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Valuation of Companies in the Technological industry of Emerging Markets

Master's thesis

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Declaration of Authorship

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Prague, August 1, 2023

Peter Palovič

Abstract

This thesis aims to examine the relationship between various asset pricing factors and the returns of IT stocks in the CEE region. Specifically, it investigates the significance of traditional CAPM beta, MMR (Micro Minus Rest), and ITMR (IT Minus Rest) as potential risk factors in explaining the variations in IT stocks' returns. To achieve this objective, we employed Fama-MacBeth two-stage regression analysis over a dataset comprising monthly returns of 50 CEE IT companies from February 2011 to June 2023. The results of our analysis reveal that there is no statistically significant relationship between the proposed factors and the returns of IT stocks. Thus, there is no evidence that these factors possess explanatory power in the cross-sections of IT stocks' returns in the CEE region. To ensure the robustness of our findings, we applied both univariate and multivariate asset pricing models. Overall, our study does not support the notion that the investigated factors are significant risk factors for the IT sector in the CEE region, as they fail to predict the variations in IT stocks' returns.

JEL Classification	G12, G14, G15
Keywords	Size premium, Emerging markets, CAPM, Fama-MacBeth regression, Asset pricing
Title	Valuation of Companies in the Technological industry of Emerging Markets

Abstrakt

Táto práca sa zaoberá skúmaním vzťahu medzi rôznymi faktormi a výnosmi akcií IT spoločností v stredoeurópskom regióne. Konkrétne sa skúma význam tradičnej CAPM bety, MMR (Micro Minus Rest) a ITMR (IT Minus Rest) ako potenciálnych rizikových faktorov pri vysvetľovaní variácií výnosov akcií IT spoločností. Za účelom dosiahnutia tohto cieľa sme použili Fama-MacBethovu dvojstupňovú regresnú analýzu na množine dát obsahujúcej mesačné výnosy 50 CEE IT spoločností od februára 2011 do júna 2023. Výsledky nášho výskumu ukazujú, že neexistuje štatisticky významný vzťah medzi navrhovanými faktormi a výnosmi akcií IT spoločností. Teda neexistujú dôkazy, ktoré by potvrdzovali, že tieto faktory majú vysvetľovaciu silu pre výnosy akcií IT spoločností v stredoeurópskom regióne. Pre overenie robustnosti našich záverov sme použili jednorozmerné a viacrozmerné modely. Celkovo náš výskum nepotvrdzuje tvrdenie, že skúmané faktory sú významnými rizikovými faktormi pre IT sektor v stredoeurópskom regióne, pretože nepredpovedajú variácie výnosov akcií IT spoločností.

Klasifikace JEL	G12, G14, G15
Klíčová slova	Veľkostné prémium, Rozvijajúce sa trhy, CAPM, Fama-MacBeth regresia, Oceňovanie aktív
Název práce	Ocenění společností v technologickém sektoru rozvíjejících trhů

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Acronyms

B/P	Book-to-Price
CAPM	Capital Asset Pricing Model
CEE	Central and Eastern Europe
CF/P	Cash flow-to-Price
EUR	Euros
E/P	Earnings-to-Price
HAC	Heteroskedasticity and Autocorrelation Consistent
HML	High Minus Low
IT	Information Technology
ITMR	Information Technology Minus Rest
MKT	Market
MMR	Micro Minus Rest
MPT	Modern Portfolio Theory
NYSE	New York Stock Exchange
OLS	Ordinary Least Squares
RF	Risk-free
SMB	Small Minus Big

Master's Thesis Proposal

Author	Bc. Peter Palovič
Supervisor	Mgr. Petr Polák, Msc., Ph.D.
Proposed topic	Valuation of Companies in the Technological industry of Emerging Markets

Motivation In corporate finance, the estimation of the target price of the company that is traded on a stock exchange is the core for the equity analysts and investment bankers. Each analysts use different assumptions and have different expectations about the price that the company should have now or later in the future.

The stocks are divided into 2 typical categories: Growth and Value stocks. Growth stocks are those companies that are considered to have the potential to outperform the overall market. Value stocks are those companies which are trading below what they should be worth and should provide the superior return. In our thesis, we will look at the technological firms, that are the part of the growth stocks.

There are a lot of studies that are exploring the valuation techniques that are most suitable for the valuation of the technological companies (Lie & Lie, 2002; Bhojraj & Lee, 2002; Fernandez, 2013). There are various preferred methods of stock valuation among the equity analysts. In our thesis, we will focus on intrinsic valuation determined by Discounted Cash-flow Model. The intrinsic valuation is based on the assumptions that analyst prepares to get the free cash-flow. This free cash-flow is then discounted, using the appropriate discount rate (Pratt, 2002). One of the discount rate factors is the systemic risk represented by beta. To estimate beta, there are plenty of models. The most popular is CAPM model that is used by more than 90% of financial professionals (Jacobs and Shivdasani, 2012). Although it is mostly widely used, it describes the risk incompletely according to some studies (Stout, L. A., 2002; Pinto et al., 2009).

The aim is to find a superior model to CAPM which might be used by the financial analysts. The comparison of the results should provide us with the answer whether there is more explanatory power in our proposed model compared to CAPM. We will empirically examine the predictive power of the model on a dataset of the CEE technological companies which was not done before us.

Hypotheses

Hypothesis #1: The size is a significant factor in estimating value of the company.

Hypothesis #2: The proposed model performs better than the traditional CAPM model for technological companies in emerging markets.

Hypothesis #3: Is there additional premium on size covered by dataset and the results?

Methodology Firstly, we need to construct the dataset of the technological companies from the Emerging Markets. We will take the indices from CEE to gather the relevant data. We will describe the price, the profitability and the size of the companies and create the relevant samples based on the size and profitability. To test our hypotheses, we will employ Fama-MacBeth methodology (Fama & MacBeth, 1973) to find out whether the size is a significant factor in predicting the future price. We will also include the comparison of the results between the CAPM and our new model adjusted for size. After obtaining the results, we will interpret the results and link it to the existing literature. Moreover, we will try to use several robustness checks – using different data samples based on the size of the companies provided in the dataset to see some improvements or patterns.

Expected Contribution There are ongoing debates between the academics and investment bankers about the valuation techniques one should use. In most of the cases, it is a discounted cash-flow model in which we need to find the appropriate discount rate (Cost of equity). One of the items in COE is the riskiness of the company relative to the market (Beta), (Koller et al. 2010). There are a plenty of models that estimate this risk but only one is widely used by the professionals. It is a CAPM model. However, despite the ease of use, a false investment decision can be easily made since it captures the risk incompletely (Pinto et al., 2009).

In this thesis, we should follow the work named Valuing emerging markets companies: New approaches to determine the effective exposure to country risk (Roggi et al., 2017). They developed a new approach to the effective exposure of a country risk in the cost of equity of the company. I would like to add the size factor to the model and empirically examine whether the size component is significant in the valuation of the technological companies since these companies are called the growth companies. We will also provide a comparison with the CAPM model (not adjusted for size and country premium) to know whether our model performs better and provides more reliable picture on the companies' expected returns.

This is unique opportunity to find a new comparable model and approach for calculation of COE on the sample of CEE technological companies. We would like to find out a predictive power of the model and whether it describes the expected returns well and should be used by the financial analysts in the future.

Outline

1. Introduction – I will introduce the topic and provide my motivation and contribution to the thesis.

2. Literature review – I will concisely describe existing literature on the topic, and will interpret the main results of the published research.

3. Data – This section will describe the process of collection of the data. The obtained dataset will be described, and summary statistics will be presented.

4. Methodology – I will describe the methods used to perform an empirical analysis. This section will include all of the theoretical models, I will use.

5. Results – I will present the obtained results, provide their interpretation and try to link them to existing literature.

6. Conclusion – In this section I will summarize the thesis, provide the possible valuation techniques that are significant based on the results of empirical analysis and I will point out any potential drawbacks and limitations. Additionally, possible topics for further research will be mentioned.

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Chapter 1

Introduction

The accurate estimation of the cost of equity is essential for effectively predicting asset returns. The choice of an appropriate asset-pricing model plays a crucial role in achieving reliable predictions for investors. Among the asset-pricing models, The Capital Asset Pricing Model (CAPM), introduced by Sharpe (1964) and Lintner (1965), has been a prominent choice in the financial industry. CAPM is a one-factor model that establishes a relationship between individual asset returns and the market factor (beta). However, extensive research on CAPM has indicated its limitations in predicting asset returns (Fama & French (1993), and others). As a result, alternative models that incorporate additional factors have been explored to enhance the predictive power of asset-pricing models.

The asset pricing literature has predominantly focused on developed markets, leaving a limited number of studies exploring Emerging and frontier markets, particularly in the Central and Eastern European (CEE) region. This presents a valuable opportunity to investigate the cross-sections of stock returns in the CEE region, given the increasing significance of these markets for investment professionals. One of the initial studies conducted for the CEE region was carried out by Barry *et al.* (2002), which revealed that the market factor alone is insufficient to predict excess returns in this region. Barry *et al.* (2002) incorporated value and size factors alongside market beta and found a robust value effect. Subsequent studies by Cakici *et al.* (2013), Zaremba (2015), and Zaremba & Umutlu (2018) confirmed that the market factor fails to explain the variations in stock returns. Consequently, there is a demand for new pricing factors to assess their impact on returns in the CEE region.

The primary aim of this research is to investigate the ability of different asset pricing models to explain the variability of stock returns within the Information Technology (IT) sector in the CEE region. The dataset comprises monthly returns and market capitalizations of 50 publicly-listed IT companies from the CEE region, covering the period from February 2011 to June 2023. To assess the explanatory power of the selected factors, we employed the Fama-Macbeth two-stage cross-sectional regression analysis, conducting both univariate and multivariate models for robustness check. To the best of our knowledge, this is the first study of its kind focusing on cross-sections of the stock returns for IT companies in the CEE region.

The thesis is structured as follows: Chapter 2 provides a comprehensive literature review on various asset pricing models and examines the existing evidence on asset pricing anomalies both globally and in the CEE region. In Chapter 3, we explore the Fama-Macbeth methodology introduced by Fama and MacBeth (1973) and discuss the rationale behind using rolling-windows in our analysis. Chapter 4 presents the data used in the study, its source, and discusses its characteristics through summary tables. Additionally, we outline the motivation for creating different risk factors based on the collected data. In Chapter 5, we present the empirical results of our study, providing detailed explanations of all employed models and their corresponding outcomes. We also link our findings to the existing literature. Finally, Chapter 6 serves as the conclusion to this thesis, where we summarize our results, acknowledge potential limitations of the study, and give propositions for further research that can build upon this investigation.

Chapter 2

Literature review

2.1 Asset pricing

2.1.1 Capital asset pricing model (CAPM)

Modern Portfolio Theory

The Capital Asset Pricing Model (CAPM), introduced by Markowitz in his seminal work Markowitz (1952), is a prominent framework for asset valuation. This Nobel Prize-winning paper introduces the Modern Portfolio Theory and proposes a methodology for constructing an optimal portfolio of assets based on the mean-variance rule. Prior to Markowitz, Williams (1939) put forth a theory aimed at maximizing expected returns without explicitly considering associated risks. Williams' approach relied on the assumption that expected and actual yields would converge due to the law of large numbers. In contrast, Markowitz was the first to recognize the intrinsic link between expected return and risk, highlighting a positive correlation between the two. Consequently, assets with higher levels of risk have the potential for greater returns. This insight allows investors to adjust their portfolio selection based on their risk tolerance level.

Markowitz's Modern Portfolio Theory (MPT) is based on the following assumptions (Jensen 1972):

i. Investors select portfolio at time t-1 that produces random return R at t.

ii. The quantities of all assets are given and short sales are prohibited ($X_i \geq 0$) for all i.

iii. Investors are risk-averse.

iv. Investors are not saturated (i.e. maximization of the portfolio's expected return given the variance).
v. There are no taxes.
vi. All assets are perfectly divisible and perfectly liquid, i.e. there are no transaction costs.

Markowitz employed a statistical framework by considering single-period returns as stochastic variables, enabling the assignment of expected values, variances, standard deviations, and correlations to them. These random variables can be characterized by two key statistical measures: the mean (μ_i) and variance (σ^2). By drawing upon probability theory, Markowitz derived the subsequent formulas.

The expected return of the portfolio is:

$$E_p = \sum_{i=1}^{n} x_i \mu_i \tag{2.1}$$

where E_p is the expected return of portfolio, x_i is the weight of the investor's asset which is allocated to the i^{th} security. μ_i is the expected return of the i^{th} security.

The variance of the portfolio is:

$$\sigma_p^2 = \sum_{i=1}^{n} \sum_{j=1}^{n} \sigma_{ij} x_i x_j \tag{2.2}$$

where σ_p^2 is the portfolio variance, x_i is the weight of the investor's asset which is allocated to the i^{th} security, x_j is the weight of the investor's asset which is allocated to the j^{th} security and σ_{ij} is the covariance between i^{th} and j^{th} security.

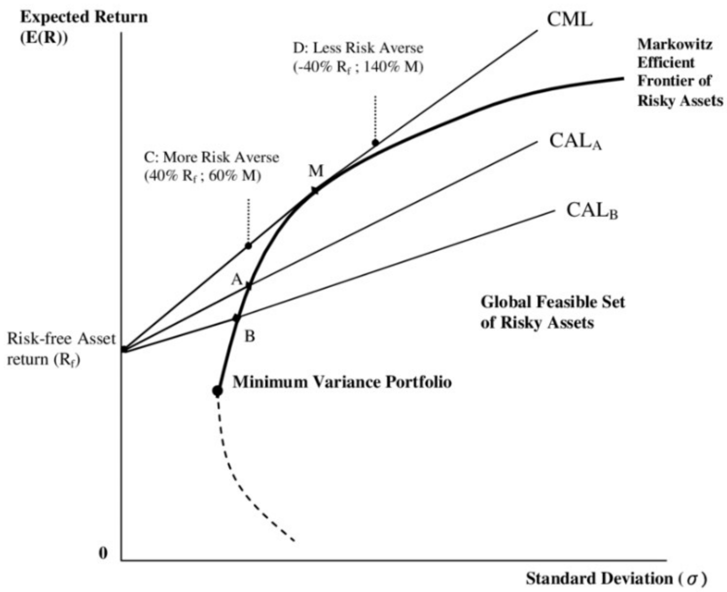
Within the framework of MPT, the concept of portfolio covariance holds significant relevance. The expression for calculating portfolio covariance is outlined as follows:

$$\sigma_{ij} = \rho_{ij} \sigma_i \sigma_j \tag{2.3}$$

In the aforementioned formula, the variable σ_{ij} represents the covariance between the i^{th} and j^{th} securities, while ρ_{ij} denotes the correlation coefficient between these securities. Furthermore, σ_i and σ_j represent the standard deviations of securities i and j, respectively. Given the imperfect correlation and the inherent volatility of the portfolio, the concept of diversification emerges as an innovative strategy. Diversification asserts that by holding different securities with returns that are imperfectly correlated, under the assumption of normal distribution of asset returns, the portfolio's volatility should be mitigated.

Within the realm of portfolio construction, the possibilities are seemingly boundless, allowing for the creation of an infinite number of portfolios. Notably, in the work of Markowitz (1959) it is argued that the most optimal portfolios can be found along the mean-variance efficient frontier. By adhering to this principle, investors can choose a portfolio from this frontier that aligns with their risk preferences, as given by their utility function, with the aim of achieving the highest anticipated return.

Figure 2.1: Markowitz's efficient portfolio



Note: The figure shows the Markowitz's efficient portfolio. The source is the work of Hodnett *et al.* (2012)

Sharpe-Lintner's CAPM

Tobin (1958) building upon the foundations laid by Markowitz (1952), extends the theoretical framework by incorporating liquidity preference into the considerations of mean and variance. This seminal contribution is commonly referred to as Tobin's Separation Theorem. In essence, this theorem asserts that investors should initially focus on constructing a portfolio that maximizes their expected return based on their individual risk tolerance. Subsequently, investors should seek an optimal combination of the risky portfolio with a risk-free asset, such as cash or bonds. Importantly, the level of risk aversion does not play a determining role when constructing the risky portfolio within the context of Tobin's Separation Theorem.

During the mid-1960s, pivotal contributions by Sharpe (1964) and Lintner (1965) revolutionized the field of asset pricing, fundamentally transforming our understanding of risk. These works introduced a groundbreaking framework that divided the total risk into two distinct components:

- systematic risk
- idiosyncratic (firm-specific) risk

Systematic risk, also referred to as non-diversifiable risk, represents a form of risk that affects the entire market or the economy. Systematic risk cannot be fully avoided. It is related to general macroeconomic conditions or a market structure. The proper example would be a business cycle, consumer inflation, or an unemployment rate.

Idiosyncratic risk encompasses risk factors that are inherently specific to individual agents within the market. The distinctive nature of this risk implies that it can be mitigated through effective diversification strategies. Unlike systematic risk, idiosyncratic risk is not priced in as it does not exhibit direct linkage to overall market conditions or factors.

In light of the aforementioned discoveries, a crucial question arises regarding the optimal approach for quantifying systematic risk. Sharpe and Lintner embarked on an initial endeavor to address this question during the mid-1960s. Their proposition was that idiosyncratic risk has no impact on asset returns. Building upon this premise, they developed a model incorporating a single factor, namely market returns, as a potential explanatory variable for asset returns. The core of their model is a linear relationship between stock returns and market returns. However, for the model to be operational, additional assumptions were necessary, supplementing the existing set of assumptions proposed by Markowitz. These additional assumptions are:

i. Perfectly efficient capital markets and perfect source of information for each participant.
ii. Existence of a risk-free asset (Rf) and no restriction on borrowing and lending at the risk-free rate.

iii. All participants should have identical subjective expectations of assets' risk and return.

Under the assumption that the joint distribution of returns is the same for all investors, a prominent strategy emerges where investors opt for a single efficient market portfolio constructed from a comprehensive range of risky assets. This portfolio is inherently diversified, encompassing a broad spectrum of investments. Consequently, investors demand a risk premium as a compensation for holding these risky assets. Mathematically, the risk can be quantified by examining the ratio of the covariance between an asset's returns and the returns of the market portfolio, relative to the variance of the market returns. Among the financial professionals and researchers, this ratio is commonly referred to as beta (β).

As previously discussed, the CAPM introduces a simple linear relationship between the returns of assets and their corresponding market betas. This model is designed to capture the systematic risk inherent in these assets. Investors, recognizing the inherent risks associated with holding such assets, expect to be compensated with higher expected returns. Sharpe and Lintner contended that the anticipated risk premium sufficiently explains the asset's returns. Building upon the aforementioned findings, the equation can be derived as follows:

$$E(R_i) = R_f + \beta_i[E(R_m) - R_f)] \tag{2.4}$$

where $E(R_i)$ is the expected return of an asset i, R_f is the risk-free rate, $E(R_m)$ is the expected market return and β_i is the asset's systematic risk, when employing a regression analysis, whereby the excess return of the asset is regressed upon the excess return of the market.

The ground-breaking papers of Sharpe and Lintner were further expanded upon by Black (1972), who introduced a modified version of the model that accommodates scenarios in which a risk-free asset is absent. He introduces so-called zero beta portfolio R_z. That might serve as a potential substitute or a proxy for the risk-free asset. This refined model is commonly referred to as the two-factor CAPM model.

Early tests

Jensen (1968) was the first to suggest that the Sharpe-Lintner CAPM model should be examined using time-series regression analysis.

$$R_{it} - R_{ft} = \alpha + \beta_{im}[E(R_{mt}) - R_{ft})] \tag{2.5}$$

In his paper, he outlined that if assets are priced fairly then the alpha term (intercept) in the regression equation should be equal to zero for each asset i. In their respective studies, Jensen *et al.* (1972) and Fama & MacBeth (1973) conducted empirical tests to examine the CAPM. A key premise of CAPM is that, under fair pricing assumptions of the assets, the alpha term in the regression equation should be zero for each asset i. These studies were testing three same hypotheses. If the market is efficient, then

1. *The expected returns for all assets are linearly related to their market betas and no other variable should have marginally explanatory power*

2. *The risk premium,* $E(R_m) - E(Rzm)$ *is positive*

3. *In the Sharpe-Lintner version of the CAPM model,* $E(Rzm)$ *is equal to risk-free rate,* R_f; Fama & French (2003).

The papers conducted by Jensen *et al.* (1972) and Fama & MacBeth (1973) focused on hypotheses 2 and 3. Hypothesis 1 was supported due to the market efficiency. The researchers rejected the third hypothesis, which means that the expected return on the market portfolio, denoted as $E(Rzm)$, is not equal to the risk-free rate, R_f. Notably, the intercept term estimated by Fama & MacBeth (1973) exhibited, on average, a higher value compared to the average risk-free rate, specifically measured by the return on a one-month Treasury Bill. These findings suggest that Black's model is more relevant in explaining asset returns.

Subsequent to these empirical examinations, concerns arose regarding the validity of Sharpe's and Lintner's CAPM, primarily due to inherent limitations in its underlying assumptions. Ross (1976) identified a fundamental issue with the CAPM, specifically related to the market portfolio, which serves as the foundation of the model. The market portfolio's efficiency in real-world scenarios was called into question due to its oversimplified assumptions and theoretical shortcomings. Consequently, the CAPM faces challenges in fully explaining the risk premium observed in stock markets, leading to instability of the model.

In their seminal paper titled "*The Cross-Section of Expected Stock Returns*," Fama & French (1992) presented an alternative perspective on asset pricing theory. The researchers went beyond the traditional reliance on the market variable (beta) and identified additional stock-related variables that play a significant role in explaining asset returns. These variables were size, book-to-market equity, earnings-price ratio, and leverage ratio. Through their analysis, Fama & French (1992) discovered that the explanatory power of market beta is comparatively weak when compared to size. Intriguingly, they observed a negative relationship between average return and size. Furthermore, the combined impact of size and the book-to-market equity ratio appears to absorb the effects of leverage and the earnings-price ratio in explaining average stock returns. These findings shed light on the intricate relationship between various stock-related variables and their impact on expected stock returns.

2.1.2 The Fama and French Three Factor Model

The usefulness and validity of the CAPM came under scrutiny, prompting researchers in the field of economics to explore alternatives for its enhancement. In 1993, professors Eugene Fama and Kenneth French from the University of Chicago introduced their model, known as the Fama and French Three Factor Model Fama & French (1993). This model serves as an extension of the CAPM, incorporating two additional risk factors to potentially enhance its explanatory power.

While the CAPM relies solely on the market portfolio as a single factor to explain stock returns, Fama and French recognized the limitations of this simplistic view in capturing the complexities of financial markets. Through extensive research, they realized that to effectively explain average stock returns, it is essential to consider not only market risk but also to account for differences in risk between small and large stocks (as indicated by market value of equity) and to distinguish between value and growth stocks. It is with this insight that the Fama and French Three Factor Model was developed, offering a more comprehensive framework for understanding the drivers of stock returns. The equation of the model is presented below:

$$R_i - R_f = \alpha + \beta_m[E(R_{mi}) - R_f)] + \beta_{smb}E(SMB_i) + \beta_{hml}E(HML_i) + \epsilon \quad (2.6)$$

for all i = 1,2,...n.

In the Fama and French Three Factor Model, the expected market return, denoted as $E(R_m)$, plays a similar role as in the CAPM. Additionally, two additional factors are introduced: the expected Small Minus Big (SMB) factor return, denoted as $E(SMB)$, and the expected High Minus Low (HML) factor return, denoted as $E(HML)$. SMB represents the difference in returns between stocks with the smallest and largest market capitalizations. Specifically, it captures the additional return that investors have earned from investing in stocks with relatively small market capitalization. This phenomenon is commonly referred to as the "size premium," highlighting the potential outperformance of smaller-cap stocks compared to larger-cap stocks. On the other hand, HML captures the difference in returns between firms with high and low book-to-market ratios. It aims to measure the "value premium," which represents the additional return potential from investing in stocks with higher book-to-market values. HML identifies the potential for outperformance by value-oriented stocks compared to growth-oriented stocks. By incorporating these additional factors into the model, the Fama and French Three Factor Model seeks to provide a more comprehensive framework for understanding the size and value premiums observed in the stock market.

The rationale behind incorporating SMB and HML factors can be explained as follows. SMB captures the risk associated with the size of a company. Smaller companies are expected to exhibit higher sensitivity to risk factors due to their longer adjustment periods in response to adverse events. For instance, during periods of negative earnings, smaller companies tend to experience prolonged earnings depressions compared to larger companies due to lower market liquidity. Thus, it is reasonable to expect a negative relationship between company size and returns. On the other hand, HML represents the risk associated with the value premium. Fama & French (1996) argued that companies with high book-to-market equity ratios tend to be riskier and more susceptible to financial distress compared to companies with low book-to-market ratios. This risk factor captures the differential performance between value-oriented companies and growth-oriented companies. In essence, the factors SMB and HML are relevant from an investor's perspective, as they capture the risks to which investors are exposed. In order to compensate for bearing these risks, investors require a higher return. Therefore, incorporating these factors in asset pricing models allows for a more comprehensive assessment of the risk-return relationship and helps investors make informed decisions.

The crucial assumption underlying the inclusion of size and value factors is that the risks associated with size and value are distinct from the risks captured by the market risk factor. This assumption is essential to ensure that the size and value factors have significant explanatory power beyond that provided by the market risk factor. In other words, if the risks inherent in size and value were already incorporated in the market risk factor, it would render the size and value factors statistically insignificant, thereby diminishing the overall explanatory ability of the model.

Fama and French conducted empirical research on US stocks to examine the empirical evidence supporting their model. Despite the promising empirical results and the intuitive rationale underlying the inclusion of these factors, there remains ongoing debate regarding their interpretation as risk factors. Lakonishok *et al.* (1994) challenged the notion that size and book-to-market equity adequately compensate for risk. They argued that the abnormal returns observed in relation to these factors could be attributed to investor misinterpretation based on past performance figures. This perspective suggests that investors tend to overreact to a company's historical performance. Furthermore, Daniel *et al.* (1997) found that firm-specific characteristics possess greater explanatory power in accounting for variations in stock returns compared to the factors employed in the Fama and French Model. Their findings suggest that additional factors related to individual firm characteristics may provide a more comprehensive explanation of stock return variability. In a similar vein, Griffin (2002) found inconclusive evidence supporting the interpretation of book-to-market equity as a measure of distress risk, as proposed in the Fama and French Model. Their research suggests that alternative explanations, such as mispricing, may offer a more consistent explanation for the observed patterns. These conflicting findings contribute to the ongoing discourse surrounding the interpretation and effectiveness of the size and book-to-market equity factors, highlighting the need for further investigation and refinement of asset pricing models.

Numerous studies have examined the comparative predictive abilities of the Fama and French Three Factor Model and the CAPM. Allen & Cleary (1998) conducted an investigation into the explanatory power of the three-factor model using data from the Bursa Malaysia Stock Exchange. Their findings revealed that the model successfully captured the variation in stock returns within the Malaysian context. Similarly, Connor & Sehgal (2001) tested the three-factor model using data from firms listed on the National Stock Exchange of India. The results demonstrated that the model effectively explained the variation in stock returns in the Indian market. These studies provide strong evidence supporting the robust explanatory power of the Fama and French Three Factor Model, particularly within emerging markets.

In case of developed markets, Ajili (2003) conducted a study specifically focused on the French Stock Market. They compared the predictive abilities of the CAPM and the Fama and French Three Factor Model. Based on their analysis of companies listed on the French Stock Market, the Three Factor Model exhibited superior performance and provided a more precise explanation for the variation observed in stock returns when compared to the CAPM. Overall, these studies collectively contribute to the literature, highlighting the significant explanatory power of the Fama and French Three Factor Model across diverse market contexts, with evidence supporting its effectiveness in both emerging and developed markets.

Despite the demonstrated superior performance of the Fama and French Three Factor Model in numerous empirical studies, its theoretical foundation raises questions regarding two additional factors, namely size and value. There are doubts why the size and value premium should be relevant factors to explain the variation in the future returns of the assets.

2.1.3 Size premium

Certainly, there were observed anomalies in the asset pricing after the publication of CAPM. The researchers have identified other risk factors besides the market risk that might explain the assets' returns. One of these anomalies is the size premium. The earliest study on the topic of the size effect was published by Banz (1981). He examined the relationship between the total market value of the stock and its return. In his research, Banz used the stocks from New York Stock Exchange from 1926 until 1975. He finds that the stock returns are explained by the firm size as well as by the market risk specified by CAPM. He observed a negative relationship between the size and returns. After that, Chan *et al.* (1985) proposed a multi-factor model as an alternative to CAPM while using different macroeconomic variables. Their model was able to explain the size premium, in particular, the size effect results from payments for risk. The first empirical results of the size as a proxy for the risk brought Fama & French (1992). Their findings lead to the fact that beta does not measure the risk completely but the size for some random factor. However, they do not add any explanation of the theory so the results are only supported by the empirical research and not some theoretically based model. Simply put, there was no theory linking the size to returns of the stock.

In response to the criticism, Berk (1995) argues that the empirical results of the size effect should be valid and recognized although there is no theory to explain this phenomena. To the criticism of induction, he states that the firm size is a proxy for a risk. Berk just relates the size effect to previous research and theory where stocks' returns have a relationship with the risk. Berk argues that Banz and others were implicitly testing theory using a deductive method by relating the firm size to risk. Moreover, he distinguishes between the size as a proxy for risk and size as a source of risk. He argues when the size effect is present, then size is a proxy for the risk factors that might be observed in smaller companies. He also adds the firm size to the pricing model and states that there is evidence that these models have more explanatory power but it cannot be taken as the proof that size is the source of the risk. Using different pricing models, he believes the size as an independent variable might contribute differently to the asset pricing models depending on other independent variables in the model.

There are number of studies which are rather skeptic about the existence of the size effect. Some studies report that the size effect is not consistent and may vary over time (Brown *et al.* (1983)). The magnitude of the size premium is sensitive to the length of the time period. A study by Van Dijk (2011) concluded that after the 1980s the size premium has disappeared in the U.S. and in the UK (Michou *et al.* (2010)). Seasonality plays a role in the size effect too. Based on the study of Keim (1983), he found out that the size premium is concentrated more in January. This is questionable since there is no reason why the small stocks are riskier only in January. This means that there is a higher premium for the small stocks however, these stocks are not riskier than other stocks in another months of the year.

Related to firm size, some studies find out that the market liquidity is an important risk factor. Amihud (2002) did a research on NYSE stocks from 1964 to 1997. He regresses the stocks' returns on the firm size, liquidity, and other variables. He claims that the market liquidity effect is more significant in smaller companies. From this finding, he suggests that the variations in the size effect may be the result of changes in market liquidity over time. In mid 2000s, Liu (2006) finds out that the market liquidity has an explanatory power. He examined U.S. stocks from 1960 to 2003. The market liquidity varied over time and so was the liquidity risk. Moreover, that the liquidity incorporates the size effect. In a later study, Chen *et al.* (2010) discovers that the liquidity effect does not capture the size effect but that the liquidity is correlated with the firm size.

Investment bankers seem to pay little attention to the recent studies on the size effect showing its disappearance. They refer to earlier studies on the empirical research of the size premium. They still give advice to the investors that small-cap stocks have performed better than large-cap stocks in the long run period. But the evidence from the studies such as (Chan *et al.* (2000), Amihud (2002)) reveal that from 1980s the gap between the returns of small-cap stocks and large-cap stocks is shrinking resulting in the underperformance of smaller stocks.

The presence of the size effect has been present in subsequent studies. Fisher *et al.* (2017) provide empirical evidence indicating that stocks originating from smaller equity markets exhibit higher average returns when compared to stocks from larger nations. Importantly, their findings emphasize that the size effect associated with country-level factors is largely distinct from the firm size effect and other quantitative factors pertaining to countries, such as momentum or value effects. Similarly, Zaremba & Umutlu (2018) validate the size effect across a comprehensive international sample, while Li & Pritamani (2015) demonstrate its influence on the returns of emerging and frontier markets.

There are a number of studies using the size premium in emerging markets as the factor for determining the risk. For the emerging markets, there are two properties which may improve the performance of the risk factors. The first property is the higher transaction costs present in these markets. The second property is the liquidity of the emerging markets. These markets are less liquid which is also directly related to the transaction costs (Lesmond (2005). The higher costs and less liquidity may imply more size and value returns as suggested by various studies (Sadka (2006), Hanna & Ready (2005). However, the exact effect of the size and value premium is not discovered yet.

2.1.4 Value premium

The value premium, as defined, refers to the difference in performance between value stocks and growth stocks, which can be measured in terms of absolute returns or risk-adjusted returns. The classification of stocks as value or growth is determined by their relative valuation, assessed through valuation ratios or other value criteria. Valuation ratios can be seen as ratios of output to input, where output represents measures like earnings, profitability, dividends, book value, or sales, and input represents factors such as market value of equity or enterprise value. The higher the output achieved per unit of input, the better the relative value. Therefore, value stocks tend to have high valuation ratios, while growth stocks have lower corresponding ratios, given the notation output to input ratio.

The principles of value investing can be traced back to the 1930s, with Graham & Dodd (1934) being notable early contributors. The first scientific evidence of the earnings-to-price (E/P) anomaly was presented by Nicholson (1960), although he did not include risk measures or risk-adjusted performance measures in the comparison of portfolios. In the late 1960s, McWilliams (1966), Breen (1968), and Nicholson (1968) conducted similar studies. Basu (1975; 1977) is credited as the first to document the outperformance of high E/P portfolios on a risk-adjusted basis. His research on a large sample of U.S. industrial firms demonstrated a consistent decline in performance from high E/P to low E/P portfolios. Basu's work faced challenges from Banz (1981) and Reinganum (1981), who argued that the E/P anomaly was explained by the small-cap anomaly, which overshadowed it. However, Basu (1983) responded by demonstrating the persistence of the E/P anomaly even after controlling for differences in firm size. He also showed that the size effect became negligible when accounting for risk and E/P ratios. In contrast, Cook & Rozeff (1984) attributed equal significance to both the E/P and size factors. Banz & Breen (1986), on the other hand, found a size effect but no independent E/P effect across all months, aligning with findings of Reinganum (1981) that were criticized by Basu (1983). In the Japanese stock markets, Chan *et al.* (1993) did not observe the E/P anomaly but identified significant cash flow-to-price (CF/P) and book-to-price (B/P) anomalies. These seemingly contradictory results can be largely explained by variations in samples, sample periods, and methodologies employed.

Fama & French (1992) discovered that the differential returns of earnings-to-price (E/P) strategies could be explained by a combination of size and book-to-price (B/P), leading them to exclude the earnings yield from their well-known three-factor model. On the other hand, Roll (1995) performed an analysis of three portfolio formation criteria (size, E/P, and B/P) using monthly frequency for portfolio reformation demonstrated the superiority of E/P over B/P and size. In a subsequent study, Fama & French (1998) noted that, among four different portfolio formation criteria (including B/P, cash flow-to-price (CF/P), and dividend-to-price (D/P)), the use of E/P as a value portfolio formation criterion would have resulted in the highest value premium in two out of 13 major national stock markets. However, while the E/P criterion generated a significant value premium in three national markets, it did not produce the highest value portfolio return in any of the 13 markets.

In contrast, Van der Hart *et al.* (2003) observed that the earnings-to-price (E/P) criterion had the highest and statistically significant value premium, as well as the highest value portfolio return when comparing equally weighted returns of value and growth portfolios composed of emerging market stocks categorized based B/P, D/P, and E/P rankings. However, when applying a slightly different sample period using the same methodology, van der Hart *et al.* (2005) found that the B/P criterion exhibited superiority over E/P. On the other hand, in their analysis of factors influencing global returns, Hou *et al.* (2011) reported the highest global value premium using E/P ratios among over 27,000 stocks from 49 countries. They also considered other valuation-related factors such as B/P, CF/P, and D/P in their study. As a result, the overall international evidence regarding the relative effectiveness of the E/P criterion in identifying undervalued stocks compared to their overvalued counterparts is contradictory.

2.1.5 Value vs. growth investing

There are a number of ideas between the academic researchers and investment practitioners in the topic of value and growth investing. Some studies have built the basis for investment strategies that are present in the stock markets. On the other hand, portfolio managers encountered different obstacles for the identification of the value and growth investing design for the performance evaluation.

The academic interest in the topic of growth vs. value investing started with Fama & French (1992) and Lakonishok *et al.* (1994). The work of Fama and French built on earlier studies of the stock market anomalies. Basu (1977) found out that stocks with low P/E ratio have higher average returns compared to the stocks with higher P/E ratio. The later study of Chan *et al.* (1991) discovered a strong support for the performance of value investing based on the Japanese data. This is just an example of the many studies which dealt with the related anomalies but on average, the academics has generally agreed that value investment strategies outperform the growth strategies. However, there is less evidence about the superiority of the returns. Lakonishok *et al.* (1994) suggested that there exists the cognitive bias underlying the transaction costs of the investment management and the behavior of the investor. This bias was the pillar of the higher returns in value investing. Other study of Kothari *et al.* (1995) claims that there were methodological issues of data-selection bias as the potential explanation of the value investing returns. Nowadays, in the field of portfolio management, value and growth investing are widely recognized specializations. There were created different specific benchmarks that contributed to performance evaluation and attribution analysis. Many of these benchmarks were used in an academic literature. One of these variables would be book value to market value of equity ratio. In the portfolio management, this is an important indicator to determine stock's orientation to be growth or value.

2.1.6 Pricing anomalies in CEE

There has been a little evidence about examining the risk factors of assets in CEE region. This is due to the geopolitical situation until 1990s. After that, financial markets started to liberalize in most of the CEE countries. Therefore, there are only a few studies regarding asset pricing in CEE. Based on the evidence from developed markets, the most of the asset pricing models have been applied in emerging markets and, thus, examining the same pricing anomalies in the emerging and frontier markets as well as in the developed markets.

One of the first studies conducted in emerging markets was the study by Claessens *et al.* (1995). Although this study does not include any country from CEE, it showed there is a size effect based on their statistical results. They based their empirical research on twenty emerging markets. The starting dates were in between the years 1976-1990 and the ending date was in December 1992.

Barry *et al.* (2002) developed a study including 35 emerging markets among which, there are countries from CEE region. The dataset used in the study covered the period from 1985 to 2000. To ensure the robustness of the findings, extreme values were excluded by omitting observations with returns in the upper or lower 1% tails of the return distribution. In order to account for the heterogeneity of companies in different markets within the sample and the potential lack of full integration of emerging markets with global capital markets, the study employed relative size and book-to-market equity as key variables. These factors were chosen due to the significant variations in the magnitudes of companies across different markets, as well as to address the uncertainty surrounding the degree of integration with global capital markets. The analysis revealed robust value effects in both relative size and book-to-market equity. However, the presence of size effects was dependent on the inclusion of extreme values. Notably, the size effect was not observed in tests that utilized absolute firm size as a factor.

De Groot *et al.* (2012) conducted an empirical investigation to compare the asset pricing anomalies in frontier emerging markets with those observed in developed markets. The study focused on a 12-year period from 1997 to 2008 and analyzed data from 24 countries across four regions, including the CEE region. The findings of the study revealed that portfolios constructed based on value and momentum strategies in frontier markets generated both economically and statistically significant excess returns. Importantly, the excess returns achieved in these frontier markets were found to be even higher than those observed in developed and traditional emerging markets. However, the study did not identify a significant size effect when considering the total group of frontier emerging market countries.

A study conducted by Cakici *et al.* (2013) investigated the size, value, and momentum effects in the stock returns of 18 emerging markets. The authors categorized the emerging markets into regional groups, namely Asia, Latin America, and Eastern Europe, and examined the anomalies within each region individually as well as collectively. The study's findings revealed a robust and statistically significant value effect across all three regions. However, no size effect was observed in any of the regions. Additionally, the study provided evidence indicating that the premiums associated with big value stocks were slightly larger compared to those associated with small value stocks.

Zaremba (2015) conducts an academic research into cross-sectional asset-pricing methodologies utilizing value, size, and momentum factors specifically on the CEE markets. The study sheds light on the distinctive contribution of microcap stocks within this context. The analysis is grounded in comprehensive stock-level data encompassing 11 countries, spanning from April 2001 to June 2014. Notably, robust empirical evidence emerges in support of the value and momentum effects, thereby raising doubts regarding the conventional size premium. Moreover, the investigation reveals notably elevated returns associated with microcap stocks.

Chapter 3

Methodology

3.1 Fama-MacBeth regression

In the empirical section of this thesis, we aim to conduct a comparative analysis between the traditional CAPM proposed by Sharpe and Lintner and the CAPM adjusted to incorporate the other factors. Our rationale for this investigation is rooted in the belief that the other factors than market beta may exhibit superior predictive capacity in forecasting excess returns. Several methodologies exist for evaluating the predictive power of an asset pricing model. To empirically test our hypotheses, we have chosen to employ the Fama-MacBeth two-stage regression model, as introduced by Fama & MacBeth (1973).

The implications of the CAPM can be tested using the cross-sectional regression methodology, which leverages the linear relationship between returns and market beta to examine the model's appropriateness as an asset pricing framework. In 1973, Fama and MacBeth introduced a novel approach to test the CAPM model, involving the projection of returns based on betas and their aggregation over T time periods. As stated by Fama & MacBeth (1973) there are three key implications: (1) the relationship between return and risk is assumed to be linear, (2) beta (β) serves as the measure of risk for a particular asset (i) within the portfolio, and (3) higher levels of risk are expected to correspond to higher returns under the assumption of risk aversion. These implications are grounded in certain methodological assumptions, such as perfect market competition and homogeneous expectations. These assumptions, in turn, imply an efficient market portfolio and alignment between ex-ante and ex-post returns.

Fama & MacBeth (1973) introduced a two-step regression procedure. Specifically, they employed the unifactorial factor model in a time series context, where individual portfolios were regressed against the CAPM model's factor, yielding a sequence of estimated betas for each portfolio across the analyzed periods. As we have already stated, This approach employs a two-stage regression methodology to estimate the parameters (risk factors) involved. In the first stage, the returns of each asset in the portfolio (R_{it}) are regressed using time-series regressions on the k risk factors to derive the factor loadings. Specifically, with i denoting the number of assets in the portfolio, OLS is utilized to estimate the following time-series regression:

$$R_{it} = \alpha_i + \beta_{i,F_1} F_{1,t} + \beta_{i,F_2} F_{2,t} + ... + \beta_{i,F_k} F_{k,t} + \varepsilon_{i,t} \qquad t = 1, ..., T \tag{3.1}$$

where R_{it} is the return of asset portfolio i at time t, while β_{i,F_1}, β_{i,F_2}, β_{i,F_k} are the estimated coefficients representing the measure of risk factor exposure. α_i is the intercept term, and $\varepsilon_{i,t}$ is the disturbance (error) term, where k denotes the number of risk factors, and T denotes the total number of time-series observations. Importantly, it is noteworthy that the same set of risk factors is utilized consistently in each regression, ensuring uniformity throughout the entire process described above.

Following the initial stage, we acquire the estimates for the beta coefficients (β), denoted as $\hat{\beta}$s. Subsequently, in the second step, we proceed with T cross-sectional regressions of the excess asset returns upon the risk factors obtained during the first stage. The primary objective is to explore the risk premium exposure of each factor. Utilizing the $\hat{\beta}$s derived from the first stage regression analysis, we conduct the following series of cross-sectional regressions for each period $t = 1, ..., T$::

$$R_{it} = \lambda_{0,t} + \lambda_{1,t}\hat{\beta}_{i,F_1} + \lambda_{2,t}\hat{\beta}_{i,F_2} + ... + \lambda_{k,t}\hat{\beta}_{i,F_k} + \varepsilon_{i,t} \qquad i = 1, ..., N \tag{3.2}$$

where R_{it} denotes the return of the portfolio or asset i at time t, representing the same variable utilized in the initial stage. The intercept term is denoted as $\lambda_{0,t}$, while $\lambda_{1,t}$, $\lambda_{2,t}$, ..., $\lambda_{k,t}$ represent the regression coefficients employed to compute the premiums associated with the risk factors.

Under the assumption of ε being independently and identically distributed (i.i.d.), the estimated coefficients obtained from the second-stage cross-sectional regression, namely $\lambda_{1,t}$, $\lambda_{2,t}$, ..., $\lambda_{k,t}$, are designated as $\hat{\lambda}1, t$, $\hat{\lambda}2, t$, ...,

$\hat{\lambda}_{k,t}$. By computing the time-series average of these coefficients, we derive the average risk premium ($\overline{\hat{\lambda}_k}$) for each risk factor k:

$$\overline{\hat{\lambda}_k} = \frac{1}{T}\sum_{t=1}^{T}\hat{\lambda}_{k,t} \tag{3.3}$$

Furthermore, to address the issue of heteroskedasticity in the error terms present in the one-step regression method (OLS), estimations of $\overline{\hat{\lambda}_k}$ need to be subsequently tested using t-statistics. We calculated the standard errors for each factor k. The variance formula is presented below:

$$\sigma^2(\lambda_k) = \frac{1}{(T^2)}\sum_{t=1}^{T}(\hat{\lambda}_{t,k} - \overline{\hat{\lambda}_k})^2 \tag{3.4}$$

There is $1/T^2$ in the denominator because we are finding standard errors of sample means (Cochrane (2005)). To calculate the t-statistics we used the following formula:

$$t(\overline{\hat{\lambda}_k}) = \frac{\overline{\hat{\lambda}_k} - \lambda_0}{\hat{\sigma}_{\lambda_k}} \tag{3.5}$$

where we assume that λ_0 is equal to zero, thus simplifying the formula to the following form:

$$t(\overline{\hat{\lambda}_k}) = \frac{\overline{\hat{\lambda}_k}}{\hat{\sigma}_{\lambda_k}} \tag{3.6}$$

The primary econometric challenge associated with the Fama & MacBeth (1973) cross-sectional methodology lies in the unknown nature of betas, leading to the utilization of estimated betas in the regressions. This introduces errors in variables (EIV) concern, wherein any deviation or error in the estimation of betas during the initial step could render the second-step regression of $\hat{\lambda}i, t$ estimates inconsistent. To mitigate this issue, it is important to employ portfolio-level data rather than individual asset data, as recommended by Fama & MacBeth (1973).

This study employs the rolling window method, with a window size of 60 observations per window, equivalent to a 60-month period, encompassing 5 years of data. The rationale behind adopting rolling windows instead of static estimations stems from the recognition that the betas of the factors in the initial step of Fama & MacBeth (1973) tend to exhibit time-varying patterns in response to shifts in the financial markets' conditions. Consequently, static regressions may not be sufficient for obtaining accurate coefficient estimations for the factors. Using the rolling window methodology allows us to account for the potential instability of the factors over time and acknowledge their non-constant behavior.

Chapter 4

Data

In the empirical section of our thesis, our objective is to investigate the impact of different risk factors on the returns of the Central and Eastern European (CEE) 11 sectors. Additionally, the focus will specifically be on the CEE IT sector to determine if there exists a statistically significant premium associated with the examined risk factors. To conduct our analysis, we have collected accounting and price data from Bloomberg. The thesis encompasses data from nine CEE countries, namely Bulgaria, Croatia, Czech Republic, Hungary, Latvia, Lithuania, Estonia, Poland, and Romania, which includes a total of 441 publicly listed companies. To be included in the sample, a company must have all the necessary characteristics available for computation. Our sample period spans from February 2011 to June 2023, resulting in 149 monthly time series observations. Through the careful analysis of these data, we aim to gain insights into the relationships between risk factors and the returns of the CEE sectors. Moreover, we will focus on CEE IT sector specifically and try to explain the variations in stock returns. This research represents one of the limited number of papers addressing asset pricing concerns within the CEE region, and is notably the first study dedicated to examining the CEE IT sector in particular. The primary market and accounting data were originally collected in local currencies. Nevertheless, considering the potential misinterpretations arising from comparing data based on various currency units, as highlighted by Bali *et al.* (2013), particular caution is warranted. Such concerns are especially pertinent in the context of emerging markets, where disparities in inflation and risk-free rates can be substantial and vary across different markets. In response to this, we adhere to the methodology utilized by Liu *et al.* (2011), wherein we transform all data into Euros (EUR) using the mean bid and ask rates retrieved from the Bloomberg database on the respective date. This practice allows us to attain standardized and internationally comparable results, thereby facilitating robust analysis and interpretations.

4.1 Company returns, Risk-free rate, and market return

For all companies in the sample, we gathered average monthly price and average market capitalization from Bloomberg database. We collected data using the indices in the individual countries and included the companies that are present during the examination period. To estimate the predictive power of the model on various risk factors, the returns of the assets needs to be calculated. Monthly returns are calculated as the difference between the natural logarithms between t and $t-1$ period.

$$R_t = ln(\frac{P_t}{P_{t-1}}) \tag{4.1}$$

Where the P_t is the price at time t and P_{t-1} is the price at time $t-1$. The logarithms of returns are normally distributed. This practice is widely adopted in the majority of financial academic research. As a result, we have a dataset comprising 149 monthly time-series observations, spanning from February 2011 to June 2023. This sample period encompasses both periods of market prosperity and financial crises, providing a comprehensive perspective on various market conditions.

As the proxy for market returns, MSCI Emerging Markets Europe Index was selected. The MSCI EM Europe Index is a free-float weighted equity index since December 1987. The excess market return $MKT - Rf$ is the difference between the MSCI Emerging Europe Index and one-month EURIBOR rate, as a proxy for risk-free rate (Rf). Moreover, to maintain data consistency throughout the study, all excess company returns utilized in the analysis are computed using the one-month EURIBOR rate as the Rf, as opposed to local rates. This approach ensures that all data are uniformly denominated in EUR. There is a summary statistics for the MKT and Rf data that can be found in the Table 4.1:

Table 4.1: Data summary of Market returns and Risk-free rate

	MKT	RF
Min.	-68.36341	-0.58300
1st Qu.	-3.74965	-0.37800
Median	-0.01238	-0.34400
Mean	-0.95537	0.05357
3rd Qu.	3.34578	0.13000
Max.	17.82861	3.39900

Note: The table displays descriptive statistics of the market returns and Risk-free rate in %. The source: Bloomberg, Author's research.

The mean market return of the MSCI EM Europe Index is observed to be -0.96%. The minimum return during the period under consideration is recorded at -68.36%, primarily attributed to the unforeseen outbreak of the COVID-19 crisis in March 2020. Conversely, the index exhibits a maximum monthly return of 17.83%, reflecting the potential for substantial gains in certain periods. Regarding the risk-free rate (R_f), the mean is found to be positive, standing at 0.05%. The minimum value observed for R_f is -0.58%, while the maximum reaches 3.4%, highlighting fluctuations in the risk-free rate over the analyzed time frame.

4.2 Sector analysis

As previously mentioned, Fama & MacBeth (1973) recommended the use of portfolios instead of individual assets. In accordance with this suggestion, we organized the 441 companies into 11 distinct sectors within the CEE region to explore the existence of a risk premium associated with the returns of these sectors. The examined sectors encompass the Consumer Discretionary, Consumer Staples, Health Care, Industrials, Information Technology, Materials, Real Estate, Financial, Energy, Telecommunications, and Utilities sectors. For a comprehensive overview of these sectors, including their respective codes and the number of companies comprising each sector, please refer to Table 4.2.

Table 4.2: Overview of analysed sectors

Sector	Code	Total
Consumer Discretionary	COND	46
Consumer Staples	CONS	40
Health Care	HLTH	28
Industrials	INDU	90
Information Technology	INFT	50
Materials	MATR	30
Real Estate	REAS	28
Financials	SPF	58
Energy	SPN	11
Communication services	COMS	39
Utility	UTIL	21

Source: Bloomberg, Author's research.

As it is shown in the table, the energy sector in our dataset is represented by a considerably limited number of companies. As a consequence, the results obtained from the analysis of this sector may be subject to potential bias and should be interpreted with caution. To ensure a comprehensive and reliable analysis, a larger sample size would be necessary for a proper examination of the energy sector. On the other hand, the available information for the remaining sectors is adequate and should yield valid results, allowing us to draw meaningful conclusions for our hypothesis.

Table 4.3: Summary statistics of sectors: Returns

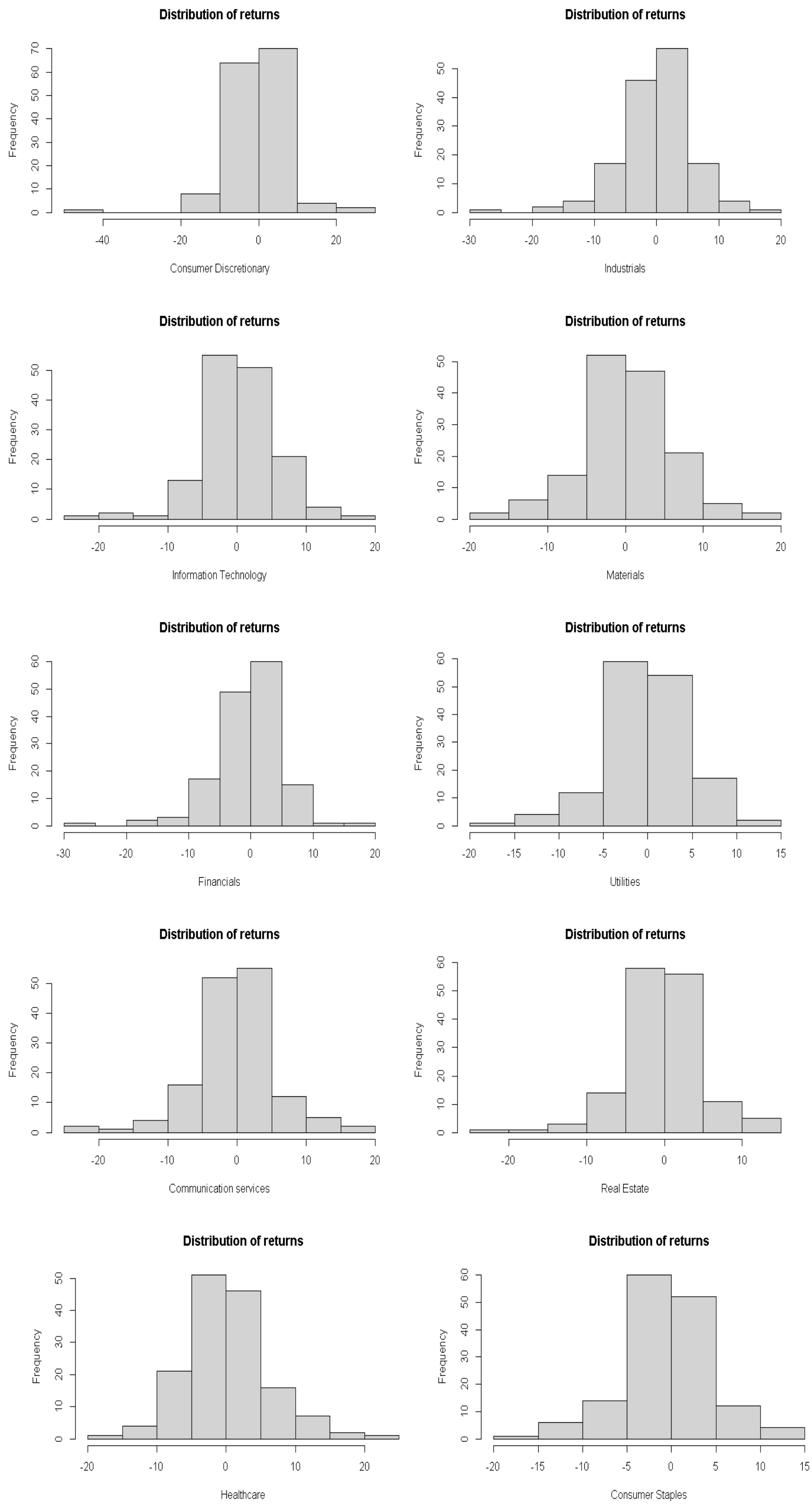
Statistic	N	Mean	St. Dev.	Min	Max
SPF	149	−0.003	0.056	−0.281	0.170
UTIL	149	−0.002	0.048	−0.170	0.111
COND	149	−0.003	0.070	−0.417	0.249
COMS	149	−0.002	0.058	−0.221	0.175
INDU	149	−0.003	0.059	−0.261	0.158
REAS	149	−0.003	0.052	−0.226	0.123
SPN	149	0.0001	0.064	−0.192	0.206
MATR	149	−0.001	0.060	−0.185	0.193
INFT	149	0.004	0.057	−0.202	0.165
HLTH	149	0.003	0.060	−0.163	0.203
CONS	149	−0.005	0.049	−0.180	0.135

Source: Bloomberg, Author's research.

The summary statistics table reveals that the monthly returns within the examination period exhibit comparable magnitudes across various sectors. However, the Consumer Discretionary sector stands out as the most volatile, displaying the highest values for both minimum (-0.417) and maximum (0.249) returns. On the other hand, the Information Technology sector exhibits the highest mean returns (0.004), while the sector of Consumer Staples presents the lowest mean return (-0.005).

The examination of sectoral portfolios is not our primary objective; rather, it serves as an initial exploration of the relationship between sectoral returns from the CEE region and market beta. As the title of the thesis implies, our focus will now shift towards a more detailed analysis of the Information Technology (IT) sector. Subsequently, histograms displaying the distribution of returns for the individual sectors can be found on the following page.

Figure 4.1: Distribution of returns on the sample of the sectors



4.3 Information Technology sector

The objective of this thesis is to investigate the stock returns of technological companies in CEE countries and ascertain the presence of risk factors that account for the variations in these returns within the specific sector. Our analysis is based on a sample of 50 companies within the Information Technology sector. To achieve this objective, we will develop various factors to test our hypotheses and draw relevant conclusions.

The market factor (MSCI EM Europe Index) and risk-free rate (Rf) used for the IT sector analysis remain unchanged from those employed in the sectoral analysis. The summary statistics for these two variables can be found in Table 4.1. As shown in the preceding section, the IT sector exhibits the highest average returns (0.004) compared to the other sectors under examination.

In order to investigate the presence of a size premium within the IT sector in CEE and see whether micro-cap stocks outperform larger-cap stocks in terms of expected returns, we collected monthly data of market capitalization (market value) at time t for each stock. To construct portfolios based on size, we classified companies into three categories: micro, small, and mid, determined by their average market capitalization over the examination period. Specifically, we formed 1x3 portfolios, each representing a distinct size category. We determined the size thresholds for our sample of CEE IT companies, comprising 50 firms. The summary table presented below displays the market capitalization thresholds and the corresponding number of companies allocated to each portfolio:

Table 4.4: Summary statistics of IT portfolios

Portfolio	Number of companies	Market capitalization in millions EUR
Micro	17	4.5-25
Small	17	25-80
Mid	16	80-1,071

Source: Bloomberg, Author's research.

Table 4.5: Average market capitalization of IT size portfolios

Portfolio	Average market capitalization in millions EUR
Micro	EUR 14.5m
Small	EUR 49m
Mid	EUR 273m

Source: Bloomberg, Author's research.

Table 4.4 and 4.5 present the descriptive statistics for the IT Micro, Small, and Mid portfolios. Both the Micro IT and Small IT portfolios comprise 17 companies each, while the Mid IT portfolio includes 16 companies. Concerning market capitalization, the smallest company within our portfolios has a market cap of EUR 4.5 million, while the largest company's market cap slightly exceeds EUR one billion. Table 4.5 displays the average market capitalization for each IT size portfolio. The Mid size portfolio exhibits a substantial spread, indicating significant variations in market capitalization among its constituent companies. Remarkably, the average market capitalization for the Micro and Small IT portfolios is positioned close to the midpoint of the overall range. On the other hand, the Mid portfolio includes only two companies with market capitalization exceeding EUR 500 million. That is why we named the portfolio Micro, Small and Mid instead of Small, Mid and Large.

Respective descriptive statistics of returns might be found in the table below:

Table 4.6: Summary statistics of IT size portfolios: Returns

Statistic	N	Mean	St. Dev.	Min	Max
Micro	149	0.004	0.061	−0.224	0.173
Small	149	0.008	0.069	−0.223	0.197
Mid	149	0.008	0.054	−0.169	0.157

Source: Author's research

The data presented in the table reveal notable differences in the average returns of the Small and Mid IT portfolios when compared to the Micro IT portfolio, with approximately twofold higher returns observed in the former two. Moreover, the Small IT portfolio exhibited the highest level of volatility, as evidenced by its larger standard deviation measure (0.069). Additionally, the Micro IT portfolio recorded the lowest return, with a minimum value of -0.224, while the Small IT portfolio attained the maximum return of 0.197 during the examination period.

4.4 MMR (Micro minus rest) factor

To account for the size premium in terms of micro cap stocks should outperform large cap stocks, we used so-called MMR (Micro minus rest) factor based on the paper of Zaremba (2015). In this thesis, we tried to incorporate other factor besides the market beta to account for the micro cap stocks could outperform large cap stocks. Zaremba (2015) provides an alternative solution to issues related to microcaps and vanishing size effects. In his study, he proposes the replacement of traditional SMB factor with a new pricing factor, MMR, which represents the returns on microcaps over the diversified returns on the remaining stock market.

The construction of the size-based return factor, termed the MMR factor in this study, addresses the central concern of pricing micro stocks. It is essential to acknowledge that the details of constructing size-based return factors can vary, and such variations are subjectively determined Waszczuk (2014). Fama & French (1993) seminal research on U.S. stocks employed two size groups and three value groups, categorized based on the median market capitalization and the 30th and 70th percentiles of the book-to-market (B/M) ratio. The intersection of these independent sorts enabled the creation of a 2x3 matrix, facilitating the computation of the Small Minus Big (SMB) factor, which represents the difference between the average returns of three portfolios comprising small companies and three portfolios comprising large companies. However, in a later study, Fama & French (2012) redefined small stocks to encompass those constituting 10 percent of the total market capitalization, thus broadening the subgroup of small companies. On the other hand, Liu *et al.* (2011) employed the 70th size percentile, instead of the median, to divide stocks in the UK market, extending the category of small stocks to include medium stocks. Naranjo & Porter (2010) used monthly NYSE 30th and 70th percentile breakpoints to create the SMB factor. Nartea *et al.* (2011) generated the SMB factor based on a one-dimensional approach, constructing a zero-cost long/short portfolio with equal weightings (33.33 percent each) on the smallest and largest companies in relevant countries. For the Polish market, Waszczuk (2013) employed the median of the half of the sample with the largest stocks as the cut-off point. Despite their diversity, all the computations suffer from common shortcomings. They typically compare the performance of small and medium stocks, disregarding the fact that only microcaps should have some form of premium. This flaw is further compounded by the use of capitalization-weighting schemes, which generally assign greater weights to the largest stocks. Consequently, all variations of the Small Minus Big (SMB) factor underscore differences in returns between medium and large companies, while downplaying the role of microcaps. Such an approach does not align with recent studies, such as the work conducted by De Moor & Sercu (2013), which observed outperformance exclusively among the smallest stocks and relatively similar returns across the other capitalization categories.

Given the aforementioned considerations, in this thesis, we have developed the Micro-Minus-Rest (MMR) asset-pricing factor to emphasize the premium associated with microcap stocks within the IT portfolio of small and mid stocks in the CEE region, based on the work of Zaremba (2015). For the computation of the MMR factor, all stocks from IT sector are sorted into 3 groups: Micro, small, and mid based on the average market value during the examination period. The calculation of size sort is described in the previous section. The returns of the MMR_t factor are then calculated as the returns on microcap stocks minus the average return on the two remaining size portfolios (Small and Mid). The relationship can be expressed as follows:

$$MMR_t = Micro_t - \frac{1}{2}(Small_t + Mid_t) \tag{4.2}$$

Respective descriptive statistics of MMR_t factor might be found in the table below:

Table 4.7: Summary statistics of MMR factor

Statistic	N	Mean	St. Dev.	Min	Max
MMR	149	−0.004	0.048	−0.205	0.108

Source: Author's research.

Table 4.7 presents the fundamental descriptive statistics for the MMR_t factor. The average value of the MMR_t factor is found to be -0.004, with a standard deviation of 0.048. The minimum value observed for the MMR_t factor is -0.205, while the maximum value is 0.108.

Chapter 5

Empirical results

For the empirical part of the thesis we will test whether the market beta has any explanatory power in predicting the assets' returns. Firstly, we will do the sectoral analysis using 11 specified sectors. After that, we will specifically examine IT sector. We will try to explain the variations in stock returns using univariate, as well as multivariate models with different factors. All models will be estimated by Fama-Machbeth procedure (Fama & MacBeth (1973)) both, conditionally and unconditionally. At first, a time-series regression is used to obtain beta estimates βs. Then, for the second stage we will apply cross-sectional regression analysis using estimated coefficients as explanatory variables. After that, we obtain risk premiums, and we will calculate own standard errors of the model and our own t-statistics. Using t-statistics we will try to explain the consequences of different models applied.

5.1 Sectoral Analysis

As described in Data section, we created 11 sectors from the sample of 447 companies. For the sectoral analysis, we will apply both conditional and unconditional approach of Fama-Macbeth procedure.

5.1.1 Unconditional Fama-Macbeth approach

Let us begin by employing the unconditional approach. Drawing inspiration from the work of Fama & MacBeth (1973), we initiate the analysis by regressing the returns of each sector on the market risk factor to ascertain the asset's betas associated with the market factor. Secondly, we regress all average asset returns on the estimated betas from the first step in order to determine whether the market risk factor have a significant effect on the risk premium. The aim of this analysis is to confirm whether the market beta alone is a sufficient tool to explain the assets' returns. For this purpose, we employ a rolling window methodology with a window size of 60 months, as recommended by Fama & MacBeth (1973). The equation representing the first step of this analysis is as follows:

$$R_{it} = \beta_{0,i} + \beta_{1,i} MKT_t + \mu_{i,t} \quad (5.1)$$

where $R_{i,t}$ is the total return of a sector i at time t, MKT_t represents the excess return on the market portfolio (MSCI EM Europe Index) at time t and β_1 is the risk factor coefficient.

The estimated equation for the second step of unconditional Fama-Macbeth procedure is defined as follows:

$$\overline{R_i} = \lambda_0 + \lambda_1 \hat{\beta}_{1,i} + \varepsilon_i \quad (5.2)$$

where $\overline{R_i}$ stands for the average return over time of asset i and λ_1 is the risk premium for the market factor respectively. Both of the aforementioned equations were estimated using the OLS method with Heteroskedasticity and Autocorrelation Consistent (HAC) standard errors. The adoption of HAC standard errors is recommended by existing literature to address the potential issues of heteroskedasticity and autocorrelation. The error term, $\mu_{i,t}$, in the specified model may be serially correlated due to the correlation of $R_{i,t}$ determinants that are not explicitly included in the model. In such cases, the use of HAC standard errors is crucial to provide valid and reliable statistical inference. By applying heteroskedasticity- and autocorrelation-consistent estimators of the variance-covariance matrix, the problem of both autocorrelation and heteroskedasticity is addressed effectively. If the error term, $\mu_{i,t}$, is indeed serially correlated and HAC standard errors are not used, the statistical inference drawn from the standard errors may be incorrect and lead to misleading conclusions. However, even if there is no serial correlation present, using HAC standard errors does not violate any assumptions, and the OLS estimators remain consistent and unbiased. The main trade-off of this approach is a potential reduction in efficiency, but it ensures the robustness of the estimates and the validity of the statistical analysis. On the following page, there is a table showing the regression results of the unconditional Fama-Macbeth approach for sectoral analysis.

Table 5.1: Cross-sectional regression output, unconditional 1-factor model

	Dependent variable:
	Sector's Returns
CAPM	−0.415
	(0.864)
Constant	0.051
	(0.439)
Observations	11
R^2	0.021
Adjusted R^2	−0.087
Residual Std. Error	0.281 (df = 9)
F Statistic	0.198 (df = 1; 9)
Note:	*p<0.1; **p<0.05; ***p<0.01

Based on the results we can conclude that unconditional approach of Fama-Macbeth did not yield any significant results. In other words, the market factor is statistically insignificant and therefore have no explanatory power in predicting the excess asset returns. The value of R^2 is only 0.02. It means that the predictive power of this model is very limited. The results are in line with the previous research. Banz (1981) found no explanatory power of the market factor for the cross-section of returns in his work. Fama & French (1993) also found out that the univariate model with only a market factor does not have explanatory power to predict the excess returns.

5.1.2 Conditional Fama-Macbeth approach

As a robustness check, we have also performed the conditional approach of Fama-Macbeth two stage regression analysis. The first stage is the same as it is in unconditional approach. Therefore, firstly we estimate a following time series regression using OLS with 60 months rolling window.

$$R_{it} = \beta_{0,i} + \beta_{1,i} MKT_t + \mu_{i,t} \tag{5.3}$$

where $R_{i,t}$ is the total return of a sector i at time t, MKT_t represents the excess return on the market portfolio (MSCI EM Europe Index) at time t and β_1 is the risk factor coefficient. Using the estimation, we obtained a set of factor loadings for each sector. Now, we can perform the second stage regression to obtain the risk premium for our market factor. For the second step, t cross-sectional regressions are run at each time period, as suggested by Cochrane (2005). We estimate the following equation:

$$R_{t+1} = \lambda_{0t} + \lambda_{1t}\hat{\beta}_{mt} + \varepsilon_t \tag{5.4}$$

where R_{t+1} represents a vector of monthly excess returns at time $t+1$, $\hat{\beta}_{mt}$ represents a vector of monthly market betas from the set of time series regressions performed in the first step, and λ_{1t} is the risk premium for the market beta factor at time t.

The following table summarizes the results for the market factor of the conditional Fama-Macbeth cross-sectional regressions.

Table 5.2: Cross-sectional regression output, CAPM model

Statistic	$\overline{\hat{\lambda}_i}$	Standard Error	$t_{\overline{\hat{\lambda}_i}}$	p-value
CAPM factor	-0.009	0.012	-0.728	0.234

In the table above, there is an average risk premium ($\overline{\hat{\lambda}_i}$) estimated from the second-step cross-sectional regression, with the corresponding standard errors, t-statistics ($t_{\overline{\hat{\lambda}_i}}$) and p-value. The results indicate a slightly negative risk premium for the market factor. Based on the t-statistics, it can be inferred that the market beta, as a risk factor, lacks explanatory power in the cross-sections of stock returns within our sample of 11 sectors. This is in line with the outcome obtained from the unconditional approach, reinforcing the notion that the market factor alone is insufficient in explaining the variations in stock returns across the examined sectors in the CEE region. This aligns with the study conducted by Palovič (2021). He conducted a robust analysis of the market factor for the 48 US industries where market beta had no explanatory power in predicting the excess returns. Similar findings were reported in other studies (Banz (1981), Fama & French (1993)). Additionally, Harvey (1995) conducted an analysis across 20 emerging markets. He found no relationship between the market beta and future excess returns. In conclusion, the evidence from our study, as well as previous research, suggests that the market factor alone does not provide a comprehensive explanation for the variations in stock returns in the sectors of the CEE region.

5.2 IT sector

In this section, our focus shifts to the examination of technological companies within the CEE region, specifically within the IT sector. Our primary objective is to investigate whether the market beta can sufficiently explain the variations in stock returns for these technological firms. Additionally, we aim to explore the impact of company size by creating three distinct portfolios based on market capitalization, thereby assessing the potential existence of a size premium, particularly in the context of microcap companies. Furthermore, we use a novel factor called the MMR factor (Zaremba (2015)), designed to explore whether microcap companies exhibit superior performance compared to larger companies, and to observe whether this factor has any predictive power in explaining the excess stock returns of technological companies. In addition to these analyses, we intend to assess the implications of an investment strategy focused solely on the IT sector (long IT sector) while simultaneously shorting the remaining sectors. This examination aims to shed light on the possibility of an additional premium associated with investing in technological companies within the CEE region.

Firstly, we run a time series regression of IT sector on market factor using OLS method. We checked the necessary assumptions and applied variance-covariance matrix to deal with the heteroskedasticity and potential autocorrelation.

Based on the output from the Table 5.3 on the next page, we can conclude that market beta has no explanatory power on 95% confidence interval. However, the factor is significant on 90% confidence interval. R^2 is 0.197 which is a small value and potentially model would need to be re-adjusted. This regression was run only for the purpose to get the idea whether CAPM model is a sufficient tool to predict the excess returns on IT sector. Srinivasan (2012) examined the IT sector in Indian Stock market. The author took 60 monthly observations of the publicly listed companies in Indian Stock market. The results revealed that the explanatory power of the market beta is insufficient, thus CAPM model fails to explain returns in Indian IT sector. This is in line with our results.

Table 5.3: Time-series regression analysis: Output

	Dependent variable:
	IT
CAPM	0.278*
	(0.149)
Constant	0.712*
	(0.372)
Observations	149
R^2	0.197
Adjusted R^2	0.192
Residual Std. Error	5.146 (df = 147)
F Statistic	36.090*** (df = 1; 147)
Note:	*p<0.1; **p<0.05; ***p<0.01

5.2.1 Conditional Fama-Macbeth approach on IT sector: Univariate model

In this subsection, we will try to find out whether the various factors such as market, size, or MMR factor have the potential explanatory power in variance of IT stocks' returns in CEE. We will start the investigation with solely a market factor using the sample of the companies in IT sector. We analyse the hypothesis using Conditional Fama-Macbeth approach (Fama & MacBeth (1973)). Firstly, we estimate time series regressions using 60 months rolling window. We obtain market betas, which we use as the explanatory variables in the second stage. Table 5.4 summarizes the results of the Fama-Macbeth cross-sectional regressions.

Table 5.4: Cross-sectional regression output for IT sector, CAPM model

Statistic	$\overline{\hat{\lambda}_i}$	Standard Error	$t_{\overline{\hat{\lambda}_i}}$	p-value
CAPM factor	-0.003	0.009	-0.279	0.391

Based on the results presented in the table above, it can be inferred that the market factor does not exhibit statistical significance at the 95% confidence interval level. Consequently, the market beta fails to adequately explain the variations in stock returns within the IT sector. Furthermore, the observed risk premium factor demonstrates a negative sign. Previous research has also delved into the issue of whether market beta can explain the returns of IT sector companies. For instance, Rui *et al.* (2018) conducted a study analyzing 24 IT firms listed on the Malaysian Stock Exchange, using monthly data from 2007 to 2015. Their findings indicated that the CAPM model could not effectively explain the excess returns of IT companies, and the predictability of stock prices using the CAPM model was questionable. Our findings are consistent with the outcomes of Rui *et al.* (2018) study, further substantiating the limited explanatory power of the market beta in the context of IT sector returns.

5.2.2 The size in the CEE IT sector

As outlined in Chapter 4, the 50 companies in our sample were categorized into three distinct size portfolios based on their market capitalization. These portfolios were designated as micro, small, and mid, respectively. We then conducted a Conditional Fama-Macbeth 2-stage regression analysis on each of these size portfolios to assess the presence of a risk premium and to investigate whether the market beta could adequately explain the returns observed in these portfolios. The findings of this analysis are concisely presented in Table 5.5.

Table 5.5: Cross-sectional regression output for IT sector, Size portfolios

Statistic	$\overline{\hat{\lambda}_i}$	Standard Error	$t_{\overline{\hat{\lambda}_i}}$	p-value
Micro	0.009	0.016	0.625	0.266
Small	-0.005	0.019	-0.253	0.401
Mid	-0.008	0.018	-0.471	0.319

As evident from the results, micro cap stocks exhibit a monthly risk premium of 0.9%. For small cap stocks, the discount is 0.5% per month, and for mid-cap stocks, the discount is even higher at 0.8% per month. However, it is important to note that these results do not achieve statistical significance, and thus, there is no substantial evidence supporting the notion that the risk factor explains variations in future returns of stocks in micro, small, and mid-sized companies. It is worth mentioning that prior research has provided evidence of the existence of a size premium, wherein size can predict stock returns and that the average risk premium is higher for micro stocks compared to larger stocks. For instance, studies conducted by Li & Pritamani (2015), Fisher *et al.* (2017), and Zaremba & Umutlu (2018) have reported the presence of a size premium in international portfolios, particularly in emerging or frontier markets. These findings suggest that the size effect remains significant in such markets, unlike in developed markets. On the other hand, Van Dijk (2011) discovered that the size effect has vanished in the USA and UK markets after the 1980s. Our empirical analysis is consistent with prior research, indicating that micro cap stocks or smaller stocks demonstrate a higher risk premium than larger companies. This evidence supports the notion that size can significantly impact the returns of stocks in the IT sector, with smaller firms exhibiting a greater risk premium compared to larger companies.

5.2.3 MMR factor: univariate model

To assess the potential impact on returns from the micro cap stocks, we used the MMR factor, introduced by Zaremba (2015). The rationale, the description as well as implications of this factor might be found in the Chapter 4. The objective is to observe whether the MMR factor might explain the stock returns in CEE IT sector. To address this issue we use Conditional Fama-Macbeth two-stage regression (Fama & MacBeth (1973)). We employ a rolling window methodology with a window size of 60 months. The equation representing the first step of this analysis is as follows:

$$R_{it} = \beta_{0,i} + \beta_{1,i} MMR_t + \mu_{i,t} \tag{5.5}$$

where $R_{i,t}$ is the total return of a sector i at time t, MMR_t represents the excess return of the MMR factor at time t and β_1 is the risk factor coefficient. Using the estimation, we obtained factor loadings for each company in the IT sector. Now, we run the second stage regression to obtain the risk premium for our MMR factor. For the second step, t cross-sectional regressions are run at each time period, as suggested by Cochrane (2005). We use the following equation:

$$R_{t+1} = \lambda_{0t} + \lambda_{1t} \hat{\beta}_{mt} + \varepsilon_t \tag{5.6}$$

where R_{t+1} represents a vector of monthly excess returns at time $t+1$, $\hat{\beta}_{mt}$ represents a vector of monthly MMR betas from the set of time series regressions performed in the first step, and λ_{1t} is the risk premium for the MMR factor at time t. The table 5.6 summarizes the results of the aforementioned analysis and estimation:

Table 5.6: Cross-sectional regression output for IT sector, MMR factor

Statistic	$\overline{\hat{\lambda}_i}$	Standard Error	$t_{\overline{\hat{\lambda}_i}}$	p-value
MMR factor	-0.003	0.006	-0.536	0.298

The table 5.6 reveals no significance of the MMR factor, thus the MMR factor alone cannot predict the excess returns in the IT sector. Moreover, the average risk premium associated with the MMR factor shows a negative sign, suggesting that there is no additional premium specifically linked to micro cap stocks in our sample of CEE IT companies. No previous study has exclusively explored the predictive power of the MMR factor for excess stock returns. Zaremba (2015) who introduced the factor uses the MMR factor in addition with the market factor and the HML factor. Therefore, we believe that our results are original and we recommend the use of the MMR factor for additional tests and research purposes in the asset pricing literature.

5.2.4 IT Sector: Bivariate model with the market and the MMR factors

In the subsequent analysis, we aim to investigate whether the combined use of the market factor and MMR factor can improve the explanatory and predictive capability of the model in explaining variations in stock returns. Unlike the previous univariate analyses, we will now employ a multivariate regression approach using the Conditional Fama-Macbeth method. The primary objective is to assess whether incorporating both factors yields improved results compared to the individual factor models. As before, we will employ a rolling window with a duration of 60 months to ensure robustness in our estimation. The first time-series regression equation is presented below:

$$R_{it} = \beta_{0,i} + \beta_{1,i}MKT_t + \beta_{2,i}MMR_t + \mu_{i,t} \tag{5.7}$$

where $R_{i,t}$ is the total return of a sector i at time t, MKT_t represents the excess return of the market factor at time t, MMR_t represents the excess return of the MMR factor at time t, and β_1, β_2 are the risk factor coefficients.

The second-stage regression equation looks as following:

$$R_{t+1} = \lambda_{0t} + \lambda_{1t}\hat{\beta}_{mt} + \lambda_{2t}\hat{\beta}_{mmrt} + \varepsilon_t \qquad (5.8)$$

where R_{t+1} represents a vector of monthly excess returns at time $t+1$, $\hat{\beta}_{mt}$ represents a vector of monthly market excess returns at time t, $\hat{\beta}_{mmrt}$ is a vector of monthly MMR betas, and λ_{1t}, λ_{2t} are the risk premiums for the MKT and MMR factor at time t. The results of the analysis might be found in the Table 5.7:

Table 5.7: Cross-sectional regression output for IT sector, MKT and MMR factor

Statistic	$\overline{\hat{\lambda}_i}$	Standard Error	$t_{\overline{\hat{\lambda}_i}}$	p-value
MKT factor	-0.005	0.009	-0.521	0.302
MMR factor	-0.004	0.006	-0.638	0.263

The regression output reveals that the incorporation of the bivariate model did not yield improvement over the univariate analyses. Both the market factor (MKT) and the MMR factor demonstrate no statistical significance at the 95% confidence level, indicating their inability to predict the excess stock returns within the CEE IT sector. Moreover, both factors show negative average risk premiums, suggesting the absence of any observable premium within the IT sector. In his study, Zaremba (2015) investigated cross-sectional asset pricing methods based on market, size, value, and momentum in CEE markets. Utilizing stock-level data from 11 countries covering the period from April 2001 to June 2014, the author identified abnormal returns, particularly in micro-cap stocks, which could not be explained by traditional three-factor and four-factor models. This raised doubts about the validity of the traditional size premium in this context. To address this, Zaremba (2015) proposed a new pricing factor called the MMR factor, aiming to assess its potential in explaining the abnormal returns observed in micro-cap stocks. The findings indicated that the MMR factor could be used as a proxy for explaining the variation in stock returns in CEE markets, surpassing the traditional size premium factor. However, our analysis in the CEE IT sector yielded different results. We found no empirical evidence to support the effectiveness of the MKT and MMR factors in explaining the variations in cross-sectional stock returns. Both factors were statistically insignificant in our analysis. The differences in results may be attributed to the smaller sample size of IT sector companies in our study, which could impact the power of statistical tests. Therefore, further research is needed to explore multifactor models that incorporate the MMR factor and to confirm the robustness of its performance in different contexts.

5.2.5 IT sector: Bivariate model with a market factor and IT minus rest factor

We conducted an additional analysis of using the market beta and the IT minus rest factor. This factor ($ITMR$) is created using the IT sector returns minus the average of the returns from other sectors. The aim is to see whether there might be an additional premium in investing solely to the IT sector. As previously, we used Conditional Fama-Macbeth two-stage regression for multifactor models with rolling windows methodology with a window size of 60 months. The results are shown in the Table 5.8:

Table 5.8: Cross-sectional regression output for IT sector, MKT and ITMR factor

Statistic	$\overline{\hat{\lambda}_i}$	Standard Error	$t_{\overline{\hat{\lambda}_i}}$	p-value
MKT factor	-0.006	0.012	-0.473	0.319
ITMR factor	-0.001	0.002	-0.583	0.281

We can conclude that both factors, market factor and $ITMR$ factor, are statistically insignificant on 95% confidence interval, therefore are unable to predict the excess stock returns. The average risk premiums of both factors have negative signs suggesting there is no additional premium in the cross-sections of IT stocks' returns in the CEE markets. In contrast, Phylaktis & Xia (2009) conducted an analysis using data from January 1990 to February 2002, encompassing 27 emerging markets and 23 developed markets. Their examination focused on country and industry effects, leading them to conclude that Eastern European markets show prominent industry effects that dominate over country effects. Moreover, they suggested the possibility of the IT sector earning higher risk premiums. However, our findings do not follow the evidence presented by Phylaktis & Xia (2009). The lack of alignment in our results and those of Phylaktis & Xia (2009) highlights the importance of conducting further research and analyses to gain deeper insights into the factors influencing the risk premiums in the CEE IT sector. Additionally, exploring other potential factors and market characteristics could offer valuable contributions to the asset pricing literature in this region.

Chapter 6

Conclusion

The significance of exploring the Central and Eastern European (CEE) financial markets has witnessed considerable growth in recent decades. Investment practitioners have displayed an increasing interest in emerging markets, seeking potential investment opportunities for their funds. Consequently, there is a notable demand for identifying robust methodologies capable of explaining and predicting returns in such emerging markets. In the realm of financial market analysis, one approach to achieve this objective is through the adoption of uni-factor or multi-factor asset-pricing models. These models serve as valuable tools to discern the factors that contribute to the cross-sectional variations in stocks' returns, enabling better comprehension and analysis of market dynamics in the CEE region.

The primary objective of this thesis is to conduct a comprehensive analysis of the CEE markets, focusing particularly on the IT sector. The study involves the collection of data from 441 publicly listed companies across 9 CEE markets, representing 11 distinct sectors. Monthly returns and market capitalization data for each company are utilized in this analysis. To evaluate the predictive power of various asset-pricing models, including the CAPM and other multi-factor models, the study employs the Fama & MacBeth (1973) two-stage cross-sectional regression analysis. This methodology is applied to investigate the predictive capabilities of these models for the overall CEE market sectors as well as for the IT sector specifically. The analysis is conducted using a rolling window approach with a window size of 60 months to account for time-varying effects and to enhance the robustness of the findings.

First of all, this study explores the relationship between the market beta and the returns of the 11 sectors in the CEE region. We found no statistically significant relationship between the returns of these sectors and market beta. Based on our study, the CAPM model cannot explain the variance in the cross-sections of the stocks' returns.

Subsequently, this study deals with a specific analysis of the IT sector, aiming to observe whether various asset-pricing factors hold explanatory power for the returns of stocks within this sector. The empirical results indicate that the CAPM is not adequate in explaining the variations in stock returns.

In further investigations, we classified the IT companies into three distinct size portfolios: micro cap, small cap, and mid cap. The findings revealed a marginal average risk premium of 0.9% per month for micro cap IT companies; however, this result lacked statistical significance. Similarly, no statistically significant results were observed for the small and mid cap companies.

To address the unique characteristics of micro cap companies, we employed the MMR factor. This factor was intended to explore whether it had any explanatory power in predicting the excess returns of IT stocks. However, our analysis found no statistically significant relationship between the MMR factor and the returns of IT companies in the CEE region.

Furthermore, we conducted a bivariate analysis, combining the market factor with the MMR factor, to determine if this combined approach would yield better explanatory power. Nevertheless, the results of both factors indicated no statistical significance in predicting the variations in excess returns for IT companies in the CEE region.

Additionally, we explored the possibility of an additional premium by investing solely in the IT sector and shorting other sectors using the market beta and the IT minus rest factor. However, this analysis yielded no statistically significant results, suggesting that the combination of these factors fails to explain the variations in excess returns for IT companies in the CEE region.

The results obtained in this study hold potential implications for investment practitioners and the calculation of the cost of equity. Currently, the CAPM model is widely employed by equity analysts to estimate the cost of equity for individual companies. However, based on our empirical findings, particularly concerning the 11 sectors and the IT sector specifically, this approach might not be appropriate for accurately estimating the cost of capital. These findings also hold relevance for international investors who engage in factor-based investment strategies within the CEE region. Understanding the limitations and inefficiencies of using traditional CAPM-based models for the region's markets can help investors in making more informed decisions and developing improved strategies based on the observed empirical evidence. Therefore, our study's outcomes offer valuable insights for practitioners and investors seeking to enhance their understanding of the CEE markets and its associated risk factors.

The main limitation of our study is the small sample size in the IT sector, given the scarcity of publicly-listed companies in the CEE region. This is a common challenge in emerging and frontier markets, where data availability is relatively restricted compared to developed markets. As a result, the generalization of our findings to other regions and sectors should be approached with caution.

For future research, it is recommended to explore the applicability of the factors used in this study to other emerging markets, such as Asian or Latin American stock markets, in analyzing the IT sector. Additionally, researchers may consider employing alternative asset pricing models, such as the three-factor model by Fama & French (1993) or the five-factor model proposed by Fama & French (2015). These extended models could potentially yield valuable insights into the cross-sectional variations of stock returns within the IT sector in the CEE region. We believe it may contribute to a deeper understanding of the factors influencing asset returns in different emerging market contexts.

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