APPLYING THE CAPITAL ASSET PRICING MODEL TO A SET OF STOCKS LISTED ON THE BUCHAREST STOCK EXCHANGE

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Abstract

The Capital Asset Pricing Model can be used to estimate the return of a stock or a portfolio based on the market risk, since the investors will not be remunerated for the specific or the unsystematic risk because it can be eliminated through diversification. The only component of risk for which investors will be compensated is the systematic risk, the one associated with the market portfolio holding.

The purpose of this study is to verify the applicability of the CAPM for seven stocks listed on the Bucharest Stock Exchange. The study used the annualized daily returns of the stocks for the period December 30, 2014 - December 30, 2023, the eight-year period being considered optimal to incorporate the general trend on the market. We used the BET-Plus index as a proxy of the market portfolio and the yield of the long-term government bonds issued by the Romanian Government for the risk-free rate.

Keywords: *Capital Asset Pricing Model (CAPM); return; capital market risk*

JEL Classification Codes: G12

1. Introduction

The modern theory of portfolio developed by Harry Markowitz (1952), which assumes that all investors are rational and risk averse, highlighted the "efficient frontier", starting from the observation that the financial market offers the possibility of minimizing risk at an expected return. Risk can be reduced through diversification provided that the securities in the portfolio are not perfectly correlated.

The Capital Asset Pricing Model, developed by Sharpe [10], Treynor [11], Lintner [7], [8] and Mossin [9], provided the first coherent framework to answer the question of which part of the asset risk can be eliminated through diversification and which cannot.

This model is still used in applications to estimate the cost of capital for companies and to evaluate the performance of the managed portfolios.

The CAPM correlates the returns of individual securities or portfolios with the returns on the market as a whole, based on the idea that investors will not be remunerated for the specific or the unsystematic risk because it can be eliminated through diversification. The only component of risk for which investors will be compensated is the systematic risk.

2. Theoretical framework

There are several versions of the model and many changes resulting from the attempt to better reflect the reality of the financial markets. Its original version is the one developed by Sharpe [10] and Lintner [8]. This study is limited to this version.

The model is an abstraction of the real-world capital markets. Due to its simplifying assumptions, and some of them even unrealistic, the CAPM is more mathematically flexible. The assumptions of the model are as follows (Fabozzi and Peterson Drake, 2009) [5]:

1. Investors make investment decisions based on the expected return and variance of returns and subscribe to the Markowitz method of portfolio diversification.
2. Investors are rational and risk averse.

1. Investors all invest for the same period of time.
2. Investors have the same expectations about the expected return and variance of all assets.
3. There is a risk-free asset and investors can borrow and lend any amount at the risk-free rate.
4. Capital markets are completely competitive and frictionless.

According to the CAPM, the expected return of a financial asset or portfolio is directly proportional to the systematic or market risk, quantified by the volatility coefficient (β). Figure 1 shows the relation between the return and the market risk, representing the asset line on the capital market.

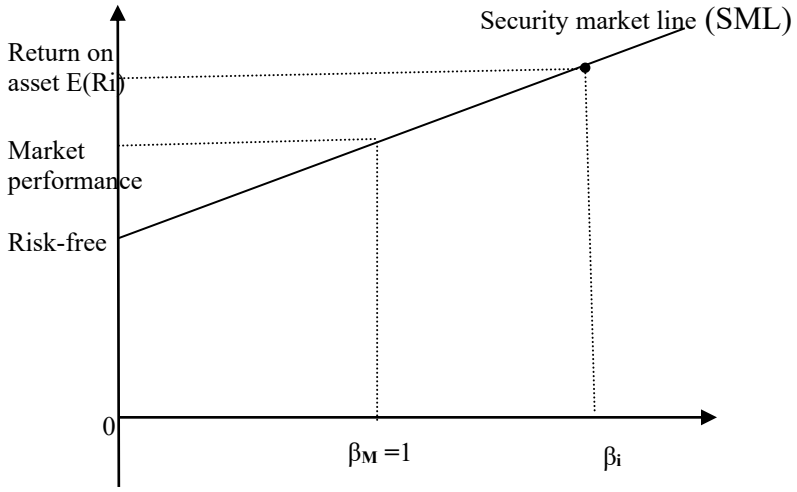

Figure 1 The Security Market Line
Source: [4] Frank J. Fabozzi (2015)

When investing the entire portfolio in government-guaranteed securities, β has the value 0, because the returns on these securities do not vary with the fluctuations on the stock market, and the portfolio rate of return will be equal to the risk-free interest rate. However, as the investor accepts greater risks, higher returns are expected. In the case of replicating the stock market portfolio by investing in index funds, the value β is 1, and the portfolio return will be equal to the stock market return.

At the same time, the profitability of the financial assets is influenced by the profitability of the market portfolio. Usually, the market portfolio is approximated by a stock market index that is as comprehensive as possible.

The relation between return and risk is highlighted by the CAPM Sharpe – Lintner equation as follows (Fama and French, 2004) [3]:

$$E(Ri) = Rf+\beta i\ [E(R_M)-R_f] \quad (1)$$

where:

E(Ri) - expected return

R_f = the return on the risk-free asset

βi - volatility coefficient of the return on title i, determined by the variation of the return on the stock market

$E(R_M)$ = overall capital market return

$[E(R_M)-R_f]$ = slope of SML representing the risk premium of the capital market

$\beta i\ [E(R_M)-R_f]$ = the risk premium of the considered asset

This equation relates the expected return of an asset E (Ri) to the sensitivity of the asset βi, to the return of the market portfolio R_M.

β coefficient, measuring the amount of systematic risk contained in a single asset, is determined as the ratio between the covariation between the return on title i and the market return (σiM) and the variation of the overall return on the stock market (σ_M^2). (Fama and French, 2004)[3]

$$\beta = \frac{\sigma_{iM}}{\sigma^2{}_M} = \frac{\sum(R_{it}-\overline{R_i})(R_{Mt}-\overline{R_M})}{\sum(R_{Mt}-\overline{R_M})^2} \quad (2)$$

but σ_{iM} can also be written as the product of the standard deviation of the title (σ_i), the standard deviation of the market portfolio (σ_M), and the correlation coefficient between these two (ρi_M).

$$\sigma_{iM}=\rho_{iM} * \sigma_i * \sigma_M \quad (3)$$

The correlation coefficient (ρ_{iM}) expresses the degree of determination of the return of title i by the return of the stock market M.

Substituting σ_{iM} from the relation (3) into the formula (2), β can be expressed as a function of the correlation coefficient as follows:

$$\beta = \frac{\sigma_{iM}}{\sigma^2{}_M} = \frac{\rho_{iM} * \sigma_i * \sigma_M}{\sigma^2{}_M} \quad (4)$$

The capital asset pricing model is an elegant theory with profound implications in determining the asset pricing and the investor's behavior.

Although contested and criticized for its simplifying and restrictive assumptions, CAPM is a model that is referred to both in the academic activity and in the current activity of portfolio managers. (Dragotă, 2009) [2].

3. Research methodology

This study is limited to the original version of the model, developed by Sharpe [10] and Lintner [7]. For the practical part, the study uses the annualized daily returns of the stocks for the period December 30, 2014 - December 30, 2022, the eight-year period being considered optimal to incorporate the general trend on the market. We proceeded as follows to select the stocks: on February 5, 2024, we ordered the 74 stocks of the Romanian companies listed on the regulated market of the Bucharest Stock Exchange, in descending order by their trading value. By setting the step of 10, the following seven symbols were chosen: TLV (Banca Transilvania), COTE (Conpet S.A.), BIO (Biofarm S.A.), CEON (Cemacon S.A.), TBM (Turbomecanica S.A.), IMP (Impact Developer & Contractor S.A.), RPH (Ropharma SA).

Table 1. List of selected stocks

Stocks	Sector / Domain	Membership to the BET Plus index
TLV (Banca Transilvania)	Financial / Banks	Yes
COTE (Conpet S.A)	Energetic / Oil transport services	Yes
BIO (Biofarm S.A.)	Pharma & Health / Medicine production	Yes
CEON (Cemacon S.A.)	Raw materials / Construction materials	Yes
TBM (Turbomecanica S.A.)	Aeronautical / Production and repairs	Yes
IMP (Impact Developer & Contractor S.A)	Real estate and constructions / Civil constructions	Yes
RPH (Ropharma SA)	Pharma & Health / Distribution of pharmaceutical and parapharmaceutical product	No

We used the BET-Plus index of the stock exchange, as an proxy of the market portfolio. The BET Plus index, launched on June 23, 2014 instead of the BET-C composite index, is a weighted index with the free float capitalization of Romanian companies (with the exception of financial investment companies) listed on the regulated market, which meets a set of minimum criteria of selection eligibility regarding liquidity and stock market capitalization adjusted with the free float.

BET-Plus includes most of the stocks traded on the Bucharest Stock Exchange, being more suitable to represent the real market portfolio compared to the BET benchmark index which only includes the 20 most liquid stocks.

The data were collected from the website https://bvb.ro in the case of BET Plus index at the daily closing value in RON and from the website https://tradeville.ro in the case of the seven stocks at the average daily price. Then we calculated the daily return and we annualized it.

The average expected return (E(Ri)) of each stock and the market portfolio "M" is approximated by the average of the previously recorded annual returns, for eight years, respectively the period December 30, 2014 – December 30, 2022.

Next, we determined the anticipated return provided by CAPM for each of the stocks and compared this return and the expected return of each security (E(Ri)) with the real annualized return recorded by each security for the period December 30, 2022 - December 30, 2023, to test applicability of the model.

The Risk-Free Rate (Rf) represents the return expected by an investor for an investment in a risk-free asset. A possible approach to this rate is the return on long-term government bonds issued by the Government of Romania.

Moody's Analytics uses as a definition for the long-term government bond yields the monthly average of central government bond yields on the secondary market, gross of tax, with around 10 years' residual maturity. According to Moody's Analytics, in January 2023, the average long-term government bond was 6.8% and will be used to approximate the risk-free rate. [13]

4. Results and discussions

Tabel 2 shows the expected return (E(Ri)) calculated for each stock "i" and the market portfolio represented by the BET Plus index, as an average of the annual returns recorded previously, for eight years, respectively the period December 30, 2014 – December 30, 2022. The covariance between the return of the market portfolio "M" with the return of each security "i" and the BETA coefficient in the CAPM are also calculated.

Table 2. Calculation of the average expected return for the market portfolio, for the securities "i" and of the beta coefficient

Period	R_BET Plus index	R_TLV	R_IMP	R_BIO	R_CEON	R_TBM	R_COTE	R_RPH
2015	-0,0046	0,2732	-0,3645	0,0107	0,2647	0,2324	0,3599	0,0056
2016	0,0268	0,0523	-0,2352	-0,0272	0,0031	1,1296	0,0572	-0,2081
2017	0,1069	0,0678	0,5204	0,1036	0,7020	1,1899	0,2882	0,3414
2018	-0,0331	0,0856	-0,0805	0,1440	0,7699	-0,2065	-0,1373	0,0099
2019	0,3040	0,4001	0,4378	0,1079	0,1924	0,5173	0,0774	-0,1705
2020	0,0131	0,0288	0,2894	0,2138	-0,0300	-0,2248	0,0797	-0,1463
2021	0,2920	0,2439	0,7236	0,7182	0,9127	-0,2712	0,0495	-0,0981
2022	-0,0906	-0,2188	-0,2622	-0,2383	-0,1205	0,0349	-0,1458	-0,0163
E(Ri)	0,0768	0,1166	0,1286	0,1291	0,3368	0,3002	0,0786	-0,0353
VAR.S	0,0217	0,0355	0,1716	0,0756	0,1619	0,3515	0,0316	0,0301
COV.S (BETPlus; i)		0,0208	0,0495	0,0276	0,0253	0,0072	0,0056	-0,004
BETA(β) coefficient		0,9594	2,2782	1,2694	1,1635	0,3334	0,2575	-0,1883

Source: own processing based on the data of the Bucharest Stock Exchange [12] and SSIF Tradeville SA [14]

The calculation of the variance was necessary to assess the covariance and the coefficient β. The variance measures the root mean square deviation from the average.

The negative covariance between the BET Plus index and the RPH stock indicates the inverse evolution of the yields of the two assets, respectively when the market return increases, the stock return decreases.

Between each of all other stocks and the market portfolio, the covariance was positive, showing the change of the two assets in the same direction.

Table 3. Calculation of share return by applying the CAPM

	BET Plus index	TLV	IMP	BIO	CEON	TBM	COTE	RPH
E(Ri)	0,0767	0,1166	0,1286	0,1291	0,3368	0,3002	0,0786	-0,0353
VAR.S	0,0217	0,0355	0,17156	0,075566	0,161954	0,351494	0,031617	0,030059
COV.S (BET Plus; i)		0,0208	0,04951	0,027586	0,025284	0,007246	0,005596	-0,00409
BETA coefficient - βi		0,9594	2,27823	1,269408	1,163460	0,333447	0,257489	-0,18829
R_f according to Moody's Analytics January 2023							0,068	
$[E(R_M)-R_f]$								0,0087
$\beta i\ [E(R_M)-R_f]$		0,0083	0,0198	0,0110	0,0101	0,0029	0,0022	-0,0016
E(Ri) CAPM		0,0763	0,0878	0,0790	0,0781	0,0709	0,0702	0,0664

Sources: authors' calculations

Since the capital market risk premium is very small, approximately 0, the return predicted by the CAPM is almost the same for all stocks and about equal to Rf, which may also be due to a high inflation rate.

$$E(Ri) = Rf+\beta i\ [E(R_M)-R_f]$$

Table 4. Calculation of the correlation coefficient and the variation coefficient

	BET Plus index	TLV	IMP	BIO	CEON	TBM	COTE	RPH
E(Ri)	0,0768	0,1166	0,1286	0,1291	0,3368	0,3002	0,0786	-0,0353
STDEV.S	0,1472	0,1885	0,4142	0,2749	0,4024	0,5929	0,1778	0,1734
CORREL - ρ	-	0,7507	0,8106	0,6795	0,4253	0,0841	0,2139	-0,1599
Coefficient of variation	1,9167	1,6167	3,2208	2,1294	1,1948	1,975	2,262	-4,91

Sources: authors' calculations

The calculation of the *standard deviation* was necessary to assess the correlation coefficient ρ, returned by the CORREL Function, a coefficient that measures the intensity of the correlation between the return of title "i" and that of the stock market "M".

The coefficient ρ can take values between -1 and 1.

If $\rho \in (0; 1]$, the correlation between the variation of the security's return and that of the market is directly proportional.

If $\rho = 0$, the variation of title "i" is independent of the market variation.

If $\rho \in [-1; 0)$, the correlation between the variation of the security's profitability and that of the market is inversely proportional.

Negative correlations are very rare on the financial market, even less so the perfectly negative ones. The most common types of correlation are the positive ones.

The rule is confirmed in this study, considering that the only action for which the correlation is weakly negative is RPH, all other actions having positive correlations with values between 0.0841 for TBM and 0.8106 for IMP.

The risk-averse investors will be attracted by CEON and TBM stocks. The expected return is higher for CEON stock (33.68%), than for TBM (30%), with volatilities to match. However, the risk, measured by the standard deviation, is the highest in the case of TBM.

Figure 2 shows the variation coefficient, which measures the risk per unit of yield.

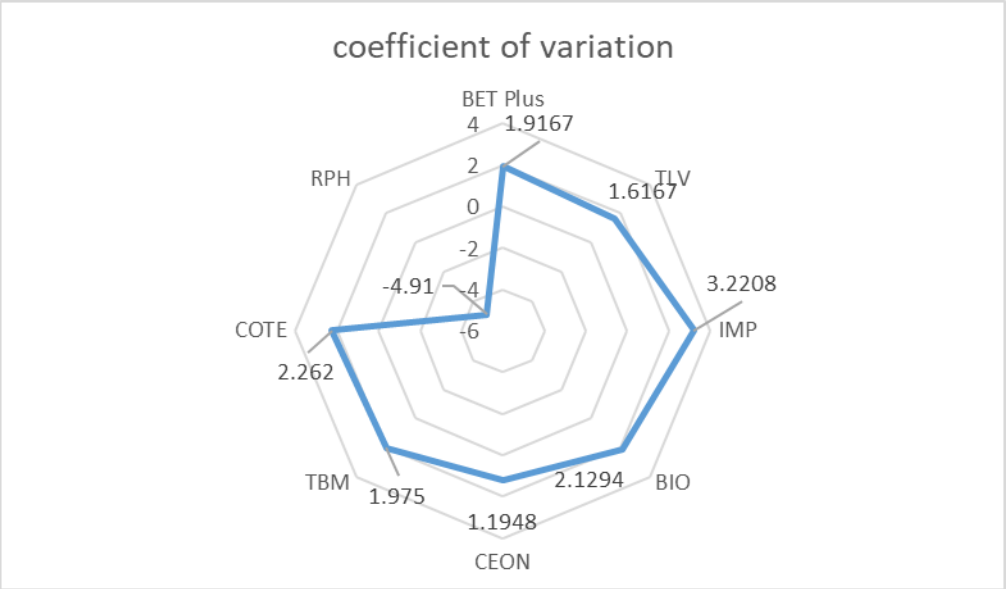

Figure 2 The coefficient of variation for the market portfolio and for the securities "i"

The variation coefficient is the lowest in the case of the CEON stock, which is why the Ceon stock seems to be the most rational choice. However, analyzing the risk measured by the standard deviation (40.24%), we can conclude that this stock is suitable only for the risk-averse investors.

The stocks of TLV, IMP and BIO have significantly lower returns and close in value, respectively 11.66%, 12.86% and 12.91%. But taking into account the risk, the decision to buy the TLV stock is rational for the risk-averse investors.

Table 5 centralizes the expected returns of the securities analyzed E(Ri), calculated as the arithmetic mean of the returns recorded in the period 30.12.2014 - 30.12.2022 and the returns according to CAPM, for the purpose of comparison with the real ones recorded in the period December 30, 2022 – December 30, 2023.

Table 5. The real and expected return of the analyzed securities

	TLV	IMP	BIO	CEON	TBM	COTE	RPH
E(Ri)	11,66%	12,86%	12,91%	33,68%	30,02%	7,86%	-3,53%
BETA (β)	0,9594	2,2782	1,2694	1,1634	0,3334	0,2575	-0,1883
E(Ri) CAPM	7,63%	8,78%	7,90%	7,81%	7,09%	7,02%	6,64%
real R for 2023	20,38%	-23,84%	30,74%	-4,10%	50,61%	21,21%	12,97%

Sources: authors' calculations

Except for the COTE stock, where the expected return and the CAPM return are roughly equal, they differ significantly for all other stocks.

Also, according to the data presented in Table 5, we notice a major discrepancy between the return estimated according to the CAPM methodology and the real one.

The expectation that the high risk is rewarded by a high return was confirmed only in the case of the BIO stock, which achieved a high return of 30.74% in 2023, at β above unity. In the case of IMP and CEON stocks, the exact opposite happened, in the sense that although the volatility coefficients were high, respectively 2.28 and 1.16, their return was negative, respectively -23.84% and -4.10%. The stocks of TLV, TBM and COTE, less risky than the market with a subunit β, recorded returns well above both the expected average and above those predicted by the

CAPM, the highest anomaly being observed in the case of TBM, which achieved a return of 50.61% in 2023, at a small β of 0 .33, the highest of all 7 shares analyzed.

In 2023, the BET Plus index had a return of 27.18%, being surpassed only by BIO and TBM stocks.

5. Conclusions

An important advantage of the capital asset pricing model is the simplicity of its application, given that in order to determine the expected return on the stocks of a company, it is not necessary to carry out an extensive financial analysis of the company and to forecast future cash flows. According to the CAPM, the only thing that needs to be known about the company is the β of its stock, a parameter usually much easier to estimate than the company's expected future cash flows. In addition, the investor must know the price paid by the stock market to assume the systematic risk $E(R_M)-R_f$.

The real return of the analyzed stocks for the year 2023 (with 2 exceptions, IMP and CEON which also have over-unit volatility coefficients) is much higher than the one estimated by CAPM. The inflation factor could explain the superior performance of these stocks. Testing an asset pricing model that uses the inflation factor could represent future research.

In the case of the examined stocks, the results generally invalidate the CAPM predictions that higher risk (measured by beta) is associated with a higher level of return and confirm empirical studies in the field (Black, Jensen and Scholes, 1972 [1]; Friend and Blume, 1970 [6]) that low-beta securities earn a higher return than the CAPM would predict (in this case TBM, COTE, RPH) and high-beta stocks earn less than it was predicted, even a negative relation between risk and profitability (in the case of IMP and CEON).

Due to its shortcomings, the investment managers should not rely exclusively on the CAPM. The model can be used together with the traditional techniques and a sound judgment to realistically estimate the value of the financial assets.

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