The evaluation of CAPM, Fama-French and APT models on the Romanian capital market

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Abstract

Ever since the Capital Asset Pricing Model (CAPM) was introduced by W. Sharpe in 1964, it's been intensely studied and criticized and a great variety of alternatives meant to improve the model were created. The purpose of this study is that by estimating six models (CAPM, The two-factor model, Downside-CAPM, Fama-French with 3 and 5 factors and Arbitrage Pricing Theory) to determine which one is applicable in Romania and explains best the variation of the stocks' returns. The data I used is composed of the daily closing price from 25 companies listed on the Bucharest Stock Exchange during 2006-2013. The results are consistent with the ones of other studies on Romania. The Fama-French with 5 factors turns out to be the best performing model.

Key words: *APT, CAPM, Fama-French, Bucharest Stock Exchange, Downside*

Literature Review

William Sharpe[1] (1964) started from Harry Markowitz's theory (1952) and developed the first single factor model of evaluation of financial assets. This model is called Capital Asset Pricing Model (CAPM). CAPM is used in finance for the theoretical determination of stocks' returns and it shows that the expected return of a stock $E(R_i)$ can be explained by a single factor: the market's expected return $E(R_M)$, the relationship between them being linear and positive. To measure the senzitivity of a stock's return to the return of the market, there's an indicator of systematic risk, called beta β. CAPM has the below equation:

$$E(R_i) = r_f + \beta_i \cdot (E(R_M) - r_f)$$

In the same time, the model was also developed by **Jack Treynor**[2] (1961), **John Lintner**[3] (1965, 1969) and **Jan Mossin**[4] (1966).

Considering the assumptions of CAPM are inconsistent with the reality of the financial market, future researches include relaxations of certain requirements of CAPM, trying to improve the model in different directions.

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[1] Sharpe, W. (1964*) Capital Asset Prices: A Theory of Market Equilibrium under Conditions of Risk*, The Journal of Finance, Vol.19, No. 3, pp. 425-442;
[2] Treynor, J. (1961) *Toward a Theory of the Market of Risky Assets*;
[3] Lintner, J. (1965) *The Valuation of Risk Assets and the Selection of the Risky Investments in Stock Portfolios and Capital Budgets*, The Review of Economics and Statistics, pp. 13-37.
4 Mossin, J. (1966*) Equilibrium in a Capital Asset Market*, Econometrica, pp. 768-783;

The two factors model

Starting from the idea that borrowing and loaning at the risk free rate isn't a realistic assumption, **Fisher Black (1972)**[5] developed the two factors model. Black proposes to determine a portfolio which is not correlated with the market (beta is zero): $E(R_Z)$. The model is the following: $E(R_i) = E(R_Z) + \beta_i \cdot (E(R_M) - E(R_Z))$

Downside CAPM

In 2002, **Javier Estrada**[6] proposes an original alternative of CAPM called Downside CAPM (D-CAPM), which is based on the assumption that investors are only worried of *downside risk*[7] measured by semivariance. The formula for beta is:

$$\beta_i^D = \frac{coSV_{iM}}{SV_M} = \frac{M \sum\{\min[(R_{i,n} - \bar{R}_i), 0] \cdot \min[(R_M - \bar{R}_M), 0]\}}{M \sum \min[(R_M - \bar{R}_M), 0]^2}$$

3 Factors Fama-French

In 1996, **Eugene Fama and Kenneth French**[8] have elaborated a model in which they showed that a stock's return can be explained by three factors: market's return, the company's size and market to book value (MBR). The equation for the model is:

$$E(R_i) - r_f = \alpha_i + \beta_M(E(R_M) - r_f) + \beta_{HML}E(R_{HML}) + \beta_{SMB}E(R_{SMB}) + \varepsilon_i$$

Where $E(R_{HML})$ is the difference between the returns of high and low companies (high minus low), $E(R_{SMB})$ is the difference between the returns of small and big companies (small minus big) and ε_i is the specific risk of company i.

5 Factors Fama-French

In November 2013 **Fama și French** published an article[9] in which they extend their initial model from 1996, adding two more factors: profitability and investments. The model is:

$$E(R_i) - r_f = \alpha_i + \beta_M(E(R_M) - r_f) + \beta_{HML}E(R_{HML}) + \beta_{SMB}E(R_{SMB}) + \beta_{RMW}E(R_{RMW}) + \beta_{SCMA}E(R_{CMA}) + \varepsilon_i$$

Where R_{RMW} is the difference between the returns of the companies with high and low profitability (robust minus weak) and R_{CMA} is the difference between the returns of the companies with big and small investments (conservative minus aggressive).

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[5] Black, F. (1972) *Capital Market Equilibrium with Restricted Borrowing*, The Journal of Business, Vol. 45, No. 3, pp. 444-455;

[6] Estrada, J. (2002) *Systematic risk in emerging markets: the D-CAPM*, Emerging Markets Review, No. 3, pp. 365-379;

[7] Downside risk is an estimation of the probability of a stock to fall in value;

[8] Fama, E., French, K. (1996) *Multifactor Explanations of Assets Pricing Anomalies* , The Journal of Finance, Vol. 51, No. 1; (1999) *Value versus Growth: International Evidence*, The Journal of Finance;

[9] Fama, E., French, K. (2013) *A Five-Factor Asset Pricing Model* (Draft), Unpublished.

Arbitrage Pricing Theory

Trying to improve the CAPM model by eliminating some of its disadvantages, **Stephen Ross** (1976)[10] formulated Arbitrage Pricing Theory. Starting from the concept of arbitrage[11], he develops a multi factors model in which the stock's return is explained by several factors of macro economical nature. The APT is presented below.

$$R_i = E(R_i) + b_{i1}F_1 + b_{i2}F_2 + b_{i3}F_3 + \cdots \ldots \ldots + b_{ik}F_k + \varepsilon_i$$

Where b_{i1} is the sensitivity of the stock's return to the change of the risk factor k and F_k is a common set of factors which influences the returns of all stocks.

Empirical Review

Among the first studies that have tested CAPM is the one of **Black, Jensen și Scholes** (1972)[12]. They have estimated beta by using the monthly returns of each stock from the New York Stock Exchange, during 1926-1965 and they formed 10 portfolios according to beta. In the first case, they assumed there is no risk free rate and that lending and borrowing is allowed and in the second case, they assumed there is a risk free rate, but the short selling isn't allowed. In both cases, the results are consistent with the predictions of the CAPM, and that is there's a linear relationship between beta and stock returns and the portfolios with high/low beta have high/low expected returns.

Using the data from NYSE, AMEX and NASDAQ, **Fama and French** (1992) have created 10 portfolios sorted by size and beta. Using cross-section regressions, they confirm that size and MBR explain the variation of the expected returns. They also confirm the results that **Reinganum** (1981), **Stambaugh** (1982) and **Lakonishok și Shapiro** (1986) obtained that the relationship between expected return and beta is flat.

One of the most famous studies in the field is the one of **Roll and Ross**[13] from 1980. Using the daily returns of 1260 stocks from NYSE and AMEX, between 1962 and 1971, they have separated the stocks into 40 groups of 30 stocks each. Identifying the number of factor of influence and their coefficients was realized though factor analysis through maximum likelihood method. The estimated coefficients were then used in explicating the variance of the expected returns and measuring the risk premium of each factor. The analysis showed there should be at least three and maximum 4 influence factors.

In Romania, the CAPM was applied by **Alina Lucia Trifan** (2009)[14], both for stocks and portfolios, using data for 24 companies from BVB, during 2003 and 2009. Her results confirm the intercept is insignificant and beta is bigger than zero. Beta doesn't pass the stability test,

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[10] Ross, S. (1976) *The Arbitrage Theory of Capital Asset Pricing*, Journal of Economic Theory 13, pp. 343-362;

[11] Arbitrage is the operation that provides an earning without taking risks or investing personal capital;

[12] Black, F., M. C. Jensen și M. Scholes. (1972) *The Capital Asset Pricing Model: Some Empirical Tests*, Studies in the Theory of Capital Markets, ed. New York: Praeger, pp. 79-121;

[13] Roll, R., Ross, S.A. (1980) *An Empirical Investigation of the Arbitrage Pricing Theory*, Journal of Finance, 35, pp. 1073-1103.

[14] Trifan, A.L. (2009) *Testing Capital Asset Pricing Model for Romanian Capital Market*, Annales Universitatis Apulensis Series Oeconomica, 11(1);

though. The APT model was tested in Romania by **F. Bîlbîie, A. Gherman and M. Tureatcă** (1998)[15]. They used both the factor analysis through maximum likelihood method and principal component analysis. They have analyzed two groups of stocks between 1997-1998, the first one being the stocks with the highest market capitalization from BVB and the second one, stocks from RASDAQ. The results have showed there are minimum two factors for the first group and minimum three factors of influence for the second one.

Empirical analysis

To test the applicability of the evaluation of financial assets on the Romanian capital market, we have selected 25 companies listed at the Bucharest Stock Exchange (BVB) from a variety of industries (pharmaceutical, auto, constructions, extractive etc.). The data is composed by the daily closing price of the companies during 8 years (01.01.2006 – 31.12.2013). When there was missing data, I used the closing price from the closest date. The data was provided by kmarket.ro. The returns of the prices were calculated (dividends were ignored). We then proceded to identify the outliers, which were eliminated, the final sample containing 2039 observations per company.

For the market portfolio we used the index BET-C, which shows the evolution of all stocks from BVB. As a risk free rate I used an average of the interest rate of the government bonds (source: bnr.ro).

The next step was to analyze the data before applying the models. The Kurtosis index is for all the stocks bigger than 3, which means that the distribution of the stocks is leptokurtic. This is also confirmed by the Jarque Bera test, the probability associated with the test being lower than the significance point of 5%, which proves the returns don't have a normal distribution. We also tested the stationarity using the Augmented Dickey Fuller (ADF) test. All stocks turned out to be stationary. Analyzing the correlation matrix we notice low correlations between stocks.

The methodology for each model is presented below.

1. Capital Asset Pricing Model

- Estimating a regression between the excess of return of each asset and the premium risk;

$$R_i - r_f = \alpha_i + \beta_i \cdot (R_M - r_f) + \varepsilon_i$$

- Grouping the stocks according to the estimated beta into 5 portfolios and estimating a regression between portfolio's excess return and market's excesss return;

$$R_P - r_f = \alpha_P + \beta_P \cdot (R_M - r_f) + \varepsilon_P$$

- Testing CAPM by regressing the portfolios excess returns with the beta estimated in the previous step, with squared beta for testing the linearity of the model and with the residual variance of the portfolios' returns $\sigma^2(RV_P)$ (to check if there are specific factors that have an influence to the returns.

[15] Bîlbîie, F., Gherman, A., Tureatcă, M. (1998) *Teoria generală a arbitrajului şi modelul de evaluare APT*, Articole fundamentale în teoria financiară, pp. 298-332.

$$R_P - r_f = \gamma_0 + \gamma_1 \cdot \beta_P + \gamma_2 \cdot {\beta_P}^2 + \gamma_3 \cdot RV_P + \varepsilon_P$$

2. The two factor model involves the same steps as CAPM with the exceptions that we use $E(R_z)$ instead of r_f. $E(R_z)$ will be a weighted average of the 25 average stock returns. The weights are found by reversing the covariance matrix, which is added a column and a line with beta and 1. The obtained E(Rz) is 0.04% and it has zero risk.

3. Downside CAPM

- Calculating downside beta using the formula described in the Literature Review chapter;
- Estimating a regression between the excess return of each stock and beta resulted from the previous step (I apply the same equation for traditional CAPM, for better comparability). $R_i - r_f = {\gamma_0}^D + {\gamma_1}^D \cdot \beta_D + {\varepsilon_i}^D$

4. Three Factors Fama-French

- Classifying the companies into high and low, small and big and calculating $R_{HML}$and R_{SMB};
- Estimating the below equation for each stock;

$$E(R_i) - r_f = \alpha_i + \beta_M\big(E(R_M) - r_f\big) + \beta_{HML}E(R_{HML}) + \beta_{SMB}E(R_{SMB}) + \varepsilon_i$$

- Forming the same portfolios as in the CAPM case and apply the above equation of them too.

5. Five factors Fama-French

- Classifying the companies into robust and weak, conservative and aggressive and calculating $R_{RMW}$and R_{CMA};
- Estimating the below equation for each stock and each portfolio.

$$E(R_i) - r_f = \alpha_i + \beta_M\big(E(R_M) - r_f\big) + \beta_{HML}E(R_{HML}) + \beta_{SMB}E(R_{SMB}) + \beta_{RMW}E(R_{RMW}) + \beta_{SCMA}E(R_{CMA}) + \varepsilon_i \quad (5.10)$$

6. *Arbitrage Pricing Theory*

- Identifying the economical variables of influence and collect the monthly data for the analyzed period;
- Establishing the number of influence factors using the principal component analysis;
- Calculating *factor loadings* for each variable and distributing the variables among factors using a maximum likelihood rotation;
- Calculating *factor scores* for each economical variable as a weighted sum with the coefficient which indicates the percent of which the variable i is reflected in the j factor (factor loadings);
- Estimating a regression in which the independent variables are the *factor scores* previously estimated, and the dependent variable is the stocks' returns, which will provide us the sensitivity coefficients b_{ik}

$$R_i = E(R_i) + b_{i1}F_1 + b_{i2}F_2 + b_{i3}F_3 + \cdots \ldots \ldots + b_{ik}F_k + \varepsilon_i$$

- Estimating a regression in which the previously estimated sensitivity coefficients are the independent variables and the average stock return is the dependent variable, which will show what macro economical variable shows influence indeed.

$$E(R_i) = \lambda_0 + \lambda_1 b_{i1} + \lambda_2 b_{i2} + \ldots . + \lambda_k b_{ik}$$

Results

In order to have a better view of the obtained results from the six models and to be able to do a better comparison, I have synthesized the data in the below table. The 30 cases mentioned refer to applying the regression to 25 stocks and 5 portfolios.

Table 1. The results obtained from the 6 models

Model	Variable	Theoretical significance	Empirical significance	Adjusted R^2
CAPM	Intercept	Insignificant	Insignificant	36.11%
	Beta	Significant and positive	Insignificant and negative	
Two factors model	Intercept	Significant	Insignificant	36.10%
	Beta	Significant and positive	Insignificant and negative	
D-CAPM	Intercept	Insignificant	Insignificant	1.46%*
	D-beta	Significant and positive	Insignificant and negative	
3F Fama-French	Intercept	Insignificant	Insignificant	50.32%**
	Beta	Significant and positive	Significant and positive	
	R_{SMB}	Significant	Significant in 26 from 30 cases	
	R_{HML}	Significant	Significant in 25 from 30 cases	
5F Fama-French	Intercept	Insignificant	Insignificant	55.76%**
	Beta	Significant and positive	Significant and positive	
	R_{SMB}	Significant	Significant in 25 from 30 cases	
	R_{HML}	Insignificant	Significant in 26 from 30 cases	
	R_{RMW}	Significant	Significant in 28 from 30 cases	
	R_{CMA}	Significant	Significant in 29 from 30 cases	
APT	Intercept	Insignificant	Insignificant	43.17%
	F1 - EUR, USD, S&P, FTSE, BETC, P	At least two significant factors	Significant	
	F2 - IPI, IPC, RD, RC		Insignificant	
	F3 - IPC, M1		Significant	

Source: Personal calculation

* The model applied for D-CAPM is different from the one applied to the other two CAPM models. For a better comparability we applied the same model to traditional CAPM and obtained an R^2 adjusted of 1.99%;
** It was calculated as an average of the R^2 adjusted statistic of the 5 portfolios.

The results obtained for the CAPM model reveal that both the intercept and beta coefficient are insignificant, with beta being less than zero and the model explaining 36.11% of the returns' variation. The results are inconsistent with the theory, which states that the variation of the returns of the stock portfolios can be explained by the evolution of the capital market and that the relation between the two is positive. We mention here that because Romania is an emergent market and it has low volume of transactions, there is a lot of missing data of the daily prices of stocks, which might affect the pattern of the returns. Also, R.H. Campbell[16] (2002) proves that emerging markets have the tendency to provide contradictory results because of the lack of integration. The reverse relation found can be a result of the financial crisis, when probably there have been registered high volatilities and anomalies of the returns. That is why we need to divide the period analyzed into two: before and after the crisis. The obtained results are consistent with other studies regarding the Romanian capital market: Florin Pieleanu tests in 2012[17] the CAPM model on two periods of time and obtains the same results, except that for sub periods the γ_3 coefficient is not statistical significant, which confirms the hypothesis that only systematic risk explains the returns of the stocks. Cristina Ioniță (2008)[18] finds that the intercept is significant and greater than zero.

The two factors model, which replaces the risk free rate with the return of the portfolio with a zero beta reveals very similar results with the ones from CAPM: the intercept and beta are insignificant and beta is negative. Adjusted R^2 is 36.10%. The intercept is not significant and equal to $E(R_z)$, and the model does not explain better than traditional CAPM the variation of the stock returns, according to Black, Jensen and Scholes (1972). The model confirms the hypothesis of the linearity but fails, like CAPM, to explain the relation between beta and portfolio returns. Furthermore, the hypothesis regarding the intercept is infirmed here, but confirmed in the CAPM model. The advantage of the two factors models is that it is closer to the financial reality than CAPM, by replacing the risk free rate with a portfolio of zero beta. The disadvantage is that implies the using of short selling operations, which are not very used because they are very strictly regulated in Romania.

Like the above two models, neither Downside CAPM managed to confirm the economical theory. Both the intercept and beta are insignificant and beta is negative. The model applied to the individual stocks managed to explain only 1.46% of their variation. Same model applied to CAPM obtains a 1.99% adjusted R^2. Like the two factors model, neither this model

[16] Bekaert, G., Campbell, R. H. (2002) *Research in Emerging Markets Finance: Looking to the Future*, Emerging Markets Review, Vol. 3, No. 4, pp. 429-448.
[17] Pieleanu, F. (2012), *Testarea empirică a modelului CAPM pe piața de capital din România;*
[18] Ioniță, C. (2008) Dissertation paper, *Empirical Test of CAPM in the Romanian capital market*.

proves doesn't respect the theory and it isn't better than traditional CAPM. One of the hypothesis of CAPM is that the returns have a normal distribution, which doesn't happen on the Romanian capital market. The advantage of D-CAPM is assigned to the asymmetry of the returns and capturing the preferences of the investors in the mode (only returns beneath the average are considered risky). Although D-CAPM uses a better measure of the risk, favorable in most emerging markets like Romania, CAPM, it fails to explain the variation of the stock returns and it proves to be invalid. These results are consistent with the ones obtained by Todea, Tulai and Pleșoianu în 2009[19] that found that no matter the measure type of the risk, there is a low influence of beta to the returns.

The three factors Fama-French, which incorporates company size and the market to book value next to the market portfolio obtains remarkable results. The intercept is zero, all the independent variables are statistically significant in most cases and it explains 50% of the returns' variance. The newly created five factors model offers a nice surprise, explaining the model even better, with an adjusted R^2 of 56%, and profitability and investments being significant. The advantage of this model is that incorporates other determined factors of the price of the stocks besides the market portfolio, which only explains a small part. This results is consistent with the one obtained by Fama and French in 1996[20]. Fama-French reveals that HML does not improve the model (the model has the same performance with or without this variable) because the HML return is captured in the other factors and the variable turns out to be insignificant anyway in their study. That is not the case in the current study ass all variables were identified as significant.

Using the analysis of the principal components, with the help of the APT model we managed to find that the stock returns can be explained by three factors, which are a weighted average of macro economical variables. Only two turned out to be significant and so the economical indicators that influence the variability of the returns are the exchange rates EUR/RON and USD/RON, the international market index S&P500 and FTSE, the Romanian capital market index BET-C, oil price, the harmonized indices of consumer prices, and money demand M1. The model explains 43% of the variation of the returns. The APT advantage is that accounts for a sum of factors, being more realistic: the variation of the market portfolio can't be explained by a single factor like the market portfolio. The APT model does not specify which the macro economical variables of influence are so there is the possibility there are others not included in the model which influence the returns. The disadvantage is that supposes there is a linear relationship between the dependent and all independent variables. This is a strong assumption and nonlinear models could be fundamental in explaining the average returns. Also,

[19] Todea, A., Tulai, H., Pleșoianu, A (2009) *D-CAPM: Empirical results on the Bucharest Stock Exhange,* Finance and economic stability in the context of financial crisis, 10th international conference.
[20] Fama, E., French, K. (1996) *Multifactor Explanations of Assets Pricing Anomalies* , The Journal of Finance, vol. 51, no.1; (1999) *Value versus Growth: International Evidence*, The Journal of Finance;

Gultekin and Gultekin (1987)[21] highlight that APT can only be valid in some months of the year; theare is proof that the January effect has an impact on the capability of APT to explain the returns. F. Bîlbîie, A. Gherman and M. Tureatcă (1998)[22] also found two factors of influence in their study.

Being said all of the above, on the Bucharest Stock Exchange during the time studied (2006-2013) I consider the best performing model is the Fama-French with three factors, which explains the variability of stocks and portfolios' returns of 55%. If I would be to rank the models, on the second place would be the Fama-French with five factors, on third place the APT model and on the last place the CAPM models.

Conclusions, limitations and further research

By trying to determine which evaluation model is best at explaining the evolution of the financial assets, useful to investors from the Romanian capital market, the Bucharest Stock Exchange, I have estimated six models: traditional CAPM, the two factors model, Fama-French with three and five factors and Arbitrage Pricing Theory. The data I used is composed of the daily returns (monthly for APT) of 25 stocks for 8 years (2006-2013).

The results revealed that neither of the CAPM models are valid and consistent with the theory on our market, with beta's market portfolio insignificant and less than zero. The APT model is valid and explains better the variability of stock returns, with an adjusted R^2 of 43%. The success of the 5 factors Fama-French (adjusted R^2 equals 56%) determines me to choose it, from all estimated models, as the one more closely to reality and explaining best the returns. The results we obtained are consistent with other from studies on Romania.

Some of the limitations encountered in the realization of the study are:

- The Romanian capital market is very young; it was reopen only in 1995 and it is characterized by low liquidity and transaction volume, few and small dimension of the listed companies;
- Lack of data due to the low transaction volume: missing data was replaces with the one from the closest day, which could alter the results;
- The stock returns aren't adjusted with dividends, as CAPM demands;
- Lack of a appropriate risk free rate as there is no Romanian Treasury-Bill;

[21] Gultekin M.N., Gultekin, N.B. (1987) *Stock Return Anomalies and the Tests of the APT*, The Journal of Finance, Vol. 42, No. 5, pp. 1213-1224.
[22] Bîlbîie, F., Gherman, A., Tureatcă, M. (1998) *Teoria generală a arbitrajului şi modelul de evaluare APT*, Articole fundamentale în teoria financiară, pp. 298-332;

- Using a proxy for the market portfolio: BET-C might not be the best measure of the capital market as 4 companies (Romgaz, Petrom, Fondul Proprietatea and BRD) represent 69,3% of it;
- The possibility of inaccuracy of calculation, of any kind, including the ones caused by the author.

The fact that even the best model explains only 56% of the returns variation reveals that there must be other factors of influence to the dependent variable that was not included in the models. Finding a model to explain all the variation is impossible, but further studies can be conducted which can include other variables in the models or improve the existent ones.

Further research can refer to:

- Conducting the study on a longer period of time and dividing it in sub periods to test the stationary of the results;
- Including all stock from Bucharest Stock Exchange in the model for a better precision of the results;
- Taking in count the great number of negative excess returns, I recommend using the methodology of Pettengill, Sundaram and Mathur (1995)[23] when applying CAM, which is dividing the data set into positive and negative prime risks and analyze them separately;
- More interest towards behavioral finance: Bontaș and Odăgescu (2011)[24] find that investors' preference towards risk and time has an influence on the evolution of stock prices, so we should analyze the investment behavioral through behavioral finance..

The above suggestions can lead to estimating better models of evaluation of the financial assets. However, no matter how precisely a model is, it remains a sketch and a simplification of the reality and it does not contain the entire complexity of reality, because then it would be one and the same.

[23] Pettengill, G., Sundaram, S., Mathur, I. (1995) *The conditional Relation between Beta and Returns*, Journal of financial and quantitative analysis, Vol. 30, No 1;
[24] Bontaș, A., Odăgescu, I. (2011) *Testing APT Model upon a BVB Stocks' Portfolio,* Informatica Economică, vol. 15, No. 4.