analysis of Pätäri and Leivo (2017), the lowest top-tertile portfolio return, as well as the lowest return-based value premium is reported for S/P. However, the discriminatory power of the S/P ratios somewhat improved when these ratios were either size- or leverage-adjusted, whereas industry-adjustment had the reverse effect.

2.1.5 **Cash-flow-to-price (CF/P) anomaly**

There are many reasons why financial analysts as well as scholars are sceptical over reported earnings figures (e.g., differences in firms' practices to calculate discretionary accruals, such as depreciations and amortizations, for example (see, e.g., Chan et al. 2006), and differences over time in calculation principles of earnings figures stemming from changing accounting standards (see, e.g., Callao and Jarne 2010)). Such deficiencies of accounting earnings have motivated many scholars to examine the relation between cash flow yields and stock returns (see, e.g., Wilson, 1986, and Bernard and Stober, 1989, for the early attempts).

To the best of my knowledge, Chan et al. (1991) were the first to use CF/P for value portfolio selection. Their results from Japanese stock markets over the period 1971–1988 indicated that CF/P was the second best after B/P among four portfolio formation criteria in predicting future stock returns (The remaining two were E/P and market value of equity). A few years later with the U.S. data, Lakonishok et al. (1994) found that CF/P outperformed both B/P and E/P, being the most efficient selection criterion. Both Chan

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[25] In Bird and Casavecchia (2007) for pan-European data from 15 developed national markets, and in Gharghori et al. (2013) for Australian data (The total number of comparable studies included in this comparison is reduced by one because Suzuki, 1998, did not report the value premiums).
[26] In Bird and Casavecchia (2007), in Gharghori et al. (2013), and in Suzuki (1998) for Japanese data.

et al. and Lakonishok et al. concluded that the observed value premium was not explained by higher risk (measured by volatility) of value stocks. In the cross-country comparison of value premiums based on four different valuation ratios (i.e., B/P, CF/P, D/P, and E/P), Fama and French (1998) reported the highest value premium for the CF/P criterion in four out of the 13 national stock markets, whereas the E/P-based value premium was the highest in only two of the 13 developed national markets. In the same study, the highest value portfolio return was documented for the CF/P criterion in five out of 13 national stock markets, whereas for the E/P criterion, it was not documented in any of the included markets.

The strong performance of CF/P-based strategies relative to E/P-based strategies is also consistent with more recent evidence. For example, for the large sample of tradable NYSE and NASDAQ stocks, Dhatt et al. (2004) found that among 16 different portfolio-formation criteria, which included the size, the B/P, CF/P, E/P, and S/P criteria, and 11 combination criteria formed on the basis of the four last-mentioned ratios, the use of the CF/P criterion resulted in the lowest risk, as well as the highest return/risk ratio. Desai et al. (2004), whose main objective was to differentiate the accruals anomaly from the value anomaly, reported the average annual return of 10.2 % for the simple E/P-based market-neutral long/short strategy, whereas the comparable return for the corresponding CF/P-based strategy was 15.3 %. Dissanaike and Lim (2010) compared the performance of value strategies based on relatively simple portfolio-formation criteria, such as B/P, CF/P, E/P and past return, as well as those based on some more sophisticated measures, such as the Ohlson (1995) model and the residual income model of Dechow, Hutton, and Sloan (1999). For the comprehensive sample of U.K. stocks, the authors found that over the period 1987–2001, simple cash flow-to-price ratios performed almost as well as, and in some cases even better than the more sophisticated alternatives. The value premiums based on both standard CF/P, as well as based on operating cash flow/price, were substantially higher than those based on either B/P or E/P.

The meta-analysis of Pätäri and Leivo (2017) includes eight such studies, in which at least three alternative portfolio-formation criteria based on single valuation ratios, including CF/P criterion, have been compared to each other. In two of them[27], the CF/P criterion has generated the highest value premium, whereas the CF/P-based value portfolio return has been the highest in 2 out of 7 cases.[28] By contrast, only one of the U.S. studies included in their meta-analysis has documented the lowest value premium and the lowest

[27] In Lakonishok et al. (1994), and in Israel and Moskowitz (2013).

[28] In Lakonishok et al. (1994), and in Desai et al. (2004). The difference in number of comparable studies stems from the fact that Hou et al. (2015) report only the value premia, but not the returns of the value portfolios.

value portfolio return for the CF/P criterion (i.e., Barbee et al. 2008). Based on similar meta-analysis for the non-U.S. sample data, the CF/P criterion has generated the highest value premium in only one out of 10 studies.[29] At the other extreme, the lowest CF/P-based value premium has been documented in two out of ten non-U.S. studies[30], whereas the lowest value portfolio return has been reported for the same criterion in only one out of eight comparable cases.[31] Hence, evidence for the relative efficacy of the CF/P criterion is slightly stronger in the U.S. than in other countries.

As noted by Pätäri and Leivo (2017), the CF/P-based value premiums can also vary remarkably depending on whether or not the firms with negative cash flows are included in the samples, similarly to value premiums based on other earnings multiples. This makes the comparison of CF/P-based results with the results based on other single selection criteria somewhat speculative. Because cash flows are in most cases higher than the corresponding earnings, the samples including only the firms with non-negative cash flows are generally larger than the samples including only the firms with non-negative earnings (see e.g., Chan et al. 1993), which makes the former samples more consistent with B/P samples than are the samples of non-negative E/P stocks. Based on overall global evidence presented in Pätäri and Leivo (2017), the comparison between the CF/P and B/P criteria shows the superiority of CF/P-based value premium in seven out of 17 comparable studies, whereas based on value portfolio returns, the superiority of the CF/P criterion has been documented in only four out of 15 studies.[32] Though overall global evidence is slightly favorable to B/P, the U.S. evidence is more balanced, as in four out of seven comparable U.S. studies included in the meta-analysis of Pätäri and Leivo (2017), the CF/P criterion has generated higher value premium, whereas in terms of value portfolio returns, the B/P criterion has performed better in equal number of cases.

Another noteworthy issue in efficacy comparisons between CF/P and other valuation ratios, as well as in cross-study comparisons of CF-based results, is that definitions to calculate cash flow component in CF/P ratios vary across the studies. For example, Lakonishok et al. (1994) and Fama and French (1998), and Yen et al. (2004) used earnings plus depreciations, while Hou et al. (2011) used *net income plus depreciation and*

[29] In Dissanaike and Lim (2010) who documented the two highest value premiums in the UK for the two cash flow–based multiples.
[30] In Doeswijk (1997) for Dutch data, and in Bauman et al. (1998) for EAFE and Canadian data.
[31] In Doeswijk (1997). Again, the difference in number of comparable studies stems from the fact that Dissanaike and Lim (2010) and Hou et al. (2011) report only the value premiums, but not the returns of value portfolios.
[32] In addition, according to Fama and French (1998), in 5 out of 12 national developed non-U.S. stock markets, the value premium has been higher based on CF/P than based on B/P, whereas in comparisons of value portfolio returns the CF/P has been superior to B/P in 6 out of 12 cases.

amortization plus *income statement deferred taxes*, the sum of which Dhatt et al. (2004) subtracted *preferred dividends* from. Moreover, Israel and Moskowitz (2013) and Hou et al. (2015) used *income before extraordinary items* plus *equity's share of depreciation*[33] plus *deferred taxes*, whereas Desai et al. (2004) and Dissanaike and Lim (2010) used operating cash flow, defined as *operating income after depreciation and amortization* minus *accruals*.[34] In order to find out the impact of cash flow definitions on the relative efficacy of CF/P ratios, Publication II in Part B of this thesis includes a comparison of four CF/P variants with another eight value measures. According to the results over the period from May 1971 to April 2013, CF/P has dominated E/P but the relative efficacy of CF/P variants is dependent on the performance metrics employed. For example, the top-decile portfolio formed on operating cash flow-to-price (CFO/P) variable generated the highest five-factor alpha (1.19 % p.a.) among the four CF/P variants. In addition, the same portfolio performed relatively well in terms of bearish-month returns, whereas its performance during bullish months was the worst among the four CF/P variants employed. In summary, the discriminatory power between CF/P variants is relatively close to each other and the differences are more pronounced between different types of valuation ratios than between CF/P variants (Pätäri et al. 2018b).

2.1.6 Anomalies based on earnings-based enterprise value multiples

The enterprise value (EV) multiples have recently started to gain popularity in value investing literature. Because EV takes the net value of a company's debt into account, it theoretically offers a more solid foundation to compare firms with diverging leverage with each other. The following income items have been employed as output variables in EV-based valuation ratios: gross profit (GP), earnings before interests, taxes, depreciations and amortizations (EBITDA), earnings before interests and taxes (EBIT), and free cash flow (FCF). In the related literature, the most frequently-used of these is EBITDA/EV, followed by EBIT/EV. One reason for the popularity of EBITDA/EV as a measure of relative valuation is in its use of operating income before depreciation as the profitability measure, as differences in depreciation methods across different companies

[33] Equity's Share of Depreciation is most commonly calculated according to Fama and French's (2006) definition as follows: [market value of equity/(total assets – book value of equity + market value of equity)]*(depreciation and amortization).

[34] Accruals are calculated following the definition of Dechow, Sloan, and Sweeney (1995): Accruals = (ΔCurrent Assets (item ACT) − ΔCash (item CH)) − (ΔCurrent Liabilities (item LCT) − ΔShort-term Debt (item DLC) − ΔTax Payable (item TXP)) − Depreciation and Amortization (item DP), where Δ represents the annual change.

can cause differences in net income or in EBIT but do not affect EBITDA. However, there are also disadvantages in omitting depreciations when measuring profitability. For example, Penman (2013) points out that depreciation is a real economic cost, and therefore, pricing a company without considering plant, copyright, and patent expenses would imply that a business could be run without these expenses. Therefore, some scholars have argued for the use of EBIT/EV instead of EBITDA/EV, because the former ratio takes account of depreciations and amortizations, which reflect a firm's capital expenditure in previous years. For example, Chan and Lui (2011) have stated that EBIT figures can give investors better guidance on profit growth and future sustainability, which makes EBIT/EV ratios more reflective of company's true profitability than EBITDA/EV ratios. However, that does not necessarily imply that EBIT/EV ratios would be superior to EBITDA/EV ratios as a basis of selection criterion for value portfolios. In fact, Gray and Vogel (2012), who compared the relative efficacy of five valuation ratios (i.e., E/P, B/P, EBITDA/EV, GP/EV, and FCF/EV), found that on the basis of value-weight quintile portfolios of U.S. stocks formed over the period from July 1971 to December 2010, both the highest value portfolio return and the greatest top-bottom quintile value premium were generated by GP/EV, which employs even a coarser profitability measure than EBITDA as income item. However, this finding is not as surprising as it may first sound in the light of the results of Novy-Marx (2013) who stated that the gross profitability is the cleanest measure of profitability, as well as the best among the profitability measures for the purpose of forming the best-performing portfolio of the near future.

To the best of my knowledge, Leivo et al. (2009) was the first published journal article that applied an EV-based multiple in value portfolio investing. Their evidence from the Finnish stock markets indicates that the EBITDA/EV ratio is useful for stock selection purposes particularly in terms of total risk-adjusted returns. In the same markets, Leivo and Pätäri (2011) found that EBITDA/EV generated the second highest value premium after the D/P criterion, but the corresponding top-sextile EBITDA/EV portfolio return was only the fourth highest among the six comparable value portfolios formed on single valuation ratios (The remaining four were B/P, E/P, CF/P, and S/P). Evidence for EBIT/EV in the Finnish stock market is shown in Publication I of Part B in this thesis. Over the sample period from May 1996 to April 2013 and based on the comparison of tertile portfolios, EBIT/EV was superior to E/P, B/P, and S/P both in terms of raw returns and after multiple risk-adjustment procedures (Pätäri et al. 2016). Parallel results from the same stock market were also reported by Davydov et al. (2016) who reported both the highest raw return and the highest Sharpe ratio, as well as the highest Sortino ratio for the EBIT/EV criterion, when comparing the relative efficacy of four individual valuation ratios (the remaining three being B/P, CF/P, and E/P) over the period from July 1996 to June 2013.

The existing U.S. evidence of the relative efficacy of earnings-based enterprise value multiples is surprisingly scant, as EV multiples have been seldom included in such comparative studies. This has been the case despite that the results of such few studies in which they have been included has been rather favorable to such multiples. For example, Loughran and Wellman (2011) reported that over the sample period from July 1963 to June 2009, EBITDA/EV-based value premium was the highest in comparison of value-weighted decile portfolios formed on four individual valuation ratios (i.e., B/P, D/P, E/P, and EBIDA/EV), whereas based on the corresponding comparison of equally weighted portfolios, EBITDA/EV was the second best after the B/P criterion. Followed by B/P-based value portfolios, the EBITDA/EV-based counterpart portfolios also generated the second highest returns on both equally and value-weighted bases, whereas Gray and Vogel (2012) reported the highest raw return based on equally-weighted quintile portfolios for EBITDA/EV, followed by FCF/EV and GP/EV over the period from June 1971 to December 2010. For value-weighted portfolios, the same enterprise value-based multiples also dominated the two price-based multiples being compared (i.e., E/P and B/P), but the rank order based on raw returns was in this case GP/EV, followed by EBITDA/EV and FCF/EV. The dominance of enterprise value-based multiples over their price-based counterparts also remained after the risk-adjustment (in terms of both Sharpe ratios and the Fama-French three-factor alphas). Parallel evidence for the relative efficacy of EBIT/EV and EBITDA/EV is also reported in Publication II of Part B in this thesis: For a comprehensive sample of U.S. firms with market capitalization above the bottom NYSE decile breakpoint over the period 1971–2013, the highest raw return (17.80 % p.a.) is documented for the top-decile EBIT/EV portfolio, whereas the highest value premium (9.09 % based on the return difference between the extreme deciles) is given by EBITDA/EV[35] (Pätäri et al. 2018b).

2.1.7 Sales-to-enterprise value (S/EV) anomaly

Perhaps the biggest pitfall in using sales multiples is that if a firm generates high sales growth while simultaneously losing significant amounts of money, S/P could erroneously indicate a low relative valuation for such a firm (see, e.g., Penman 2013). Sales can also

[35] For international evidence on the return-relations of enterprise value multiples, see Walkshäusl and Lobe (2015), for example.

be increased by increasing debt, which in most cases increases S/P.[36] However, the S/P ratio does not reveal the degree of leverage with which the sales have been generated, although leverage certainly makes a difference to the risks of the firms being compared. For this reason, the S/EV ratio has a more solid theoretical foundation as a value multiple than S/P. In the light of this fact, it is somewhat surprising that the number of academic research related to the relative efficacy of S/EV has been even lower than it has been for S/P.

Although S/EV has been included as one sub-criterion in the composite value criteria in few previous studies (see Asness, Friedman, Krail, and Liew 2000; Israel and Maloney 2014; Ilmanen, Nielsen, and Chandra 2015), Publications II and III of Part B in this thesis are, to the best of my knowledge, the first academic articles in which the relative efficacy of S/EV as a stand-alone valuation criterion has been compared with that of other value multiples, as well as in which S/EV has been systematically combined with varying sets of other sub-criteria. These two papers contribute to the existing literature by providing evidence of strong relative efficacy of S/EV (besides two other enterprise value multiples that are EBIT/EV and EBITDA/EV) in comparison with the most frequently used price-based multiples, such as B/P and E/P. S/EV is also the most unique among the valuation ratios as the S/EV-based top-bottom decile return difference factor does not correlate with either the HML or the WML factors. With respect to long-only portfolios, S/EV might serve a kind of hybrid portfolio-formation criterion that would simultaneously take account of both value and momentum dimensions in stock selection as among the value portfolios, their S/EV-based counterparts have clearly the strongest return correlation with the corresponding momentum portfolios. Moreover, the relative efficacy of S/EV is particularly strong in the large-cap sample that consists of the firms whose market equity value is higher than the NYSE breakpoint of the second highest size quintile. This finding is of particular interest in the light of the results of Israel and Moskowitz (2013), who showed that B/P-based value premium is largely concentrated only in small stocks, while being insignificant among 40% of the largest-cap stocks. Motivated by their results, we tested whether the value premiums determined on the basis of valuation ratios other than B/P behave analogously in the similarly designed sample of large-cap stocks. Interestingly, our results showed that the value premium is remarkably higher based on many other valuation ratios, particularly based on S/EV, for which it is more than double that based on B/P. (Pätäri et al. 2018a,b)

[36] In exceptional cases, the stock price may rise (as a result of higher leverage) by a higher percentage than that of sales growth generated by increased debt, thereby resulting in a lower S/P ratio. However, in most cases, the impact of increased debt on the S/P ratio is positive (see, e.g., Damodaran, 2012 for details).

2.2 Other anomalies

2.2.1 Size anomaly

To the best of my knowledge, Banz (1981) was the first to document the size anomaly, which states that, on average, small-cap stocks generate higher average returns than large-cap stocks. By analyzing all common stocks listed on the NYSE between 1936 and 1975, he reported that an annual risk-adjusted return on the stocks in the smallest-cap quintile portfolio was almost 5 % higher than the corresponding return on the remaining firms. Based on Fama-MacBeth (1973) regressions, Banz (1981) showed further a negative and significant relation between returns and market values of equity. The observed size effect was not linear, being at its strongest for the smallest firms in the sample. By using a broader sample of NYSE and AMEX stocks over the period 1963–1977 and decile portfolios, Reinganum (1981) reinforced the main findings of Banz (1981) and found that that the smallest size decile outperformed the largest by 1.77 % per month. Keim (1983) extended the breadth of the sample further and reported a size premium of as high as 2.5 % per month for NYSE and AMEX stocks over the period 1963–1979. He showed further that, on average, small-cap stocks had higher betas than large-cap stocks, but the return differential was not fully explained by the differences in portfolio betas. He also found that almost 50 % of the size effect was attributed to the abnormally high January returns of small-cap stocks. Similar relation between the size anomaly and the January effect has also been documented by Brown, Kleidon, and Marsh (1983) and Daniel and Titman (1997), among others. Based on 20 size-sorted portfolios and by using a very large sample of stocks, Lamoureux and Sanger (1989) found a size premium of 2.0 % per month for NASDAQ stocks and of 1.7 % for NYSE/AMEX stocks over the period 1973–1985. Interestingly, they reported a lower beta for small-cap stocks than for large-cap stocks on NASDAQ.

Although the seminal paper of Banz (1981) already made the researchers to at least consider the impact of size effect as a potential explanation on almost all other anomalies, another cornerstone article with this respect was that of Fama and French (1992), in which they demonstrated a fundamental empirical shortcoming of the CAPM-based beta to predict stock returns. Based on a comprehensive sample of NYSE, AMEX, and NASDAQ stocks over the period 1963–1990, Fama and French reported the smallest market-cap decile to have outperformed the largest by 0.63 % per month. After dividing each size decile into ten beta-sorted portfolios, they found no relation between CAPM-betas and returns. In addition, the authors ran Fama–MacBeth (1973) regressions to confirm that after including size and book-to-market in their cross-sectional regression model as explanatory variables besides beta, the explanatory power of beta was insignificant. As a consequence of this striking finding, the size factor has become an important part of many asset pricing models, such as the Fama-French 3- and 5-factor models (Fama and French, 1993 and 2015), and the *q*-factor model suggested by Hou et al. (2015), for example.

However, since the very first studies on size anomaly, a strong time-variability of the size effect has been identified (see, e.g., Banz 1981; Keim 1983). Also Handa, Kothari, and Wasley (1989) reported an outstanding time-variability of the size effect for the three subperiods within their sample period 1941–1982, and particularly, for the subperiod 1941–1954, when the size effect was negative (though not significant in statistical sense). In addition, many papers published approximately in the turn of the millennium claimed that the size anomaly would have disappeared after the early 1980s (see, e.g., Dimson and Marsh 1999; Chan, Karceski, and Lakonishok 2000; Horowitz, Loughran, and Savin 2000; Hirshleifer 2001). However, recent evidence provided by van Dijk (2011) showed that its disappearance was only a part of time-varying characteristic of this particular anomaly.[37] Based on size quintile returns on all NYSE, AMEX, and NASDAQ stocks over the period 1927–2010, he reported the annual value-weighted return differential between the smallest and the largest size quintile of 6.7 % p.a., on average. On the other hand, in 38 out of 84 years, the size premium has been negative, and averaged over the most recent 30 years included in his sample period, the corresponding return differential was only 1.2 % p.a. By contrast, over the last decade included in the sample period, the average size premium was as high as 11.3 % per year. Based on overall long-term evidence, van Dijk (2011) deems the conclusion on the size effect's "death" premature. Correspondingly, Publication IV of Part B of this thesis documents the equal-weighted size-quintile premium of 3.15 % p.a. over the 42-year sample period for the sample of all-but microcap U.S. stocks.

In general, anomalies tend to concentrate in smaller stocks, and the evidence from Publication IV of Part B in this thesis reinforces this conclusion, even for the sample, of which microcaps are excluded (Karell and Yeomans 2018).[38] After holding size dimension constant in 5x5 conditional double-sorts, the value effect is mostly concentrated in smaller stocks as noted by Fama and French (2008, 2015) and Israel and

[37] E.g., Pettengill, Sundaram, and Mathur (2002) and Hur, Pettengill, and Singh (2014) have shown that the size effect differs across bull and bear markets.

[38] This tendency may stem from investors' preferences to hold large and liquid stocks partially due to the higher trading costs of smaller firms (see, e.g., Chiyachantana, Jain, Jiang, and Wood 2004).

Moskowitz (2013). The asset growth anomaly is stronger among smaller stocks consistent with Cooper, Gulen, Schill (2008), Fama and French (2008, 2015), and Lipson, Mortal, and Schill (2011). Also the momentum effect seems to be especially strong among smaller firms after controlling for firm size. This finding is in line with Hong, Lim, and Stein (2000) and Lesmond, Schill, and Zhou (2004) who find that the momentum effect is stronger among small stocks, but in contrast with Israel and Moskowitz (2013) who conclude that momentum is largely unaffected by firm size.[39] Finally, profitability anomaly differs from the above anomalies in that it does not seem to produce consistent return patterns within size quintiles.

2.2.2 **Momentum anomaly**

By definition, momentum refers to tendency of securities, which have performed well relative to their peers (winners) in the recent past, to continue outperforming, whereas securities that have performed relatively poorly (losers) tend to continue to underperform in the near future. To the best of my knowledge, the first academic evidence of price momentum was provided Jegadeesh and Titman (1993), who showed that long-short momentum strategies earned profits of about 1 % per month for the following year in the U.S. stock market during the sample period of 1965–1989. In general, the stocks that have performed well (poorly) during the previous 3–12 months, continued to outperform (underperform) during the subsequent holding periods from 3 to 12 months.[40] A few years later, the same authors showed that their seminal results were not due to data snooping bias, since the momentum effect continued to exist over the period from 1990 to 1998 (Jegadeesh and Titman 2001). Their overall results were not explained by systematic risk giving support for the behavioral explanations.[41]

Since the seminal paper by Jegadeesh and Titman (1993), the momentum effect has attracted both portfolio managers and academic researchers, and many variants for price momentum strategies have been suggested (see, e.g., Daniel and Titman 1999; Hong et

[39] However, our results are not totally comparable with these three studies, owing to the difference between the lengths of the holding period (Both Hong et al., 2000, and Lesmond et al., 2004, used 6-month holding periods, whereas Israel and Moskowitz (2013) used 1-month holding periods for the momentum indicator based on 12-month past returns by skipping the most recent monthly return).

[40] For example, the momentum strategy based on 6-month past returns and 6-month holding periods produced a compounded excess return of 12.01 % p.a. on average.

[41] For the rational explanations for the momentum effect, see for example Sagi and Seasholes (2007), Berk, Green, and Naik (1999), and Johnson 2002.

al. 2000; Jegadeesh and Titman 2001; George and Hwang 2004; Grinblatt and Moskowitz 2004; Fama and French 2008, 2012; Novy-Marx 2012; Israel and Moskowitz 2013; Barroso and Santa-Clara 2015; Daniel and Moskowitz 2016). The results of Publication IV of Part B in this thesis find the typical negative correlation between momentum (6-month momentum with one month lag) and value characteristics consistent with Asness (1997), Asness Moskowitz, and Pedersen (2013), and Fisher, Shah, and Titman (2016), among others (Karell and Yeomans 2018). The 5x5 conditional portfolio sorts show a strong momentum effect for firms that have experienced a large expansion or contraction in their total assets, consistent with Nyberg and Pöyry (2014). The highest average return among all the double-sorted portfolios (including both long-only and long/short portfolios) is reported for high momentum/ low asset growth portfolio (17.79 % p.a.). The results of the annual cross-sectional Fama-MacBeth (1973) regressions to predict a subsequent year's stock return suggest that momentum is highly significant and robust across all the models employed. This finding is in contrast with Cooper et al. (2008), and Penman and Zhu (2014) who use similar methodology, but unlike in Publication IV, microcaps are included in their samples, which could at least partially explain the differences in the results.

The benefits of combining price momentum and value indicators have also been shown in many recent papers (see, e.g., Asness et al. 2013; Asness et al. 2015; Fisher et al. 2016). Publication III of Part B in this thesis finds similar evidence, but in addition, it contributes to the existing literature by showing that in the best-performing combination criteria, S/EV may serve as a potential substitute for price momentum indicator as a constituent of the combination criteria, since the return generation pattern of the high-S/EV stocks is, at least at the portfolio level, surprisingly similar to that of the high-momentum stocks (see Pätäri et al. 2018a, and Table 8 in Pätäri et al. 2018b).

2.2.3 Return-on-assets (ROA) anomaly

Early evidence of the profitability anomaly is found by Haugen and Baker (1996). Using practically the entire U.S. stock market population (i.e., Russel 3000 index firms) from the period from 1979 to 1993, they found a positive relation between the relative expected monthly returns (computed by summing the products of the factor exposures for each stock and the average of the factor payoffs over the previous 12 months) and all profitability measures employed in their study (i.e., profit margin, asset turnover, return on assets and equity, and trailing rates of growth in earnings per share). In addition, the authors reported that this relation is more pronounced when moving from the lowest-expected-return stock portfolio (decile 1) to the highest one (decile 10). Return on assets (ROA) measured as net operating income divided by total assets was slightly negative for the decile 1, peaked at the decile 6, and was clearly positive within the deciles 7–10. The profitability results were not driven by small firms, and, actually, the most profitable stocks tended to be larger firms with better liquidity. The overall evidence of Haugen and Baker (1996) casted doubt on the Efficient Market Hypothesis, because the results were neither driven by risk.

More recent evidence on the ROA anomaly is shown by Balakrishnan, Bartov, and Faurel (2010) who examined the phenomena through drift following quarterly loss/profit announcements, where losses/profits were scaled by total assets. They employed a sample of the U.S. firms from 1976 to 2005 and found that firms in the lowest ROA portfolio exhibited a negative post announcement drift of nearly six percent, whereas the portfolio with the most profitable stocks exhibit a positive drift of over four percent. These results were based on ROA measured as earnings before extraordinary items and discontinued operations divided by beginning-of-quarter total assets. The untabulated results from two alternative earnings measures (i.e., earnings before extraordinary items, discontinued operations, and special items, as well as net income) were very similar, thereby implying that the results were robust to the earnings definition. Univariate and multivariate tests showed that the suggested mispricing was distinct from and incremental to the post-earnings-announcement drift, the value anomaly, and the accruals anomaly. For example, the evidence from their multivariate test showed that more profitable firms were more likely to generate higher returns than less profitable firms even after controlling for B/P. The ROA effect was also robust to alternative risk adjustments, up and down markets, distress risk, short sales constraints, transaction costs, and three 10-year sub-periods within the 30-year full-sample period.

Hou et al. (2017b) replicated 447 anomalies found in finance and accounting anomaly literature. The anomaly categories (variables) were momentum (57), value (68), investment (38), profitability (79), intangibles (103), and trading frictions (102). They argued that a majority (i.e., 286 out of 447) of the reportedly existing anomaly variables are insignificant at the conventional 5 % level based on the high-minus-low decile portfolio return, and further, that the 161 significant anomalies were often much weaker in magnitude than reported in the original papers. They defined return on assets as income before extraordinary items divided by one-quarter-lagged total assets (see, e.g., Balakrishnan et al. 2010) and calculated monthly decile returns for three different holding periods within one year. According to Hou et al. (2017b), the ROA anomaly was statistically significant only for one-month holding period, while being insignificant for six- and 12-month holding periods. In addition, change in ROA seemed to be more efficient in shorter holding periods since it was insignificant for 12-month, but significant for one- and six-month holding periods. Hou et. al. (2017a) compared the performance of the same trading strategies against the traditional CAPM, the Fama-French three-factor model, the Pastor-Stambaugh (2003) liquidity model, the Carhart (1997) four-factor model, the *q*-factor model, and the Fama-French (2015) five-factor model. On average, the ROA strategy with one-month holding period clearly outperformed the two ROA change variables in terms of alphas, although the ROA change with one-month holding period generated marginally higher spread portfolio return than the corresponding ROA. In sum, ROA did not seem to be particularly good or bad when compared to the other profitability measures.[42]

Based on the results of Publication IV of Part B in this thesis, the returns on ROA-sorted portfolios exhibited an inverse U-shaped pattern, where the return of the high minus low hedge portfolio was slightly positive (Karell and Yeomans 2018). Although the margin was not very big, the same relation held, on average, for 5x5 conditional double-sorts where profitability quintiles were sorted on size, value, investment, or momentum. Moreover, the results from the investment sorted ROA quintiles revealed that the most unprofitable firms that invest a lot have very low average returns, in line with Fama and French (2015), for example. Similar unconditional inverse U-shaped return pattern for ROA-sorted portfolios was also reported by Penman and Zhu (2014). The conclusions from the annual Fama-MacBeth (1973) regressions regarding the explanatory power of ROA on subsequent stock returns are also similar to those of Penman and Zhu (2014) and Fama and French (2015). ROA does not additionally forecast stock returns in the presence of other firm characteristics, such as B/P or momentum.

[42] Other profitability measures included in Hou et al. (2017a,b) are such as return on equity (see, e.g., Hou et al. 2015), return on net operating assets (see, e.g., Soliman 2008), profit margin (see, e.g., Soliman 2008), asset turnover (see, e.g., Soliman 2008), capital turnover (see, e.g., Haugen and Baker 1996), gross profits-to-assets (see, e.g., Novy-Marx 2013), operating profits to equity (see, e.g., Fama and French 2015), operating profits-to-assets (see, e.g., Ball, Gerakos, Linnainmaa, and Nikolaev 2015), cash-based operating profitability (see, e.g., Ball, Gerakos, Linnainmaa, and Nikolaev 2016), F-score (see, e.g., Piotroski 2000), failure probability (see, e.g., Campbell, Hilscher, and Szilagyi 2008), Ohlson's O-score (see, e.g., Dichev 1998), Altman's Z-score (see, e.g., Dichev 1998), growth score (see, e.g., Mohanram 2005), credit ratings (see, e.g., Avramov, Chordia, Jostova, and Philipov 2009), taxable income-to-book income (see, e.g., Green, Hand, and Zhang 2013), and book leverage (see, e.g., Fama and French 1992).

2.2.4 Investment (asset growth) anomaly

There is much evidence that corporate events associated with asset expansion (contraction) tend to be followed by periods of abnormally low (high) returns. Measures of investment intensity such as investment-to-asset ratio (suggested by Lyandres, Sun, and Zhang 2008), the firm capital expenditures divided by the average capital expenditures over the past 3 years (Titman, Wei, and Xie 2004), the ratio of capital expenditures to net property, plant, and equipment (Polk and Sapienza 2009), and the 3-year growth rate in capital expenditures (Anderson and Garcia-Feijoo 2006) have been documented to predict stock returns.[43] However, Cooper et al. (2008) were the first to document the asset growth anomaly in terms of a very simple measure calculated as year-on-year percentage change in total assets. They showed that such an aggregate measure of firm growth benefits from the predictability of all of the major subcomponents from both the left-hand (investment) side and right-hand (financing) side of the balance sheet, allowing asset growth to better predict the future returns relative to any single component of growth.

Fama and French (2008) argued that the asset growth anomaly is less robust and holds only for microcap and small-cap stocks but not for large-cap stocks. However, Lipson et al. (2011) argued that the asset growth measure employed in the first-mentioned study (i.e., the change in the natural log of assets per split-adjusted share) dampens the asset growth effect by excluding growth arising from equity issues, affecting especially on the large-cap results. Moreover, Lipson et al. (2011) showed that asset growth has largely subsumed other measures of investment intensity, such as those employed in Lyandres et al. (2008), Titman et al. (2004), Polk and Sapienza (2009), and Anderson and Garcia-Feijoo (2006), and it is quite persistent for firms of all sizes. Overall U.S. evidence for the investment-related anomalies is strong, as according to the recent results of Hou et al. (2017a) for an approximately similar all-but microcap sample as in Publication IV of Part B in this thesis, but for slightly different sample period 1967–2014, as many as 36 out of the 38 related anomalies being compared generated a statistically significant top-bottom decile return difference. Among the 36 significant ones and in the same terms, asset growth variants were among the most efficient.[44] Consistent with Cooper et al. (2008),

[43] See also Fairfield, Whisenant, and Yohn (2003), Hirshleifer, Hou, Teoh, and Zhang (2004), Pontiff and Woodgate (2008), Broussard, Michayluk, and Neely (2005), and Zhang (2007).

[44] The highest top-bottom decile premium (i.e., –0.84 % per month) was generated by quarterly asset growth with 6-month holding period (Quarterly asset growth was defined as quarterly total assets divided by four-quarter-lagged total assets. At the beginning of each month *t*, Hou et al. (2017b) sorted stocks into deciles based on Iag for the latest fiscal quarter ending at least four months ago. Monthly decile returns were then calculated for month *t* to *t* + 5, and the deciles were rebalanced at the beginning of each month, implying

Lipson et al. (2011), and Fama and French (2015), the asset growth-sorted results of Publication IV of Part B in this thesis indicate that this anomaly remains robust after controlling for size (Karell and Yeomans 2018). Although the asset growth anomaly is stronger among smaller-cap stocks even within the all-but microcap sample, it is not limited to the smallest firms, as was also shown by Hou et al. (2017b). The results also indicate that based on the quintile return differences, the discriminatory power of asset growth variable is superior to the remaining four anomaly variables being examined, as the highest overall quintile return is generated by the low asset growth (INV) quintile, whereas the lowest corresponding return is documented for the high asset growth quintile, resulting in the top-bottom quintile return differential of 7.95 % per annum. In addition, the results of the annual cross-sectional Fama-MacBeth (1973) regressions show that the negative return-relation of asset growth is dominant relative to size and B/P, in line with Cooper et al. (2008) who used similar setup.

that for a given decile in each month and for the 6-month holding period, there existed six sub-deciles, each of which was initiated in a different month in the prior six months. The simple average of the sub-decile returns was used as the monthly return of each decile). Correspondingly, the standard asset growth variable suggested by Cooper et al. (2008) generated the top-bottom decile return differential of –0.69% per month during the same sample period.

3 Methodology

3.1 Research approach

This thesis approaches the pricing anomalies from a practical portfolio management perspective putting a great emphasis on the implementability of the examined trading strategies. The central research approach of this thesis is to form portfolios sorted on lagged anomaly variables and accumulate the returns of these portfolios through time (see, e.g., Fama and French 2008). The constituent stocks included in each portfolio are equally-weighted at annual frequency in order to follow a stable and realistic portfolio-formation principle, which would be valid also from the practitioners' point of view. The stocks with the highest ranking scores (determined on the basis of either individual valuation ratio, momentum indicator, or combination criteria) are placed in the top-quantile portfolio, whereas the bottom quantile consists of the stocks with the lowest criteria. The weight changes of the stocks stemming from their return differences within the holding periods are taken into account in the calculation of monthly quantile portfolio returns. In addition, Publication IV employs conditional double-sorted portfolios, as well as Fama and MacBeth (1973) style regressions to explain the cross-section of average stock returns.

The equal-weighted quantile portfolios are formed at the end of April of year t and held for one year from May of year t through April of year $t + 1$. Year $t - 1$ financial statement data are used as constituents of valuation ratios, as there may be a 4-month lag in the publication of financial statements after the end of the fiscal year (see, e.g., Fama and French 1992). By contrast, the market values of equity used in denominators of price multiples and EV multiples are updated to match those prevailing at the end of April in year t for all firms in order to use the latest available information without look-ahead bias (see, e.g., Lakonishok et al. 1994; Desai et al. 2004; Asness and Frazzini 2013; Fisher et al. 2016).

3.2 Data and variables

Publication I employs comprehensive financial statement data of the Finnish exchange-traded companies obtained from DataStream and supplemented with the stock price data of Helsinki Stock Exchange (OMX Helsinki) over the period from 1996 to 2013. In accordance with the majority of related literature, financial stocks are excluded. In addition, only the stocks quoted on the main list of the OMX Helsinki are included. By contrast, the data in Publications II–IV consist of non-financial U.S. firms quoted on the NYSE, AMEX, and NASDAQ exchanges during the period 1969–2013. The sample period starts no earlier than year 1969, because the availability of accounting data decreases dramatically when moving back in time to the 1960s. The price data is collected from the Center for Research in Security Prices (CRSP) database, whereas the accounting-based variables required for the calculation of valuation ratios are collected from the Compustat database. The sample comprises only firms with ordinary common equity on CRSP. Adjustments of returns for dividends, splits, and capitalization issues are made appropriately. To avoid survivorship bias, CRSP delisting returns are incorporated according to Beaver, McNichols, and Price (2007), with the exception that new delisting return estimates are recalculated for firms with missing delisting returns on CRSP for each stock exchange based on the available and traceable delisting returns over the 1971–2013 period.

Unlike in most of the peer-group studies, the firms must have all the information available for the calculation of each single selection criteria being examined at each portfolio-formation point to be included in the final sample in each publication. This prerequisite is necessary in order to ensure the best possible comparability of the results based on different single selection criteria and/or combination criteria, although it reduces the number of otherwise usable firm-year observations. To alleviate backfill bias, in accordance with Fama and French (1993), firms are required to have two-year accounting data before entering each sample. For example, firms included in the sample at the beginning of the sample period (i.e., at the end of April 1971) had to have financial statement data available for the fiscal years ending in 1969 and 1970. In addition, only firms with fiscal year durations of 12 months are included in the final sample. Consistent with the existing literature (see, e.g., Fama and French 2008; Loughran and Wellman 2011), the thesis also excludes firm-year observations for which the book value of equity is negative. The same practice is also followed in cases of negative enterprise values. Finally, Publications II and III exclude firms for which market capitalization at the beginning of each 1-year holding period is below the bottom NYSE decile breakpoint (see, e.g., Jegadeesh and Titman 2001; Chan and Lakonishok 2004; Avramov, Chordia, Jostova, and Philipov 2007), whereas Publication IV restricts the sample by excluding firms with a market cap below the 20th NYSE percentile breakpoint (see, e.g., Chen, Hong, and Stein 2001; Nyberg and Pöyry 2014).

The selected variables represent both the traditional and less frequently-used measures of stock market anomalies. By definition, value stocks have high fundamentals-to-price ratios and/or high fundamentals-to-enterprise value ratios, whereas the corresponding ratios for the glamour stocks are low. In this thesis, the value anomaly is captured by *book*-to-*price* (B/P), four variants of *cash flow*-to-*price* (CF1/P, CF2/P, CF3/P, and CFO/P), *dividend*-to-*price* (D/P), *earnings*-to-*price* (E/P), *sales*-to-*price* (S/P), *earnings before interest and taxes*-to-*enterprise value* (EBIT/EV), *earnings before interest, taxes, depreciation, and amortization*-to-*enterprise value* (EBITDA/EV), *free cash flow*-to-*enterprise value* (FCF/EV), and *sales*-to-*enterprise value* (S/EV). The other anomalies discussed in this thesis are the size anomaly (market value of equity), the momentum anomaly (6-month momentum with one month lag), the profitability anomaly (return on assets), and the investment anomaly (asset growth).

3.3 **Analysis methods**

3.3.1 **Cluster-adjusted valuation scores**

The cluster-adjusted valuation scores is a new and innovative methodology for value portfolio selection introduced in Publication I. The methodology makes the valuation scores additive, which allows for capturing both several dimensions of relative value and several peer-group comparisons at the same time. To generate valuation scores, valuation ratios are harmonized by calculating first the full sample median E/P ratios at each portfolio-formation point (i.e., at the end of April each year). Second, other valuation ratios at the same moment are scaled by multiplying them with the absolute value of the ratio of the full sample median E/P and the corresponding median of the valuation ratio being harmonized. Finally, size-, industry- and leverage-adjusted valuation ratios are calculated by subtracting the median of each valuation ratio calculated over the companies within the corresponding size, industry or leverage cluster from the corresponding firm-specific valuation ratios. The cluster-adjusted E/P-based valuation scores are given as follows:

$$cluster\ adjusted\ \frac{E_i}{P_i} = \frac{E_i}{P_i} - M_{E/P}^{G(i)} \quad (1)$$

where $M_{E/P}^{G(i)}$ refers to the E/P median for the cluster *G* to which company *i* belongs. Other cluster-adjusted valuation scores are calculated analogously to the example of B/P as follows:

$$cluster\ adjusted\ \frac{B_i}{P_i} = \frac{B_i}{P_i} \times \frac{|M_{E/P}|}{|M_{B/P}|} - M_{B/P}^{G(i)} \quad (2)$$

where $M_{B/P}^{G(i)}$ refers to the B/P median for the cluster *G* to which company *i* belongs. $M_{E/P}$ and $M_{B/P}$ are E/P and B/P medians for the full sample, respectively.

3.3.2 Multicriteria decision-making (MCDM) methods

Median-scaling (MS)

Analogous to Dhatt et al. (2004), the median-scaled composite measures are calculated by first standardizing each metric of a single selection criterion of a firm in a particular year by its cross-sectional median at the same time point and then computing the average of these median-scaled scores for each combination. For example, if the B/P for a firm at some point is 0.9, while the median B/P for the sample is 0.6 at the same time point, then the median-scaled B/P for that firm is 1.5. The corresponding scores for momentum are calculated by dividing the past 6-month return by the median 6-month sample return at the same time point (both returns expressed in an investment relative form, i.e., as $1+r$).

The Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS)

TOPSIS was developed by Hwang and Yoon (1981) as an alternative approach to multiple attribute decision-making problems. It simultaneously considers the distances to the positive and negative ideal solutions regarding each alternative and selects the most relative closeness to the positive ideal solution and the farthest one from the negative ideal solution. The procedure of TOPSIS begins with the construction of an evaluation matrix $X=[x_{ij}]$ where x_{ij} denotes the score of the i^{th} alternative with respect to the j^{th} evaluation criterion and can be summarized as follows:

Step 1: Forming the normalized decision matrix $\tilde{\theta}=[\Theta_{ij}]$

$$\Theta_{ij} = \frac{x_{ij}}{\sqrt{\sum_{j=1}^{m} x_{ij}^2}}, j = 1, \dots, m, i = 1, \dots, n \tag{3}$$

where x_{ij} is i^{th} company's score on j^{th} criterion.

Step 2: Determining the weighted normalized decision matrix $\Psi=[\psi_{ij}]$

$$\psi_{ij} = \Theta_{ij}(\cdot)w_j, j = 1, \dots, m, i = 1, \dots, n \tag{4}$$

Step 3: Computation of the positive and negative ideal solution $\tilde{X}^{+}$ and $\tilde{X}^{-}$:

$$\tilde{X}^{+} = \{\psi_1^{+}, \dots, \psi_m^{+}\} = \{(max_i \psi_{ij} | j \in B), (min_i \psi_{ij} | j \in C)\}$$

$$\tilde{X}^{-} = \{\psi_1^{-}, \dots, \psi_m^{-}\} = \{(min_i \psi_{ij} | j \in B), (max_i \psi_{ij} | j \in C)\} \tag{5}$$

where *B* refers to benefit criteria and *C* to cost criteria, respectively.

Step 4: Calculation of the distance of each alternative from the positive ideal solution and from the negative ideal solution:

$$d_i^{+} = \sqrt{\sum_{j=1}^{m} \left(\psi_{ij} - \psi_j^{+}\right)^2}, j = 1, \dots, m$$

$$d_i^{-} = \sqrt{\sum_{j=1}^{m} \left(\psi_{ij} - \psi_j^{-}\right)^2}, j = 1, \dots, m \tag{6}$$

Step 5: Calculation of the relative closeness to the ideal solutions:

$$CC_i = \frac{d_i^{-}}{d_i^{+} + d_i^{-}}, j = 1, \dots, m \tag{7}$$

Step 6: Ranking of alternatives: the closer the CC_i is to unity, the higher the priority of the *i*th alternative.

All the criteria are judged as benefit criteria, because all the portfolio-formation variables are designed so that the higher values are more desirable than the lower values in

Publication III where TOPSIS is implemented. Moreover, each sub-criterion is given equal weight in Eq. (4) (i.e., $w_j = 1, \forall j$).

The Analytic Hierarchy Process (AHP)

The AHP developed by Saaty (1977) is a multicriteria decision-making method that employs a procedure of multiple comparisons to rank alternative solutions to a multicriteria decision problem. Basically, it provides a set of tools first to evaluate the mutual importance of given criteria, usually located at the different levels of a hierarchical tree-based structure, then to compare the alternatives to each criterion located at the bottom level of the hierarchy, and finally, to synthesize the results into one total ranking of alternatives.

The basic assumption in the AHP is that pairwise comparisons between criteria (or alternatives) on a ratio scale are carried out so that, for instance, the expression "*x_h is twice better than x_k*" means that the score of x_h is two times higher than the score of x_k. To avoid ranking paradoxes in the AHP stemming from negative values, all the single criteria values are first scaled at each portfolio-formation point to positive values with the upper limit in unity. Next, pairwise comparisons within each of the single criteria are done by calculating the ratios of these scaled values for each possible pair of the two alternatives x_h/x_k, where x_h and x_k represent the scaled ranking variables of the companies h and k at each portfolio-formation point. Otherwise, the AHP procedure used in this study is similar to Saaty (1977).

Assuming, for instance, that given the set $\{x_1,\dots, x_m\}$ of alternatives we want to provide a rank order to achieve a predetermined goal, the pairwise comparisons are carried out with respect to the given goal and the outcomes are recorded in a matrix. The weights in the AHP denoted by $w_1,\dots,w_m$ ($w_i > 0$, $w_1+\dots+w_m = 1$) representing the ranking scores of alternatives are determined using the eigenvalue method.

The procedure is settled as follows: from each of the criteria, a comparison matrix, also known as reciprocal matrix $C = [c_{ij}]$, is constructed. The largest eigenvalues and corresponding eigenvectors are then computed from the reciprocal matrices. In brief, the procedure is as follows:

1) Compute normalized relative weight: $\tilde{R}_{ij} = \frac{c_{ij}}{\sum_{i=1}^{n} c_{ij}}$

2) Calculate weight $\widetilde{W}_i$: $\widetilde{W}_i = \sum_{j=1}^{n} \tilde{R}_{ij}$

3) Normalize weight W_i: $W_i = \frac{\widetilde{W}_i}{\sum_{i=1}^{n} \widetilde{W}_i}$

4) Compute the approximation of the largest eigenvalue $\lambda_{max} = \frac{1}{n} \sum_{i=1}^{n} \frac{(CW)_i}{W_i}$

The additive Data Envelopment Analysis (additive DEA)

Data Envelopment Analysis (DEA) is a mathematical programming method used for measuring the relative efficiencies of a homogenous set of decision-making units. The main advantage of DEA is its ability to combine the multiple outputs and inputs of an entity into a single efficiency score that indicates the relation between them. However, most DEA models are constrained in the sense that they assume that each output or input variable must have the same sign. In this dissertation, a DEA variant that does not have such a restriction is tested. Whereas in the traditional BCC DEA model[45] a decision-maker has to make a choice between output- or input-orientation, depending on whether she aims at reducing the inputs while keeping the present output levels or maximizing the outputs while keeping the present input levels, the additive DEA model introduced by Charnes, Cooper, Golany, Seiford, and Stutz (1985) can cope with both orientations simultaneously.

Unlike the previously introduced MCDM methods that take the ratio-type variables as given, DEA is based on forming the ratios of all possible combinations of separate output and input variables, where the numerators of the valuation ratios examined are used as output variables and the denominators as input variables. For example, the *book*-to-*price* ratio employs *book value of equity* as an output variable and *market value of equity* as an input variable. In the case of n alternatives (companies, in this particular case) with m_1 outputs, denoted by y_{rk} ($r=1,\dots,m_1$) and m_2 inputs denoted by x_{ik} ($i=1,\dots,m_2$), the additive DEA efficiency score h for k^{th} company can be computed as follows:

[45] The BCC DEA model was introduced by Banker, Charnes, and Cooper (1984).

$$h_k = \max \sum_{i=1}^{m_2} s_i^- + \sum_{r=1}^{m_1} s_r^+ \tag{8}$$

subject to

$$\sum_{k=1}^{n} \lambda_k x_{ik} + s_i^- = x_{i0}, \quad i = 1, \dots, m_2$$

$$\sum_{k=1}^{n} \lambda_k y_{rk} - s_r^+ = y_{r0}, \quad r = 1, \dots, m_1$$

$$\sum_{k=1}^{n} \lambda_k = 1$$

$$\lambda_k, s_i^-, s_r^+ \geq 0, \quad \forall k, i, r$$

where λ_k refers to the weights, and s_i^- and s_r^+ refer to the sums of the horizontal and vertical distances from the efficient DEA frontier, respectively.

3.3.3 **Performance measures**

The performance of pricing anomalies is primarily evaluated based on the average return and the Sharpe ratio (Sharpe 1966) by employing monthly time-series of quantile portfolios. In order to avoid validity problems stemming from the negative excess returns in the context of the Sharpe ratio comparisons, a refined version of the Sharpe ratio introduced by Israelsen (2005) is used as follows:

$$SR = \frac{r_i - r_f}{\sigma_i^{(ER/|ER|)}} \tag{9}$$

where r_i = the average monthly return of a portfolio i

r_f = the average monthly risk-free rate of the return

σ_i = the standard deviation of the monthly excess returns of a portfolio i

ER = the average excess return of portfolio i.

The thesis also employs a closely-related skewness- and kurtosis-adjusted Sharpe ratio (SKASR) as a supplementary total risk-adjusted performance measure. As introduced in Pätäri (2011), the SKASR measure can be presented as follows:

$$SR = \frac{r_i - r_f}{SKAD_i^{(ER/|ER|)}} \tag{10}$$

where $SKAD_i$ refers to the skewness- and kurtosis-adjusted deviation of the monthly excess returns of a portfolio i.

The thesis employs several multi-factor models to evaluate potential abnormal returns. The primary regression equations are as follows:

$$r_{it} - r_{ft} = \alpha_i + b_i MKT_t + s_i SMB_t + \varepsilon_{it} \tag{11}$$

$$r_{it} - r_{ft} = \alpha_i + b_i MKT_t + s_i SMB_t + h_i HML_t + m_i WML_t + \varepsilon_{it} \tag{12}$$

$$r_{it} - r_{ft} = \alpha_i + b_i MKT_t + s_i SMB_t + h_i HML_t + m_i WML_t + v_i SMV_t + \varepsilon_{it} \tag{13}$$

where r_{it} = the return of a portfolio *i*

r_{ft} = the risk-free rate of return

α_i = the multi-factor alpha of portfolio *i* (the abnormal return over and above what might be expected based on the multi-factor model employed)

r_{mt} = the stock market return[46]

MKT_t = the return of the market factor (i.e., the return difference between r_{mt} and r_{ft})

SMB_t = the return of the size factor (i.e., the return difference between small- and large-cap portfolios)

HML_t = the return of the book-to-market (B/P) factor (i.e., the return difference between high- and low-B/P portfolios)

WML_t = the return of the momentum factor (i.e., the return difference between winner and loser stock portfolios)

[46] The thesis uses the sample average return instead of the value-weighted stock market return employed in the standard Fama-French factor models because the former is a more valid proxy for the market portfolio return in cases where the left-hand side portfolios are equal-weighted. This also makes the multi-factor alphas more comparable to the total risk-based performance metrics, because the significance levels for outperformance/underperformance based on the latter are calculated against the equal-weighted time-series of sample average returns.

SMV_t = the return of the volatility factor (i.e., the return difference between low- and high-volatility (stable and volatile) portfolios)

b_i, s_i, h_i, m_i, *and* v_i are factor sensitivities to MKT, SMB, HML, WML, and SMV factors, respectively.

ε_{it} = the residual term.

Eq. (11) corresponds to the Fama-French three-factor model, whereas Eq. (12) represents the Carhart four-factor model. Motivated by Clarke, de Silva, and Thorley (2010, 2014), the volatility (SMV) factor is added as the fifth factor in Eq. (13) beside the factors included in the Carhart 4-factor model.

The thesis also implements several statistical tests and adjustment in order to evaluate the results. The statistical significances of the differences between comparable pairs of total risk-adjusted returns are given by the *p*-values of the Ledoit-Wolf (2008) test. The thesis also tests the significance of multi-factor alphas based on their *t*-statistic, which is closely related to the Treynor-Black (1973) multifactor appraisal ratio, also known as the information ratio (see, e.g., Lewellen 2010). Following Kosowski, Naik, and Teo (2007), the thesis tests the statistical significance for the difference between the top- and bottom-decile portfolio alphas. The monotonicity of the returns as well as alphas is investigated by the monotonic relation (MR) test of Patton and Timmermann (2010). The Gibbons, Ross, and Shanken (1989) test statistic is also calculated for the alphas. In order to avoid problems related to autocorrelation and heteroscedasticity, the thesis employs Newey-West (1987) standard errors in the statistical tests. Finally, the thesis also carries out Jarque and Bera's (1980) normality test for regression residuals and a test for the existence of multicollinearity in the multifactor regression models.

4 Summary of the Publications

4.1 Publication I: Can size-, industry-, and leverage-adjustment of valuation ratios benefit the value investor?

Publication I introduces a new and innovative methodology for value portfolio selection employing a comprehensive sample of Finnish data obtained from DataStream and supplemented with the price data of OMX Helsinki and the companies' financial statements, covering the period 1996–2013. Motivated by the findings of Anderson and Brooks (2006) and Novy-Marx (2011), Publication I suggests a simple method that adjusts conventional valuation ratios (i.e., E/P, B/P, S/P, and EBIT/EV) for firm size, industry classification, and financial leverage. The study also introduces a new method to make the valuation scores additive, which allows for combining size-, industry-, and leverage-adjusted valuation ratios with each other, as well as with the full sample-adjusted valuation ratios.

The sample stocks are ranked on the basis of conventional valuation ratios or relative valuation scores at annual frequency. To generate valuation scores, valuation ratios are harmonized by calculating first the full sample median E/P ratios at each portfolio-formation point (i.e., at the end of April each year). Second, other valuation ratios at the same moment are scaled by multiplying them with the absolute value of the ratio of the full sample median E/P and the corresponding median of the valuation ratio being harmonized. Finally, size-, industry- and leverage-adjusted valuation ratios are calculated by subtracting the median of each valuation ratio calculated over the companies within the corresponding size, industry or leverage cluster from the corresponding firm-specific valuation ratios. This methodology generates size-, industry-, and leverage-adjusted valuation ratios for E/P, B/P, S/P, and EBIT/EV ratios. The stocks are then divided into equal-weighted tercile portfolios based on the relative valuation scores. The performance of these portfolios is evaluated based on the average return, the Sharpe ratio, the skewness- and kurtosis-adjusted Sharpe ratio (SKASR), and a two-factor model including the market (MKT) factor and the size (SMB) factor.

The results of this paper show that the price-based valuation ratios (i.e., B/P, E/P, and S/P) have not been very efficient in separating undervalued stocks from their overvalued counterparts in the Finnish stock market over the 17-year sample period from May 1996 to April 2013. Instead, less frequently used EBIT/EV ratio proved to be the most successful individual valuation ratio for equity portfolio selection. In addition, the results show that the added-value of size-, industry- and leverage-adjustment depends on the valuation ratio being adjusted, providing the greatest benefits for the E/P ratios, and the smallest for the EBIT/EV ratios. After harmonizing the size-, industry-, and leverage-adjusted valuation ratios, the methodology also allows for combining the resulting valuation scores into composite selection criteria. The evidence shows that combining several dimensions of relative value and several peer-group comparisons would have paid off to value investors in the Finnish stock market. The division of the full 17-year sample period into bullish and bearish periods demonstrates that the success of the value portfolios mainly results from their outperformance during the bearish periods (i.e., less losses compared to the market portfolio or to the corresponding glamour portfolios), in line with the previous studies. Moreover, composite criteria seem to offer better downside protection during the bearish conditions than provided by any individual valuation criterion.

4.2 Publication II: The dirty dozen of valuation ratios: Is one better than another?

Publication II compares the efficacy of 12 individual valuation ratios, as well as that of an extensive set of related combination criteria, in identifying the future best-performing stocks for a comprehensive U.S. sample over the 1971–2013 period. The set of 12 individual valuations ratios consists of eight price-based ratios (i.e., B/P, CF1/P, CF2/P, CF3/P, CFO/P, D/P, E/P, and S/P) and four EV-based multiples (i.e., EBIT/EV, EBITDA/EV, FCF/EV, and S/EV). The use of the EV-based multiples is motivated by encouraging results of few studies (see, e.g., Loughran and Wellman 2011; Gray and Vogel 2012; Walkshäusl and Lobe 2015; Pätäri et al. 2016), with the exception of S/EV that has not been examined before in this context. Because the evidence for a good discriminatory power of EV multiples in detecting under- and/or overvalued stocks is quite recent, they may offer higher anomalous returns than price-based multiples, for which the documented history of anomalous returns is much longer (see, e.g., McLean and Pontiff 2016; Pätäri and Leivo 2017). In addition, leverage is only implicitly included in price-based multiples, whereas it has direct influence on EV multiples.

The equal-weighted portfolios are formed on sorting the valuation ratios based on year $t-1$ financial statement data in decile portfolios at the end of April of year t and held for one year from May of year *t* through April of year *t* + 1. In addition to the comparison of 12 individual valuation ratios, Publication II also analyzes 2-, 3-, and 4-combinations of them by calculating the corresponding median-scaled composite measures for each combination analogous to Dhatt et al. (2004).[47] The stocks with the highest valuation ratios or the highest median-scaled composite measures are placed into the top-decile portfolios, whereas the bottom deciles consist of the stocks with the lowest ratios or the lowest median-scaled measures. The performance of the portfolios is mainly evaluated based on the average raw return, the Sharpe ratio, and a five-factor model including the market (MKT), size (SMB), value (HML), momentum (WML), and volatility (SMV) factors.

The results on the discriminatory power of the 12 individual valuation ratios support the use of EBIT/EV, EBITDA/EV, and S/EV as a value indicator instead of the most frequently used price-based multiples, such as B/P and E/P. In addition, the results show that value portfolios formed on different criteria have remarkably different exposures to size, value, momentum, and volatility factors. As a practical implication of this study, investors could take into account these different style exposures when choosing the value criteria that fit best to their portfolio-selection purposes. Especially the unique characteristic of S/EV contributes to the existing literature that has not yet examined S/EV as a stand-alone criterion in value investing context. More specifically, the top-decile S/EV portfolio has some characteristics that are typical for a momentum strategy implying that S/EV is a good supplementary valuation criterion for a value investor who is not willing to construct a value-momentum combination criterion, but would like to have momentum-type characteristics embedded in the composite value criterion. The D/P value portfolio, in turn, is among the worst-performing value portfolios in raw return comparisons, but it is the best overall decile portfolio in terms of total-risk adjusted returns, representing a low-risk strategy and offering the best protection against declining stock prices among all the examined long-only decile portfolios.

Based on the efficacy comparisons of median-scaled combination criteria, a defensive characteristic of high D/P stocks extends to such combinations in which D/P is included as one sub-criterion. Based on the median-scaling method, the added value of forming combinations within the value dimension is limited and, in many cases, non-existent at least for this particular sample data. The potential benefits of combining individual valuation ratios have not been examined extensively in the U.S. market prior to

[47] Median-scaling method first standardizes each individual valuation ratio for a firm in a given year by its cross-sectional median at the same time point and then computes the average of these median-scaled scores for each combination. For example, if B/P for a firm in a given year is 0.9 and the median B/P for the sample is 0.6, then the median-scaled B/P for that firm is 1.5.

Publication II, although the subject have been foreseen in a few recent academic papers (see, e.g., Israel and Moskowitz 2013; Asness, Ilmanen, Israel, and Moskowitz 2015).

4.3 Publication III: Comparison of the multicriteria decision-making methods for equity portfolio selection: The U.S. evidence

Publication III serves as a sequel to Publication II, focusing particularly on the combination benefits provided by four different MCDM methods: median-scaling (MS), the Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS), the Analytic Hierarchy Process (AHP), and the additive Data Envelopment Analysis (additive DEA). By using the same 12 valuation ratios augmented with a price momentum indicator as constituent variables, a large number of combination criteria, totalling 1 924 combinations, is formed on the basis of the four above-mentioned MCDM methods. Because some valuation ratios are close proxies for each other, the number of potential combinations was restricted so that only one of earnings or cash flow variables included in price-based multiples (i.e., earnings, CF1, CF2, CF3, or CFO) and one of the corresponding variables included in EV multiples (i.e., EBIT, EBITDA, or FCF) at a time can occur in the combination comparisons.

The results show that the MCDM methods are applicable for combining value and momentum indicators into a single efficiency score. For other combination methods than median-scaling, the average performance statistics of the top-decile stock portfolios improve when moving from 2-combinations to 3-combinations, and further, from 3-combinations to 4-combinations, indicating that the combination benefits increase with the number of variables included in the combinations. The discriminatory power of the AHP- and TOPSIS-based combinations is somewhat better than that of the MS- and additive DEA-based combinations. Although the best variable combinations vary, there is some consistency in what variables are most commonly included in the best combination strategies. Evidence for the inclusion of D/P to reduce portfolio risk and to enhance the total risk-adjusted portfolio performance is found. Furthermore, the benefits from the inclusion of one or more EV multiple(s) are also evident in most cases, as are the benefits of including a momentum indicator. Overall, the results show that the MCDM methods examined in this paper can successfully be applied to equity portfolio selection in the most developed and efficient stock markets, i.e., in the U.S. stock markets. However, the comparison of the best combination criteria within each MCDM method reveal that the use of different MCDM methods seems to result in different style exposures. As a practical implication, equity investors following a certain investing style could take advantage of the different style exposures to market, size, value, and momentum factors of stock portfolios provided by different MCDM methods.

4.4 Publication IV: Anomaly interactions and the cross-section of stock returns

Publication IV offers new evidence on anomaly interactions and the cross-section of stock returns in the universe of all-but microcap U.S. stocks by employing a research design that aims to provide a coherent picture of five prominent pricing anomalies documented in the current financial literature. In the spirit of the five-factor model of Fama and French (2015), the pairwise interrelations of four anomaly variables representing the size, value, profitability, and investment/asset growth anomalies supplemented by a momentum variable are analyzed. Hence, this study examines five distinct anomalies that are well documented, yet lacking of unified frame to evaluate, which of them is the most influential after controlling for the others.

This paper employs 5x5 conditional/sequential double-sorting technique similar to Sagi and Seasholes (2007). The first-stage sorting determines which dimension is fixed, whereas the second-stage sorting exhibits the stock returns with respect to the secondary variable conditional on being in the predetermined quintile portfolio. As a result, the portfolios are fully comparable in size as each portfolio contains an equal number of firms (or the closest possible number if the sample/quintile is not divisible by five) in a given year. The interrelation between each pair of anomaly variables is primarily evaluated based on the monotonic relation (MR) test of Patton and Timmermann (2010). With the MR test it is possible to get a more comprehensive picture of anomalous return patterns than would be possible based on a standard *t*-test, which relies on the high minus low return of the extreme portfolios and is therefore unable to determine any deviations from the hypothesized return patterns across the intervening portfolios. In addition to the 5x5 portfolio sorts, annual Fama-MacBeth (1973) style regressions are used in order to draw inferences about which anomaly variables show marginal explanatory power in the presence of the others.

Overall results of Publication IV show that investment/asset growth and momentum dimensions capture the cross-sectional return patterns better than size, value, or profitability. Among all 5x5 portfolio sorts, the highest average return of 17.79 % p.a. is generated by recent winners with the lowest asset growth rate. The positive effect of momentum and negative effect of investment/asset growth on future stock returns is evident based on not only the 5x5 conditional double-sort portfolios, but also on the basis of Fama-MacBeth style regressions. The robustness of the asset growth anomaly is consistent with Cooper et al. (2008) and Lipson et al. (2011) but the cross-sectional return-relation of the momentum anomaly in the non-microcap stock universe is stronger than reported by Cooper et al. (2008) and Penman and Zhu (2014) for the full market-cap universe of the U.S. stocks.

In addition, the results shed light on the current literature on the anomaly interactions by providing an explanation to the relative weakness of the profitability (ROA) anomaly. Profitable firms seem to be prone to exaggerated growth expectations in terms of both value and investment/asset growth dimensions. Consequently, investors get disappointed as mean reversion of growth takes place, consistent with the behavioral view.

4.5 Limitations

This doctoral thesis has some limitations that are mostly associated with research design. First, the thesis does not include transaction costs because their level is investor and trade-specific (see, e.g., Keim and Madhavan 1997; Frazzini, Israel, and Moskowitz 2015). Excluding transaction costs in line with the most studies in the current financial literature creates a small upward bias in the real-world performance statistics of the stock portfolios, but recent evidence suggests that such a bias should be marginal for low-turnover strategies like those examined throughout this doctoral thesis (see, e.g., Frazzini et al. 2015; Novy-Marx and Velikov 2016), as all the portfolios are updated and rebalanced only once a year. Moreover, many stocks remain in the same portfolio after the annual reformation, and in such cases, an investor would need to execute only the rebalancing trades. The inclusion of transaction costs would slightly decrease the statistical significance of the outperformance of the best portfolios while increasing the significance of the underperformance of the worst. Considering transaction costs can affect the relative performance of the portfolios that have remarkably different trading costs resulting from differences in their market-cap exposures (see, e.g., Chiyachantana, Jain, Jiang, and Wood 2004).

Second, the stocks were equally-weighted at annual portfolio-formation points throughout the thesis. The weight changes stemming from return difference during the one-year holding periods were taken into account in the calculation of the monthly time-series returns of the sort portfolios. Equal-weighting was chosen instead of value-weighting because of the former is more realistic from the viewpoint of practical portfolio management. However, portfolio sorts can suffer from equal-weight approach, and hence, cause an unrepresentative picture of anomalous patterns, if sample selection is not carefully considered. Stocks with market capitalization below the 20th NYSE percentile breakpoint (i.e., microcaps as defined by Fama and French (2008)) are typically overrepresented in the extreme equal-weight sort portfolios. If anomalous returns are limited to these illiquid microcaps, equity investors are unlikely to be successful in realizing strategies based on the observed return patterns because of the high trading costs associated with such stocks (see, e.g., Chiyachantana et al. 2004). On the other hand, value-weighting is likely to cause an opposite bias in extreme sort portfolios as the results are easily driven by a few big stocks. This thesis addresses the potential problems by restricting the sample of Publications II and III to those firms with a market cap above the 10th NYSE percentile breakpoint (see, e.g., Jegadeesh and Titman 2001; Avramov et al. 2007) and the sample of Publication IV to those firms with a market cap above the 20th NYSE percentile breakpoint (see, e.g., Chen et al. 2001; Nyberg and Pöyry 2014). However, the value-weighted returns could have yielded in different results, although an additional robustness check for the sample of the largest 40th NYSE market-cap stocks in Publication III showed no remarkable differences between the two samples.

Third, the MCDM methods employed in this doctoral thesis consist of relatively simple variations of applicable methodologies in creating combination strategies for stock portfolios. The combination benefits could have been better captured by more sophisticated or simpler portfolio-formation approach. For example, Israel and Moskowitz (2013) employ simple average rankings of several individual valuation ratios, whereas outranking techniques such as the PROMETHEE (see, e.g., Albadvi, Chaharsooghi, and Esfahanipour 2007) and the ELECTRE Tri (see, e.g., Huck 2009) have also been used in the context of equity portfolio selection.

Fourth, the results of this thesis are based on a simple back-testing approach in line with the research design commonly used in the financial literature. Although many sub-period tests show consistency in the relative performance of individual portfolio-formation criteria and related combination criteria, the results do not imply that the same would hold also in the future. A comprehensive out-of-sample test would provide an interesting topic for further research, although the results would also be specific to the sample period.

Fifth, the added value of forming combinations with the MCDM methods seemed to be greater when the anomaly variables included more than one dimension. That is, the inclusion of a momentum indicator besides value measures seemed to offer attractive combination benefits for an equity investor. It is possible that combining other anomaly dimensions, such as investment/asset growth, profitability, and size examined in Publication IV, could enhance the portfolio performance even more. That would be an interesting subject for further research.

5 Conclusions

The objective of this doctoral thesis is to examine efficacy of anomaly-based equity trading strategies in the Finnish and the U.S stock markets. Overall, the results of this thesis show that both of the examined stock markets have offered interesting trading opportunities for the investors who have based their investment decisions on systematic trading strategies. By comparing the discriminatory power of a comprehensive set of anomaly-based trading strategies, as well as the interrelations of the examined anomalies, the research approach is pragmatically oriented pursuing to serve portfolio practitioners' purposes as well. The main idea of the thesis is to execute in-depth analysis of a selected set of pricing anomalies, and further, to investigate the benefits of combining them by means of multicriteria decision-making (MCDM) methods. The main focus of the publications included in this thesis is on different manifestations of value anomalies, but the momentum, size, profitability, and investment anomalies are also examined. This thesis contributes to the existing literature by showing that equity investors can benefit from applying MCDM methods in their portfolio selection.

The aggregate results of this thesis give strong evidence for the value premium, which cannot be explained by conventional style factors. Based on overall evidence of the dissertation, value portfolios have significantly outperformed both the market portfolio and comparable glamour portfolios. The results show further that the risk-adjusted performance of value portfolios can be somewhat enhanced by basing portfolio-selection criteria on composite value measures. However, remarkable efficacy differences between the individual valuation ratios both in the Finnish and the U.S. stock markets exist. With many respects, the most traditional and frequently-used individual valuation ratios, such as B/P and E/P, are dominated by multiples based on enterprise value (EV). The evidence from the Finnish stocks shows superiority of EBIT/EV over three price-based value multiples (i.e., B/P, E/P, and S/P), whereas the evidence for a larger variable set for a comprehensive sample of U.S. stocks finds support for EBIT/EV, EBITDA/EV, and S/EV. In particular, the evidence for the unique characteristics of S/EV contributes to the existing literature. In general, the superiority of EV-based valuation ratios, for which the documented history of academic research is quite recent compared to the more traditional price-based value measures, is in line with Chordia, Subrahmanyam, and Tong (2014), McLean and Pontiff (2016), and Jones and Pomorski (2017) who all conclude that pricing anomalies tend to attenuate after their publication.

Moreover, combining individual anomaly variables into single efficiency scores with the MCDM methods can add value to equity investors based on the finding that, in general, the discriminatory power of higher level combinations tends to be higher than that of lower level combinations. Although the best variable combinations vary, there is some consistency in what variables are most commonly included in the best combination strategies. For example, including one or more EV-based multiple(s) and/or a momentum indicator in combination strategies improves the average discriminatory power of the related investing strategies. In addition, a tendency of high dividend yield stocks to reduce portfolio risk and enhance the total risk-adjusted returns is pervasive, as the low-volatility characteristic of high D/P stocks tends to extend to the combination criteria in which D/P is included as one sub-criterion. Therefore, such combination criteria can reduce downside risk faced by investors during the periods of market turmoil. In addition, the overall results of this thesis show that different MCDM methods treat the anomalous variables differently so that equity investors following certain investing styles could take advantage of the different style factor exposures of the resulting portfolios when choosing the portfolio-formation criteria that best suit their investing styles.

The findings of this thesis are useful for both academics and portfolio practitioners who are interested in enhancing performance of their equity portfolios in terms of raw returns and/or risk-adjusted returns. Altogether, the results give interesting insights to trading opportunities in two different national stock markets and provide many useful implications for both unidimensional, as well as for multidimensional portfolio management.

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PART B: PUBLICATIONS

Publication I

Pätäri, E. J., Karell, V., and Luukka, P.
Can size-, industry-, and leverage-adjustment of valuation ratios benefit the value investor?

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Publication II

Pätäri, E. J., Karell, V., Luukka, P., and Yeomans, J. S.
The dirty dozen of valuation ratios: Is one better than another?

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Vol. 16, pp. 1-34, 2018

Publication III

Pätäri, E. J., Karell, V., Luukka, P., and Yeomans, J. S.
Comparison of the multicriteria decision-making methods for equity portfolio selection: The U.S. evidence

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Publication IV

Karell, V., and Yeomans, J. S.
Anomaly interactions and the cross-section of stock returns

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