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Tomić, Bojan

Effectus College for Law and Finance

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THE APPLICATION OF THE CAPITAL ASSET PRICING MODEL ON THE CROATIAN CAPITAL MARKET

Bojan Tomić, str.spec.oec

ABSTRACT The paper describes and analyzes the application of the capital asset pricing model (CAPM) and the single-index model on the Zagreb stock exchange during the drop in the total trade turnover, and mostly in the trade of equity securities. This model shows through the analysis techniques used to estimate the systematic risk per share compared to the market portfolio. Also, the model quantifies the environment in which a company and its stocks exist, expressing it as risk, or a beta coefficient. Furthermore, with respect to the market stagnation, one can also discuss the usefulness of the model, especially if the quality of the input data is questionable. In this regard, the importance of the proper application and interpretation of the results obtained based on the model during the stagnation of the market, and especially during the stagnation of the trade of equity securities, is gaining even greater importance and significance. On the other hand, the results obtained through the analysis of data point to problems arising during the application of the model. It turns out the main problem of applying the CAPM model is the market index with negative returns during the observation period.

KEYWORDS: systematic risk, CAPM, beta coefficients, rate of return.

JEL: G11, G12, G15

1. INTRODUCTION

Over the past 5 years we have been witnesses to the global economic crisis. This global economic crisis, which started as the crisis in the sector of the real estate market in the USA, extending into the crisis of the financial sector (banking and finance), and finally turned into the crisis in the real sector, has also generated the crisis of the capital markets, which manifested through the drop in the value of securities and the stagnation in the trade of securities on a global level. The negative changes have also occurred in the capital market in the Republic of Croatia are primarily the effects of the global economic crisis, and ultimately the crisis in the euro zone. The main function of financial markets and financial intermediaries is to connect investors with surplus cash and investment opportunities. Therefore, it is important to mention the significance of a financial market that enables the realisation of efficient allocation of capital, and allows transfer of funds from people lacking opportunities for productive investment to people having such opportunities (Mishkin and Eakins 2005). With regard to the above-mentioned, the necessity to intensify the functioning of the primary and

the secondary financial markets becomes obvious, but that is not the case in Croatia. And also, the stocks existing on the poorly developed markets are less liquid, making it difficult to calculate the increasingly complex financial models. In addition to the problem of the level of development of the financial market, there is also the issue of the crisis of confidence that further aggravates the current situation on the capital market in the Republic of Croatia.

One of the basic and most common model for estimating investments is the Capital Asset Pricing Model (CAPM). CAPM is a linear equilibrium model of return on investments that explains expected returns above the risk free rate¹ using covariance of expected returns on individual investments and covariance of expected returns with the overall market. It is also a model that determines the relationship between risk and equilibrium expected returns of a risky asset. The said connection is used for two purposes. First, to calculate the expected rate of return to be used in the evaluation of potential investments which is the subject of this paper. Second, to determine the expected return on the assets that have not yet been traded in the market (Bodie & et al., 2004). Given the problems faced by the econometric analysis on the underdeveloped markets and markets in stagnation, the functioning and reliability of such a model is put under scrutiny, therefore it is of the utmost importance to also examine the calculation of the beta coefficient on the observed market.

1.1. The purpose of the paper

The purpose of this paper is to present the theoretical and practical application of the Capital Asset Pricing Model in the case of the Croatian capital market and its function in reviewing investment opportunities. The paper also attempts to discover how well the said model evaluates and describes the measure of systematic risk in the target market.

1.2. The basic hypothesis

In the Croatian capital market, during the drop in the trade of equity securities, it is possible to apply the Capital Asset Pricing Model which, depending on the preferences of investors with respect to risk and return, justifies the act of entering or exiting an investment.

1.3. The methodology of the paper

During the writing of this paper, in its first part, the prevalent method was the descriptive method used to describe different approaches to calculating rates of return and standards of their disclosure. Furthermore, the basic characteristics of the CAPM model and its applicability through the single-index model are explained. The basic method used in this paper is a mathematical method. In order to achieve better analysis of the data, in addition to mathematical methods, the methods used include statistical methods through which the relationships between the observed securities and the market index were further explained. The input data, necessary for such a research, were mostly collected from the

¹ In the context of the CAPM, this is the rate of return that can be safely earned. For example, investing in short-term government debt securities.

Zagreb Stock Exchange, where they were publicly available. Additionally, the input data for the risk-free interest rate were obtained from the CNB's website.

2. THE RESULTS OF THE PAPER

The results obtained using the regression analysis are shown in Table 1. The systematic risk for the stock of the Zagreb Stock Exchange, expressed as a beta (β) coefficient, totals 1.08. The regression intercept alpha (α) has a negative value (-0.01) and the coefficient of determination ($[R]^2$) totals 0.44. In addition, Table 1 shows additional statistical calculations required for the further analysis of the observed stocks and indexes, as well as average returns of the observed stocks.

Table 1: The results of the regression analysis and statistical indicators

| | Simbol | ZABA-R-A | ADPL-R-A | CROBEX |
|------------------------------|-------------------|----------|----------|--------|
| Systematic risk | Beta (β) | 1,08 | 0,94 | 1 |
| Regression intercept | Alfa (α) | -0,01 | 0,01 | / |
| Covariance | Cov | 0,01037 | 0,00900 | / |
| Correlation coefficient | ρ | 0,67 | 0,72 | 1 |
| Coefficient of determination | (R^2) | 0,44 | 0,50 | / |
| Standard deviation | σ | 15,90% | 12,86% | 9,67% |
| Average rate of return | R_i | -2,93% | 0,53% | -1,45% |

Figure 1: Characteristic line of ZABA-R-A

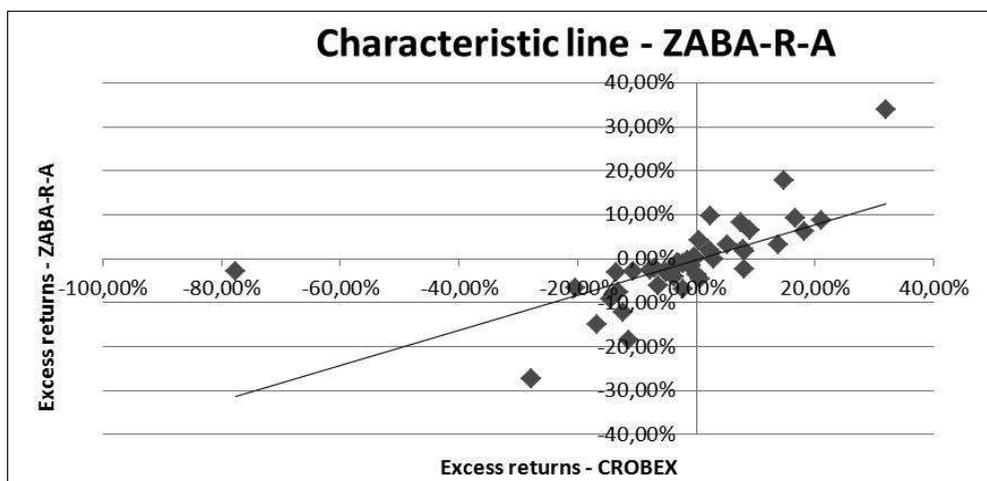


Figure 1 - shows the characteristic line for the stock of Zagrebačka banka. The stock's beta is given as the inclination of the characteristic line. The intercept of the typical line which intersects the vertical coordinate is alpha ($[\alpha]$).

Figure 2: Characteristic line of ADPL-R-A

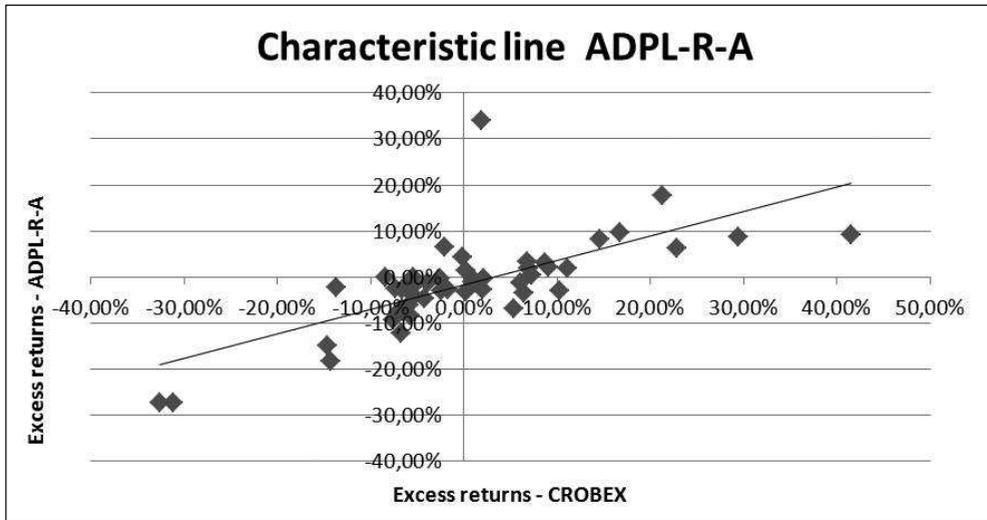


Figure 2 shows a characteristic line for the stock of Ad Plastik. The beta ($[\beta]$) of the ADPL-R-A stock is 0.94, which means the systematic risk is smaller than the systematic risk of the stock of ZABA-R-A. This is confirmed by the inclination of the characteristic line shown in Figure 2 which is smaller than the inclination shown in Figure 1. The stock of ADPL-RA has a positive regression intercept (α) 0.01 and the coefficient of determination ($[R]^2$) totalling 0.50. The values, along with other statistical indicators, are shown in Table 1.

The calculation of the return on investment and disclosure standards for rates of return

The rate of return is generally defined as a percentage return on invested capital. Also, the rate by which the resources have increased during the investment period is a key measure of the investment’s success on the capital market. It can be said there isn’t just one generally accepted measure of risk and return, therefore return on investment on the capital market can be observed from several perspectives. One of them is the total return for the period of investment Holding Period Return (HPR), which depends on the increase (decrease) in the price and dividends paid, that is, the price appreciation plus dividends per currency invested.

$$HPR = \frac{(P_{nt} - P_{nt-1}) + D_{nt}}{P_{nt-1}} \tag{1}$$

Where: HPR is the return in the investment period, n is stock, t is time, D_{nt} is dividend, P_{nt} is share price. In addition to the above equation, if investment funds, want to determine the fund’s performance during a five-year period, they employ even more complex calculations to measure the return during several periods of investments. Let’s list a few of them;

arithmetic mean, geometric mean and value weighted average return. Each of these measures has its advantages and disadvantages. The arithmetic mean of a security i equals the sum of the returns of all periods divided by the number of periods.

$$\bar{r}_i = \frac{1}{n}(r_{i1} + r_{i2} + \dots + r_{in}) \quad (2)$$

or

$$\bar{r}_i = \frac{1}{n} \sum_{t=1}^n r_{it} \quad (3)$$

Where: n is the number of time periods. However this calculation ignores the complex compounding, but for practical reasons, it is used as a method to predict future expected returns. The return on securities is a complex return, obtained through complex decursive compounding. The return calculated using the geometric mean meets the requirement of complex compounding. This is the return for the period, which is calculated using all values of the series of actual returns, and its calculation employs the relative number when expressing the return, i.e. $1 + r$. The geometric mean for a security i is determined by the formula:

$$G_i = \left[\prod_{t=1}^n rr_{it} \right]^{1/n} \quad (4)$$

Where: P - stands for the product of multiplying all relative returns rr_{it} for n years. Therefore, the geometric mean is the n -th root of the product of n relative annual returns. The value-weighted average return is in fact the internal rate of return (IRR²) which is used in finance to calculate the investment profitability of projects. It is used by investment funds to calculate return when they want to include changes in the volume of a fund's assets, where the fund's cash flows are treated as cash flows of an investment project, the initial value of the fund as the initial value of the investment project and the final value of the portfolio as a residual value of the project (Bodie & et al., 2004). It is important to emphasise the rate that reduces fund's cash flows to its initial value is a value weighted average return, or IRR. IRR is given in the formula:

$$\text{Fund's initial value} = \sum_{t=1}^n \frac{\text{fund's cash flow}}{(1 + y)^t} + \frac{\text{final value of the portfolio}}{(1 + y)^n} \quad (5)$$

Where IRR is value weighted average return.

The common standards in the disclosure of rates of return are kept on an annual basis. For example, in case of a quarterly investment and the quarterly return generated by that investment, the rate of return should be adjusted to the annual investment, so that the

² The acronym IRR stands for Internal Rate of Return.

said investment can be comparative to opportunity investments. Some asset returns with continuous cash flows, which last less than one year, such as mortgages and semi-annual bonds, may be upgraded to a yearly level Annual Percentage Rate (APR), using a simple interest calculation, and ignoring the compounding, by multiplying the rate of return during the period of investment with the known number of periods in a year.

$$APR = HPR * \text{numer of periods in year} \quad (6)$$

The annual return is calculated using complex, decursive compounding is called effective annual return Effective Annual Rate (EAR). Naturally, such calculation of returns also requires knowing the number of the investment periods so that the known rate of return could be converted into effective annual return. The relations are given in the following formulas:

$$1 + EAR = (\text{rate in period})^n = \left(1 + \frac{APR}{n}\right)^n \quad (7)$$

That is:

$$APR = [(1 + EAR)^{1/n} - 1] \times n \quad (8)$$

Where the formula for the cumulative return is:

$$EAR = \left(1 + \frac{APR}{n}\right)^n - 1 \quad (9)$$

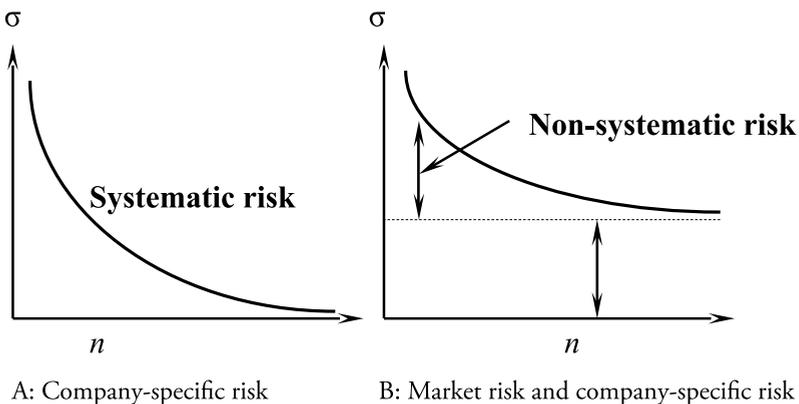
Where EAR is the effective annual return, and other symbols are as before. The effective annual return, is calculated using complex, decursive compounding. It is important to emphasise such calculation includes the reinvestment of funds by the same realised rate, so that in addition to the effective annual rate of return, the actual rate of return is calculated as well. Also, due to the change in the purchasing power of money, i.e. inflation, we differentiate between two rates of return; the nominal which is not adjusted to the inflation rate and the real interest rate which is corrected, which is not the subject of this paper.

3. CAPITAL ASSET PRICING MODEL (CAPM)

The modern portfolio theory (MPT) developed by Markowitz (1952) is one of the key elements helping investors to choose a set of securities that will give them a higher portfolio return with the desired level of risk. This is one of the most popular approaches to designing and selecting portfolios. The criteria, the profitability of the portfolio, which determines the expected return, and the risk of the portfolio as measured by portfolio return variance, are sufficient to meet the preferences of an investor. When applied in practice, the Markowitz's portfolio theory has had a few drawbacks.

One of the major problems was the large number of input data in the optimization of the portfolio, and that demands more resources and time during the process of analysis. For example, for a portfolio containing 100 securities, it is necessary to calculate 100 expected returns, 100 variances, and $100 \times 99/22 = 4.950$ covariances. And a set of 100 securities is considered to be actually rather small. The model for capital asset pricing (CAPM) was developed by Sharpe (1963, 1964) and Lintner (1965) with the aim to simplify the existing Markowitz's model. They observed the existing correlation between stock returns and the market during the changes in market conditions. Further they split the total return of a security in the return related to the market and the return which is not dependent on the market. They also noted the overall risk of a security can be separated into the systematic and non-systematic risk, that is, in factors causing the risk. The non-systematic risk is the risk which directly affects the volatility of the company's stocks. It is defined by certain decisions of the company's management which caused the lower profitability of the company and ultimately the drop in stock prices. It is important to emphasize that due to designing a portfolio with various securities, the non-systematic risk expressed in standard deviation, i.e. stock return variance, can diversify given the optimal combination of risk and return. The systematic risk is defined by the environment within which a company operates (economic, political, financial, fiscal and legal). From the company's point of view, this is the environment in which it operates, but which cannot be influenced or predicted with certainty. For example, in case of changes of interest rates on the market, indebted companies must pay a higher interest rate on their loans. That way, their profitability decreases, causing the market to respond through a decrease in the value of their stock prices, i.e. returns. Figure 3 shows the relationship between risk and the number of securities in the portfolio from which it is clear that by increasing the number of securities in the portfolio, the non-systematic risk decreases, while the systematic risk remains the same, which sustains the idea of the impossibility of its diversifying. Where: n - stands for the number of securities in the portfolio.

Figure 3: Portfolio risk as a function of the number of stocks in the portfolio



Source: (Bodie & et al., 2004).

The CAPM model shows the relationship between risk and equilibrium expected return on a risky asset based on the fact that for investments in the capital market the relevant risk is the systematic one. Since the systemic risk does not decrease with diversification. It is based on certain simplified assumptions that allow the understanding of the essence of the model. After that, it is possible to introduce the complexity of the environment and see how the theory can be extended and modified in order to achieve more realistic and comprehensible results. The first assumption of the CAPM model argues that no investor is big enough to influence individual securities by means of its own trading on the capital market. The second, all investors have the same investment time horizon. The next assumption relates to putting together a portfolio where all investors can build a portfolio out of any publicly available financial assets and are able to give and take loans at a risk-free rate without any limits. The fourth defines the absence of tax and transaction costs when trading securities. The fifth assumption states that all investors are rational, i.e., they seek to design portfolios set on the efficacy threshold. The sixth refers to equal analysis, and the possession of equal information. That is why the estimated probability distribution of future cash flows is identical for all investors. Also, when building an optimal risky portfolio, investors will use the same expected returns, standard deviations and correlations to generate the efficacy threshold and a unique optimal portfolio.

These assumptions, not only enable a better understanding of the process of balancing the prices of securities in the market, but they also have certain consequences. Firstly, all investors have the same market portfolio (M). For the sake of simplicity, let's call all assets, stocks. The share of each stock in the market portfolio equals the stock's market value (price per stock times the number of stocks issued), divided by the total value of all stocks. The second, the market portfolio will be set on the efficacy threshold. This is also the optimal risky portfolio that is set on the capital allocation line Capital Allocation Line (CAL³) and which touches the efficacy threshold of possible portfolios. In other words, the capital market line (CML⁴) is actually the best attainable capital allocation line (CAL). All investors differ among themselves only by the amount of funds invested in a risky portfolio and risk-free assets. The third, the premium on the market portfolio is proportional to the market portfolio variance and the level of investors' aversion to risk:

$$E(r_M) - r_f = A^* \sigma_M^2 \quad (10)$$

Where: $E(r_M)$ – stands for the expected market portfolio return, r_f – risk-free interest rate, σ_M^2 – market portfolio variance and A^* – the number representing the level of investors' aversion to risk. The fourth, the risk premium of individual securities will be proportional to the risk premium of the market portfolio (M) and the security's beta (β) in the market portfolio which defines the rate of return of the market portfolio as the only factor in the securities market. From these afore-mentioned assumptions, it is clear why all investors have the same risky portfolios.

³ CAL shows how much the return for an additional risk unit increases.

⁴ If a market portfolio is an optimal risky portfolio, then CAL is called the capital market line (CML).

3.1. The risk premium and the expected return of individual assets

For any risky investment on the capital market, investors want compensation or a reward. Further to the above-said, the logical question for investors would concern the amount of the expected reward compensating the risk taken due to buying risky securities. The reward is defined as the difference between the expected return during the period of investment of risky securities and the rate of return on the risk-free assets. Most investors believe that the instruments of the money market are adequate risk-free assets. The difference between risky and risk-free assets is defined as a risk premium.

$$\text{Risk premium} = R_i - r_f \quad (11)$$

Where: R is the total return on a security i , r_f is rate of return on the risk-free assets. CAPM defines a risk premium of an asset as a contribution of the risk of total assets in the investor's portfolio. In other words, if the risk of individual assets increases the risk of the total investor's portfolio, the premium for the risk of individual assets must be higher. Since the non-systematic risk can be reduced to a large proportion by efficient diversifying of the portfolio, investors demand a reward for the risk only for the portion that relates to the systematic risk, which explains the fourth consequence of the assumptions stating the risk premium of individual assets will be proportional to its beta:

$$\frac{E(r_M) - r_f}{1} = \frac{E(r_i) - r_f}{\beta_i} \quad (12)$$

The ratio of the total expected return and the beta of the CAPM model is expressed in the formula:

$$E(r_i) = r_f + \beta_i [E(r_M) - r_f] \quad (13)$$

Where: $E(r_i)$ is the expected return of individual assets, β_i is the individual assets' beta, while other symbols are the same as before. The formula shows the total expected return of individual assets is greater than the risk-free assets for the risk premium, which is calculated by multiplying the systematic risk (measured using the beta) and the market portfolio's risk premium.

3.2. The single-index model and CAPM

Taking into consideration the above-mentioned assumptions, the CAPM model may restrict investors. The reason for that is the assumed market portfolio that should consist of a variety of assets (real estate, foreign stocks, precious metals, etc.). Also, the assumed market portfolio is the optimal portfolio of risky assets and should be set at the efficacy threshold, which requires its construction and analysis. Furthermore, the CAPM employs expected, rather than actual portfolio's and stock's returns. It is a known fact that the actual returns during a certain investment period are rarely equal to their forecasts. To draw the CAPM model closer to reality and to justify the possibility of its practical application,

we'll use the ZSE CROBEX index for the market portfolio. The stocks that will be compared with the index of the Zagreb Stock Exchange are the shares of Zagrebačka bank and Ad Plastik. The companies included in the ZSE index are the companies listed in Table 2.

Table 2: Companies within CROBEX

| Br. Dionica | Simbol | Izdavatelj | Udjel |
|-------------|----------|---------------------------------|--------|
| 1 | ATPL-R-A | Atlantska plovidba d.d. | 2,90% |
| 2 | KOEI-R-A | Končar - elektroindustrija d.d. | 5,67% |
| 3 | KRAS-R-A | Kraš d.d. | 4,55% |
| 4 | PODR-R-A | Podravka d.d. | 6,58% |
| 5 | RIVP-R-A | Riviera Adria d.d. | 4,38% |
| 6 | ZABA-R-A | Zagrebačka banka d.d. | 5,13% |
| 7 | DLKV-R-A | Dalekovod d.d. | 3,11% |
| 8 | ERNT-R-A | Ericsson Nikola Tesla d.d. | 7,68% |
| 9 | ATGR-R-A | Atlantic Grupa d.d. | 3,32% |
| 10 | PTKM-R-A | Petrokemija d.d. | 3,66% |
| 11 | ADPL-R-A | AD Plastik d.d. | 2,97% |
| 12 | LKRI-R-A | Luka Rijeka d.d. | 1,94% |
| 13 | LEDO-R-A | Ledo d.d. | 3,47% |
| 14 | IGH-R-A | Institut IGH d.d. | 0,80% |
| 15 | ADRS-P-A | Adris grupa d.d. | 15,67% |
| 16 | TISK-R-A | Tisak d.d. | 0,52% |
| 17 | ULPL-R-A | Uljanik Plovidba d.d. | 1,27% |
| 18 | KORF-R-A | Vahmar Adria Holding d.d. | 3,66% |
| 19 | LKPC-R-A | Luka Ploče d.d. | 1,70% |
| 20 | INGR-R-A | Ingra d.d. | 0,67% |
| 21 | VPIK-R-A | Vupik d.d. | 0,67% |
| 22 | VIRO-R-A | Viro tvornica šećera d.d. | 2,02% |
| 23 | BLJE-R-A | Belje d.d. Darda | 1,75% |
| 24 | DDJH-R-A | Đuro Đaković Holding d.d. | 1,20% |
| 25 | HT-R-A | HT d.d. | 14,74% |

Source: ZSE

3.3. Example of calculating the historical beta using the regression model

Depending on the input data used for calculating a beta coefficient, betas are calculated as: historical (ex post) beta coefficients, expected (ex ante) beta coefficients and expected adjusted (ex ante) beta coefficients. Historical beta coefficients are calculated on the basis of historical input data on the returns of individual assets and the market portfolio. There

are two possible modes of calculation: (a) using the regression model of the dependent and independent variable, (b) using the method of calculating the relationship between two variables expressed by the covariance and variance of the market portfolio. Since the calculation of the expected beta coefficients requires drafting the expected probability distribution of possible scenarios in the economy, which demands a larger data repository and previous analyses. In this paper I will present the calculation and interpretation of historic beta coefficients by means of the regression analysis. The example will demonstrate the calculation of historical betas using the regression line equation. The regression line equation is given in the formula:

$$R_i - r_f = \alpha_i + \beta_i(R_M - r_f) + e_i \quad (14)$$

Where: R_i is the actual return on individual securities, α_i is the stock's rate of return beyond the market yield, e_i is the company-specific events affecting solely the security in question, R_M is the actual market yield (index), other symbols are as before. Table 3 shows the monthly values of stock prices for Zagrebačka banka, Ad Plastik and the ZSE index (CROBEX) with the corresponding yields⁵ in the investment period for the time horizon of 4 year. For the sake of simplicity of the model, dividends paid are not included in the total yield.

⁵ The return in the investment period is given in the formula 1.

Table 3: Monthly values of stocks and indexes

| Number of samples | Date | ZABA | HPR ZABA | ADPL | HPR ADPL | CROBEX | HPR CROBEX | Risk-free interest rate ANNUAL | Risk-free interest rate MONTHLY | Excess Returns ZABA | Excess Returns ADPL | Excess Returns CROBEX |
|-------------------|------------|--------|----------------|-------|----------------|----------|------------|--------------------------------|---------------------------------|--------------------------------|--------------------------------|--------------------------------|
| | | | R _i | | R _i | | RM | | r _i | R _i -r _i | R _i -r _i | R _m -r _i |
| / | 1.9.2008 | 370,00 | / | 99,01 | / | 3.494,41 | / | / | / | / | / | / |
| 1 | 30.9.2008 | 310,00 | -16,22% | 85,00 | -14,15% | 2.990,97 | -14,41% | 5,857 | 0,48% | -16,69% | -14,63% | -14,88% |
| 2 | 31.10.2008 | 225,60 | -27,23% | 59,00 | -30,59% | 2.191,84 | -26,72% | 6,773 | 0,55% | -27,77% | -31,14% | -27,27% |
| 3 | 28.11.2008 | 164,24 | -27,20% | 40,10 | -32,03% | 1.607,29 | -26,67% | 7,000 | 0,57% | -27,76% | -32,60% | -27,23% |
| 4 | 31.12.2008 | 180,05 | 9,63% | 39,51 | -1,47% | 1.722,29 | 7,15% | 7,950 | 0,64% | 8,99% | -2,11% | 6,51% |
| 5 | 30.1.2009 | 157,01 | -12,80% | 38,78 | -1,85% | 1.681,77 | -2,35% | 7,950 | 0,64% | -13,44% | -2,49% | -2,99% |
| 6 | 27.2.2009 | 140,00 | -10,83% | 33,50 | -13,62% | 1.383,71 | -17,72% | 7,800 | 0,63% | -11,46% | -14,24% | -18,35% |
| 7 | 31.3.2009 | 141,59 | 1,14% | 33,65 | 0,45% | 1.451,32 | 4,89% | 7,765 | 0,63% | 0,51% | -0,18% | 4,26% |
| 8 | 30.4.2009 | 166,00 | 17,24% | 47,83 | 42,14% | 1.593,57 | 9,80% | 7,792 | 0,63% | 16,61% | 41,51% | 9,17% |
| 10 | 29.5.2009 | 220,00 | 32,53% | 49,00 | 2,45% | 2.144,14 | 34,55% | 7,600 | 0,61% | 31,92% | 1,83% | 33,94% |
| 11 | 30.6.2009 | 194,00 | -11,82% | 46,00 | -6,12% | 1.896,36 | -11,56% | 7,685 | 0,62% | -12,44% | -6,74% | -12,18% |
| 12 | 31.7.2009 | 193,50 | -0,26% | 43,61 | -5,20% | 1.878,94 | -0,92% | 7,783 | 0,63% | -0,88% | -5,82% | -1,55% |
| 13 | 31.8.2009 | 230,01 | 18,87% | 53,84 | 23,46% | 2.009,02 | 6,92% | 7,80% | 0,63% | 0,18% | 0,23% | 0,06% |
| 14 | 30.9.2009 | 280,00 | 21,73% | 70,00 | 30,01% | 2.197,36 | 9,37% | 7,79% | 0,63% | 0,21% | 0,29% | 0,09% |
| 15 | 30.10.2009 | 267,59 | -4,43% | 77,60 | 10,86% | 2.144,77 | -2,39% | 7,62% | 0,61% | -0,05% | 0,10% | -0,03% |
| 16 | 30.11.2009 | 258,80 | -3,28% | 73,85 | -4,83% | 2.066,91 | -3,63% | 6,57% | 0,53% | -0,04% | -0,05% | -0,04% |
| 17 | 31.12.2009 | 260,00 | 0,46% | 79,00 | 6,97% | 2.004,06 | -3,04% | 6,06% | 0,49% | 0,00% | 0,06% | -0,04% |
| 18 | 29.1.2010 | 267,02 | 2,70% | 92,50 | 17,09% | 2.203,40 | 9,95% | 3,63% | 0,30% | 0,02% | 0,17% | 0,10% |
| 19 | 31.3.2010 | 255,11 | -0,39% | 85,50 | -8,06% | 2.142,82 | 0,22% | 3,68% | 0,30% | -0,69% | -8,37% | -0,08% |
| 20 | 30.4.2010 | 255,00 | -0,04% | 92,00 | 7,60% | 2.161,26 | 0,86% | 3,95% | 0,32% | -0,37% | 7,28% | 0,54% |
| 21 | 31.5.2010 | 22,52 | -13,52% | 87,00 | -5,43% | 1.986,40 | -8,09% | 3,95% | 0,32% | -13,84% | -5,76% | -8,41% |
| 22 | 30.6.2010 | 216,22 | -1,95% | 92,00 | 5,75% | 1.855,19 | -6,61% | 4,05% | 0,33% | -2,28% | 5,42% | -6,94% |
| 23 | 30.7.2010 | 216,00 | -0,10% | 89,98 | -2,20% | 1.856,55 | 0,07% | 4,31% | 0,35% | -0,45% | -2,55% | -0,28% |

| | | | | | | | | | | | | |
|----|------------|--------|---------|--------|---------|----------|--------|-------|-------|---------|---------|--------|
| 24 | 31.8.2010 | 210,00 | -2,78% | 91,37 | 1,54% | 1.848,06 | -0,46% | 4,20% | 0,34% | -3,12% | 1,20% | -0,80% |
| 25 | 30.9.2010 | 239,00 | 14,24% | 97,90 | 7,15% | 1.915,58 | 3,65% | 4,20% | 0,34% | 13,89% | 6,80% | 3,31% |
| 26 | 29.10.2010 | 215,00 | -10,38% | 100,15 | 2,30% | 1.869,36 | -2,41% | 4,18% | 0,34% | -10,72% | 1,96% | -2,76% |
| 27 | 30.11.2010 | 217,20 | 1,02% | 96,25 | -3,89% | 1.787,15 | -4,40% | 3,91% | 0,31% | 0,70% | -4,21% | -4,72% |
| 28 | 31.12.2010 | 250,05 | 15,12% | 117,00 | 21,56% | 2.110,93 | 18,12% | 3,84% | 0,31% | 14,81% | 21,24% | 17,80% |
| 29 | 31.1.2011 | 269,50 | 7,78% | 134,50 | 14,96% | 2.292,58 | 8,61% | 3,96% | 0,32% | 7,45% | 14,63% | 8,28% |
| 30 | 28.2.2011 | 259,00 | -3,90% | 125,00 | -7,06% | 2.241,04 | -2,25% | 3,98% | 0,33% | -4,22% | -7,39% | -2,57% |
| 31 | 31.3.2011 | 265,00 | 2,32% | 134,00 | 7,20% | 2.290,45 | 2020% | 2,85% | 0,23% | 2,08% | 6,97% | 1,97% |
| 32 | 29.4.2011 | 245,00 | -7,55% | 131,99 | -1,50% | 2.233,97 | -2,47% | 3,00% | 0,25% | -7,79% | -1,75% | -2,71% |
| 33 | 31.5.2011 | 265,50 | 8,37% | 146,99 | 11,36% | 2.278,88 | 2,01% | 2,70% | 0,22% | 8,15% | 11,14% | 1,79% |
| 34 | 30.6.2011 | 287,71 | 8,37% | 127,13 | -13,51% | 2.230,85 | -2,11% | 2,45% | 0,20% | 8,16% | -13,71% | -2,31% |
| 35 | 29.7.2011 | 65,00 | -77,41% | 119,00 | -6,40% | 2.173,73 | -2,56% | 2,50% | 0,21% | -77,61% | -6,60% | -2,77% |
| 36 | 31.8.2011 | 52,00 | -20,00% | 111,50 | -6,30% | 2.033,92 | -6,43% | 3,95% | 0,32% | -20,32% | -6,63% | -6,76% |
| 37 | 30.9.2011 | 44,70 | -14,04% | 103,50 | -7,17% | 1.854,41 | -8,83% | 4,50% | 0,37% | -14,41% | -7,54% | -9,19% |
| 38 | 31.10.2011 | 43,60 | -2,46% | 104,80 | 1,26% | 1.842,63 | -0,64% | 4,50% | 0,37% | -2,83% | 0,89% | -1,00% |
| 39 | 30.11.2011 | 41,00 | -5,96% | 99,04 | -5,50% | 1.739,20 | -5,61% | 5,20% | 0,42% | -6,39% | -5,92% | -6,04% |
| 40 | 30.12.2011 | 40,58 | -1,02% | 101,49 | 2,47% | 1.740,20 | 0,06% | 4,98% | 0,41% | -1,43% | 2,07% | -0,35% |
| 41 | 31.1.2012 | 39,80 | -1,92% | 108,00 | 6,41% | 1.727,28 | -0,74% | 4,83% | 0,39% | -2,32% | 6,02% | -1,14% |
| 42 | 29.2.2012 | 42,00 | 5,53% | 117,87 | 9,14% | 1.787,23 | 3,47% | 4,84% | 0,39% | 5,13% | 8,74% | 3,08% |
| 43 | 30.3.2012 | 45,48 | 8,29% | 128,95 | 9,40% | 1.833,54 | 2,59% | 4,39% | 0,36% | 7,93% | 9,04% | 2,23% |
| 44 | 30.4.2012 | 42,43 | -6,71% | 122,20 | -5,23% | 1.800,76 | -1,79% | 4,05% | 0,33% | -7,04% | -5,57% | -2,12% |
| 45 | 31.5.2012 | 37,00 | -12,80% | 114,00 | -6,71% | 1.668,46 | -7,35% | 3,30% | 0,27% | -13,07% | -6,98% | -7,62% |
| 46 | 29.6.2012 | 38,01 | 2,73% | 114,50 | 0,44% | 1.693,85 | 1,52% | 2,25% | 0,19% | 2,54% | 0,25% | 1,34% |
| 47 | 31.7.2012 | 39,21 | 3,16% | 108,60 | -5,15% | 1.698,23 | 0,26% | 3,50% | 0,29% | 2,87% | -5,44% | -0,03% |
| 48 | 31.8.2012 | 38,79 | -1,07% | 104,76 | -3,54% | 1.679,95 | -1,08% | 3,60% | 0,30% | -1,37% | -3,83% | -1,37% |

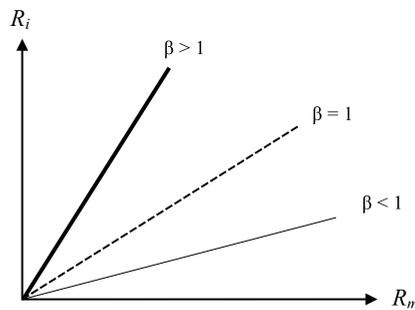
Source: Zagreb Stock Exchange, CNB, Zagreb Money Market

Reference risk-free interest rate is the rate of return on the treasury bills of the Ministry of Finance for the pertaining period⁶. Since the risk free interest rates are expressed on an annual basis, they must be converted to a monthly basis in order to make them comparative to monthly stock returns and CROBEX. The aforementioned formula 8 is used to calculate the monthly interest rate.

$$\text{Monthly rate of return} = [(1 + EAR)^{1/n} - 1] \times 100$$

Where n is the number of periods within the year. The beta value (β) calculated using the regression analysis for the stock of Zagrebačka banka totals 1.08. Since the beta is a measure of the systematic risk, beta values are interpreted as: $\beta < 1,0$ below-average risky investment, $\beta > 1,0$ above-average risky investment, $\beta = 1,0$ average risky investment and $\beta = 0$ risk-free investment.

Figure 4: Return on a security as a beta function



Beta is also the inclination of the regression line shown in Figure 1. The calculated value of 1.08 indicates that the stock of Zagrebačka banka presents an above-average risky investment. The stock's risk expressed in beta is actually the volatility (changeability) of the stock relative to the market, in this case the index. In the case of 1.00 betas, the stock volatility would be equal to the volatility of the market index. Since the beta totals 1.08, the stock volatility is slightly higher than the market index. Adding a new ZABA-R-A stock to the portfolio would contribute to increasing the overall risk of the investor's portfolio. On the other hand, investors demand higher risk premiums for the risks taken, which again confirms the proportional relationship between expected premiums for overall portfolio risks and betas with the expected premium for the risk of individual securities used by the CAPM model. In other words, if the expected risk premium of the total portfolio is increased by 2%, the expected risk premium for individual securities increases by 0.08% of the premium, i.e. to 2.16%.

$$2 \times 1.08\% = 2.16\%$$

If the stock's beta was 1.00, the stock would, according to the CAPM model, be averagely risky, i.e. by adding the stock to their portfolio investors would not require additional yield as a reward for the risk taken.

⁶ The rates of return on treasury bills are available on the CNB's website (www.hnb.hr).

The value of the regression intercept alpha (α_i) totals (-0.01). This is the intercept of the characteristic of line intersects the vertical coordinate and defines the specific above-average return of a stock. If alpha is negative, the observed stock is overvalued, while a positive alpha could indicate undervalued stocks. A negative alpha indicates a negative additional yield, in which case rational investors would avoid investing in such a stock. Following the assumptions of the CAPM model, all investors analyze securities equally and all come to the same end results. Ultimately, all investors would avoid the said stock which would result in the drop in its value and the increase of the expected return. If alpha is positive, which would indicate the stock is undervalued, a reverse process would occur, and the value of the stock would rise. This process is called the process of balancing stock prices (Van Horne, 2002). On the other hand, the CAPM model assumes the value of alpha is zero and the specified deviances are attributed to the influence of residual deviation and defined as a certain specificity of a company that contributes to changes in additional return on stocks. The next thing you should consider is the question of direction of stock movement relative to the market index and the strength of this connection. The direction of stock movement is expressed by the correlation coefficient for additional stock and market yields. The correlation coefficient, not only shows the direction of movement of the two variables, but it also shows the strength of their relationship. In order to reduce risk, negative correlations are what investors strive for, because they provide greater opportunities for the diversification of investments. The correlation coefficient is calculated by contrasting the covariance of the return on an individual security and the market (index) and the product of multiplication of the standard deviation of the return of an individual security and that of the market (index).

$$\rho = \frac{Cov_{iM}}{\sigma_i \times \sigma_M} \quad (15)$$

Where: ρ is the return correlation coefficient Cov_{iM} is the return covariance of an individual security and the market (index), σ_i is the standard stock i return deviation, σ_M is the standard market yield deviation (index). The covariance of the return of an individual security and the market (index) is given in the formula:

$$Cov_{iM} = \frac{1}{N-1} \sum_{t=1}^n (\bar{r}_i - r_{it})(\bar{r}_M - r_{Mt}) \quad (16)$$

Where: Cov_{iM} is the covariance of the return of an individual security and of the market (index) \bar{M} , \bar{r}_i is the average return on the security i , \bar{r}_M is the average market yield (index) r_{it} is the stock's return in time t , r_{Mt} is the market yield in time t . The average return of a security is calculated as an arithmetic mean. The formula (2) demonstrates the calculation of average returns. The risk of investing can be shown by means of dispersion around the mean value. Variance, i.e. standard deviation is used as a measure of dispersion. Standard deviation measures the deviation of each scenario's return around the mean or expected value. To calculate the deviation variance around the mean value, the following formula is used:

$$\sigma^2 = \frac{1}{n-1} \sum_{t=1}^n (r_{it} - \bar{r}_i)^2 \quad (17)$$

Where σ^2 is the variance and other symbols are as before. Standard deviation is expressed in the formula:

$$\sigma = \sqrt{\frac{1}{n-1} \sum_{t=1}^n (r_{it} - \bar{r}_i)^2} \quad (18)$$

Where σ is the standard deviation and other symbols are as before. If the correlation coefficient totals 1.0 or -1.0 a security's return is fully dependent on market trends. The stock of Zagrebačka banka has a positive correlation with the market index, which means that changes of the stock's return and index are moving in the same direction. The correlation coefficient (ρ) is 0.67, which confirms a statistical connection between the stock and the index. The value of the coefficient of determination (R^2) totals 0,44. It shows how much of the variability of the stock's return in the observed period can be attributed to changes in the market return (Bedeković, 2000). The coefficient of determination can be calculated using the following formula for the correlation coefficient. It is a squared correlation coefficient given in the formula:

$$R^2 = \rho^2 \quad (19)$$

Where: R^2 is the coefficient of determination, ρ is the return correlation coefficient. In the example shown, the coefficient of determination indicates that 0.44% of changes in return of Zagrebačka banka is defined by the market returns or the index. Figure 1 shows the regression line, which is called the Security Characteristic Line (SCL⁷). The regression line defines the dependency relationship between the additional ZABA-R-A return and the additional return of the market portfolio, in this case the CROBEX index. The inclination of the regression line, i.e., the stock's sensitivity to the index is expressed in the beta (β). Figure (2) shows the characteristic line for the ADPL-R-A stock. The beta value (β) calculated with the regression for the Ad Plastik stock totals 0.94, implies considering the market trends, the stock risk is below-average. In other words, investors do not require an additional yield to take the risk of buying these stocks. Changes in the stock return for Ad Plastik and the index are also moving in the same direction, which is confirmed by a positive correlation. The value of the correlation coefficient is 0.72 which indicates that the stock of Ad Plastik is in greater connection with the market or the index than the stock of Zagrebačka banka. The value of the regression intercept alpha (α_1) totals 0.01, and the coefficient of determination (R^2) is 0.50, which means 50% of changes in stock returns is defined by the changes of the index return. From the standpoint of the CAPM model, what does the correlation coefficient value really

⁷ This is a visual representation of the functional link between the return of an individual security and the market yield.

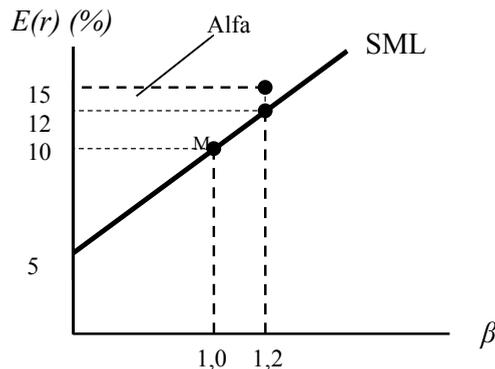
explain? According to the CAPM model, the volatility of the market (index) is a systematic risk. Since when calculating the correlation, the stock's return is compared with the return of the index, the correlation coefficient explains the share of the systematic risk in the total risk of the security. By calculating the coefficient of determination using the formula 19, we get a share in the total stock risk, which is defined by the changes in the index return. The remaining part of the total stock risk is not dependent on the changes in the index and can be reduced by diversification.

3.4. The Security market line

The relationship between the expected return and beta can be shown graphically using the stock market line (SML⁸). Since beta is a measure of the systematic risk measuring standard deviation of the market portfolio, investors expect a reward for the risk taken that is proportional to the increase of the portfolio risk, so the risk premium demanded by investors is a beta function:

$$\beta[E(r_M) - r_f] \quad (20)$$

Figure 5 Security market line-SML



Source: (Bodie & et al., 2004).

The stock market line is used to evaluate investment performance and presents a standard in the evaluation of investment results. For a risk measured by the beta, SML defines the required rate of return which will compensate for the investor's risk. If the expected rate of return for an individual security, or a portfolio. Calculated using, for example, the fundamental analysis, is higher than the expected rate of return adjusted by the beta, or a formula that uses the CAPM model, the security would be considered undervalued. On the other hand, overvalued stocks have a lower expected return than the return that is corrected by the beta. To calculate the expected rate of return for individual securities that are corrected by the beta, we use the already mentioned formula (13) of the CAPM model:

⁸ The acronym SML stands for Security Market Line.

$$E(r_i) = r_f + \beta_i [E(r_M) - r_f]$$

The formula requires prior knowledge of the beta, the security, the total expected market return and the risk free interest rate. The application of the formula to the observed stocks of Zagrebačka banka and Ad Plastik with such time horizon and historical input data is not possible. The reason for this is the monthly average return of CROBEX which has a negative value, and which would be taken as the expected market return $E(r_M)$. Therefore, to enable the functioning of the model with the stock and index values set in this way, it would be necessary to generate a more optimistic probability distribution that would give positive results for the expected market or index return. Also, since the index represents the market portfolio, the question of its quality within the functioning of the market portfolio arises. The shares of stocks in the index are in contrast with the rational diversification of the market portfolio envisaged by the CAPM model. The single-index model is characterised by its simplicity and convenience in use. Although the construction of a new market index would change the structure of the shares, which would give positive results for monthly returns, this leads us to the question of the model's practicality of use. The next possibility is to change the observation time horizon. On the other hand, if you change the time horizon for the calculation of the index return, the question of the reliability of the results arises. When weekly samples are used to calculate beta coefficients, the usual time horizon is two years. With monthly samples, the time horizon is about 5 years.

4. CONCLUSION

With respect to the examined possible application of the model, and the results obtained accordingly, this paper can be divided into two parts. The first part, describes the calculation of beta coefficients and the interpretation of the obtained results, the second part which relates to the application of the CAPM model in calculating the adjusted rate of return by means of beta coefficients. The advantage of calculating beta coefficients using the regression analysis, i.e. of the application of the CAPM model in the calculation of the adjusted rate of return is evident in its practicality. This is also the main advantage of the CAPM model, as opposed to the MPT theory. The logical question that arises is the question of reliability of the obtained results. The input data used to calculate beta coefficients are time series of returns of 4 years. With regard to that, the requirement of a time horizon for calculating beta coefficients is satisfied. Furthermore, from the aspect of the risk of non-liquidity, and taking into consideration the current market situation, it would be desirable to correct beta coefficients. Lackovic (2001) describes the risk of non-liquidity as being considerable on poorly developed markets, which can be equalised with the current situation on the market. He also points out that in the case of less liquid stocks, the correction of betas must be greater and vice versa.

The goal of every investor is to achieve as high of a return on the invested capital as possible and to reduce the risk of losing the invested capital. With regard to this assumption, the application of the formula (13) of the CAPM model is put under scrutiny. As it has already been mentioned, the average index return is a negative value, which is why

the application of the formula would be in contrast with the principles of every rational investor. Given the established hypothesis of a possible application of the CAPM model on the Croatian capital market, it is difficult to give either a positive or a negative answer. The reason for this is that Fruk and Huljak (2003) proved in their work that by constructing a market index with a different share structure, that is, by limiting shares at a certain limit and a different number of stocks, it is possible to construct an optimal market index, which provides the highest possible return for a given risk unit, which is one of the prerequisites of the CAPM model. Finally, on developed capital markets, the use of the capital asset pricing model does not require additional observations and analysis, which gives room for further academic debate about the applicability of the model in the Croatian capital market.

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