

# Preliminary Master Thesis Report

## - Evaluation of asset pricing models on the Norwegian and Romanian stock market -

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# Content

<b>ABSTRACT</b> .....	<b>II</b>
<b>INTRODUCTION</b> .....	<b>III</b>
<b>I. THEORY</b> .....	<b>1</b>
1.1 CAPM.....	1
1.2 APT .....	2
1.3 HOU, XUE AND ZHANG'S FOUR-FACTOR MODEL .....	5
<b>II. LITERATURE REVIEW</b> .....	<b>6</b>
2.1 CAPM.....	7
2.2 APT .....	10
2.3 HOU, XUE AND ZHANG'S Q-FACTOR MODEL .....	13
2.4 INTERNATIONAL ATTEMPTS.....	14
<b>III. METHODOLOGY</b> .....	<b>17</b>
3.1 THE CONSTRUCTION OF FACTORS .....	17
3.2 THE CONSTRUCTION OF PORTFOLIOS .....	19
3.3 REGRESSION EQUATIONS .....	20
<b>REFERENCES</b> .....	<b>21</b>

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## Abstract

This master thesis will focus on the evaluation of three main asset-pricing models in both the Norwegian and the Romanian stock market in order to:

- assess which asset-pricing model is best suited for the markets in question; (developed vs developing);
- identify what factors best describe the markets;
- compare the differences between a developed stock market and a developing one on the basis of the analysis aforementioned (e.g. the existence of more noise traders in the Romanian stock market than in the Norwegian stock market).

This study is inspired by the paper “*Evaluating asset pricing models in the Korean stock market*” written by Soon-Ho Kim, Dongcheol Kim, Hyun-Soo Shin and published in the Pacific-Basin Finance Journal. The asset pricing models used for evaluating the stock markets will be: Sharpe – Lintner CAPM, Fama and French APT five-factor model (2014) and Hou, Xue and Zhang four-factor model (2012). These models will be evaluated and compared with time-series and cross-sectional regressions based on t-tests, GRS-tests and  $R^2$  measures. The stock return data are obtained from Oslo Bors, Bucharest Stock Exchange, Bloomberg, from January 1996 to December 2016.

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## Introduction

Asset pricing models have a fairly extensive list of uses, from estimating equilibrium models to the evaluation of performance of fund managers to the determination of the cost of capital for a particular company. The vast literature is thus unsurprising on this subject.

But despite this, there is no consensus on a common model that does not fail when empirically tested. Rather a multitude of additions and subtractions have been made in order to accommodate as best as possible the reality of finance to the positive predictions made by the theoretical frameworks such as CAPM and APT. And with the advent of behavioural finance, the common practice amongst professionals nowadays is to utilize both CAPM (and CAPM variant models) together with APT-models.

This paper does not, unfortunately, set out to identify a model that could bridge the existing gap between normative and descriptive models but rather to evaluate three asset pricing models on two distinct cases: a developed market and a developing one. Therefore, this paper will focus on the evaluation of three main asset-pricing models in both the Norwegian and Romanian stock market in order to:

- evaluate what asset-pricing model is best suited for the markets in question (developed vs developing);
- identify what factors best describe the markets;
- infer the possible roots of the differences (if any) between a developed stock market and a developing one on the basis of the analysis aforementioned.

This study is inspired by the paper *“Evaluating asset pricing models in the Korean stock market”* written by Soon-Ho Kim, Dongcheol Kim, Hyun-Soo Shin and published in the Pacific-Basin Finance Journal. The asset pricing model will be: Sharpe-Lintner CAPM, Fama and French APT five-factor model (2014) and Hou, Xue and Zhang’s four-factor model (2015).

One could understandably question the inclusion of CAPM when it is well known that there have been over 40 years of studies done on CAPM and most suggest that CAPM is not supported empirically. It has been suggested that “CAPM should be

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abandoned and that it should be replaced simply by an assumption that investors expect the same return on all assets, regardless of their relative risk.” (Brown and Walter 2013, 44)

To these concerns one could argue however that:

- 1) Although the CAPM model has been empirically rejected numerous times, it still the foundation of all asset-evaluation techniques to this date. All the other models that may better explain the observed returns of any assets are in one way or another derived from CAPM. It would thus feel an incomplete study if CAPM were not to be included;
- 2) The majority of the studies on CAPM used developed markets (especially the U.S. market). This does not mean that CAPM might perform better on other markets that are quantitatively and qualitatively different from the U.S. stock market, such as Romania, but it surely requires a broader approach regarding testing CAPM on other international stock markets, either mature or incipient.

The author does not imply that the findings of this study are applicable to all developed and developing markets. The study’s truly focus is on the Romanian stock market, with the addition of a benchmark, the Norwegian stock market, which has been included in numerous studies with the scope of evaluating asset pricing models, but has not been in and of itself tested.

This paper has the following structure: section I makes a quick introduction into the theory of asset pricing models, section II reviews the literature, section III presents the methodology, section IV explains the data and descriptive statistics, section V examines the results and section VI concludes.

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## I. Theory

### 1.1 CAPM

CAPM was derived from the work done by Harry Markowitz, namely the development of the theory of portfolio choice presented in the article “Portfolio Selection”, published in 1952 (Markowitz 1999). The theory of portfolio choice, broadly speaking, stipulates the benefits of diversification – a common observed behaviour of investors but until then not properly theorized. William Sharpe builds upon this theory and in 1964, the Capital Asset Pricing Model is published in the paper “Capital Asset Prices: A Theory of Market Equilibrium under Conditions of Risk” (Sharpe F. 1964). The theory also makes use of other key pieces such as Tobin’s two-fund separation (Tobin 1958), whereby the process of investment choice can be separated into two funds: the market portfolio, which is the optimal portfolio that lies on the efficient set and a riskless asset, such as an asset that earns a risk-free interest rate (Sharpe F. 1964). One year later, in 1965, John Lintner, in his paper “The Valuation of Risk Assets and the Selection of Risky Investments in Stock Portfolios and Capital Budgets” theorizes the Capital Asset Pricing Model using also, as his point of departure, Tobin’s two-fund separation (Lintner 1965).

In its definition, Capital Asset Pricing Model states that the pricing of assets is performed under the basis of a trade-off between undiversifiable risk (measured by beta) and the expected returns of the assets. CAPM is built on several assumptions, including the efficient market hypothesis assumption and the fact that investors are rational expected utility maximizers.

Upon these assumptions and taking into consideration Tobin’s two-fund separation, the Capital Asset Pricing Model is derived in the following mathematical form:

$$E(R_i) = R_f + (E(R_M) - R_f) * \delta_{iM} / \delta^2_M, \text{ where } \delta_{iM} / \delta^2_M = \beta_i \quad (1)$$

Equation 1 states that the expected return on asset  $i$  is equal to the risk-free rate of return plus a risk premium. The risk premium is the price of the risk multiplied by

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the quantity of risk, where the price of the risk is the difference between the expected return of the market portfolio and the risk-free rate asset, and the quantity of the risk is  $\beta_i$  which measures the sensitivity of the asset's  $i$  return to variation of the market portfolio's return (Copeland, Weston and Shastri 2013). It is thus covariance that matters in the process of choosing the assets for building a portfolio. Beta, in other words, represents the quantity of undiversifiable risk that the investors are willing to accept given a certain price of risk, or risk premium:  $(E(R_M) - R_f)$ , or the risk premium is simply proportional to the beta coefficient.

The ex post empirical equation is the following:

$$R'_{pt} = \gamma_0 + \gamma_1 \beta_p + \varepsilon_{pt}, \quad (2)$$

where  $\gamma_1 = R_{mt} - R_f$  and  $R'_{pt}$  represents the excess return on portfolio  $p = (R_{pt} - R_f)$  (Copeland, Weston and Shastri 2013)

Based on CAMP, the predictions of the aforementioned model are (Copeland, Weston and Shastri 2013):

- $\gamma_0$  approximately equals 0.
- Beta should be the only factor that influences the rate of return.
- The relationship should be linear;
- $\gamma_1 = R_{mt} - R_f$ .

## **1.2 APT**

CAPM is a simple model that links the expected return of an asset to its betas, or the systematic risks that naturally exist in an economy. In this respect though, CAPM is unidimensional. Beta is indeed a powerful yet simple factor measuring undiversifiable risk but it is hard to identify it empirically. One reason is that it requires the identification of the true market portfolio. It has not been theoretically defined and throughout the studies that will be further described in the next section the market portfolio was replaced by a proxy which, according to Brown and Walter

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(2013, 47) encounters two difficulties: “the proxy might be mean-variance efficient even when the true market portfolio is not” or the proxy might be altogether inefficient.

Moreover, even if the efficient market portfolio would be properly identified and measured, one would expect an asset’s return to be influenced by more than its sensitivity to the overall portfolio risk. Factors such as inflation rate, business cycles, interest rate could impact an asset’s return just as much as its sensitivity to aggregate market movements, or in some cases, even more. For this reason, there have been developed multifactor models that take into account specific factors that influence an asset’s return. These models provide a point of departure for knowing the exact location of an asset’s return relative to those factors and thus being able to manage the exposure properly and efficiently. The Arbitrage Pricing Theory (APT) is one of these multifactor models and it can be regarded as a multidimensional CAPM, or CAPM can be regarded as a special case of APT. (Bodie, Kane and Marcus 2014) (Copeland, Weston and Shastri 2013)

The Arbitrage Pricing Theory can be derived from the powerful relation stated in Ross (1977), where “if two riskless assets offer rates of return of  $\rho$  and  $\rho'$ , then (in the absence of transactions costs):

$$\rho = \rho' \quad (3)$$

This is known as the Law of One Price. If the above condition is violated, then there exists an arbitrage opportunity and, as a consequence, it would indicate, according to Bodie, Kane and Marcus (2014,328) “the grossest form of market irrationality.” Furthermore, APT departs from the formation of an arbitrage portfolio, with weights  $\sum w_i = 0$  (no change in wealth), that the following excess return is given by:

$$R_P = E(R_P) + \beta_P F_k + \varepsilon_P \quad (4)$$

where  $\beta_P = \sum w_i \beta_{ik}$ ;  $E(R_P) = \sum w_i E(R_i)$ ;  $\varepsilon_P = \sum w_i \varepsilon_i$ ;  $F_k$  – a vector of expected returns of  $k$  factors are the weighted averages of the  $\beta_i$ , risk premiums of the  $n$  securities and the weighted average of the  $\varepsilon_i$  of the  $n$  securities (Bodie, Kane and Marcus 2014). Through diversification though  $\varepsilon_P$  becomes negligible and so equation 4 becomes: (Bodie, Kane and Marcus 2014)



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$$R_P = E(R_P) + \beta_P F \quad (5)$$

Furthermore, because there is no change in wealth ( $\sum w_i = 0$ ), then  $R_P$ , from a random variable, becomes equal to  $E(R_P)$ . This means that all systematic risk has been eliminated as well, so that a proper pure arbitrage portfolio has been formed. In other words:

$$R_P = \sum w_i E(R_i) = 0 \quad (6)$$

If the equation 6 were not true, then by using no wealth one would be able to obtain a riskless return. Moreover, this riskless return could be maximized simply by scaling up the arbitrage portfolio. This is however incompatible with the no-arbitrage condition and the Law of One Price and as such, assuming a riskless rate of return  $R_f$  with zero beta, the arbitrage pricing theory is the following:

$$E(R_i) - R_f = \sum [F_k - R_f] \beta_{ik} \quad (7)$$

APT does require that investors have a risk-averse utility function but its simplicity lies purely on the Law of One Price and no-arbitrage condition. It does not make any assumption about the distribution of asset returns; it does not require the entire universe of assets, and as such, there is no special place for the market portfolio, and it includes numerous factors. This last statement is a quality in and of itself due to its practicality for minimizing one's exposure against changes in one or multiple factors. It also helps explain, from a theoretical point of view at least, the factors that might, more or less, influence assets from an economy as whole. CAPM, as mentioned in the beginning, can be thought of as a special case of APT if one would use only one factor, and that is the market portfolio. However a multifactorial APT is not only useful for the above reasons but also necessary as there have been discovered, over the years, multiple anomalies unaccounted for by CAPM. These anomalies will be more thoroughly revised in the following sector but a few are worth mentioning here as they can bridge the gap between a general multifactorial APT to a more concrete one, such as a five-factor model.

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Based on empirical research conducted by Chan and Chen (1991), cited in Fama and French (1996, 56) that revealed covariation in returns related to relative distress not captured by the market return, and Huberman and Kandel (1987), cited in Fama and French (1996, 56) that also surfaced covariation in the returns of small stocks not fully explained by the market return, Fama and French (1996) introduced a three-factor model using HML (high minus low – the difference between the returns of a portfolio of high book-to-market stocks and the returns of a portfolio with low book-to-market stocks) and SMB (small minus big – the difference in the returns of a portfolio of small stocks to that composed of large stocks as measured by their market capitalization) proxy factors for the relative distress in returns. As such, the expected excess return on portfolio  $P$  is,

$$E(R_p) - R_f = b_p[E(R_M) - R_f] + s_pE(SMB) + h_pE(HML) \quad (8)$$

where  $[E(R_M) - R_f]$ ,  $E(SMB)$  and  $E(HML)$  are expected premiums and  $b_p$ ,  $s_p$  and  $h_p$  are the factor sensitivities in relation to the return of the portfolio. The five-factor model that will be tested in this paper is simply an extension of the three-factor model that incorporates profitability and investment. According to Fama and French (2014, 2) “much of the variation in average returns related to profitability and investment is left unexplained” by the three-factor model aforementioned. From this perspective, the two factors added to the above equation are RMW (a proxy factor that consists in the difference between the returns on portfolios composed of high and low profitability) and the CMA (a proxy factor that consists in the difference between the returns of portfolios composed of stocks of low and high investment companies). (Fama and French 2014) Equation 8 takes the following form:

$$E(R_p) - R_f = b_p[E(R_M) - R_f] + s_pE(SMB) + h_pE(HML) + r_pE(RMW) + c_pE(CMA) \quad (9)$$

### ***1.3 Hou, Xue and Zhang's four-factor model***

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Another recent model is the Hou, Xue and Zhang's four-factor model, introduced in 2012. It is based on the q-theory of investment and it has the following mathematical form:

$$E[r^i] - r^f = \beta_{MKT}^i E[MKT] + \beta_{ME}^i E[r_{ME}] + \beta_{\Delta A/A}^i E[r_{\Delta A/A}] + \beta_{ROE}^i E[r_{ROE}] \quad (10)$$

where  $MKT$  is the market excess return,  $r_{ME}$  "is the difference between the return on a portfolio of small-market equity stocks and the return on a portfolio of big-market equity stocks",  $r_{\Delta A/A}$  "is the difference between the return on a portfolio of low-investment stocks and the return on a portfolio of high-investment stocks" and  $r_{ROE}$  "is the difference between the return on a portfolio of high ROE stocks and the return on a portfolio of low ROE stocks" and  $\beta_{MKT}^i$ ,  $\beta_{ME}^i$ ,  $\beta_{\Delta A/A}^i$ ,  $\beta_{ROE}^i$  are the factor loadings. (Hou, Xue and Zhang 2012)

In Hou, Xue and Zhang (2012), the new factor-model is compared against the Fama-French three-factor model and the Carhart (1997) four-factor model and overall it performs similarly or better than the latter models, especially in explaining anomalies.

## II. Literature review

Before considering the numerous empirical studies done on CAPM, there needs to be a brief introduction in the Efficient Market Hypothesis (EMH), which states that the current price of an asset is close to its intrinsic value. According to Statman (2005), the EMH is the second building block of the standard finance that describes economic agents as rational beings that always prefer more to less, are mean-variance maximization-driven and regard an increase in their wealth in the same way, regardless of its origin. EMH has three forms: weak, semi strong and strong. The weak EMH states that the market prices incorporate all market information, the semi strong EMH underlies the fact that the market prices incorporate all publicly available information, always adjusting to absorb new information, and the strong EMH refers to the fact that market prices reflect all information, both public and private.

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## 2.1 CAPM

CAPM is closely related to EMH due to the fact that, in order to test the second form of EMH, one would need a model that could adjust for the differences in risk among stocks, in other words, one would need a variable that could explain the returns of the asset not in terms of standard deviation but in terms of covariance. As such, CAPM's beta came in great use. One such example that tested EMH using CAPM is related in Basu (1977). In this study, it is tested whether low P/E ratio portfolios tend to have larger returns than high P/E ratio portfolios. If this were the case, then both CAPM and EMH would be violated. The study focused on over 1400 industrial firms that traded on NYSE during the period September 1956 – August 1971 and it showed that low P/E portfolios have, on average, higher returns compared to those of high P/E portfolios. In addition, there was a delay in the ascription of new information into the market prices suggesting that EMH, even though not completely amiss, might need some adjustments. This study however focuses on EMH using CAPM. But there are numerous other studies which their main focus is the empirical performance of CAPM.

One of the first studies that questioned the validity of CAPM is Friend and Blume (1970). The paper tests the one-parameter performance measures to risk measure of 200 random portfolios selected from 788 common stocks that traded on NYSE during the period January 1960 – June 1968. The performance measures were Sharpe ratio, Treynor's ratio and Jensen's ratio, while the risk measure was beta.

Until this paper, CAPM had been tested on performance of portfolios in such papers such as Sharpe (1966), Jensen (1968) and Lintner (1965) cited in Friend and Blume (1970, 574), but only Friend and Blume's study questioned the validity of CAPM as it found out a bias in the performance measures relative to beta. In addition, throughout the paper, Friend and Blume question the assumptions underlying CAPM and in doing so, they try to explain this biasness through the unrealistic characteristics of the assumptions, one such assumption being the ability of the investors to borrow and lend unlimited quantities at the same risk-free rate. Black (1972) would, later on, replace the risk free rate with a portfolio  $R_z$  that has zero-

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beta with the market portfolio and it is, like the risk free rate, the minimum variance portfolio. By doing so, CAPM would thus introduce restricted borrowing which is much closer to reality. However, even with one assumption relaxed, CAPM still underperformed when tested.

As such, numerous studies had been further produced in order to discover if there were any other factors that could explain returns better than beta. Banz (1981,14) suggested that CAPM was specified incorrectly, lacking a factor (or multiple) that would otherwise take into consideration the size effect, where “on average, small NYSE firms have had significantly larger risk adjusted returns than large NYSE firms over a forty year period.” In the same line of thinking is Reinganum (1981a), where E/P anomaly discovered by Basu (1977) is overtaken by the size effect; it also concludes that this size effect is not due to a market anomaly but rather due to a misspecification of CAPM.

The size effect continues in more recent times to appear in papers testing CAPM, one such example being Campbell and Vuolteenaho (2004) whereby they characterized beta as either good or bad and suggested that the poor performance of CAPM is largely due to the fact that growth stocks are described by good betas.

In a Miller-Modigliani world, dividend yields would have no effect whatsoever on the returns of the stocks. However, Litzenberger and Ramaswamy (1979) acknowledged the fact that there exists a positive relation between dividend yields and expected returns; they also pointed out to the clientele effect, whereby some economic agents impacted by high taxes prefer stocks with low dividend yields whereas those that have low taxes or no taxes at all (not-for-profit organizations) prefers stocks with high dividend yields.

Following upon the results published in Litzenberger and Ramaswamy 1979 paper and after the discovery of seasonality in stock returns – so-called January effect whereby most of the excess return is generated in one month, as reported in Keim (1983)– Keim (1985) argued that even though there seems to exist a positive relation between dividend yields and stock returns, this relation has more statistical

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significance in January and cannot be solely attributed to the clientele effect, suggesting thus a different phenomenon, such as size effect, that might be more relevant.

However, Roll (1981) argued that one possible explanation of the discovery of the size effect lies in the autocorrelation of the portfolio returns due to infrequent trading. This autocorrelation would cause the sample observations used in the studies aforementioned not to be independently distributed. With regards to the dividend yield however, the results are mixed. As stated in Roll (1981, 887), “perhaps the mixed evidence on dividend yield is due partly to a complex relationship between dividend yield and trading frequency with a correspondingly complex relationship between yield and the bias in risk measures.”

Dimson (1979) proposed some estimators to replace beta estimates in order to eliminate the bias that conventionally arises when analysing data based on stocks that are infrequently traded, while Gibbons (1982) argued that a new approach, called multivariate statistics, is better suited to test CAPM (and other asset pricing models as well) due to the fact that some methodological problems are neatly avoided (such as the errors-in-the-variable problem). However, one of the most prominent paper with regards to the discovery of econometric issues when testing CAPM (and not only), is Roll’s paper (1977) which firmly implied that there is a severe limitation to evaluating asset pricing models such as CAPM due to the fact that the true market portfolio is not properly defined (Roll 1977). In addition, he adds that using a proxy for the market portfolio might render the test to fall into either of the two aforementioned fallacies: that either the proxy is mean-variance efficient while the true market portfolio is not, or vice versa.

Following upon the aforementioned limitations in testing CAMP, Stambaugh (1982) tested both Sharpe-Lintner CAPM and Black’s CAPM using a variety of assets (stocks, bonds, preferred stocks) and a multivariate test analysis. Upon these changes, he argued that Sharpe-Lintner CAPM is rejected using the inclusive set of assets while Black’s CAPM is not; on the other hand, he pointed out to the fact that a different composition of a set of assets could conclude in different results, such as a rejection of Black’s CAPM and not of Sharpe-Lintner CAPM.

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Other than the size effect, seasonality or the sensitivity of the CAPM to the formation of the market factor proxy, Chan, Hamao and Lakonishok (1991) argued that, upon studying the returns of the Japan's stock market in relation to earnings yield, size, book to market equity ratio and cash flow yield (as what they referred to as "fundamentals"), there is a significant positive relation between the book to market equity ratio and cash flow yield relative to the expected returns.

As reported in Fama and French landmark paper (1992,450), Stattman (1980) and Rosernberg, Reid and Lanstein (1985) derived the same positive relation implied by Chan, Hamao and Lakonishok (1991) study on the Japanese stock market between book to market equity ratio and expected returns on the U.S. stock market.

With all these market anomalies discovered during the years and with the growing influence of behavioural finance looming over ((Kahneman and Tversky 1979), (De Bondt and Thaler 1985)), Fama and French (1992) set out, in their paper, to establish whether the market is inefficient or the CAPM model is lacking in explanatory power. Unlike the aforementioned papers, they used a large database, stretching from 1963 to 1990 for NYSE and AMEX stocks, and adding NASDAQ stocks from 1973 to 1990. Firstly they separated size and beta in order to escape the correlation implicit between these variables, and in so doing they formed portfolios based on size and based on beta. The results showed that when portfolios are formed on size, there exists a positive relation between returns and beta whilst when portfolios are formed on beta alone, the link between returns and beta disappears. In addition, they ran multiple regressions with the individual stock return as the dependent variable and show that book to market equity ratio and size are the factors that explain best the returns. As a consequence, Fama and French introduced in 1993 a three-factor model.

## ***2.2 APT***

However, before the introduction of the three-factor model by Fama and French, there had been some empirical investigations on APT. One such paper is Roll and

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Ross (1980), whereby they explore the existence of factors and the number of factors that could explain the returns. They concluded that there are at least three factors in the model. The specification of the factors however could not be determined through factor analysis but Roll and Ross (1980) argued that if an alternative variable is statistically significant in explaining the expected return then APT could be rejected. They tested whether the standard deviation is such an alternative variable and discovered, albeit the high correlation between returns and the standard deviation, it does not bring “explanatory power to that of the factor loadings.” (Roll and Ross 1980, 1073)

Reinganum (1981b), on the other hand, contended that the firm size effect is still existent and statistically significant even when APT risk is tested with a three-, four- or five-factor model. N.-F. Chen (1983) however, using the data of Reinganum, supported the findings of Roll and Ross (1980), whereby the standard deviation did not add explanatory power to the returns and rejected the findings of Reinganum (1981b), where firm size effect adds explanatory power to the returns. He also proposed that an economic interpretation of the common factors should represent the implicit direction of future research on APT, whereby macro factors explaining realized returns are to be determined empirically. And this is what Chen, along with Roll and Ross set out to examine three years later.

Chen, Roll and Ross (1986) proposed several economic variables that had been considered potent factors in explaining the expected returns. Upon these economic variables, they derive the following state variables: industrial production, change in expected inflation, unexpected inflation, risk premium, term structure, a value-weighted index, real per capita consumption and an index of oil price changes. Amongst these variables, only the first five factors were found to be statistically significant in explaining the stock returns, while the other three variables added no explanatory power whatsoever. In the meantime, other papers suggested that only few factors are sufficient in explaining expected returns. One such example is Brown and Weinstein (1983) whereby using a bilinear paradigm, they rejected a five – and a seven-factor model and concluded that few economic factors might appear to be integrated in APT. Christofi and Philippatos (1987) tested APT at an international level, on monthly stock market indices on 14 industrial countries



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during the period January 1959 and December 1978. Their conclusion is consistent with Brown and Weinstein (1983) conclusion, pointing out to only one common factor existent across the industrial share-price indices. Shanken (1982) argued that APT is not truly testable unless the true market portfolio's returns are incorporated.

Despite such mixed empirical results, Fama and French (1993) introduced both a three-factor model. In 2014, the three-factor model will have been updated with two factors: RMW (the difference between stocks with robust and weak profitability) and CMA (the difference between stocks of low and high investment companies). The 2014 Fama and French five-factor model was tested internationally in Fama and French (2015) both on a regional and a global basis. Due to the poor performance of global three- and five-factor models on regional portfolios, they concentrated their analysis locally. There were some difference amongst the regions (North America and Canada; Japan; Asia Pacific; Europe) such as the investment factor having no explanatory power in Europe and Japan, but the striking result, common to all regions, was that portfolios of small stocks but with high investment but low profitability wreak havoc on asset pricing models. The five-factor model, in words of Fama and French (2015,22) “captures the troublesome average returns in some sorts, but not in the Size-Op-Inv sorts that best isolate stocks of firms that invest a lot despite low profitability.”

However, despite the imperfectness of the model, Fama and French (2015) suggested that the five-factor model is quite appropriate for the evaluation of portfolio manager or the selection of a portfolio itself. A comparative study was performed by Hou, Xue and Zhang (2016), whereby they tested several classic and also new asset pricing models, including the Hou, Xue and Zhang (2012) q-factor model and the Fama and French five-factor model (2014), against a series of hundreds of anomalies. Their enormous study drew two major conclusions: 1) when controlling for stocks with small market capitalizations, a large number of anomalies become statistically insignificant; 2) amongst the statistically significant anomalies, the Hou, Xue and Zhang (2012) q-factor model and the Fama and French five-factor model are the best performing models.

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### *2.3 Hou, Xue and Zhang's q-factor model*

The four-factor model introduced by Hou, Xue and Zhang (2012) is a by-product of all the empirical research conducted over the years since the appearance of CAPM and APT. As it was previously shown, Sharpe-Lintner CAPM was consistently underperforming from an empirical standpoint and as such Black (1972) introduced CAPM with restricted borrowing, whereby the riskfree interest rate would be replaced by a zero-beta, minimum-variance asset. Merton (1973, 868) developed an intertemporal CAPM, whereby the limitations of the static CAPM have been expanded to include “a changing investment opportunity set.” Jarrow and Rosenfeld (1984) extended the intertemporal CAPM to include diffusion paths in stock prices but the empirical evidence conducted by them suggested that the market portfolio does not appear to have a jump component. Consumption CAPM had been introduced by Breeden (1979), in which assets are traded continuously and beta is measured relative to the aggregate real consumption growth rather than the market. Later on, Mankiw and Shapiro (1986) tested the consumption versus the market beta and reported that the market beta incorporates more information regarding its return than the consumption beta. One possible explanation for this is that not all consumers are active participants in the stock market. As such, CAPM has been constantly modified and changed in order to incorporate “the market anomalies” and a more realistic approach towards the pricing of assets.

APT, on the other hand, even though is not regarded as an equilibrium model but more as an arbitrage model, has had its share of modifications. At first, APT seemed promising due to the fact that returns were not linked only to one risk factor but multiple ones. However, as it was previously shown, the discovery of those multiple risk factors has been more “trial and error”. As such, Fama and French introduced a three-factor model in 1993. Carhart (1997) expanded the three-factor model with a fourth one, called momentum in stock returns and found that it improved the mean absolute error of the three-factor model. D. Kim (2006) provided a risk-based asset pricing model for the January effect by suggesting a two-factor model that contains a market factor and an earning informations uncertainty factor. Chen, Marx-Novy

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and Zhang (2011) replaced the two factors from Fama and French three-factor model with investment and ROE as these factors have an effect on discount rates and further on, an impact on stock returns. Later on, Fama and French (2014) introduced a five-factor model that is different from the five-factor model proposed in 1993, with market, size, book-to-market ratio, profitability and investment in order to capture the variation of average returns relative to profitability and investment, while the three-factor model of Chen, Marx-Novy and Zhang (2012) is updated with a size factor.

Hou, Xue and Zhang (2012) proposed a new factor model, called the q-factor model due to its linkage with the q-theory of investment, whereby the two most prominent explanatory factors are investment and ROE, while size is more of an adjustment factor. They tested it against Fama and French three-factor model and Carhart (1997) four-factor model in explaining various anomalies such as earnings surprise or financial distress, and their results suggest that it outperforms the two models aforementioned and can be thus considered, according to Hou, Xue and Zhang (2012,35) “a new workhorse model for academic research and investment management practice.”

#### ***2.4 International attempts***

On an international level, there has been a growing debate on whether there exists some common global or sector factors that explain asset returns due to the rapid integration and liberalization of markets around the world. Fama and French (1998) argued that a one-state-variable international CAPM or a two-factor APT (a world market and a world book-to-market equity) explain international stock returns. However, Griffin (2002) pointed out to the fact that Fama and French (1998) study is somewhat flawed as they failed to compare the world factor model to country-specific models. In turn, when this analysis is conducted, Griffin (2002) found out that, when comparing a world three-factor model to country-specific models, the country-specific models add more explanatory power to time-series variation in portfolio and individual stock returns than the world model. As a results, Griffin

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(2002) suggested that asset pricing, performance evaluation and risk analysis is better conducted on a country-specific basis than on a global basis.

Other proponents of Griffin's results are Koedijk and van Dijk (2004) that measured whether global risk factors are better in computing cost of capital. Koedijk and van Dijk (2004) conducted the analysis on a sample of 3300 stock from nine industrialized countries (from Europe as well) and proved that global risk factors add no power to the cost-of-capital computation. Chen, Bennett and Zheng (2006) examined whether sector effects (industry effects) in both developed and emerging markets have a more dominant influence than country-specific factors. The analysis was conducted on 23 developed countries (including Norway) and 26 emerging countries (excluding Romania) on the period January 1994 through May 2005. The results suggested that sector effects are more relevant in developed markets whilst country effects are more relevant in developing countries when explaining returns. Bekaert, Hodrick and Zhang (2009), when examining international stock return correlations on 23 developed countries (including Norway), found out that, despite the fact that Fama-French (1998) model explained the data quite accurately, there is still a great predominance of country-specific factors over industry-specific factors.

Hou, Karoly and Kho (2011) set out to specifically pinpoint the factors that might explain stock returns, bridging thus the gap between whether country-specific factors or global factors are more relevant. They examined size, dividend, earnings yields (dividend to price ratio, earnings to price ratio), cash flow-to-price ratio, book-to-market equity ratio, leverage, and momentum for 27000 stocks from 49 countries (including Norway but excluding Romania), stretching from period 1981 to 2003. Three lines of analysis are followed in this analysis and these are: 1) which factors are most relevant in the explanation of variation in global stock returns; 2) whether the factors discovered precedently are derived from a country perspective or from a global perspective, or a mix of both; 3) and whether these factors result from firm-level characteristics or from the covariance structure of returns that is related to them.

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Their analysis revealed that cash flow-to-price ratio and not size and book-to-market ratio is relevant in explaining stock returns and a global cash flow-to-price portfolio together with a global factor-portfolio and a global market portfolio is the most appropriate model to explain stock returns. On the second point though, there seems to be a predominance of local components over the global component especially regarding emerging markets. On the third inquiry, not only is the cash flow-to-price ratio related to a global covariance risk factor, but it also reinforces the first point, where book-to-market ratio and size are rejected as explanatory factors linked to covariance risk.

Notwithstanding the vast literature on developed countries regarding the evaluation of asset pricing models, there has not been a somewhat similar effort regarding emerging markets. There are though some papers worth mentioning. Buckberg (1995) investigated the complete integration of emerging stock markets with the global market and discovered that prior to 1984 International CAPM is rejected, but on a second analysis conducted on a sample dated 1984 – 1991, there is strong evidence that emerging markets were integrated with the world market. Harvey (1995), on the other hand, argued that stock returns of emerging markets are influenced more by local variables rather than global ones pinpointing either to a segmentation of emerging markets from the world market or to a time variation in the risk exposures of emerging markets. Moreover, there has been in recent years a movement towards the analysis of emerging markets from an asset-pricing perspective on a singular basis, rather than coupled with other emerging markets or developed ones, as in Mateev and Videv (2008), Pieleanu (2012), Bontaş and Odăgescu (2011).

In light of this, this paper will focus on the evaluation of three main asset-pricing models in both the Norwegian and Romanian stock market in order to:

- evaluate what asset-pricing model is best suited for the markets in question (developed vs developing);
- reveal what factors best describe the markets;
- infer the possible roots of the differences (if any) between a developed stock market and a developing one on the basis of the analysis aforementioned.

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### III. Methodology

This paper will test CAPM, Fama and French five-factor model and Hou, Xue and Zhang's four-factor model on the Norwegian and Romanian stock market using time-series and cross-sectional regressions based on GRS test of Gibbons, Ross and Shanken (1989),  $t$ -tests and  $R^2$  tests. The stock data are obtained monthly, from January 1996 to December 2016 from Oslo Børs, Bucharest Stock Exchange and Bloomberg. The testing period will start from January 2000 due to the calculation of the asset values changes, necessary for the construction of the factors. Financial firms and companies with negative book equity are not included in the sample.

#### 3.1 The construction of factors

The Market factor ( $MKT$ ) is the value-weighted return with dividends of the Norwegian and Romanian stocks in surplus of the risk-free return.

The Fama and French factors are constructed from 2x3 independent sorts on:

- *Size* (market capitalization) and combinations of
  - o  $B/M$  (the ratio of book equity to market equity),
  - o  $OP$  ( Sales minus COGS, SGA and interest expense, all divided by book equity),
  - o  $Inv$  (Total Assets from  $y^1-1$  minus Total Assets from  $y-2$  divided by Total Assets from  $y-2$ ) as in Hou, Xue and Zhang (2016)

The stocks will be sorted based on market capitalization as in Fama and French (2015): 90% of the market capitalization for both Norway and Romania will be considered big stocks, while the remainder will be considered small stocks. The breakpoints for  $B/M$ ,  $OP$  and  $Inv$  are 30<sup>th</sup> and 70<sup>th</sup> percentiles for both the Norwegian and Romanian stocks. This allows for the following portfolio formations:

- *Size* and  $B/M$ : 6 portfolios from the intersection of the two *Size* and the three  $B/M$  groups: SL, SM, SH, BL, BM, BH, where S and B are indicatives of

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<sup>1</sup> y – year; t – month

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small and big, and L, M and H are indicative of low (the bottom 30%), middle (40%), and high (the top 30%) as in Kim, Kim and Shin (2012).

- *Size* and *OP*: 6 portfolios from the intersection of the two *Size* and the three *OP* groups: SR, SN, SW, BR, BN, BW, where S and B are indicatives of small and big, and R, N, and W are indicatives of robust (R), neutral (N), and weak (W) as in Fama and French (2014);
- *Size* and *Inv*: 6 portfolios from the intersection of the two *Size* and the three *Inv* groups: SC, SN, SA, BC, BN, BA, where S and B are indicatives of small and big, and C, N and A are indicatives of conservative (C), neutral (N) and aggressive (A) as in Fama and French (2014).

Monthly-equally weighted returns for all 18 portfolios are calculated from April of year  $t$  to March of year  $t+1$ .  $SMB_{B/M}$  is the equally-weighted average of the returns of the portfolios SL, SM and SH minus the average of the returns of the portfolios BL, BM and BH.  $SMB_{OP}$  and  $SMB_{INV}$  are constructed in the same manner as  $SMB_{B/M}$ , and the overall *Size* factor  $SMB$  is the average of  $SMB_{B/M}$ ,  $SMB_{OP}$  and  $SMB_{INV}$ .

The factor  $HML$  is the average of  $HML_S$  and  $HML_B$ , which are in turn constructed in the following manner:  $HML_S = SH - SL$ ;  $HML_B = BH - BL$ .

The factors  $RMW$  and  $CMA$  are constructed in the same manner as  $HML$ :

- $RMW = [(SR - SW) + (BR - BW)]/2$
- $CMA = [(SC - SA) + (BC - BA)]/2$

The Hou, Xue and Zhang's four-factor model, which will be referred henceforth as the  $q$ -factor model contain the following factors:  $MKT$ , *Size*, *Investment* and  $ROE$ .

The  $q$ -factors are derived from a 2x3x3 sort on:

- *Size* (market capitalization, the same as in Fama and French five-factor model);
  - o with *Investment-to-assets* ( $I/A$ ), which is equal to the Fama and French *Inv* factor.

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- and with *ROE*, which is income before extraordinary items divided by one-quarter-lagged book equity<sup>2</sup>, as in Hou, Xue and Zhang (2016).

The stocks will be sorted based on market capitalization as in Fama and French (2015): 90% of the market capitalization for both Norway and Romania will be considered big stocks, while the remainder will be considered small stocks. The breakpoints for *I/A* and *ROE* are 30th and 70th percentiles for both the Norwegian and Romanian stocks, as follows:

- *I/A*: low 30%, middle 40% and high 30%
- *ROE*: low 30%, middle 40% and high 30%/

This allows for 18 portfolio formations<sup>3</sup>. Monthly-equally weighted returns for all 18 portfolios are calculated from April of year *y* to March of year *y*+1. The construction of factors follows the method of Hou, Xue and Zhang (2016):

- $R_{ME}$  factor (size) is the difference, each month, between the equally-weighted average of the returns on the nine small-cap portfolios and the equally-weighted average of the returns on the nine big-cap portfolios.
- $R_{AAA}$  factor (investment) is the difference, each month, between the equally-weighted average of the returns on the six low *I/A* portfolios and the equally-weighted average of the returns on the six high *I/A* portfolios.
- $R_{ROE}$  factor is the difference, each month, between the equally-weighted average of the returns on the six high *ROE* portfolios and the equally-weighted average of the returns on the six low *ROE* portfolios.

### ***3.2 The construction of portfolios***

Following the literature, at the end of June each year I shall construct 16 *Size-B/M*, 16 *Size-Op*, 16 *Size-Inv*, 16 *Size-ROE*, and 16 *Inv-ROE* portfolios to be used in asset pricing regressions. The breakpoints for *Size* and *Inv* are the 3<sup>rd</sup>, 7<sup>th</sup>, 13<sup>th</sup>, and 25<sup>th</sup> percentiles of the market capitalization of each country. Following Kim, Kim and

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<sup>2</sup> Book equity is shareholder's equity (=Total Assets minus Total Liabilities), plus balance sheet deferred taxes and investment tax credit, if available, minus the book value of preferred stock, as in Hou, Xue and Zhang (2016).

<sup>3</sup>  $P_{ijq}$ , where *i*=Small or Big; *j* = *I/A* low, medium or high; *q* = *ROE* low, medium or high.



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Shin (2012), I shall also use individual stocks as test assets in order to obtain results that are not prone to portfolio formation errors.

### 3.3 Regression Equations

The time-series regression equations are:

$$R_{pt} - R_{ft} = \alpha_p + \beta_{p1}F_{1t} + \dots + \beta_{pk}F_{kt} + \varepsilon_{pt}$$

or

(11)

$$R_{pt} - R_{ft} = \alpha_p + \beta_p F_t + \varepsilon_{pt}$$

where  $R_{pt}$  is the return on the test portfolio  $p$  ( $p=1, \dots, N$ ) at time  $t$  ( $t=1, \dots, T$ )

$R_{ft}$  is the risk free rate

$F_{kt}$  is the return on the  $k$ -th portfolio factor at time  $t$

$\beta_{pk}$  is the factor loading on the  $k$ -th portfolio factor

$F_t$  is a ( $K \times 1$ ) vector of the returns of the factor portfolios

$\beta_p$  is a ( $K \times 1$ ) vector of the factor loadings

$\varepsilon_{pt}$  is the residual return with mean 0.

To evaluate the performance of the time-series regressions,  $t$ -tests, GRS tests and  $R^2$  will be employed. In addition, in order to strengthen the power of tests, required by a possible violation of the normal distribution of the residuals, the HJ distance will be utilized.

In order to pinpoint which factors best describe the markets, the Fama and MacBeth (1973) two-pass regression method will be employed. In the first pass, the betas will be estimated using time-series regressions; in the second pass, the betas from the first pass will be utilized as explanatory variables. The cross-sectional regression equation is:

$$R_{pt} - R_{ft} = \gamma_{0t} + \gamma_{1t}\hat{\beta}_{1p,t} + \dots + \gamma_{kt}\hat{\beta}_{kp,t} + \varepsilon_{pt}, \quad p=1, \dots, N \quad (12)$$

where  $\hat{\beta}_{kp,t}$  is the portfolio's beta estimate on the  $k$ -th factor from the time-series regression. To evaluate the performance of the cross-sectional regressions, the Shanken errors-in-variables  $t$ -statistic and the  $R^2$  measure will be used. For a robustness check, I shall employ Kan, Robotti and Shanken (2012) misspecification robust  $t$ -statistics.

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