TESTING MULTI-FACTOR ASSET PRICING MODELS IN THE VISEGRAD COUNTRIES

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Abstract

There is no consensus in the literature as to which model should be used to estimate the stock returns and the cost of capital in the emerging markets. The Capital Asset Pricing Model (CAPM) that is most often used for this purpose in the developed markets has a poor empirical record and is likely not to hold in the less developed and less liquid emerging markets. Various factor models have been proposed to overcome the shortcomings of the CAPM. This paper examines both the CAPM and the macroeconomic factor models in terms of their ability to explain the average stock returns using the data from the Visegrad countries. We find, as expected, that the CAPM is not able to do this task. However, a four-factor model, including factors such as: excess market return, excess industrial production, excess inflation, and excess term structure, can in fact explain part of the variance in the Visegrad countries' stock returns.

Abstrakt

V literatuře není konsensus ohledně toho, který model by měl být používán k odhadování výnosů z cenných papírů a kapitálových nákladů na rozvíjejících se trzích. Kapitálový model oceňování aktiv (KMOA), který je nejčastěji pro tento účel používán v rozvinutých trzích má slabou empirickou podporu a je pravděpodobné, že neplatí pro méně rozvinuté a méně likvidní rozvíjející se trhy. Různé faktorové modely byly navrženy, aby překlenuly nedostatky KMOA. Tato práce prozkoumává jak KMOA, tak makroekonomické faktorové modely ve světle jejich schopnosti vysvětlit průměrné výnosy z cenných papírů využívajíc data z Vyšegradských zemí. Zjišťujeme, v souladu s očekáváním, že KMOA není schopen tento požadavek naplnit. Nicméně, čtyřfaktorový model zahrnující faktory jako je tržní prémium, růst průmyslové produkce, inflace a struktura úrokových sazeb může ve skutečnosti vysvětlit část variance výnosů cenných papírů v zemích Vyšegradu.

JEL Classification: G10, G 11, G12, G15, G31
Keywords: CAPM, macroeconomic factor models, asset pricing, cost of capital, Poland

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1. Introduction

Emerging markets have been quite extensively studied due to the large interest of investors who view them as an attractive alternative to investing in more developed markets. Emerging markets are typically characterized by relatively higher returns, but also higher volatility of stock returns as compared to the developed ones. However, there is no consensus in the literature as to which model should be used to explain the returns in these markets and estimate the cost of equity capital. The aim of this paper is to propose such a model for the stock markets in Visegrad countries: the Czech Republic, Hungary, Poland, and the Slovak Republic. More specifically, we will analyze how different models perform in explaining the variations in stock returns on the stock markets and which one of these models should be used to estimate the cost of equity capital in this market.

Cost of equity capital is crucial information that is needed in order to assess the investment opportunities and the performance of managed portfolios. The cost of equity capital is used as a discount factor when calculating the net present value (NPV) of the investment projects. In principle, by using the net present value, investors want to verify whether the payoff of the investment exceeds its cost[1]. The future payoffs expected from a particular investment need to be discounted, so that they can be compared to the costs of the investment that need to be incurred at the present time. In

[1] A good discussion of the NPV methodology can be found in Brealey and Myers (1988). In short, a simple NPV formula is as follows: $NPV = C_0 + \frac{C_1}{1+r} + \frac{C_2}{(1+r)^2} + \ldots$,
where C_0 is the cash flow today (i.e. the cost of investment, a negative number), the C_1 is the payoff from the investment one-period ahead, and r is the rate of return that investors demand for the delayed payment. This is the cost of capital.

developed markets, the capital asset pricing model (CAPM) is commonly used by financial managers to calculate the cost of the equity capital, as well as to assess the performance of managed portfolios, such as mutual funds (Fama and French 2004). Graham and Harvey (2001) report that 75.5 percent of the 392 respondents to their survey use the CAPM to estimate the cost of equity capital, which is then used to calculate the net present value (NPV) of the investment projects, where the cost of equity capital is used as the discount rate. The rationale behind using the cost of equity capital estimated by the CAPM is the following: since the future payoffs from the investment are risky, i.e. not certain, the rate of return used to calculate the NPV of this investment should come from a comparably risky alternative investment opportunity. A good candidate for such an alternative is investment in the stock market. Therefore, the expected rate of return on the investment in the local stock market, as predicted by the CAPM, can be used as a discount rate in calculating the NPV of the investment project to be undertaken in a given market. If the estimate of the firm's beta coming from the CAPM is biased upward it may lead to a rejection of profitable investments projects, i.e. when the internal rate of return is not greater than the upward biased hurdle rate.

The CAPM formulated first by Sharpe (1964), Lintner (1965), and Black (1972) describes the relationship between risk and expected return and is used to price risky securities. A very clear and intuitive link between an asset's risk in relation to the risk of the overall market and an asset's expected return is one of the main advantages of the CAPM and is key to understanding its widespread use. There are, however, also some caveats to using the CAPM. Specifically, there are many empirical studies showing that the CAPM in its classical version does not hold for the period of the second half of the twentieth century even in developed markets. While Black, Jensen and Scholes (1972) and Fama and Macbeth (1973) find that the CAPM holds for the 1926-1968 period, more recent studies of the period 1960's-2000's find otherwise. Among the first studies to report the disappearance of the simple relation between the asset's risk and the average return, as predicted by CAPM, were Reinganum (1981) and Lakonishok and Shapiro (1986). Fama and French (1993) propose a multi-factor model, which includes factors related to the firm's size and firm's book value. This model performs better than the classical CAPM and they argue that stock risks are multidimensional and therefore the addition of other factors improves the CAPM power to explain the average stock returns.

Fama-French factors (FF factors) are the most commonly used in the literature as they turned out to be the most successful empirically. In order to obtain these factors the stocks need to be grouped into portfolios on the basis of the firm's size, as well as firm's book-to-market value[2]. In addition, factors related to some macro variables have also proven to be able to explain the variation in stock returns. Chen, Roll and Ross (1986) test whether additional sources of risk such as innovations in macroeconomic variables are priced in the stock market. They find that indeed some of these variables do affect the stock market. The significantly priced macro variables include: the spread between long- and short-term interest rates, expected and unexpected inflation, industrial production, and the spread between high- and low-grade

[2] Specifically, they advocate the multi-factor model with the following three factors: market return, the return on small stocks minus the return on the big stocks (SMB), and the return on stocks with high book to market ratio minus the return on stocks with low book to market ratio (HML).

bonds. Moreover they argue that neither the market portfolio, nor aggregate consumption is priced separately. Given the widespread of factor models and they empirical success, we will also propose and test a factor model that could be used to explain the stock returns in the stock markets of Visegrad countries and allow to estimate the cost of equity in these markets, subject to data limitations.

The CAPM, as well as most factor models, include the overall market return as a factor. Market portfolio by definition should contain all the traded and non-traded assets and so in practice the composition of such true market portfolio is unknown. Therefore, the researchers use various proxies for the market portfolio that most often consist of traded stocks. Roll (1977) argued that violations of the CAPM that are found in empirical works might be due to the choice of the market portfolio. Low and Nayak (2005) show that the choice of market portfolio is irrelevant for the validity of the CAPM. They conduct comprehensive simulations to show that if the CAPM is found to hold using one proxy for the market portfolio, it holds for all the alternative proxies. More importantly, this is also true in an opposite case; if the CAPM does not hold for one of the specifications, it does not hold for any other, where different proxies for market portfolio are used. Similarly, Bartholdy and Peare (2003) show that the Fama-Macbeth procedure (FMB) results in an unbiased estimate of the expected returns even though a proxy is used for the market portfolio. Moreover, they argue that unbiased results are obtained independently from the proxy used as long as the FMB procedure is executed correctly.

As discussed above, the classical CAPM model does not always hold in practice when used to analyze the markets in developed countries. The markets in emerging markets, including the stock markets in Visegrad countries, are less efficient and less liquid compared to the developed markets and so it is likely that the CAPM model, especially in its classical formulation, may not be suitable for estimating the cost of capital for these economies. Harvey (1995) argues that the emerging markets are characterized by low betas and the CAPM model is not able to capture the relationship between the stock returns in these countries and the market portfolio. Based on this finding there are several studies that analyze various factors that influence the stock returns in the emerging markets and propose models suitable for estimating the cost of capital in these markets. Erb, Harvey, and Viskanta (1995, 1996) find that country credit ratings are significantly related to stock returns, and they propose a model based on these indices. Similarly, Harvey (2004) argues that the country risk rating from the International Country Risk Guide impacts the expected returns in emerging markets and so he incorporates these indices in his version of the CAPM model.

The issue of the relative integration of the emerging markets with the global markets and its implications on the stock returns in these markets has been central in the literature. Bekaert and Harvey (1995) argue that the integration of the emerging markets with the global markets has been a dynamic process and therefore also the cost of capital should be allowed to vary over time as the relative measure of the integration with global markets changes. In a more recent paper, Bekaert and Harvey (2000) develop a model, in which dividend yields are used as a measure of the equity cost of capital. They find that the cost of capital declines as the emerging markets become more integrated with global markets. In one of the few papers that study the markets in Central and Eastern Europe (CEE), Sokalska (2001) finds that stock prices of the Czech Republic, Hungary and Poland move together. She argues that local macroeconomic fundamentals are of relatively small importance in those markets and that the key factors influencing the movements of stock prices are exogenous. Namely, she claims that it is the flow of foreign portfolio capital that can be traced to affect the movement of stock prices in those markets. De Jong and de Roon (2001) link the issue of time varying market integration with expected returns in emerging markets. They develop a model, in which expected returns depend on the degree of market segmentation, measured as a ratio of assets in a given market that cannot be traded by foreign investors. Given that the degree of segmentation changes over time, they allow the expected returns to also vary with time. Using data from 30 emerging markets, including the Visegrad countries, de Jong and de Roon provide evidence that the market segmentation has a significant effect on the expected returns. They find in line with the theory that increasing market integration (or decreasing market segmentation) leads to lower expected returns and hence lower cost of capital.

There are some important data and methodological issues that need to be addressed in the Visegrad countries. First, the data available is of relatively short time span, which may influence the plausibility of our results. Second, there is a limited number of stocks traded on these stock exchanges[3], which makes some of the commonly used portfolio techniques not feasible. Taking these considerations into account, we used the FMB procedure to estimate

[3] The variability in the number of stocks traded in the sample is given in Table I and Table II.

our models. This procedure is extensively used by the researchers to estimate and test the single- and multi-factor models' predictions. It gives unbiased estimates even when there is correlation between observations on different firms in the same year. It also accounts for a variation coming from both time-series and cross-section regressions, which is especially important when there is a limited number of observations, as it is the case with the Visegrad countries' data.

First, we estimated the CAPM by the FMB procedure to see how this model performs in stock markets of Visegrad countries. We found that we could not reject the classical CAPM in Hungary and in Slovakia since the constant term was not statistically different from zero. However, also the slope coefficients on the excess market return were not significant, indicating that they local market alone was not able to explain the variation in stock returns in these markets. For the Czech Republic and Poland we could reject the CAPM since the constant terms were significantly different from zero, which indicated the presence of pricing errors in this model specification.

Given these results we proceeded with the estimation of the factor model. Due to data limitations, we were not able to construct the FF factors. Therefore, we developed a model, in which the macroeconomic factors are used. We extended the classical CAPM by adding the following three factors: industrial production, inflation, and the term structure. Similarly to the CAPM, this four-factor model was not sufficient to explain the variation in stock returns on these markets, although it had some explanatory power in Poland and in Hungary. Specifically, both in Poland and in Hungary the term structure was significantly priced, indicating that this factor is able to explain part of the variation in the average stock returns in these markets. In Poland inflation was similarly a priced factor. The presence of pricing errors was detected in the model for Czech Republic, Poland, and the Slovak Republic since the constant terms were significant. In addition, we estimated alternative factor models, which included other variables that we believe may be important in Visegrad countries. Some of the additional factors, which turned out to be significantly priced, included money, exchange rate, and German industrial production.

Given mixed results stemming from macroeconomic factor models we proceeded to estimate other multi-factor models, in which we used the principal components as factors. For all Visegrad countries we estimated a four-factor model with excess market return and three first principal factors. In case of Poland, all four factors were significant, though the constant term was still significant, indicating the presence of pricing errors. The third principal factor was also significant for Slovakia but none of the factors turned out to be significant in other countries. Keeping in mind that there may be some errors-in-variables present in the FMB estimation, we decided to proceed with an alternative estimation method as a robustness check. The method that appears to be the most suitable for this purpose is the General Method of Moments (GMM), in which both time series factor sensitivities (betas) and time-varying cross sectional loadings on the risk premia (gammas) are estimated simultaneously, instead of two-stage estimation procedure in FMB. We were able to obtain these alternative estimates only for Poland since we run into empirical problems with data from other Visegrad countries[4]. The results for Poland confirm that FMB estimation causes the estimates of coefficients to be somewhat biased. The estimates obtained using the GMM, an estimation method free of errors-in-variables problem, changed in the way that is in line with literature on the errors-in-variables: estimates of slope coefficients (gammas) increased and estimates of constant term decreased, resulting in many factors that were previously not priced significantly turning significant and resulting in constant terms loosing their significance.

This paper is organized as follows. In Section 2 we discuss CAPM and factor models in greater detail, as well as the testing procedures. In Section 3 we introduce the data and discuss some its limitations that make the use of some standard techniques impossible. Section 4 contains the empirical results from testing the CAPM and factor models in the Visegrad countries. In Section 5, we briefly summarize the findings of this paper and suggest some direction for further research.

2. Methodology

The main objective of this paper is to point to suitable asset-pricing model that could be used to estimate the cost of equity capital in the Visegrad countries. The first candidate is the Capital Asset Pricing Model (CAPM). According to this classical model specification, the expected return on the security or on the portfolio of securities should be equal to the risk-free rate plus a risk premium, which consists of the portfolio's beta multiplied by the

[4] The residual variance-covariance matrices for the Czech Republic, Hungary and Slovakia turned were not positive definite, hence it was not possible to invert these matrices to obtain the estimates.

expected excess return of the market portfolio (return on the market portfolio minus the risk free rate). A classical, one-factor CAPM looks as follows:

$$E(r_{it})\text{-}r_t^{\,f} = \beta_i\left(E(r_t^{\,m}) - r_t^{\,f}\right), \qquad (1)$$

where E(r_{it}) is the expected *i-th* stock return (*i=1….N*), $r_t^{\,f}$ is the risk-free rate, and $E(r_t^{\,m})$ is the expected market return. This model can be empirically tested using the following regression equation:

$$r_{it}\text{-}r_t^{\,f} = \alpha_i + \beta_i^m\left(r_t^{\,m} - r_t^{\,f}\right) + \varepsilon_{it} \qquad (2)$$

where r_{it} - $r_t^{\,f}$ is the excess market return on *i-th* stock, r_{mt} is the market return α_i is the constant term, β_i^m is the coefficient on the excess market return for each of the *i* stocks, and ε_{it} is the error term. According to the CAPM prediction, the constant term, α_i, should be statistically insignificant (i.e. equal to zero) for each of the *i* stocks. If this is the case, the pricing errors are zero and the CAPM is said to hold empirically. In addition, the slope coefficient, β_i^m, should be significantly different from zero, indicating that the excess market return is indeed priced by the stock market, i.e. it helps to explain the variation in the stock returns. Moreover this coefficient, which represents the measure of one stock's risk as compared to the risk of the overall market, should vary among the stocks.

We also considered an extension of the classical CAPM - a multi-factor model. Suppose there are *k-factors* that are believed to influence the stock returns in a given market. The *k-factor* model can be tested by using the following regression equation:

$$r_{it}\text{-}r_t^{\,f} = \alpha_i + \beta_i^m\left(r_t^{\,m} - r_t^{\,f}\right) + \beta_i^2\left(r_t^{\,2}\right) + ...+ \beta_i^K\left(r_t^{\,K}\right) + \varepsilon_{it} \qquad (3)$$

where $r_t^{\,m}$ is a local index return, $r_t^{\,k}$ is the *k-th* factor return (*k=2…K*), r_{it} is the *i-th* stock return, $r_t^{\,f}$ is the risk-free rate, α_i is the constant term, and ε_{it} is the error term. Similarly to the CAPM, this multi-factor model predicts that the constant terms, α_i, should be insignificant and the slope coefficients, β_i^m and β_i^k, should be significantly different from zero. As discussed, these factors may include Fama-French factors or other factors, including macroeconomic variables or the principal factors obtained by the principal component analysis.

In the literature one can find several ways of testing the capital asset pricing models. They can be divided into the following three categories: tests involving time-series regressions, tests involving cross-section regression, and the tests involving a combination of the above[5]. One of the most widely used methods is the FMB procedure, which combines the time series and the cross section regressions. Suppose we have *N* firms returns for any given month *t*, R_t. In the first stage we regress the excess stock return on the excess market return and other *k-factors* in order to obtain the CAPM cross-section betas, $\hat{\beta}_i^m$ and $\hat{\beta}_i^k$, where *i* is a firm's subscript (*i =1….N*), *m* stands for the market return, and *k* is a factor's subscript (*k=2….K*). In the second

[5] A detailed discussion of these various methods can be found in Cuthbertson and Nitzsche (2001).

stage we run the following cross-section Ordinary Least Squares (OLS) regression for any single month t[6]:

$$R_i = \gamma_0 + \gamma^m \hat{\beta}_i^m + \gamma^k \hat{\beta}_i^k + \eta_i \qquad (4)$$

where $R_i=(R_1, R_2,\ldots, R_N)$ is a $Nx1$ vector of cross-section excess monthly stock returns

$\hat{\beta}_i^m$ and $\hat{\beta}_i^k$ are NxK matrices of CAPM betas (obtained in the first stage regressions)

γ^m and γ^k are vectors of cross-section coefficients for each of the *k- factors*

γ_0 is a scalar and an estimate of intercept

η_i is a $Nx1$ vector of cross-section error terms

Then we repeat this regression as in (4) for each month $t=1,2,\ldots T$ and obtain T estimates of γ_0, γ^m and γ^k. Finally, the time-series estimates of these parameters are tested to see if: $E(\gamma_0) = 0$ (i.e. pricing errors are zero), $E(\gamma^m) > 0$ (i.e. positive risk premium on the excess market return), and $E(\gamma^k) > 0$ (i.e. positive risk premium on betas for each of the *k* factors). Assuming the returns are *iid* and normally distributed the following t-statistic is used:

[6] This exposition of the FMB procedure is based on Cuthbertson and Nitzsche (2001) p. 193.

$$t_\gamma = \frac{\bar{\hat{\gamma}}^k}{\sigma(\hat{\gamma}^k)} \quad \text{, where} \quad \sigma^2(\hat{\gamma}^k) = \frac{1}{T(T-1)} \sum_{t=1}^{T} (\hat{\gamma}^k - \bar{\hat{\gamma}}^k)^2 \qquad (5)$$

Similarly, one can obtain t-statistics t_γ for γ^m and γ_0 and test all of the CAPM restrictions.

There is one important caveat to the FMB approach. Since the estimates of betas, $\hat{\beta}_i^m$ and $\hat{\beta}_i^k$, obtained in the first stage regressions may be measured with error, we may encounter the 'errors-in-variables' problem in the second stage regressions. Specifically, if the estimates of $\hat{\beta}_i^m$ and $\hat{\beta}_i^k$ that we use in the second stage regressions contain measurement error, then the estimates γ^m and γ^k will be biased[7]. The most common approach to minimizing this problem is to group the stocks into portfolios[8] and estimate the portfolio betas instead of the stock betas in the first stage regression. Then, in the second stage, the average excess return $\bar{r}_i - \bar{r}^f$ for each of the stocks is regressed on the appropriate portfolio beta. This approach reduces the measurement error but it does not completely resolve this problem since it still uses betas estimated in the first step in the regressions in the second step. Using portfolios rather than individual stocks can, however, improve the estimates mainly due to utilizing the portfolios' betas rather than the individual stocks' betas, which may contain structural breaks. Due to limited number of companies listed on the Visegrad stock exchanges, there is not enough observations at any given point of time to form portfolios of individuals stocks.

[7] In the least squares regressions, the errors-in-variables are likely to cause the estimates of the slope coefficients to be biased downward and the estimate of a constant term to be biased upward.

[8] The portfolios can be formed based on the size, beta or book-to-market ratio of individual stocks obtained from running the time-series regressions.

Instead, we proceed with alternative estimation method that allows for a simultaneous estimation of betas and gammas, and therefore avoids the errors-in-variable problem altogether. Cochrane (2005) shows that it is possible to use the GMM estimation in this fashion. More specifically, in case of single factor he proposes to combine the moment conditions used to estimate betas and gammas in the following way:

$$gT(b) = \begin{bmatrix} E\left(R_t^{\,e} - \alpha - \beta f_t\right) \\ E\left[\left(R_t^{\,e} - \alpha - \beta f_t\right) f_t\right] \\ E\left(R^e - \beta\gamma\right) \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix} \qquad (6)$$

In this system there are *N(1+K+1)* moment conditions since for each asset *N* we have one moment condition for the constant, *K* moment conditions for *K* factors and one moment condition that allows to estimate the lambdas (asset-pricing model condition).

To summarize, in this paper we estimated several alternative models, including the classical CAPM, macroeconomic factor models and principal factor model using the two alternative estimation methods: the FMB and the GMM. One of the main advantages of FMB estimation procedure is that it uses all the information available for a given data point, accounting for variation coming from both sources: time-series and cross-section. Given relatively short time spans of data available for the stock markets in Visegrad countries, it is key to be able to utilize all the available data points to their maximum. This procedure is, however, prone to errors-in-variables problem due to a two-stage estimation. In order to account for this problem, we obtained alternative estimates for Poland using the GMM one-step procedure, which allowed us to assess the potential importance of the errors-in-variables in our models. Unfortunately, we were not able to obtain similar estimates for other Visegrad countries due to the variance-covariance matrices not being positive definite, hence not invertible.

3. Data

Data on individual stocks, as well as local market indices needed in order to test the validity of the classical CAPM in Visegrad countries were obtained from Wharton Research Data Services. Other data was obtained from IMF's International Financial Statistics Database, national banks' and minister of finance' websites. The summary of these variables is presented in Table I.

Table I

Summary Statistics for Variables Used in the CAPM Regressions

Sample mean, standard deviation, maximum and minimum values are reported for the variables used in the CAPM regression. These statistics are reported for the cross sectional distribution, where the number of firms varies from 8 to 74 depending on the country. All the variables represent monthly returns in local currency. Stock_rt stands for stock return, market_rt is the local market return, and tbill is a monthly return on short term government securities.

Variable/ Country	Mean	Std. Dev.	Min.	Max.
Czech Republic				
4660 obs; 1994:02 – 2003:02				
No of Companies: 9-74				
stock_rt	-.0068	.1654	-.6325	1.535
market_rt	-.0094	.0732	-.2059	.1699
Local t-bill	.0074	.0025	.0021	.0129
Hungary				
1867 obs; 1993:01-2003:02				
No of Companies: 12-18				
stock_rt	.0181	.1760	-.5707	2.260
market_rt	.0196	.1088	-.3582	.4583
Local t-bill	.0151	.0063	.0044	.0283
Poland				
2937 obs; 1994:02-2003:02				
No of Companies: 12-35				
stock_rt	.0050	.1569	-.9962	1.895
market_rt	.0057	.1055	-.3233	.3970
Local t-bill	.0142	.0047	.0049	.0252
Slovak Republic				
1200 obs; 1996:08-2003:02				
No of Companies: 8-20				
stock_rt	.0427	1.008	-.9810	26.78
market_rt	-.0097	.0759	-.1709	.3079
Local t-bill	.0119	.0044	.0050	.0217

As argued, the classical, one-factor CAPM does not always hold empirically and therefore various multi-factor models have been proposed in the literature. FF factors are the most commonly used in the literature as they turned out to be the most successful empirically. In order to obtain these factors the stocks need to be grouped into portfolios on the basis of the firm's size, as well as firm's book-to-market value. Due to a limited number of stocks traded in the stock markets of Visegrad countries, the portfolio grouping is not possible.

Therefore, in this paper a second best approach is used, namely the macroeconomic factor model. It has been noted that observable economic time series like inflation and interest rates can be used as measures of pervasive and common factors in stock returns. Chen, Roll and Ross (1986) argue that the stock prices can be expressed as expected discounted dividends:

$$p = \frac{E(c)}{k} \tag{6}$$

where *c* is the dividend stream and *k* is the discount factor. From this it can be deducted that the economic variables that influence discount factors as well as expected cash flows will also influence the expected returns. Chen, Roll and Ross (CRR) use the following factors: industrial production growth, a measure of unexpected inflation, changes in expected inflation, the difference in returns on low grade corporate bonds and long-term government bonds (risk premia), the difference in returns on long-term government bonds and the short-term Treasury bills (term structure), changes in real consumption, and oil prices. In our factor model, similarly to CRR, we included a monthly industrial growth and the term structure. In contrast to CRR, we did not include two inflation variables in order to avoid likely correlations between them. Instead, we used only the monthly inflation. Since there is no time-series data on corporate bond grading in Visegrad countries, we did not incorporate any measure of risk premia in our model. CRR find that changes in consumption and oil prices are not significantly related to the stock returns.

Therefore, we did not include these two factors in our specification. To summarize, in our baseline factor model we used the following four factors: market return, monthly growth rate of industrial production, inflation, and term structure. Changes in the level of industrial production affect the real value of cash flows. In addition, a direct link between the returns and production is specified in the business cycle models. Inflation influences the nominal value of cash flows, as well as the nominal interest rate. Finally, the discount rate is affected by the changes in the term structure spreads between different maturities. In addition, we estimated alternative factor models, which included variables that we believe may be important in Visegrad countries. The additional variables included: exchange rate, German industrial production, money, and exports. Given that all these countries are relatively small, open economies, the fluctuations in exchange rate, exports and money base are likely to have strong impact on other macroeconomic variables. The economic situation in Germany (proxied by its industrial production), one of the most important trading partners for the Visegrad countries, may have a significant impact on the economies of these countries and therefore may also influence their stock markets. The time series of all these additional variables were obtained from the IMF International Financial Statistics Database. The summary of these variables is presented in Table II.

In order to overcome the limitations of factor models with respect to the small number of variables that can be used in the estimation, we employed the principal component analysis to extract the main factors driving the economies of the Visegrad countries. This method is mainly used for forecasting purposes. It is based on the principle that there are a few forces driving the dynamics of all macroeconomic series. Since these forces are unobservable they need to be estimated from a large number of economic time series. Given the still transitionary character of the Visegrad stock markets, as well as the limited span of data available, principal component analysis may be very useful for explaining the stock returns in these countries. The list of variables used to obtain the principal factors is included in the Appendix. The first three principal factors, which explained most of the variance of the average stock returns, were then used as the factors in the alternative multi-factor model (principal factor model). In addition, the same number of factors as the baseline multi-factor model, allowed a direct comparison of the performance of these two models. The summary statistics of the three first principal factors used in the principal factor model are presented in Table III.

Table II

Summary Statistics for the Additional Variables Used in the Factor Model Regressions

Sample mean, standard deviation, maximum and minimum values are reported for the additional variables used in the multi-factor model regression (market return, stock return and local t-bill statistics are reported in Table I). These statistics are reported for the cross sectional distribution, where the number of firms varies from 8 to 74 depending on the country. All the variables represent monthly returns or growth rates in local currency. The time series for term structure was obtained by subtracting a monthly return on treasury bills from a monthly return on long-term government bonds. In the subsequent statistical analysis CPI inflation and term structure used in first differences since their original time series contain unit roots. Indprod stands for monthly industrial production growth rate, infl represents monthly growth in inflation, ts is a term structure, exrate is a monthly appreciation/depreciation of the national currency as compared to euro, ger_indprod stands for a monthly industrial production growth in Germany, money represents monthly growth in M1, and exports is a monthly growth in exports.

Variable/ Country	Mean	Std. Dev.	Min.	Max.
Czech Republic				
4660 obs; 1994:02 – 2003:02				
No of Companies: 9-74				
indprod	.0086	.0942	-.2391	.2141
infl	-.0002	.0091	-.0337	.0357
ts	.0004	.0011	-.0032	.0036
exrate	.0080	.0852	-.0739	.9369
ger_indprod	.0059	.0755	-.1088	.1917
money	.0065	.0336	-.1049	.2437
exports	.0220	.1142	-.3016	.2922
Hungary				
1151 obs; 1997:02 – 2003:02				
No of Companies: 12-18				
indprod	.01068	.0902	-.1725	.2619
infl	-.0004	.0075	-.0193	.0234
ts	-.0019	.0010	-.0042	.0010
exrate	.0148	.1029	-.0561	.8893
ger_indprod	.0048	.0703	-.1088	.1685
money	.0138	.0338	-.1014	.0938
exports	.0270	.1397	-.2604	.4532
Poland				
2937 obs; 1994:02 – 2003:02				
No of Companies: 12-35				
indprod	.0067	.0650	-.1989	.2091
infl	-.0002	.0083	-.0200	.0280
ts	-.0017	.0011	-.0040	.0012
exrate	.0149	.1036	-.1031	.9296
ger_indprod	.0040	.0717	-.1088	.1917
money	.0154	.0378	-.1086	.1554
exports	.0193	.0881	-.1609	.2329
Slovak Republic				
1200 obs; 1996:08 – 2003:02				
No of Companies: 8-20				
indprod	.0064	.0623	-.1010	.1541
infl	.0001	.0132	-.0516	.0520
ts	.0005	.0030	-.0047	.0093
exrate	.0161	.1187	-.0567	.9322
ger_indprod	.0011	.1144	-.1952	.2712
money	.0042	.0391	-.1158	.1145
exports	.0182	.1020	-.2309	.2492

Table III

Summary Statistics for the Factors Obtained from the Principal Component Analysis

Sample mean, standard deviation, maximum and minimum values are reported for the first three leading factors obtained from the principal component analysis. These statistics are reported for the cross sectional distribution, where the number of firms varies from 8 to 74 depending on the country.

Principal components	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Czech Republic 4660 obs; Aug 1996 – Feb 2003 No of Companies: 9-74				
Pc 1	.2753125	1.572405	-3.939665	4.25058
Pc 2	.0906176	1.408384	-2.782753	2.872529
Pc 3	-.2358732	1.288445	-4.73856	6.000414
Hungary 1151 obs; Feb 1997 – Feb 2003 No of Companies: 12-18				
Pc 1	.6208512	1.669118	-3.753944	4.502163
Pc 2	.5866697	1.451879	- 2.114966	4.119454
Pc 3	.4055286	1.40061	-2.040843	4.104701
Poland 2937 obs; 1994:02 – 2003:02 No of Companies: 12-35				
Pc 1	1.178026	1.753528	-2.95811	10.70719
Pc 2	.1220507	2.364502	12.76142	3.589532
Pc 3	-.109039	2.117285	-8.281503	9.921389
Slovak Republic 983 obs; May 1999 – Dec 2002 No of Companies: 8-20				
Pc 1	.0111274	3.714044	-13.02892	13.76797
Pc 2	.0928082	3.166589	-7.305079	8.128183
Pc 3	.0319989	2.321968	-7.864149	5.494952

4. Estimation

The CAPM (single-factor model) was estimated using the regression equation (2) by the FMB procedure, where local market indices were used as proxies for market portfolio[9], and monthly returns on local t-bills represented risk-free rate. The results obtained for the four Visegrad markets are presented in Table IV.

Table IV

Average Slopes and t-Statistics (reported in parenthesis) from Month-by-Month Regressions of Excess Stock Returns on Betas of Excess Market Returns

We estimated the CAPM by the FMB procedure using the following regression equation: $r_{it}\text{-}r_t^{\,f} = \alpha_i + \beta_i^m\left(r_t^{\,m} - r_t^{\,f}\right) + \varepsilon_{it}$, where r_{it} is the i-th stock return (i =1….N), $r_t^{\,f}$ is the risk-free rate, $r_t^{\,m}$ is the market return α_i is the constant term and ε_{it} is the error term. In the first stage, we regressed the excess stock return $r_{it} - r_t^{\,f}$ on the excess market return $r_t^{\,m} - r_t^{\,f}$ in order to obtain the CAPM betas, $\hat{\beta}_i$, where *i* is a firm's subscript. These beta estimates were then used in the second stage as the independent variable in the following regression equation: $r_i - r^f = \gamma_0 + \gamma^m \hat{\beta}_i^m + \eta_i$. This regression was repeated for each month and we obtained *T* estimates of γ_0 and γ^m. Specifically, first beta estimates were obtained for the first 24 months of data and then used to calculate the gammas (γ_0 and γ^m) for the twenty-fourth month. Then, the betas were obtained for the period from second to twenty-fifth month, and used in the second stage to obtain the estimate of gammas for the twenty-fifth month. This procedure of rolling regressions with a fixed window of twenty-four months was used to cover the whole sample of data. Finally, we tested the averages of these *T* estimates to see if: $E(\gamma_0) = 0$ (i.e. pricing errors are zero) and $E(\gamma^m) > 0$ (i.e. positive risk premium on excess market return Monthly return on a local index was used as a proxy for market portfolio's

[9] Initially we considered using the following three alternative variables as a proxy for the market portfolio: local market index, S&P 500 index and the MSCI world index. We tested these various specifications for the Polish market and found that the choice of market proxy did not influence the test of the validity of the CAPM. Our findings are consistent with Low and Nayak (2005), who show that the choice of market portfolio is irrelevant for the validity of CAPM. Therefore, we proceeded with the local market index as a proxy for the market portfolio.

return and monthly return on a local t-bill was used as a risk-free rate. *, **, *** indicate significant difference at the 10, 5, and 1 percent levels, respectively.

Country	Sample	Local index (γ^m)	Constant (γ_0)
Czech Republic	Feb 1994 - Feb 2003	0.0026 (0.3117)	-0.0141 (-2.8732***)
Hungary	Jan 1993 - Feb 2003	0.0113 (0.7577)	-0.0109 (-0.8286)
Poland	Jan 1993 - Feb 2003	0.0106 (0.9052)	-0.0173 (-2.1076**)
Slovak Republic	Aug 1996 - Feb 2003	0.0114 (0.3225)	0.0207 (0.8865)

These results indicate that the CAPM should not be rejected for Hungary and the Slovak Republic, as none of the constant terms was statistically different from zero. However, also the coefficients gammas (γ^m) were not statistically different from zero, which implies that the market return was not priced. Results for the Czech Republic and Poland indicated that the CAPM should be rejected, as the constant terms were significantly different from zero, which indicates the presence of pricing errors in this model specification. This result is not surprising and is in line with the literature covering the behavior of stock exchanges in the second half of the twentieth century. Therefore, we extended the single-factor model by adding additional macroeconomic factors. In the baseline factor model, we added the following three variables: industrial production, inflation, and the term structure. This extended four-factor model was also tested following the FMB procedure. The results from these regressions are presented in Table V.

Table V

Average Slopes and t-Statistics (reported in parenthesis) from Month-by-Month Regressions of Excess Stock Returns on Betas on Excess Market Returns, Inflation, Industrial Production, and Term Structure

We estimated the four-factor model by the FMB procedure using the following regression equation: $r_{it}\text{-}r_t^{\,f} = \alpha_i + \beta_i^m\left(r_t^m - r_t^{\,f}\right) + \beta_i^2\left(r_t^{\,2}\right) + \ldots.. + \beta_i^4\left(r_t^{\,4}\right) + \varepsilon_{it}$, where r_t^m is a local index return, r_t^k is the *k-th* factor return (*k=2…4*), r_{it} is the i-th stock return, $r_t^{\,f}$ is the risk-free rate, α_i is the constant term, and ε_{it} is the error term. Monthly return on a local index was used as a proxy for market portfolio's return and monthly return on a local t-bill was used as a risk-free rate. We considered the following four factors: excess market return, inflation, industrial production, and term structure. All series represent monthly growth rates or monthly returns. Inflation and term structure are used in first differences since the unit root tests detected nonstationarity in these series. Similarly to the CAPM, this multi-factor model predicts that the constant terms, should be insignificant and the slope coefficients should be significantly different from zero. In the first stage, we regressed the excess stock return $r_{it} - r_t^{\,f}$ on the four factors in order to obtain the betas, $\hat{\beta}_i^m$ and $\hat{\beta}_i^{\,f}$, where *i* is a firm's subscript, *m* indicates the excess market return, and *f* is the factor's subscript *(f=2…4).* These beta estimates were then used in the second stage as the independent variables in the following regression equation: $r_i - r^f = \gamma_0 + \gamma^m\hat{\beta}_i^m + \gamma^f\hat{\beta}_i^{\,f} + \eta_i$. This regression was repeated for each month and we obtained *T* estimates of γ_0, γ^m and γ^f (for each of the factors *f*). Specifically, first beta estimates were obtained for the first 24 months of data and then used to calculate the gammas (γ_0, γ^m and γ^f) for the twenty-fourth month. Then, the betas were obtained for the period from second to twenty-fifth month, and used in the second stage to obtain the estimate of gammas for the twenty-fifth month. This procedure of rolling regressions with a fixed window of twenty-four months was used to cover the whole sample of data. Finally, we tested the averages of these *T* estimates to see if: $E\left(\gamma_0\right) = 0$ (i.e. pricing errors are zero), $E\left(\gamma^m\right) > 0$ and $E\left(\gamma^f\right) > 0$ (i.e. positive risk premium on excess market return and other factors *f*). *, **, *** indicate significant difference at the 10, 5, and 1 percent levels, respectively.

Country	Sample	Excess Market Return (γ^m)	Inflation (γ^2)	Ind. Prod. (γ^3)	Term Structure (γ^4)	Constant (γ_0)
Czech Republic	Feb 1994 - Feb 2003	-0.0008 (-0.0812)	-0.0003 (-0.1654)	-0.0158 (-1.1195)	-0.0001 (-0.4219)	-0.0081 (-1.4085*)
Hungary	Feb 1997 - Feb 2003	-0.0042 (-0.1452)	-0.0018 (-0.8171)	0.0119 (0.2822)	0.0002 (1.7116**)	-0.0018 (-0.0691)
Poland	Feb 1994 - Feb 2003	0.0137 (1.0603)	0.0032 (2.5756***)	-0.0091 (-0.8997)	0.0001 (1.3201*)	-0.0142 (-1.7594**)
Slovak Republic	Aug 1996 - Feb 2003	0.0052 (0.3068)	-0.0072 (-1.0086)	0.0078 (0.2198)	-0.0008 (-1.0297)	0.0235 (1.3006*)

Some of the factors turned out to be indeed significantly priced in Poland and in Hungary. In Poland, two factors: inflation and the term structure were able to explain part of the variation in the average stock returns. In Hungary, only the term structure seemed to have some explanatory power. While none of the factors turned out to be significant in the Czech Republic and in Slovakia, some of the t-statistics were quite high, bordering the significance at the 10 percent level (for industrial production in the Czech Republic and for inflation and the term structure in Slovakia). These lower values may be due to a downward bias, caused by the presence of errors-in-variables resulting from the two-step estimation in FMB. Hungary was the only country, for which the constant was not statistically significant, indicating that no pricing errors were present in this specification.

Given these mixed results we proceeded with alternative multi-factor models, in which we included additional variables such as exchange rate, German industrial production, money, and exports. The results of these alternative estimations are presented in Table VI. None of the factors was significant in the model for the Czech Republic, indicating that these commonly used macroeconomic factors were not able to explain the variation in average stock returns in this country. Given these results we decided to proceed with the basic factor model for the Czech Republic. For Hungary, the term structure was statistically significant in al model specifications, indicating that this factor had some explanatory power in this market. By adding additional factors we are also able to reduce the significance of constant terms, thus reducing the pricing errors in these models. Having confirmed the importance of term structure for the Hungarian market even when other factors are included, we decided to continue with the basic factor model. In case of Poland, as before, the term structure and inflation were significantly priced. When money was included in a model, the slope coefficient on inflation turned insignificant, as money gained explanatory power. By adding additional factors, we were able to reduce the significance of constant terms. Given the trade-off between inflation and money, we decided to proceed with the basic factor model and include inflation rather than money in case of the Polish market. In the Slovak market, exchange rate and the German industrial production were both significant when included together with the four factors encompassing the basic factor model.

Table VI

Average Slopes (t-Statistics) from Month-by-Month Regressions of Excess Stock Returns on Betas on Excess Market Returns, Inflation, Industrial Production, Term Structure, Ex. Rate, German Industrial Production, Money and Exports

We estimated the multi-factor model by the FMB procedure using the following regression equation: $r_{it}\text{-}r_t^{\,f} = \alpha_i + \beta_i^m\left(r_t^{\,m} - r_t^{\,f}\right) + \beta_i^2\left(r_t^{\,2}\right) + \ldots\ldots + \beta_i^8\left(r_t^{\,8}\right) + \varepsilon_{it}$, where $r_t^{\,m}$ is a local index return, $r_t^{\,k}$ is the *k-th* factor return (*k=2…8*), r_{it} is the i-th stock return, $r_t^{\,f}$ is the risk-free rate, α_i is the constant term, and ε_{it} is the error term. Monthly return on a local index was used as a proxy for market portfolio's return and monthly return on a local t-bill was used as a risk-free rate. Compared to the baseline four-factor model (results in Table V), we added up to four additional variables, including: exchange rate, German industrial production, money, and exports. All series represent monthly growth rates or monthly returns. Inflation and term structure are used in first differences (unless otherwise indicated) since the unit root tests detected nonstationarity in these series. Similarly to the CAPM, this multi-factor model predicts that the constant terms, should be insignificant and the slope coefficients should be significantly different from zero. In the first stage, we regressed the excess stock return $r_{it} - r_t^{\,f}$ on the four factors in order to obtain the betas, $\hat{\beta}_i^m$ and $\hat{\beta}_i^f$, where *i* is a firm's subscript, *m* indicates the excess market return, and *f* is the factor's subscript *(f=2…8).* These beta estimates were then used in the second stage as the independent variables in the following regression equation: $r_i - r^f = \gamma_0 + \gamma^m\hat{\beta}_i^m + \gamma^f\hat{\beta}_i^f + \eta_i$. This regression was repeated for each month and we obtained *T* estimates of gammas (γ_0, γ^m and γ^f) for each of the factors *f*. Specifically, first beta estimates were obtained for the first 24 months of data and then used to calculate the gammas for the twenty-fourth month. Then, the betas were obtained for the period from second to twenty-fifth month, and used in the second stage to obtain the estimate of gammas for the twenty-fifth month. This procedure of rolling regressions with a fixed window of twenty-four months was used to cover the whole sample of data. Finally, we tested the averages of these *T* estimates to see if: $E\left(\gamma_0\right) = 0$ (i.e. pricing errors are zero), $E\left(\gamma^m\right) > 0$ and $E\left(\gamma^f\right) > 0$ (i.e. positive risk premium on excess market return and other factors *f*). *, **, *** indicate significant difference at the 10, 5, and 1 percent levels, respectively.

Excess Market Return (γ^m)	Inflation (γ^2)	Ind. Prod. (γ^3)	Term Structure (γ^4)	Exchange Rate (γ^5)	German Ind. Prod. (γ^6)	Money (γ^7)	Exports (γ^8)	Constant (γ_0)
Czech Republic Feb 1994-Feb 2003 (ts in first differences but not inflation)								
0.0049 (0.4699)	0.0003 (0.2554)	-0.0078 (-0.5594)	0.0000 (-0.3774)	0.0106 (0.6798)	0.0036 (0.2776)			-0.0145 (-2.4496***)
0.0053 (0.4499)	-0.0010 (-0.6550)	-0.0112 (-0.7608)	0.0000 (-0.3061)	0.0159 (0.9880)	0.0071 (0.5405)	-0.0009 (-0.1411)	-0.0019 (-0.1001)	-0.0129 (-1.5766*)
Hungary Feb 1997-Feb 2003 (money in first differences indicated by M)								
0.0187 (1.0672)	-0.0023 (-1.0325)	-0.0015 (-0.0531)	0.0003 (2.0763**)	-0.0057 (-0.1536)	-0.0101 (-0.5692)			-0.0263 (-2.6206**)
0.0099 (0.4325)	-0.0018 (-0.8114)	0.0239 (0.7536)	0.0004 (2.9398***)	0.0242 (0.6870)	0.0021 (0.0968)	0.0161 (0.9473) M	0.0115 (0.2681)	-0.0198 (-1.1510*)
0.0074 (0.3671)	-0.0017 (-0.8248)	-0.0063 (-0.2324)	0.0002 (1.2143)			-0.0026 (-0.1691) M		-0.0171 (-1.1635*)

Poland Feb 1994 - Feb 2003								
0.0145 (1.0917)	0.0016 (1.5969*)	-0.0112 (-1.2187)	0.0001 (0.5423)	-0.0009 (-0.0718)	0.0040 (0.4059)			-0.0147 (-1.8957**)
0.0079 (0.6858)	0.0010 (0.7348)	-0.0101 (-1.1014)	0.0001 (1.3070*)	0.0049 (0.3865)	0.0077 (0.7488)	-0.0142 (-1.6670**)	0.0006 (0.0500)	-0.0098 (-1.5903*)
0.0084 (0.6754)	0.0034 (0.9496)	-0.0092 (-0.8465)	0.0002 (1.9772**)			-0.0189 (-1.9010**)		-0.0102 (-1.3336*)
0.0097 (0.8033)		-0.0058 (-0.5443)	0.0002 (1.3238*)			-0.0170 (-1.6481**)		-0.0115 (-1.5659*)
0.0122 (1.0129)			0.0001 (1.0238)			-0.0171 (-1.7302**)		-0.0133 (-1.6993**)
Slovakia Aug 1996-Feb 2003								
-0.0092 (-0.4443)	-0.0051 (-0.5006)	-0.0161 (-0.5697)	0.0000 (0.0646)	-0.0870 (-2.0689**)	-0.0529 (-1.7538*)			0.0183 (0.9716*)
0.0220 (0.6210)	-0.0109 (-1.3398*)	0.0274 (0.5873)	-0.0007 (-0.5537)	-0.0520 (-0.9212)	0.0187 (0.2743)	0.0300 (2.3262***)	0.0669 (0.6648)	-0.0237 (-0.7017)

In the next stage, we employed the principal component analysis to obtain the leading factors, which we then incorporated into a factor model together with an excess market return. This four-factor model (including three principal factors/components and an excess market return) was estimated using FMB. The results of this estimation are presented in Table VII.

Table VII

Average Slopes and t-Statistics (reported in parenthesis) from Month-by-Month Regressions of Excess Stock Returns on Betas on Excess Market Returns and First Three Principal Factors

We estimated the principal model by the FMB procedure using the following regression equation: $r_{it}\text{-}r_t^{\,f} = \alpha_i + \beta_i^m\left(r_t^{\,m} - r_t^{\,f}\right) + \beta_i^2\left(r_t^{\,2}\right) + ...+ \beta_i^4\left(r_t^{\,4}\right) + \varepsilon_{it}$, where $r_t^{\,m}$ is a local index return, $r_t^{\,k}$ is the *k-th* principal factor return (*k=2…4*), r_{it} is the i-th stock return, $r_t^{\,f}$ is the risk-free rate, α_i is the constant term, and ε_{it} is the error term. Monthly return on a local index was used as a proxy for market portfolio's return and monthly return on a local t-bill was used as a risk-free rate. We obtained the principal factors using the principal component analysis. Then, we used the first three as the principal factors in the asset-pricing model. Similarly to the CAPM, this multi-factor model predicts that the constant terms, should be insignificant and the slope coefficients should be significantly different from zero. In the first stage, we regressed the excess stock return $r_{it} - r_t^{\,f}$ on the excess market return and on the three first principal factors in order to obtain the betas ($\hat{\beta}_i^m$ and $\hat{\beta}_i^f$), where *i* is a firm's subscript, *m* indicates the excess market return, and *f* is the principal factor's subscript *(f=2…4).* These beta estimates were then used in the second stage as the independent variables in the following regression equation: $r_i - r^f = \gamma_0 + \gamma^m\hat{\beta}_i^m + \gamma^f\hat{\beta}_i^f + \eta_i$. This regression was repeated for each month and we obtained *T* estimates of γ_0, γ^m and γ^f (for each of the factors *f*). Specifically, first beta estimates were obtained for the first 24 months of data and then used to calculate the gammas (γ_0, γ^m and γ^f) for the twenty-fourth month. Then, the betas were obtained for the period from second to twenty-fifth month, and used in the second stage to obtain the estimate of gammas for the twenty-fifth month. This procedure of rolling regressions with a fixed window of twenty-four months was used to cover the whole sample of data. Finally, we tested the averages of these *T* estimates to see if: $E\left(\gamma_0\right) = 0$ (i.e. pricing errors are zero), $E\left(\gamma^m\right) > 0$ and $E\left(\gamma^f\right) > 0$ (i.e. positive risk premium on excess market return and other factors *f*). *, **, *** indicate significant difference at the 10, 5, and 1 percent levels, respectively.

Country	Sample	Excess Market Return (γ^m)	Pc1 (γ^2)	Pc2 (γ^3)	Pc3 (γ^4)	Constant (γ_0)
Czech Republic	Jul 1997 – Feb 2003	0.0021 (0.2175)	-0.1335 (-0.7441)	0.0083 (-0.0433)	0.0526 (0.2177)	-0.0131 (-2.4174***)
Hungary	Jan 1999 – Feb 2003	0.0023 (0.1451)	0.3067 (0.8919)	0.0566 (0.1777)	0.3640 (1.0919)	-0.0107 (-1.1197)
Poland	Feb 1994 - Feb 2003	0.0178 (1.3421*)	0.4562 (1.7947**)	-0.6822 (-1.8727**)	0.5878 (1.7155**)	-0.0166 (-1.7764**)
Slovak Republic	May 1999 – Dec 2002	0.0317 (1.1219)	-0.2340 (-0.2009)	0.1778 (0.1520)	-3.4302 (-1.3085*)	0.0016 (0.1015)

According to the results presented in Table VII, the principal factors were all significant in case of Poland and one factor was significant in case of the Slovak Republic. Unlike in previous CAPM and factor models, the local index was significant in Poland, indicating that it was able to explain some of the volatility of the stock returns in the Polish market when principal factors were included. In case of the Slovak Republic, only the third factor was significant, which captured most of the variation included previously in exchange rate. None of the principal factors, nor the local market were significant for the Czech Republic and Hungary.

As argued, the results obtained by using FMB procedure are likely to be biased due to errors-in-variables problem. In order to verify this hypothesis we proceeded with alternative GMM estimation, in which all the slope coefficients (betas and gammas) are estimated simultaneously. We obtained satisfactory confirmation of this hypothesis for Poland. For other countries, however, we were not able to obtain the GMM estimates due to data issues. Specifically, it was not possible to obtain the inverses of the variance-covariance matrices of residuals defined in (6) in these systems (these matrices were not positive definite). The estimates obtained for the four-factor model for Poland from the one-step GMM estimation are presented in Table VIII.

The results presented in Table VIII clearly confirm the hypothesis that the FMB estimates of the slope coefficients were biased downward. The estimates obtained by one-step GMM for the four factors are in all cases greater than the FMB estimates. More importantly, they all turned significant, as compared with only two factors: inflation and term structure being significant in the FMB case.

Table VIII

Average Slopes and t-Statistics (reported in parenthesis) from One-Step GMM Estimation of Excess Stock Returns on Excess Market Returns, Inflation, Industrial Production, and Term Structure

We estimated the GMM system, in which moment restrictions allowed for a joint estimation of betas and gammas, as specified in the FMB. Based on Cochrane (2005) we wrote the moment conditions in the following way:

$$gT(b) = \begin{bmatrix} E\left(R_{ti}^{\ e} - a_i - \beta_i^{\ m} f_t^{\ m} - \beta_i^{\ 2} f_t^{\ 2} - \ldots - \beta_i^{\ k} f_t^{\ k}\right) \\ E\begin{bmatrix} \left(R_{ti}^{\ e} - a_i - \beta_i^{\ m} f_t^{\ m} - \beta_i^{\ 2} f_t^{\ 2} - \ldots - \beta_i^{\ k} f_t^{\ k}\right) f_t^{\ m} \\ \left(R_{ti}^{\ e} - a_i - \beta_i^{\ m} f_t^{\ m} - \beta_i^{\ 2} f_t^{\ 2} - \ldots - \beta_i^{\ k} f_t^{\ k}\right) f_t^{\ 2} \\ \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \\ \left(R_{ti}^{\ e} - a_i - \beta_i^{\ m} f_t^{\ m} - \beta_i^{\ 2} f_t^{\ 2} - \ldots - \beta_i^{\ k} f_t^{\ k}\right) f_t^{\ k} \end{bmatrix} \\ E\left(R_{ti}^{\ e} - \beta_i^{\ m} \gamma^m - \beta_i^{\ 2} \gamma^2 - \ldots - \beta_i^{\ k} \gamma^k\right) \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$$

where R_{ti}^{e} is the i-th stock excess return (i-th stock return minus risk-free rate), f_t^{m} is a local index excess return (local index return minus risk-free rate), f_t^{k} is the *k-th* factor return (*k=2…4).*
In this system there are *N(1+K+1)* moment conditions since for each asset *N* we have one moment condition for the constant, *K* moment conditions for *K* factors and one moment condition that allows to estimate the lambdas (asset-pricing model condition). We estimated this system by GMM, in which the optimal weighting matrix was obtained in an iterative process by sequential updating of the coefficients. To test the overall model we calculated the J-statistic in the following way: $T * J = T * \left[g_T(\hat{b}) \hat{S}^{-1} g_T(\hat{b}) \right]$, where $g_T(\hat{b})$ are the moment conditions evaluated at estimated values of coefficients β and γ, whereas $\hat{S}^{-1}$ is the inverse of optimal weighting matrix (variance-covariance matrix). This statistic follows approximately χ^2 distribution with degrees of freedom equal to number of moment conditions minus the number of parameters. In our case J-statistic was equal to *17.4*, whereas χ^2 critical value at 95 percent level of significance with 39 degrees of freedom was *18.5*. Since J-statistic was less than the appropriate critical value we could not reject the model. *, **, *** indicate significant difference at the 10, 5, and 1 percent levels, respectively.

Excess Market Return (γ^m)	Inflation (γ^2)	Ind. Prod. (γ^3)	Term Structure (γ^4)
-0.0935 (-2.3566**)	-0.0073 (-1.9595*)	-0.0400 (-1.8555*)	-0.0016 (-2.3029**)

5. Summary

Emerging markets returns have been quite extensively studied in the last decade. However, there is still no consensus in the literature as to which model should be used to explain the returns in these markets and to estimate the cost of capital. Cost of capital is important information that is needed to evaluate the investment opportunities, as well as to assess the performance of managed portfolios. In the developed markets, the CAPM is most often used to estimate the cost of capital, even though its empirical record is quite poor. Factor models have been developed to overcome some of the CAPM's shortcomings, namely the inability of the excess market return alone to explain the variance of the average stock returns. Factor models extend the CAPM by adding additional factors to the excess market return in order to improve the predictive power of the model.

In this paper we tested various asset-pricing models and evaluated their relative performance in explaining the average stock returns in the Visegrad countries. These models, as argued, can be used to estimate the cost of capital, which is then used to evaluate investment opportunities. There is no consensus in the literature as to which model should be used for this purpose in the emerging markets. We began by formally estimating the CAPM by the FMB procedure using the data from the Visegrad markets to see how it performs. While we were not able to reject the null hypothesis that the CAPM holds (i.e. constant terms are not significantly different from zero) for Hungary and Slovakia, we were also not able to reject the null hypothesis that the coefficients on the factor loading (betas of the excess market return) were statistically insignificant. In contrast, we could reject the CAPM for the Czech and Polish markets. Having confirmed the low power of the CAPM in explaining the variance of the average stock returns we then proceeded to estimate a factor model. Due to a limited number of stocks traded in the Visegrad markets we were not able to construct the FF factors. Another alternative is to use so-called 'macroeconomic factor models', in which the observable economic time series like inflation or interest rates are used as measures of pervasive or common factors in asset returns. We employed a macroeconomic factor model based on the factors used by CRR (1986). In our model we included the following four factors: excess market return, industrial production, inflation, and excess term structure. We estimated this four-factor model using the FMB procedure. This model had some explanatory power in Poland and in Hungary since some of the slope coefficients were significant, indicating that the factors were priced. Moreover, in Hungary, the coefficient on the constant term was not significant; hence there were no pricing errors present in this specification. The coefficients on the constant terms were, however, significant in the Czech Republic, Poland and in the Slovak Republic, indicating that some pricing errors were present. Using alternative macroeconomic variables, as factors largely did not improve the results[10]. Given these mixed results, we decided to proceed with the principal component analysis in order to extract the key factors that explain the variability of stock returns in these countries. The principal factor model had some explanatory power in case of Poland and the Slovak Republic. Unlike in previous CAPM and factor models, the local index was significant in Poland, indicating that it was able to explain some of the volatility of the stock returns in the Polish market when principal factors were included. In case of the Slovak Republic, the slope coefficient on the third factor was significant, indicating that this factor was priced. The principal factors did not add an explanatory power in the Czech Republic and Hungary. Based on these results we concluded that macroeconomic factor model, rather than the capital asset pricing or the principal factor models, is suitable for estimating the cost of capital in Visegrad countries. Our conclusion is supported by the results obtained for Poland when using the one-step GMM estimation method. These alternative estimates, free of errors-in-variables problem, resulted in all the factors turning significant, confirming that the FMB estimates were biased downward. Even though due to empirical problems we were not able to obtain similar alternative estimates for other Visegrad countries we can expect that the estimates obtained by the FMB most likely undermine the significance of macroeconomic factors in explaining the average stock returns.

[10] With the exception of Slovakia, for which the exchange rate and the German industrial production were significantly priced in contrast with the factors included in the baseline four-factor model, which were all insignificant.

6. References

Bartholdy, J. and P. Peare, 2003, Unbiased Estimation of Expected Return Using CAPM, International Review of Financial Analysis, No12, 69–81.

Bekaert, G., and C. Harvey, 1995, Time-Varying World Market Integration, Journal of Finance, 50, 403-444.

Bekaert, G. and C. Harvey, 2000, Foreign Speculators and Emerging Equity Markets, he Journal of Finance, Vol. 55, No. 2, 565-613

Black, F., 1972, Capital Market Equilibrium with Restricted Borrowing, Journal of Business, 45, 444-455.

Black F., M. Jensen and M. Scholes, 1972, The Capital-Asset Pricing Model: Some empirical tests, in Jensen: Studies in the Theory of Capital Markets.

Brealey, R. A. and S. C. Myers, 1988, Principles of Corporate Finance, McGraw-Hill Book Company.

Chen, N., R. Roll, and S.A. Ross, 1986, Economic Forces and the Stock Market, Journal of Business 59, 383-403.

Cochrane, J. H., 2005, Asset Pricing, Princeton University Press, pp. 241-242.

Cuthbertson, K. and D. Nitzsche, 2004, Quantitative Financial Economics : Stocks, Bonds and Foreign Exchange, John Wiley & Sons Ltd.

Erb, C., C. Harvey, and T. Viskanta, 1995, Country Risk and Global Equity Selection, Journal of Portfolio Management, Winter, 74-83.

Erb, C., C. Harvey, and T. Viskanta, 1996, Expected Returns and Volatility in 135 Countries, Journal of Portfolio Management, Spring, 46-58.

Fama, E.F. and K.R. French, 1993, Common Risk Factors in the Returns on Stocks and Bonds, Journal of Financial Economics, 33, 3-56.

Fama, E.F. and K.R. French, 2004, The CAPM: Theory and Evidence, Journal of Economic Perspectives, 18, 25-46.

Fama, E.F. and J.D. MacBeth, 1973, Risk, Return, and Equilibrium: Empirical Tests, Journal of Political Economy, 81, 607-636.

Graham, J.R. and C. R Harvey, 2001, The Theory and Practice of Corporate Finance: Evidence from the Field, Journal of Financial Economics: 60, 187-243.

Harvey, C. R., 1995, Predictable Risk and Returns in Emerging Markets, The Review of Financial Studies, Vol. 8, No. 3, 773-816.

De Jong, F. and F. A. de Roon, 2001, Time-Varying Market Integration and Expected Returns in Emerging Markets, CentER Discussion Paper, No 78.

Koulafetis, P. and M. Levis, 2002, The Fama-MacBeth Methodology versus the Non-Linear Unrelated Regression and Different Portfolio Formation Criteria, EFMA 2002 London Meetings, http://ssrn.com/abstract=314383

Lakonishok, J. and A. Shapiro, 1986, Systematic Risk, Total Risk, and Size as Determinants of Stock Market Returns, Journal of Banking and Finance, 10, 115-132.

Leledakis, G., I. Davidson and G. Karathanassis, 2003, Cross-sectional Estimation of Stock Returns in Small Markets: The Case of the Athens Stock Exchange, Applied Financial Economics, No. 13, 413-426.

Lintner, J., 1965, The Valuation of Risky Assets and the Selection of Risky Investments in Stock Portfolios and Capital Budgets, Review of Economics and Statistics 47, 13-37.

Low, C. and S. Nayak, 2005, The Non-Relevance of the Elusive Holy Grail of Asset Pricing Tests: the 'True' Market Portfolio Doesn't Really Matter", EFA 2005 Moscow Meetings Paper, http://ssrn.com/abstract=675423

Reinganum, M., 1981, Misspecification of Capital Asset Pricing: Empirical anomalies, Journal of Financial Economics 9, 19-46.

Roll R., 1977, A Critique of the Asset Pricing Theory’s Tests, Journal of Financial Economics, No 4, 129-176.

Sharpe, W., 1964, Capital Asset Prices: A Theory of Market Equilibrium Under Conditions of Risk, The Journal of Finance, 19, 425-442.

Sokalska, M., 2001, What Drives Equity Returns in Central and Eastern Europe, Working Paper, Warsaw School of Economics.

Appendix: Description of Data Used in the Principal Component Analysis

All data was downloaded from the IMF' International Financial Statistics (IFS) Database. The series were downloaded for the quarterly frequency and then transformed into monthly frequency by the constant sum method (the quarterly value is divided by three and for each of the three months in this quarter the same value is repeated). The time series were imported into Eviews and automatically converted into logarithms of the original series if the values were positive. Then, unit root tests were performed and each series was differenced sufficient number of times to achieve stationarity. These series were then used in the principal component analysis.

Series name	Units
Foreign Assets (Net)	Units of National Currency
Domestic Credit	Units of National Currency
Claims on General Government (Net)	Units of National Currency
Claims on Other Resident Sectors	Units of National Currency
Money, Seasonally Adjusted	Units of National Currency
Changes in Money	Percent Per Annum
Money	Units of National Currency
Quasi-Money	Units of National Currency
Capital Accounts	Units of National Currency
Other Items (Net)	Units of National Currency
Monetary Authorities: Other Liabilities	Millions of US$
Discount Rate (End of Period)	Percent Per Annum
Money Market Rate	Percent Per Annum
Treasury Bill Rate	Percent Per Annum
Deposit Rate	Percent Per Annum
Lending Rate	Percent Per Annum
Share Price Index	Index Number
Producer Prices: Industry	Index Number
Changes in Consumer Prices	Percent Per Annum
Wages: Average Earnings	Index Number
Industrial Production	Index Number
Industrial Employment	Index Number
Unemployment	Unspecified Unit
Employment	Unspecified Unit
Unemployment Rate	Percent Per Annum
Exports	Millions of US$
Exports, F.O.B.	Units of National Currency
Imports	Millions of US$

Imports, C.I.F.	Units of National Currency
Imports, National Currency FOB	Units of National Currency
Volume of Exports	Index Number
Import Unit Value	Index Number
Export Prices	Index Number
Import Prices	Index Number
Export Prices	Index Number
Import Prices	Index Number
Deposit Money Banks: Assets	Millions of US$
Deposit Money Banks: Liabilities	Millions of US$
Deficit (-) or Surplus	Units of National Currency
Total Financing	Units of National Currency
Revenues	Units of National Currency
Total Revenue and Grants	Units of National Currency
Grants	Units of National Currency
Expenditure	Units of National Currency
Expenditure & Lending Minus Repayments	Units of National Currency
Lending Minus Repayments	Units of National Currency
Domestic	Units of National Currency
Foreign	Units of National Currency
Total Debt by Residence	Units of National Currency
Domestic	Units of National Currency
Foreign	Units of National Currency
Exports of Goods and Services	Units of National Currency
Government Consumption Expenditures	Units of National Currency
Gross Fixed Capital Formation	Units of National Currency
Changes in Inventories	Units of National Currency
Household Consumption Expenditures Including NPISHS	Units of National Currency
Imports of Goods and Services	Units of National Currency
Gross Domestic Product (GDP)	Units of National Currency
GDP Deflator 1995=100	Index Number
GDP Volume (1995=100)	Index Number
Official Rate	Units of National Currency
Exchange Rate Index 1995=100	Index Number
Nominal Effective Exchange Rate	Index Number
Real Effective Exchange Rate	Index Number
Actual Holdings in % of Quota	Index Number
Total Liabilities % of Quota	Index Number

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