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IS CAPM VALID? EVIDENCE FROM SLOVENIA

In this paper we empirically test the validity of CAPM of Sharpe (1964) and Lintner (1965) at Slovenian stock market. We apply the 2-stage method of Fama and MacBeth (1973) on daily returns and 2 alternative empirical models: a cross-section and panel data model. The results show that the explanatory power of the CAPM for Slovenian stock market is weak, regardless the empirical model tested. We found that the CAPM is invalidated as 2 important implications of the CAPM cannot be confirmed. We found, firstly, that the zero beta stocks do not yield the same return as risk-free assets. Secondly, for Slovenian stock market significant positive risk-return relationship could not be confirmed.

Keywords: *stock market, CAPM, Slovenia.*

JEL classification: *G15, G11, D53, D92.*

Сільво Дайчман

ДІЄВІСТЬ МОДЕЛІ ОЦІНЮВАННЯ КАПІТАЛЬНИХ АКТИВІВ: ЗА ДАНИМИ СЛОВЕНІЇ

У статті емпірично перевірено дієвість моделі оцінювання капітальних активів (CAPM) Шарпа (1964) і Лінтнера (1965) для словенського фондового ринку. Застосовано двоступінчастий метод Фами і Макбета (1973) до щоденних показників дохідностей і 2 альтернативних емпіричних моделей: поперечний зріз і модель панельних даних. Результати показали слабку дієвість CAPM для словенського фондового ринку в обох моделях. Дві важливі умови CAPM не дотримано: по-перше, акції з нульовою бетою не приносять такого ж доходу як безризикові активи, по-друге, для словенського фондового ринку позитивну взаємозалежність ризику і прибутковості не підтверджено.

Ключові слова: *фондовий ринок, CAPM, Словенія.*

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ДЕЙСТВЕННОСТЬ МОДЕЛИ ОЦЕНКИ КАПИТАЛЬНЫХ АКТИВОВ: ПО ДАННЫМ СЛОВЕНИИ

В статье эмпирически проверена действенность модели оценки капитальных активов (CAPM) Шарпа (1964) и Линтнера (1965) для словенского фондового рынка. Применен двухступенчатый метод Фамы и Макбета (1973) к ежедневным показателям доходностей и 2 альтернативным эмпирическим моделям: поперечный срез и модель панельных данных. Результаты показали слабую действенность CAPM для словенского фондового рынка в обеих моделях. Два важных условия CAPM не соблюдены: во-первых, акции с нулевой бетой не приносят такого же дохода как безрисковые активы; во-вторых, для словенского фондового рынка положительная взаимозависимость риска и доходности не может быть подтверждена.

Ключевые слова: *фондовый рынок, CAPM, Словения.*

1. Introduction. The capital asset pricing model (CAPM) developed by Sharpe (1964) and Lintner (1965) has been the corner-stone of modern finance for more than 4 decades. In the financial praxis, financial managers, asset managers and individual investors have been applying this model to evaluate not just securities, but any

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investment. CAPM predicts that the risk premium of an individual asset (i.e., excess return of an asset over the risk-free return) should be proportional to market premium (i.e., excess return of a market portfolio over risk-free return). The factor of proportionality is known as systematic risk or beta (β) of an asset.

The CAPM theory generates 4 main implications: i) the risk premium for assets with positive beta should be positive; ii) there should be a linear relationship between betas and excess returns of assets; iii) an asset that is uncorrelated with market portfolio has an expected return equal to the risk-free rate, and iv) there should be no systematic effect of non-beta risk on excess returns of assets.

The literature provides no clear evidence on validity of CAPM. The early empirical studies on CAPM (Douglas, 1968; Black, 1972; Black, et al. 1972; Blume and Friend, 1973; Fama and MacBeth, 1973) were partially supportive of the implications of the model. They found that the relationship between beta and expected returns is positive; however, the studies consistently found that empirical models underestimated the market premium expected from the theoretical CAPM (Campbell, 2000). Many studies in the 80s and 90s questioned the validity of the Sharpe-Lintner-Mossin's CAPM. The empirical studies of Reinganum (1981), Gibbons (1982), Shanken (1985) and Fama and French (1992) found that the return generation process depended not only on the beta of an asset but also on other variables like size, the book-to-market ratio and the earnings/price ratio.

The present paper will examine evidence for the validity of CAPM implications for Slovenia. We use the 2-stage procedure of testing CAPM multiscale proposed by Fama and MacBeth (1973) and apply 2 econometric techniques - ordinary least squares and the generalized method of moments.

2. Methodology.

2.1. The capital asset pricing model (CAPM). The CAPM model of Sharpe (1964) and Lintner (1965) builds on the model of portfolio choice developed by Markowitz (1952). The portfolio model provides an algebraic condition on asset weights in mean variance-efficient portfolios. The CAPM turns this algebraic statement into a testable prediction about the relation between risk and expected return by identifying a portfolio that must be efficient if asset prices are to clear the market of all assets (Fama and French, 2004). It adds 2 additional assumptions to the portfolio theory, namely homogeneity of beliefs (all economic agents have the same beliefs of the expected return distribution of the assets) and the unlimited borrowing and lending at a risk-free rate, which is the same for all investors and does not depend on the amount borrowed or lent.

At equilibrium, the rate of return from an asset must satisfy the following (CAPM) equation:

$$E(r_{it}) = r_{0t} + \beta_i E(r_{mt} - r_{0t}), \tag{1}$$

where E denotes expected value, r_{0t} is the risk-free rate of return, β_i is the beta of the asset, defined as:

$$\beta_i = \frac{\mathrm{cov}(r_{it}, r_{mt})}{\sigma_m^2},$$

σ^2_m is volatility of market return. r_{mt} is the return of market portfolio (consisting of all traded assets at market), $E(r_{0t}-r_{0t})$ is referred to as the expected market risk premium, given that it represents the return over the risk-free rate required by investors to hold market portfolio.

Rearranging equation (1), we obtain:

$$E(r_{it}) - r_{0t} = \beta_i E(r_{mt} - r_{0t}), \tag{2}$$

from which it follows that the risk premium on an individual asset equals its beta time the market risk premium.

In empirical studies β_i is usually estimated by ordinary least squares (OLS) from the following regression (Fernandez, 2006):

$$r_{it} - r_{0t} = \alpha_i + \beta_i (r_{mt} - r_{0t}) + \varepsilon_{it} \tag{3}$$

or alternatively $$er_{it} = \alpha_i + \beta_i er_{mt} + \varepsilon_{it},$$

where er_{it} is the excess return of asset i over the riskless asset return in time period t, is a regression constant, which according to CAPM should be zero for all assets, er_{mt} is the excess return of market portfolio over riskless asset return in time period t and ε_{it} is the random error term.

We follow the procedure of Fama and MacBeth (1973) and test the validity of CAPM in a 2-stage procedure. In the first stage the time-series regressions of equation (3) are run to obtain beta estimates for each stock i. In the second step a cross-section regression is estimated:

$$er_i = \gamma_0 + \gamma_1 \beta_i + \gamma_2 \beta_i^2 + \gamma_3 RV_i + \varepsilon_i, \tag{4}$$

where $i(i = 1,...,N)$ is the number of stocks, er_i is the expected excess return on stock i where β_i are estimates of the betas from the first stage regression, RV_i are residual variances of the first stage regression and ε_i is the random error term.

The CAPM theory generates 4 main testable implications (Campbell et al. 1997):

1) $H_0 : \gamma_0 = 0$, implying that for zero-beta stocks the excess return should be zero.

2) $H_0 : \gamma_1 > 0$. CAPM implicates that the risk return trade-off should be positive, implying the stocks with higher beta should generate higher excess returns.

3) $H_0 : \gamma_2 = 0$. CAPM implicates linear relationship between the beta and the excess return of stock.

4) $H_0 : \gamma_3 = 0$. CAPM implicates no systematic effect of non-beta (non-systematic) risk on excess return of stocks.

The regression equation is tested by the ordinary least squares (OLS) and the generalized method of moments (GMM). The literature (Cochrane, 2000; Mertens, 2002) on testing CAPM has identified several advantages of the GMM over the OLS.

- Unlike the OLS method, it is not a subject to a problem of "errors in variables" that occurs because the betas used in the second stage regression are estimates of the true, unknown betas.

- GMM appropriately addresses the problem of serial correlation in the residual returns and cross-sectional correlation of the standard errors.

The GMM estimator provides us with a consistent, asymptotically normal, and asymptotically efficient estimator of regression coefficients (Hansen, 1982). For smaller samples (which is a standard case when CAPM is tested for undeveloped and small stock markets like Slovenian), the GMM estimator may be biased (Altonji and Segal, 1996; Wolldridge, 2001). Therefore, we also estimate a panel data regression model:

$$er_{it} = \gamma_0 + \gamma_1\beta_{it} + \gamma_2\beta_{it}^2 + \gamma_3 RV_{it} + \varepsilon_{it}, \tag{5}$$

where betas of particular stocks are obtained in the first stage for each year t ($t = 1,...,T$).

3. Data and empirical results. The validity of CAPM is tested by considering the major stocks traded at Slovenian stock market. The main national stock market index is taken as a proxy for the market portfolio return. The longest possible time series of stock (stock index) returns is taken at the time of this research, by considering at the same time the availability of the risk-free asset return time series. A major drawback of testing CAPM at emerging stock markets, like Slovenian, is the low number of quoted stocks and the relatively short historical time series[2]. The 3-month money market rates are taken as proxies for the countries' risk-free rates of returns[3]. Given that we worked with nominal returns, we used a nominal proxy for the risk-free rate.

The first date of observation was January 3, 2002. In the cases when there was no trading with a particular stock on a specific day, we took the closing price of the last trading day. We considered stock splits and reverse stock splits and accordingly adjusted prices of stocks. The data for stock (stock indices) prices were taken from the web pages of the Ljubljana Stock Exchange.

Tables 1 and 2 present some descriptive statistics of the data. The data appear extremely non-normal, with excess (i.e. the one over normal distribution) skewness and kurtosis. The Jarque-Bera test rejects the hypothesis of normally distributed returns for all stocks as well as the stock index (LJSEX).

The stationarity excess returns and market premium was checked using the augmented Dickey-Fuller (ADF) test, the Phillips-Perron (PP) and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests. The fourth moment (kurtosis) is finite for all the investigated stock returns and market premiums (Table 2).

In order to test the CAPM implications in a proposed 2-step procedure we estimated systematic risk (i.e. beta) of stocks at the stock market in the first stage. For the panel data model, the beta for each individual stock was recalculated for each subsample of 250 trading days (approximately 1 trading year) over the full observation period. The effective observation period for the panel data model, for which the CAPM was tested, was therefore January 3, 2002 - January 8, 2010. For the panel data model there are in total 72 observations entering the second stage regression to test the CAPM implications. Hypothesis testing is based on the 2-sided t-test, except

[1] We included all the stocks in the Slovenian stock market that satisfy the above condition. Pooling time-series and cross-section data enlarges the dataset and increases the variability of the data. The efficiency of the GMM estimator is thus increased.

[2] In empirical literature different proxies are used for risk-free rates. We use the 3-month money market rates due to the availability of historical data. A 3-month money market rate was used for instance in Gencay et al. (2005) and Rhaeim et al. (2007).

for the hypothesis $H_0 : \gamma_1 > 0$ for which the workable null hypothesis is $H^r_0 : \gamma_1 > 0$. For this hypothesis a 1-sided t-test is used. A rejection of the null hypothesis $H^r_0 : \gamma_1 = 0$ leads to the acceptance of the hypothesis ($H_0 : \gamma_1 > 0$). The results of testing the CAPM by the cross-section model (equation (4)) are presented in Table 3 and the results for the panel data model (equation (5)) in Table 4.

Table 1. **Descriptive statistics for returns series of the stocks listed at Slovenian stock exchange and its representative national stock index**

Stock/ stock index	Period of observation	Number of observations	Min	Max	Mean	Std. deviation	Skewness	Kurtosis	Jarque-Bera statistics
Aerodrom Ljubljana	3.1.2002-20.7.2010	2,132	-0.1557	0.1656	0.0002093	0.02059	-0.0075	10.2004	4,605.59***
Gorenje	3.1.2002-20.7.2010	2.132	-0,08299	0,08311	0,000209	0,01056	0,0332	6,5058	1.092.22***
Intereuropa	3.1.2002-20.7.2010	2,132	-0.1016	0.1542	-0.0007253	0.01769	0.4093	12.1373	7,476.29***
Krka	3.1.2002-20.7.2010	2,132	-0.1025	0.1984	0.0007877	0.01591	0.7510	19.4131	24,131.11***
Lasko	3.1.2002-20.7.2010	2,132	-0.1504	0.1263	-0.0001693	0.0211	-0.1598	9.0080	3,215.55***
Luka Koper	3.1.2002-20.7.2010	2,132	-0.09647	0.1281	0.00003834	0.01813	-0.0842	7.3082	1,651.34***
Mercator	3.1.2002-20.7.2010	2,132	-0.09486	0.1129	0.0003171	0.01682	0.0224	8.9387	3,133.19***
Petrol	3.1.2002-20.7.2010	2,132	-0.102	0.1328	0.0004018	0.01691	0.3232	12.0602	7,329.22***
Sava	3.1.2002-20.7.2010	2,132	-0.1274	0.1535	0.0004029	0.01949	-0.0042	8.9099	3,102,66***
LJSEX (index)	3.1.2002-20.7.2010	2,132	-0.08299	0.08311	0.000209	0.01056	-0.4683	15.3840	13,701.78***
3-month money market interest rate	4.1.2002-20.7.2010	2,132	0.00003	0.000354	0.0001757	0.00009	0.0669	2.5994	15.85***

Notes: With the stocks listed in this table, a major share of stock market trading turnover is taking place at Slovenian stock market. Jarque-Bera test: the null hypothesis is that the sample data come from a normal distribution with unknown mean and variance, against the alternative that it does not come from a normal distribution. Jarque-Bera statistics:
*** indicate that the null hypothesis (of normal distribution) is rejected at the 1% significance level.

Table 2. **Stationarity of excess returns of stocks and market premiums at Slovenian stock market**

Excess returns of stocks	Kurtosis	KPSS test (a constant + trend)	KPSS test (a constant)	PP test (a constant + trend)	PP test (a constant)	ADF test (a constant + trend)	ADF test (a constant)
Aerodrom Ljubljana	10.2017	0.170** (3) trend is significant	0.811*** (2)	-47.425*** (1)	-47.315*** (3)	-47.425*** (L = 0)	-47.304*** (L = 0)
Gorenje	6.5125	0.127* (7) trend is significant	0.759*** (9)	-44.908*** (6)	-44.822*** (8)	-44.844*** (L = 0)	-44.699*** (L=0)
Inter-europa	12.1558	0.153** (12) trend is significant	1.115*** (14)	-40.523*** (9)	-40.388*** (11)	- 40.6103*** (L = 0)	-40.340*** (L = 0)
Krka	19.4197	0.128** (4)	0.447* (2)	-42.926*** (7)	-42.874*** (6)	-33.986*** (L = 1)	-33.920*** (L = 1)
Lasko	9.0068	0.302** (28)	0.754*** (26)	-55.792*** (20)	-55.600*** (18)	-55.152*** (L = 0)	-55.050*** (L = 0)
Luka Koper	7.3127	0.186** (5) trend is signif	0.931*** (7)	-44.384*** (3)	-44.254*** (6)	-44.382*** (L = 0)	-44.222*** (L = 0)
Mercator	8.9424	0.095 (14)	0.528** (12)	-49.735*** (11)	-49.573*** (9)	-49.522*** (L = 0)	-49.444*** (L = 0)
Petrol	12.0661	0.135* (4) trend is significant	0.842*** (0)	-42.692*** (7)	-42.622*** (4)	-42.770*** (L = 0)	-42.649*** (L = 0)
Sava	8.9084	0.156** (6)	0.507** (5)	-49.544*** (4)	-49.379*** (2)	-49.439*** (L = 0)	-49.367*** (L = 0)
Market premium	15.3870	0.205** (7) trend is significant	1.151*** (9)	-35.874*** (8)	-35.736*** (5)	-31.073*** (L = 1)	-30.846*** (L = 1)

Notes: KPSS and PP tests are performed for 2 models: for a model with a constant and for the model with a constant plus trend. Bartlett Kernel estimation method is used with Newey-West automatic bandwidth selection. Optimal bandwidth is indicated in parentheses under the statistics. For ADF test, 2 models are applied: a model with a constant and the model with a constant plus trend; number of lags to be included (L) for ADF test were selected by SIC criteria (30 was a maximum lag). Exceeded critical values for rejection of null hypothesis are marked by *** (1% significance level), ** (5% significance level) and * (10% significance level). If trend of return series for a stock or stock index is significant, this is denoted in the table.

The results of the OLS regression show that the explanatory power (as measured by R^2) of the CAPM for Slovenian stock market is weak, regardless the empirical model applied. One can see that the t-statistics of the regression coefficients estimated by OLS and GMM differ. The Durbin-Watson statistics indicate the problem of serial correlation in both the cross-section and panel data model, which in turn makes the standard errors of the parameter estimates incorrect, even asymptotically (Shanken and Zhou, 2006). The associated tests based on t-statistics may no longer be valid; therefore, inferences regarding the CAPM hypotheses should be made on the basis of the robust results of the GMM estimator. For the later method to be robust, the sample size must be big enough. For this reason we base our evaluation on the validity of the CAPM for Slovenia on the panel data model estimated by GMM.

Table 3. **Results of testing CAPM implication for the cross-section data model**

γ_0	γ_1	γ_2	γ_3	Statistical parameters of OLS regression
0.006245 (0.52) (0.68)	-0.01244 (-0.47) (-0.64)	0.006599 (0.46) (0.64)	-1.9988784 (-0.73) (-0.75)	$R^2 = 0.124$ DW = 2.4269

Notes: In the first parenthesis the t-statistics based on the OLS estimates of the gammas are presented and in the second parentheses under the gamma estimates t-statistics based on GMM estimates of the gammas are presented. Exceeded critical values for the rejection of the null hypotheses are indicated by *** for the 1% significance level, by ** for the 5% significance level and by * for the 10% significance level. In the application of GMM we set explanatory variables as instrumental variables. The model is thus just identified. Furthermore, the Newey-West estimator with Bartlett Kernel weights was used to estimate the GMM asymptotic variance-covariance matrix. As the GMM is just identified the OLS and GMM estimates of gammas are equal.

Table 4. **Results of testing CAPM implication for the panel data model**

γ_0	γ_1	γ_2	γ_3	Statistical parameters of OLS regression
0.0017226 (1.58) (4.09)***	-0.0028493 (-0.92) (-1.14)	0.010036 (0.47) (0.46)	-0.0003844 (-0.17) (-1.91)	$R^2 = 0.0474$ DW = 2.3611

Notes: See notes for Table 3.

Regarding CAPM hypotheses, the following conclusions may be drawn from the GMM estimator results. The hypothesis $H_0 : \gamma_0 = 0$, that must not be rejected if CAPM is valid, is rejected. The zero-beta stocks thus do not yield the risk-free rate of return. According to CAPM, one should expect a positive relationship between risk (as measured by beta) and return of the stocks, meaning that the stocks with higher beta should generate higher excess returns. This in turn means that the security market line has a positive slope. For the CAPM to be valid, the hypothesis $H^r_0 : \gamma_0 = 0$ must be rejected. For the Slovenian stock market this hypothesis cannot be rejected, thus implying that the CAPM implication of a positive risk-return relationship can be rejected. The hypothesis of a linear relationship between the betas of the stocks and their excess returns ($H_0 : \gamma_2 = 0$) cannot be rejected. Finally, the result of testing the null hypothesis $H_0 : \gamma_3 = 0$ show that no other factors but the beta can systematically explain the excess on investigated stocks. Based on these results, we may conclude that the CAPM is invalidated for 2 reasons. Firstly, by the fact that the zero beta stocks do not yield the same return as risk-free assets. Secondly, for Slovenian stock market a significant positive risk-return relationship could not be confirmed.

4. Conclusion. This paper examines the validity of CAPM in Slovenia. We test 4 empirical implications that the CAPM implies by the method of Fama and MecBeth (1973), applying the ordinary least squares and the general method of moments. The results show that the explanatory power of the CAPM for Slovenian stock market is weak, regardless whether we test the hypotheses on the basis of cross-section or panel data empirical model. We found that the zero-beta stocks do not yield the risk-free rate of return.

According to CAPM, one should expect a positive relationship between risk (as measured by beta) and return, meaning that the stocks with higher beta should generate higher excess returns. For Slovenian stock market the hypothesis of a positive risk-return relationship, indeed, is not rejected. The hypothesis of a linear relationship between the betas of the stocks and their excess returns also could not be rejected. Finally, the results indicate that no other factors but the beta can systematically explain the excess on investigated stocks. Based on these results, we may conclude that support for the validity of CAPM is weak. The CAPM is invalidated by the fact that the zero beta stocks do not yield the same return as risk-free assets. Further, we could not confirm a significant positive risk-return relationship for Slovenian stock market.

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