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Performance of International Portfolio Diversification Strategies: The Viewpoint of German and Hungarian Investors*

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I. Introduction

Since the time that *Grubel* (1968) extended the concepts of modern portfolio analysis to international capital markets, a large number of empirical studies have examined the advantages of international diversification. Earlier studies, such as *Levy/Sarnat* (1970), *Lessard* (1973, 1976), and *Solnik* (1974) investigated the performance of ex post efficient portfolios and demonstrated that the benefits of internationally diversified portfolios stem from the fact that the co-movements between different national stock markets are relatively low. More recent studies, including *Jorion* (1985), *Eun/Resnick* (1988, 1994), *Levy/Lim* (1994) and *Liljeblum/Löflund/Krokfors* (1997), evaluated ex ante portfolio strategies taking the estimation risk of the expected return on portfolios into account. They also investigated the effect of hedging the currency risk on the performance of internationally diversified portfolios.

Most of the empirical work in the field of international diversification has focused on dollar-based investors or, at least, investors in large capital markets. The result of these studies was that international diversification has potential benefits compared to domestic portfolio holdings. Despite the long tradition of studies in international portfolio diversification, we do not know much about the potential advantages of such strategies for non-U.S. investors. More recent studies dealing with this

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question are the works of *Eun/Resnick* (1994) analyzing the case of Japanese, *Adjaouté/Tuchschmid* (1996) the case of Swiss and *Liljeblom/Löflund/Krokfors* (1997) the case of Scandinavian investors. Similarly to the case of US-investors, the general results of these studies indicate the possibility of substantial benefits from international diversification.

The main objective of this paper is to narrow the gap in empirical work dealing with international portfolio diversification from the viewpoint of investors outside the US. We have studied therefore the extent of the benefits derived from international diversification of stock portfolios from the Hungarian as well as the German point of view, which is based on a completely new database. The paper is organized as follows: Section II. describes the data used in the analysis and the basic institutional conditions for international equity investments of and into both countries. In Section III., we study the contribution of local stock market returns and exchange rate returns to total returns for Hungarian and German investors. In Section IV., we examine the co-movements between the total returns in the different countries. Section V. provides an ex post analysis of the benefits of international diversification from the Hungarian and the German point of view. Section VI. evaluates the performance of various ex ante diversification strategies. Section VII. offers a summary and some conclusions.

II. Data

The data used in this analysis are time series of 9 national stock portfolio returns on a monthly basis. Similar to many other empirical studies about the benefits of international portfolio diversification, the capital markets considered besides Germany (D) and Hungary (HUN) are: Australia (AUS), Canada (CAN), Switzerland (CH), France (FR), Great Britain (GB), Japan (JP) and the United States of America (US). To represent the stock portfolio of each country we have chosen well-diversified stock indices provided by Morgan and Stanley Capital International, except for Hungary. The data for the Hungarian stock exchange index (BUX) come from the Budapest Stock Exchange. The current version of this index has been constructed since January 1991. The companies quoted in the BUX represent more than 80% of the market capitalization and the trading volume of the listed firms on the Budapest Stock Exchange. Like the MSCI-Indices, the stock market returns of the BUX include capital gains as well as dividend payments and are based on a value-weighted index formed from major companies (based on market capitalization) listed on the Budapest Stock Exchange (cf. Budapest Stock Index Manual, 1997).

As the Hungarian stock index restricted our choice regarding the time period, we chose to study the period from January 1991 to October 1998. This means we have been able to use 94 monthly returns for each of the time series. To analyze the total returns from a German and a Hungarian point of view, we converted the local stock market index prices by using month-end exchange rates for the German and Hungarian currencies. As a proxy for the local risk-free rate, we used the monthly money market returns provided by the Deutsche Bundesbank and the Hungarian National Bank.

In contrast to the German capital market, which is one of the largest markets in the world, the Hungarian Stock Exchange is an emerging market, influenced by a process of transformation that began with the collapse of socialism in Central and Eastern Europe at the end of the last decade. So it is reasonable to give some historical and institutional information about the Hungarian Stock Exchange. Hungary has a stock exchange tradition going back to the 19th century. The Budapest Commodity and Stock Exchange was founded in 1864. Based upon market capitalization, the old stock exchange was then one of the largest in Europe. After the Second World War it was closed down. As a consequence of the transition process, namely the political and economic changes at the end of 1980s, the Budapest Stock Exchange reopened its floor on June 21, 1990 according to the Securities Act (Act VI. of 1990). Despite some negative experiences due to economic recession the stock exchange has developed rapidly. Liquidity, measured by the average daily turnover has continuously increased since 1990 from 33.8 million to 54,200.7 million Hungarian Forints (HUF) in November 1998 (cf. Statistical Reports Budapest Stock Exchange).

The Budapest Stock Exchange (BSE) arrived at an important milestone in its history in July 1996. At this time a foreign security, the depository receipts of Cofinec, was the first to be listed on an exchange place in Central and Eastern Europe as a result of government efforts to liberalize foreign exchange regulations. The BSE was also the first in the region to open a securities-based derivatives market. The trading of futures for the BUX index, three main currencies (the dollar, the Deutsche Mark and the ECU) and 3-month T-bills started in March 1995. In July 1996 the Options Market Development Project Board was set up to support launching standardized option contracts at the BSE in 1997.

The regulatory environment has kept pace with market development, i.e. a major step that was taken was the admission of foreigners to trade BUX derivatives according to the authorization of the Hungarian National Bank. An additional step to improve the regulatory environment of the Hungarian capital market was the adoption of the new Securities Act on January 1, 1997. In accordance with the new act the BSE has developed a multi-market exchange model with three different sections (corporate securities, government securities and derivatives). The new structure consists of separate trading and clearing rights.

The new Currency Act was passed by Parliament in 1997. For Hungarian investors, the Currency Act and the associated government legislation determine the conditions for aquiring foreign securities. Generally, it is necessary for the security of a foreign company to have an authorization from the Hungarian National Bank to be listed on the BSE or to be traded at the Hungarian over-the-counter market. A government order from 1996 partly liberalized this field. According to this rule it is possible to launch a security into the Hungarian capital market and trade it without permission from the Currency Authority, on condition that it is listed on a stock exchange or traded on a capital market in a country belonging to the OECD. At the same time the investment in the security in question has to be recommended by a renowned international financial ranking institution. It is necessary for Hungarian investors to receive permission from the Hungarian National Bank to buy a security in a foreign country apart from the above mentioned securities traded in OECD countries. The investors have to use a domestic brokerage firm as an intermediate to carry out this transaction. In sum, the institutional standards of the Hungarian stock exchange are nowadays comparable to those of the other markets considered.

III. Risk and Return Characteristics of Individual Stock Markets and Exchange Rates

In order to investigate the contribution of stock market return and currency return to total return, a decomposition of the total return from the investment in one single foreign market was performed. Let us define S_{it} as the spot Deutsche Mark (DM) price of foreign currency i at time t, and P_{it} as the foreign country stock index value. The total return in DM at the end of each holding period for a German investor can be calculated as

$$(1) \qquad R_{i.\,DM} = \frac{S_{it}\,P_{it}}{S_{it-1}\,P_{it-t}} - 1 = (1+R_i)\,(1+e_{i.\,DM}) - 1 = R_i + e_{i.\,DM} + R_i\,e_{i.\,DM}$$

where R_i is the local return on the ith market and $e_{i,\,DM}$ is the exchange rate return of the ith local currency against the Deutsche Mark. The expected rate of return can be decomposed as

$$(2) \qquad E\,(R_{i.\,DM}) = E\,(R_i) + E\,(e_{i.\,DM}) + E\,(R_i\,e_{i.\,DM}).$$

Of course, the same formula will apply to the total return ($R_{i.\,HUF}$) for Hungarian investors, where $e_{i.\,HUF}$ is the exchange rate return of the local currency against the Hungarian Forint. Altogether, the expected total return is the joint result of the expected return of the local index, the expected exchange rate return and a cross term. Using the Deutsche Mark as the numéraire currency, the first part of Table 1 presents the decomposition of the total mean return into the different components during the sample period of January 1991 - October 1998 while the second part shows the same decomposition from the perspective of a Hungarian investor.

In the case of Hungary all the exchange rate returns are positive and have a relatively high contribution to the total mean return. The highest contribution of exchange rate return comes from a Japanese investment with 1.60% and the lowest from a Canadian one with about 1.08%. Furthermore, in all cases the impact of the cross product term on the expected return is relatively low. We can observe that for a German investor the exchange rate returns only slightly contribute to the total return except for Hungary (-1.21%) and Japan (0.34%). The high negative exchange rate return of the Hungarian Forint does not imply that an investment into the Hungarian stock market is undemanding for German investors, because at the same time Hungary has the highest (local) stock market return (2.65%).

As is commonly known, the performance of a portfolio strategy should not only be evaluated in terms of total returns but also with regard to the risk of the strategy. According to the mean-variance approach introduced by *Markowitz*, we use the variance or the standard deviation of returns as a measure of risk. From the viewpoint of a German investor the variance of the rate of return can be calculated as follows:

$$(3) \qquad \mathrm{Var}\,(R_{i.\,DM}) = \mathrm{Var}\,(R_i) + \mathrm{Var}\,(e_{i.\,DM}) + 2\,\mathrm{Cov}\,(R_i,\ e_{i.\,DM}) + \Delta\,\mathrm{Var}$$

where $\mathrm{Var}(R_i)$ is the variance of the ith foreign stock market return and $\mathrm{Var}(e_{i,\,DM})$ is the variance of the exchange rate return against the

Table 1: **$\bar{R}_{i,DM}$ ($\bar{R}_{i,HUF}$) is the arithmetic average return in % p.m. calculated from the 94 monthly total returns against the *i*th market in the time period 01/1991 - 10/1998 from the viewpoint of a German (Hungarian) investor. $\bar{R}_i$ shows the local return, $\bar{e}_{i,DM}$ ($\bar{e}_{i,HUF}$) the exchange rate return and $\bar{R}_i \cdot \bar{e}_{i,DM}$ ($\bar{R}_i \cdot \bar{e}_{i,HUF}$) the cross product.**

FROM THE GERMAN PERSPECTIVE									
	AUS	CAN	CH	D	FR	GB	HUN	JP	US
$\overline{R}_{i,DM}$	1.13	0.91	2.01	1.35	1.38	1.33	1.45	0.14	1.77
$\overline{R}_i$	1.14	1.02	1,96	1,35	1,36	1.35	2.65	-0.20	1.61
$\overline{e}_{i,DM}$	-0.04	-0.14	0,05	0	0,02	-0.02	-1.21	0.34	0.16
$\overline{R}_i \cdot \overline{e}_{i,DM}$	0.03	0.03	-0.00	0	0.00	0.00	0.01	0.00	0.00
FROM THE HUNGARIAN PERSPECTIVE									
	AUS	CAN	CH	D	FR	GB	HUN	JP	US
$\overline{R}_{i,HUF}$	2.36	2.13	3.30	2.62	2.66	2.60	2.65	1.39	3.01
$\overline{R}_i$	1.14	1.02	1.96	1.35	1.36	1.35	2.65	-0.20	1.61
$\overline{e}_{i,HUF}$	1.18	1.08	1.36	1.29	1.31	1.26	0	1.60	1.38
$\overline{R}_i \cdot \overline{e}_{i,HUF}$	0.04	0.03	-0.02	-0.02	-0.01	-0.01	0	-0.01	0.02

Deutsche Mark, $\text{Cov}(R_i, e_{i.DM})$ represents the contribution of the co-movements between the exchange rate and the local stock market return and $\Delta\,\text{Var}$ represents the contribution of the cross product term $R_i e_{i,DM}$ to the variance of the DM rate of return. Again, the same formula holds for the Hungarian investors, mutatis mutandis. Table 2 presents the decomposition of the variance of the Deutsche Mark and the Hungarian Forint returns during the sample period.

Table 2 demonstrates that from the Hungarian perspective, the contribution of exchange rate return volatility to the variance of the total returns is substantial and varies between 17.76% for Japan and 6.74% for USA. But the correlation between the local stock market and the exchange rate return is negative for all European countries and Japan and often high in magnitude. Nevertheless the effect of exchange rate uncertainty increases the risk of foreign investments. In the case of Germany, the effect of exchange rate uncertainty of international investments clearly increases the total risk. The above mentioned "risk increasing" effect is small in magnitude for most of the European countries (including Hungary!). This relatively low contribution of the exchange rate risk for Hungary is due to the high variance of the local stock market.

IV. The Impact of Co-movements on Total Portfolio Returns

In order to evaluate the performance of an international multi-asset portfolio it is necessary to extend the equation (1) as follows:

$$R_p = \sum_{i=1}^{N} x_i R_{i.DM} \tag{4}$$

where R_p is the total return on the portfolio of a German investor and x_i represents the fraction of wealth invested in the ith of the N stock markets. The expected return of this menu of assets is a weighted average of the total returns on each stock market:

$$E(R_p) = \sum_{i=1}^{N} x_i E(R_{i.DM}) \tag{5}$$

To calculate the risk of the portfolio we have to determine not only the pure variance of each total return but also the co-movement between the different markets. The variance can be calculated as follows:

$$\text{Var}(R_p) = \sum_{i=1}^{N} x_i^2\, \text{Var}(R_{i.DM}) + \sum_{i=1}^{N} \sum_{\substack{j=1 \\ i \neq j}}^{N} x_i x_j \,\text{Cov}(R_{i.DM},\ R_{j.DM}) \tag{6}$$

Table 2: **$\mathbf{Var(R_{i,DM})[Var(R_{i,DM})]}$ is the empirical variance calculated from the 94 monthly total returns against the ith market in the period 01/1991 - 10/1998. $\mathbf{Var(R_i)}$ and $\mathbf{Var(e_{i,DM})[Var(e_{i,HUF})]}$ represent the empirical variance of the local return and the exchange rate return, respectively. $\mathbf{Cov(R_i, e_{i,DM})[Cov(R_i, e_{i,HUF})]}$ is the covariance of the local return and the exchange rate return and ΔVar is the contribution of the cross product term from the viewpoint of a German (Hungarian) investor.**

FROM THE GERMAN PERSPECTIVE									
	AUS	CAN	CH	D	FR	GB	HUN	JP	US
$Var(R_{i,DM})$	39.12	35.52	26.17	26.16	29.31	22.05	183.42	46.89	25.18
$Var(R_i)$	16.43	16.71	25.35	26.16	28.72	16.02	171.12	32.40	13.30
$Var(e_{i,DM})$	15.62	12.26	1.41	0	0.35	5.45	6.79	12.33	10.40
$2Cov(R_i, e_{i,DM})$	6.98	6.69	-0.86	0	0.21	0.51	8.25	2.06	1.21
ΔVar	0.09	-0.14	0.27	0	0.03	0.07	-2.74	0.10	0.27
FROM THE HUNGARIAN PERSPECTIVE									
	AUS	CAN	CH	D	FR	GB	HUN	JP	US
$Var(R_{i,HUF})$	35.03	30.03	28.66	26.95	31.87	23.42	171.12	50.35	21.61
$Var(R_i)$	16.43	16.71	25.35	26.16	28.72	16.02	171.12	32.40	13.30
$Var(e_{i,HUF})$	12.99	8.59	11.64	8.06	8.25	10.42	0	17.76	6.74
$2Cov(R_i, e_{i,HUF})$	4.73	4.17	-9.43	-7.95	-6.15	-3.84	0	-0.75	0.80
ΔVar	0.88	0.56	1.10	0.68	1.05	0.82	0	0.94	0.77

The lower the values of the elements in the correlation matrix are, the higher the potential risk reduction benefits may be in an internationally diversified portfolio. Table 3 provides the correlation matrix of the total monthly returns between the different countries. The elements above the diagonal show the empirical correlations for a Hungarian investor and those below the diagonal for a German one.

By comparing the elements of the two correlation matrices it becomes obvious that in 26 out of 36 cases the correlation in the case of Germany was higher than in the case of Hungary. Based on *Meric/Meric* (1989) and *Longin/Solnik* (1995) we calculated the average coefficient of correlation, which is 0.57 for Germany and 0.53 for Hungary. Neither result indicates a systematic lower co-movement, therefore a higher possible risk reduction potential for Hungarian investors. To be more precise, we tested the null hypothesis stating that the correlation matrix of total returns for Hungary is equal to the correlation matrix for Germany against the alternative hypothesis which claims that the elements of the former matrix are lower than those of the latter. For this purpose, the test developed by *Jennrich* (1970) was used. This test has an asymptotic chi-square distribution. In our case this means a 9 by 9 matrix and a χ^2 distribution having 36 degrees of freedom. The value of the χ^2 statistics is 4.125 and it does not indicate any significant difference between the two matrices.

V. The Gains from International Diversification: Ex Post Analysis

1. Description of the strategies

To illustrate the potential gains from international stock investments, we made an ex post evaluation of some portfolio strategies by comparing their risk-return characteristics to those of the domestic portfolio. For both countries four strategies are considered: an equally weighted portfolio (EQW), the minimum variance portfolio (MVP), the certainty-equivalence-tangency portfolio (CET) and a portfolio on the efficient frontier with a risk equal to a domestic one (ERP).

According to the EQW approach, the same fractions of the budget are invested into each stock market. It can be regarded as an attempt to capture some of the potential benefits from international investment without using information on the security returns, risks and co-movements. The other three approaches use information on historical returns to identify portfolios which are on the mean-variance efficient frontier of risky

Table 3: **Correlations between total stock market returns, calculated from the 94 monthly returns in the time period 1/1991 - 10/1998. The elements above the diagonal are in Hungarian Forint, below the diagonal are in Deutsche Mark.**

	AUS	CAN	CH	D	FR	GB	HUN	JP	US
AUS		0.69	0.48	0.50	0.55	0.66	0.44	0.54	0.62
CAN	0.75		0.54	0.52	0.56	0.62	0.50	0.39	0.80
CH	0.51	0.58		0.62	0.67	0.65	0.48	0.44	0.59
D	0.56	0.59	0.60		0.75	0.65	0.30	0.31	0.56
FR	0.60	0.63	0.65	0.74		0.77	0.38	0.43	0.60
GB	0.71	0.67	0.62	0.63	0.77		0.36	0.48	0.67
HUN	0.52	0.57	0.57	0.39	0.48	0.47		0.28	0.44
JP	0.56	0.46	0.42	0.31	0.42	0.46	0.35		0.36
US	0.70	0.83	0.60	0.61	0.66	0.72	0.53	0.41	

assets. Throughout all of these approaches we assume rational expectations and use ex post data as a means of measurement of expectations. In practice, investors are prohibited from taking short positions because of institutional restrictions. For example, in the case of German investment funds and insurance companies which are the most important media for individual investors to participate in internationally diversified portfolios, short sales are generally forbidden due to the supervision act. The same is true in the Hungarian case. Therefore, in this study we have examined portfolios where short-selling restrictions are imposed.

The minimum variance strategy determines the portfolio with the lowest anticipated risk, not explicitly using any information on the asset-specific expected returns, because it is not required as an input to solve the portfolio selection problem. This may be regarded as a candidate for a conservative strategy. Excluding short sales, this portfolio can be calculated by solving the following constrained optimization problem:

$$\min\ V(x) = \sum_{i=1}^{N}\sum_{j=1}^{N} x_i\, x_j\ \mathrm{Cov}\,(R_{i.DM},\ R_{j.DM})$$

subject to

$$\sum_{i=1}^{N} x_i = 1 \qquad (x_i \geq 0,\ i = 1,\ 2,\ \ldots,\ N) \tag{7}$$

According to *Eun/Resnick* (1994) the certainty-equivalence-tangency (CET) portfolio strategy investigates the composition of the portfolio which maximizes the anticipated Sharpe-index, the ratio of excess return over the risk-free rate to volatility. Such a strategy explicitly uses information about the expected returns of the different investments and can be seen in relation to the minimum variance portfolio as an aggressive strategy. The CET portfolio can be identified by solving the maximization problem as follows:

$$\max\ S(x) = \frac{\sum_{i=1}^{N} x_i\, [E\,(R_{i.DM}) - r_f]}{\sqrt{\sum_{i=1}^{N}\sum_{j=1}^{N} x_i\, x_j\ \mathrm{Cov}\,(R_{i.DM},\ R_{j.DM})}}$$

subject to

$$\sum_{i=1}^{N} x_i = 1 \qquad (x_i \geq 0,\ i = 1,\ 2,\ \ldots,\ N) \tag{8}$$

with r_f being the risk-free rate of return.

To directly evaluate the benefits from international diversification, it seems obvious to use the domestic portfolio as a benchmark and to compare it with an internationally diversified menu of assets which has dominant risk-return characteristics. According to *Haavisto/Hansson* (1992) this can be done by identifying an efficient portfolio with the same expected return but a lower risk than that of the domestic one. In this study we chose a portfolio on the efficient frontier which has the same risk as the domestic portfolio. If the efficient frontier includes such an equal risk portfolio (ERP) which is not identical with the domestic one, then the former dominates the latter in the sense that for the same anticipated risk ERP has a higher expected return than the domestic portfolio. By excluding short sales, efficient frontier may not include such an equally risky portfolio because the domestic portfolio is more risky than the efficient portfolio with the highest expected return. In such a case, it is reasonable to choose the portfolio with the highest expected return. If $\mathbf{x}^{\mathbf{e}}$ represents a vector of portfolio weights which is on the efficient frontier, then the ERP can be determined by solving the following maximization problem:

$$\max E(x) = \sum_{i=1}^{N} x_i E(R_{i.DM})$$

subject to

$$(9)\qquad \begin{aligned} &\sum_{i=1}^{N}\sum_{j=1}^{N} x_i x_j \operatorname{Cov}(R_{i.DM}, R_{j.DM}) \le \operatorname{Var}(R_{DM}) \\ &\sum_{i=1}^{N} x_i = 1, \qquad \mathbf{x} \in \mathbf{x}^{\mathbf{e}}, \qquad (x_i \ge 0,\ i = 1, 2, \ldots, N) \end{aligned}$$

Figure 1 illustrates the efficient portfolio strategies we used.

Usually the performances of international diversification strategies are also considered by hedging the currency risk, e.g. *Glen/Jorion* (1993), *Eun/Resnick* (1994), *Liljeblum/Löflund/ Krokfors* (1997) and *Rudolph/Zimmermann* (1998), assuming that it is possible for the domestic investor to buy derivative currency contracts, like futures or forwards. Nowadays, the market for these hedging instruments is continuously developing in Hungary. However, for the whole time period considered, these instruments were not available by an organized market for Hungarian Forint. This is the reason why we have not considered such a possibility for neither German nor Hungarian investors in this study.

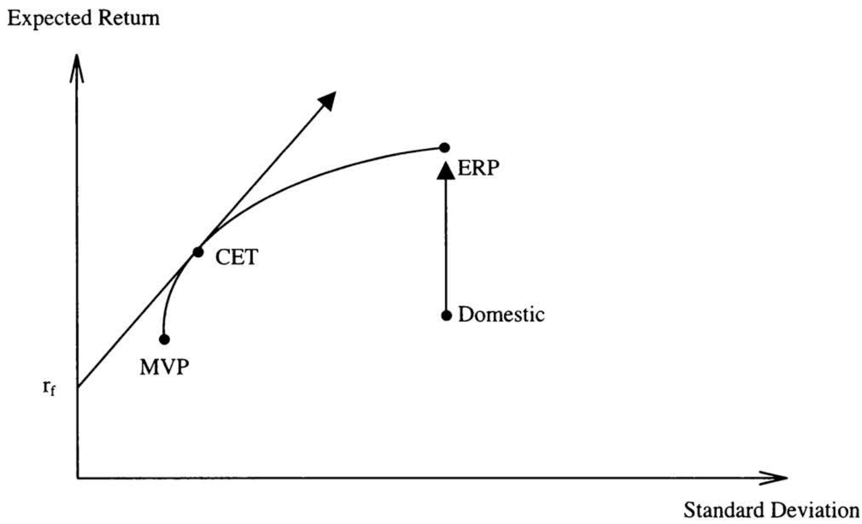

Figure 1: Efficient portfolio strategies in risky assets

2. Empirical Results

Using the information in Tables 1 - 3 as input parameters, in this section we examine the anticipated risk and return characteristics of the portfolios mentioned above. Furthermore, we calculate the standard performance measure provided by Sharpe. Table 4 presents the results:

If the Deutsche Mark is used as the numéraire currency, the MVP, CET and ERP dominates the domestic portfolio, i.e. it has a higher return and a lower risk. For these strategies we can also observe a substantial increase in the Sharpe-ratio; of course, the Sharpe-ratio for the CET must (per constructionem) be the highest among all strategies. However, in the case of the EQW strategy, international diversification does not improve risk adjusted performance relative to the domestic stock portfolio.

In the case of Hungary, the potential benefits from international diversification accrue for the EQW and MVP strategy particularly in terms of risk reduction. Even the naive strategy results in a high risk reduction benefit compared to domestic investment. The standard deviation of the MVP is nearly 70% less than the monthly standard deviation of the domestic portfolio for Hungary. This confirms the high risk reduction effect for this strategy which, together with a moderate increase in aver-

Table 4: **Performance of ex post portfolios in the period from 01/1991 - 10/1998. The mean and the standard deviation (STD) are reported in % per month. EQW is the Equally Weighted Portfolio, MVP is the Minimum Variance Portfolio, CET is the Certainty Equivalent Tangency Portfolio, ERP is the Equal Risk Portfolio and Domestic stands for the local stock market index.**

	Germany			Hungary		
	Mean	STD	Sharpe-ratio	Mean	STD	Sharpe-ratio
EQW	1.27	5.00	0.16	2.52	4.75	0.22
MVP	1.41	4.17	0.23	2.71	4.13	0.30
CET	1.93	4.59	0.32	3.15	4.46	0.37
ERP	2.01	5.11	0.30	3.30	5.35	0.34
Domestic	1.35	5.11	0.17	2.65	13.08	0.09

age return, results in a substantial improvement in performance measured with the Sharpe-ratio. Furthermore, for Hungary, the MVP and the CET have simultaneously a higher return and a lower risk than the domestic portfolio. As a consequence of the short sales restriction, in the case of the ERP, there is no portfolio on the efficient frontier which has the same risk as the domestic one. So the whole budget is invested in the (efficient) portfolio with the highest expected return, i.e. Switzerland. Table 5 presents the optimal portfolio weights for the "efficient frontier" strategies considered.

For the German MVP strategy, Great Britain (28.5%) has the highest positive weight among all the countries while Australia, Canada, France and Hungary have zero weights. For Hungary, the highest weights of the MVP strategy are in the US (41.8%), while again Australia, Canada, France and Hungary receive a zero weight. The structure of the CET portfolio is mostly orientated to the individual Sharpe-ratios. So, for both German and Hungarian investors, Switzerland and the US are the only markets with positive portfolio weights. For both countries, in the case of the ERP strategy (nearly) the entire budget is invested in the Swiss stock market. It is remarkable that for both countries, Hungary does not receive a positive weight in any of the strategies. However, Germany is playing an important role in the MVP from the German as well as from the Hungarian viewpoint.

VI. International Diversification in the Context of Ex Ante Strategies

1. Methodology

The results in the previous section suggest that during the time period of 01/1991 - 10/1998, internationally diversified portfolios can perform better than domestic ones. Unfortunately, because of the ex post nature of this technique, the optimal portfolio weights are only revealed afterwards. Therefore, an interesting question is whether the promised benefits of an international portfolio strategy occur if investment decisions are only based on prior information (*Glen/Jorion* 1993, p. 1882).

A widely accepted approach to evaluating the performance of different portfolio strategies under these realistic conditions is to use an "ex ante" resp. "out-of-the-sample" backtesting procedure (e.g. *Eun/Resnick* (1988,1994), *Glen/Jorion* (1993), *Levy/Lim* (1994) and *Liljeblom/Löflund/Krokfors* (1997)). In order to carry this out, two different time

Table 5: **Weights (in %) of ex post portfolio strategies. MVP is the Minimum Variance Portfolio, CET is the Certainty Equivalent Tangency Portfolio, ERP is the Equal Risk Portfolio and Domestic stands for the local stock market index.**

	AUS	CAN	CH	D	FR	GB	HUN	JP	US
FROM THE GERMAN PERSPECTIVE									
MVP	0	0	19.8	23.1	0	28.5	0	11.4	17.2
CET	0	0	64.4	0	0	0	0	0	35.6
ERP	0	0	99.98	0	0	0	0	0	0.2
FROM THE HUNGARIAN PERSPECTIVE									
	AUS	CAN	CH	D	FR	GB	HUN	JP	US
MVP	0	0	8.7	22.4	0	16.3	0	10.8	41.8
CET	0	0	49.8	0	0	0	0	0	50.2
ERP	0	0	100.0	0	0	0	0	0	0

horizons are used. To obtain estimates for anticipated returns, risk measures and co-movements, a sliding window of 24 months (the first is from 01/1991 to 12/1992, the second from 02/1991 to 01/1993 etc.) prior to the beginning of the holding period is reserved. We then identified the optimal portfolio weights for a holding period of the subsequent month forward. By using new statistical information at the end of each month, the portfolios are revised shifting the sample interval by one month. This is an "ex ante" strategy, as investment decisions are based on prior information. In total, with this rolling technique we have generated 70 out-of-sample, non-overlapping monthly returns for each strategy.

For each strategy which traces out the set of efficient portfolios using the tenets of mean-variance portfolio theory, it is necessary at the beginning of every holding period to estimate the (inverse) of the variance-covariance matrix (**V**) of the returns stated in terms of the numéraire currency. For this purpose we have used the unbiased estimator of this matrix proposed by *Jobson/Korkie* (1981a):

$$\mathbf{V}^{-1} = \frac{T - N - 2}{T - 1} \cdot \mathbf{S}^{-1} \tag{10}$$

where **S** is the usual N X N sample variance-covariance matrix, T is the length of the estimation period and N is the number of assets. In our case $T = 24$ and $N = 9$.

With this information in hand, the weights of the minimum variance portfolio can be obtained for all of the 70 out-of-sample periods by solving the optimization problem (7). To determine the CET and the ERP portfolio, the investor has to obtain some estimates of the expected returns for each of the assets. A first possibility is to use the ex post (historical) sample mean return vector as we have done in the previous section. This approach uses only historical information on the time series of the specific stock returns. As *Jorion* (1985,1986) pointed out, the problem with such an estimation technique is that the sample mean could be very unstable over time and it is exposed to estimation risk. Because of the generally high influence of the expected return vector on the optimal weights of the tangency portfolio, this estimation risk often leads to the instability of portfolio weights. This instability often causes unacceptable portfolio turnovers and therefore, it could be responsible for extreme, volatile portfolio returns.[1]

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1 Especially, when short sales are allowed the portfolio weights can have extremely high (e.g. more than 200%) short or long positions in specific countries. In

Variances and correlation of portfolio returns are also exposed to estimation risk, but as *Merton* (1980), *Jorion* (1986), *Kaplanis* (1988) and others have pointed out, these parameters are generally more stable over time. In our case, to test the inter-temporal stability of correlation matrix of total returns, we divided the total estimation period for both countries into two adjacent sub-periods: 01/1991 - 11/1994 and 12/1994 - 10/1998. The *Jennrich*-test of equality of two matrices has an asymptotic chi-square distribution with 36 degrees of freedom for a 9 by 9 matrix. The null hypothesis of the equality of the two correlation matrices cannot be rejected at the usual 5% level of significance for Germany as well as for Hungary. Such inter-temporal stability of stock market movements is consistent with the empirical findings of many other researchers, e.g. *Meric/Meric* (1988), *Kaplanis* (1988) *Longin/Solnik* (1995) or *Liljeblom/Löflund/Krokfors* (1997). However, an additional finding of these studies is that the covariance matrix is not stable over time, indicating inter-temporal changes in variances. A similar test as in the case of the correlation matrices can be applied to test the equality of two covariance matrices, although the number of degrees of freedom is now 45 since the diagonal elements can vary over time (cf. *Longin/Solnik* 1995, p. 5). Using the same database for the calculation of the correlation matrices, for both countries the *Jennrich* test leads to a rejection of the null hypothesis of equal covariance matrices at the 5% level of significance for Germany and 3% for Hungary, respectively.

Jorion (1985) suggests to predict the return of each country by pooling the data from all countries and combining the estimation and optimization process.[2] Using arguments from statistical decision theory he shows that an optimal forecast rule (depending on historical information) for the expected return vector is:

$$\mathbf{e}^{*} = (1 - w)\,\mathbf{e} + w\,\mathbf{1}\,e_0 \tag{11}$$

where $\mathbf{e}$ is the sample mean return vector of N assets, $\mathbf{1}$ is a vector of ones, and e_0 denotes the mean return from the ex post minimum variance portfolio. The parameter w represents a shrinkage factor for shifting the

an analysis, not reported here, based on the same data and strategies, but allowing short sales the authors observed "wonderful" high and "catastrophic" low out-of-sample returns by modifying slightly the length of the in-sample estimation period. For readers interested, these results are available from the authors upon request.

[2] There is an analogy in actuarial risk theory, the so-called credibility estimation, cf. e.g. *Klugman* (1992) and *Makov* et al. (1996).

elements of $\mathbf{e}$ towards e_0. In line with *Jorion* (1985), the shrinkage factor can be calculated as follows:

$$(12) \qquad w = \frac{(N+2)(T-1)}{(N+2)(T-1) + (\mathbf{e} - e_0\mathbf{1})^T \, T\mathbf{S}^{-1}(T-N-2)(\mathbf{e} - e_0\mathbf{1})}$$

Coupling the results with (10) and solving the optimization problem (8) results in the "*Bayes-Stein*" tangency portfolio (BST). As special cases, for $w = 0$ and $w = 1$ we can get the classical tangency portfolio and the minimum variance portfolio respectively. For $0 < w < 1$ we achieve a portfolio which is more aggressive than the minimum variance portfolio and less aggressive than the traditional tangency portfolio.[3] It can be shown (cf. the Appendix B) that in the case of ERP a *Bayes-Stein* estimation technique for the mean return vector gives the same portfolio weights as the sample mean vector. So, no improvement in portfolio performance can be expected by combining the *Bayes-Stein* estimation technique with the ERP strategy.

2. *Empirical Results*

For each strategy, the average return, the standard deviation (STD) and the Sharpe-ratio are calculated and presented in Table 6. Furthermore, the difference between the Sharpe-ratios of the various strategies and their domestic counterparts was tested by implementing the z-statistic developed by *Jobson/Korkie* (1981b). A negative z-statistic indicates a higher, while a positive indicates a lower Sharpe-ratio than that of the domestic portfolio.

Similar to the ex post analysis, the gains from international diversification for a Hungarian investor accrue mostly in terms of risk reduction. At the same time, one can observe a substantial decline in the average return for the above mentioned portfolio strategies. However, in terms of risk adjusted performance measure, all these strategies are better than the domestic stock investment, except for the ERP strategy. Furthermore, by controlling estimation risk according to the BST strategy properly, it is possible to achieve a distinct enhancement in performance relative to the CET strategy. It is also remarkable that the out-of-sample returns of

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3 If the expected return of the tangency portfolio has a lower expected return as the riskless interest rate, i.e. a negative anticipated Sharpe-ratio, all the budget is invested in the riskless interest rate for this period, cf. *Liljeblom/Löflund/Krokfors* (1997).

Table 6: **Performance statistics of 70 out-of-the-sample portfolio returns in the period from 01/1993 - 0/1998. EQW is the Equally Weighted Portfolio, MVP is the Minimum Variance Portfolio, CET is the Certainty Equivalent Tangency Portfolio, BST is the Bayes Stein Tangency Portfolio, ERP is the Equal Risk Portfolio and Domestic stands for the local stock market index. 24 previous months are used in the estimation of mean returns and covariance matrix. Jobson/Korkie z-statistic (p-value in parenthesis) tests the difference between Sharpe-ratios for each strategy against the domestic portfolio. The (arithmetic) average mean and the standard deviation (STD) are reported in % per month.**

	Germany					Hungary				
	Mean	STD	Sharpe-ratio	JK-statistic	(prob.)	Mean	STD	Sharpe-ratio	JK-statistic	(prob.)
EQW	1.46	5.32	0.20	0.36	(0.36)	2.79	4.94	0.28	-1.05	(0.15)
MVP	1.90	4.58	0.33	-0.69	(0.25)	2.95	4.08	0.38	-1.68	(0.04)
CET	1.69	4.70	0.28	-0.25	(0.40)	2.94	4.29	0.36	-1.52	(0.06)
BST	1.76	4.45	0.31	-0.50	(0.31)	2.91	3.99	0.37	-1.64	(0.05)
ERP	1.05	5.54	0.12	1.46	(0.07)	2.09	8.98	0.08	0.61	(0.27)
Domestic	1.70	5.35	0.25	-	-	3.68	14.81	0.15	-	-

the BST strategy have a lower standard deviation and a lower average return than in the MVP strategy, which would not have been expected from the ex post analysis.

According to the results for German investors, we can also register a risk reduction effect from multi-currency portfolios, but this effect is not as large as in the case of Hungary. For the ERP strategy, the standard deviation is nearly the same as that of the domestic portfolio, but in contrast to ex post analysis, the average return is lower than that of the domestic one. The EQW also results in a nearly identical standard deviation and a lower average return than the local German stock index. For those strategies (MVP, CET, BST) which use historical information on average returns, variances and correlations in order to identify efficient portfolios, we can observe an improvement in risk adjusted performance. For the MVP and BST strategies we can detect a higher average return and a lower risk simultaneously. Furthermore, as in the Hungarian case, controlling the estimation risk results in a better performance than that of the CET strategy. However, in none of the cases is the Sharpe-ratio significantly higher than that of the domestic portfolio.

Table 7 provides the average portfolio weights of the ex ante strategies. As a measure of inter-temporal portfolio stability, we also presented the average turnover rates (defined as the transaction volume divided by the market value of the portfolio) for the strategies considered.

In the out-of-the-sample analysis, similar to the case of the ex post efficient portfolios, for Hungarian and German investors applying any of the strategies, Switzerland is an important country. GB and the US are also significant stock markets for internationally diversified stock portfolios. As in the ex post analysis, the average portfolio weights of Australia, Canada and France do not exceed 4% and they are often zero. For a German investor an investment in the Hungarian stock market is only important in the case of the ERP strategy with an average portfolio weight of 8.0. On the other hand, Germany plays an important role for the Hungarian investors, e.g. in the case of the MVP, the average portfolio weight is 19.4% and it is 17.2% in the BST strategy.

From a Hungarian point of view it is interesting to note that only for the ERP portfolio the Hungarian stock market has an important weight of 47.1%. The reason for this high average weight is that, due to the Hausse on the Budapest Stock Exchange in 1996, in 33 of 70 subperiods the Hungarian domestic portfolio has both the highest anticipated risk and the highest expected return. From the viewpoint of a German

Table 7: **Average weights of the ex ante portfolios in %. MVP is the Minimum Variance Portfolio, CET is the Certainty Equivalent Tangency Portfolio, BST is the Bayes-Stein Tangency Portfolio and ERP is the Equal Risk Portfolio. Turnover is for each strategy the average transaction volume p.m. divided by the market value of the portfolio.**

FROM THE GERMAN PERSPECTIVE										
	AUS	CAN	CH	D	FR	GB	HUN	JP	US	Turnover
MVP	0.0	0.0	26.6	18.5	0.6	25.2	1.8	7.5	19.8	21.4
CET	0.0	0.0	58.3	4.1	0.3	21.1	1.3	3.7	11.2	24.2
BST	1.0	1.0	41.6	10.8	1.1	25.7	2.6	4.4	11.8	47.6
ERP	0.1	0.0	27.7	37.6	0.1	12.9	8.0	4.7	8.9	52.2
FROM THE HUNGARIAN PERSPECTIVE										
	AUS	CAN	CH	D	FR	GB	HUN	JP	US	Turnover
MVP	0.0	4.0	14.3	19.4	0.7	22.8	2.5	5.6	30.7	18.7
CET	0.0	0.0	43.6	8.3	0.1	22.0	2.2	2.9	20.9	29.2
BST	1.0	1.7	22.9	17.2	1.4	23.8	1.4	3.8	26.8	22.3
ERP	2.9	0.1	31.9	0.0	1.5	0.0	47.1	7.1	9.4	52.7

investor, the local stock market is also the most important in the case of the ERP strategy. In contrast to Hungary, the domestic market also plays an important role in the case of the MVP and the BST strategy.

The monthly turnover rate for the MVP is 21.4% for Germany and 18.7% for Hungary, indicating a relative stability of the portfolios over time. The turnover rates for the ERP indicate frequent portfolio revisions with a value of 52.2% for Germany and 52.7% for Hungary. This is in contrast with the bad risk adjusted performance of this strategy.

VII. Summary and conclusions

In this paper we have investigated the potential benefits of international diversification from the viewpoint of investors of two European countries, namely Hungary and Germany, and have considered stock portfolios during the sample period of 01/1991 - 10/1998. We have evaluated the performance of internationally diversified portfolio strategies compared to domestic investment on an ex post and an ex ante basis. Following the work of *Eun/Resnick* (1994), *Liljeblom/Löflund/ Krokfors* (1997) and others, the portfolio strategies considered have been the equally weighted, the minimum variance, and the certainty-equivalence-tangency strategy. As a technique to control parameter uncertainty in the expected return vector, the *Bayes-Stein* estimation was used. In addition, we theoretically and empirically examined a portfolio strategy with the same anticipated risk as that of the domestic portfolio. The major findings of the analysis are summarized as follows.

Firstly, the ex post analysis revealed that, in the absence of parameter uncertainty, both German and Hungarian investors could capture gains from international diversification. For Hungarian investors the potential gain accrued particularly in terms of risk reduction, while German investors benefited from higher returns and risk reduction at the same time. However, the risk reduction effect for German investors was much smaller in magnitude than for their Hungarian counterparts.

Secondly, similar to the ex post analysis, in the presence of parameter uncertainty, the out-of-the-sample analysis revealed benefits mostly in terms of risk reduction from the viewpoint of Hungarian investors. Also, Hungarian investors can capture gains from international diversification by controlling estimation risk in to the expected return vector. The conclusion therefore is that international diversification would "pay" for a Hungarian investor. The above mentioned effect was not as clear for a

German investor, i.e. in three out of five international strategies a higher Sharpe-ratio than that of the domestic portfolio could be observed. But the magnitude of the performance improvement is much lower than for Hungarian investors and in none of the strategies is it statistically significant. Again, investors can capture gains from international diversification by controlling estimation risk in the expected return vector. All in all, the most conservative minimum variance portfolio has the best risk adjusted performance for both countries.

Appendix A

Correlation between total stock market returns in Deutsche Mark

January 1991 - November 1994 above diagonal

December 1994 - October 1998 below diagonal

	AUS	CAN	CH	D	FR	GB	HUN	JP	US
AUS		0.78	0.58	0.49	0.65	0.68	0.45	0.45	0.71
CAN	0.75		0.54	0.42	0.51	0.55	0.40	0.42	0.78
CH	0.49	0.61		0.44	0.59	0.67	0.50	0.34	0.57
D	0.68	0.72	0.69		0.72	0.59	0.12	0.20	0.41
FR	0.59	0.72	0.69	0.75		0.78	0.33	0.32	0.62
GB	0.79	0.81	0.61	0.70	0.78		0.32	0.39	0.67
HUN	0.61	0.69	0.61	0.56	0.58	0.63		0.29	0.35
JP	0.69	0.52	0.52	0.43	0.54	0.59	0.44		0.30
US	0.74	0.87	0.61	0.73	0.69	0.79	0.65	0.55	

	χ^2	Dgf	prob.
Jennrich Stability-Test for correlation matrix	42.717	36	0.205
Jennrich Stability-Test for covariance matrix	62.133	45	0.046

Correlation between total stock market returns in Hungarian Forint
January 1991 - November 1994 above diagonal
December 1994 - October 1998 below diagonal

	AUS	CAN	CH	D	FR	GB	HUN	JP	US
AUS		0.76	0.57	0.49	0.62	0.66	0.41	0.45	0.65
CAN	0.67		0.54	0.42	0.46	0.55	0.31	0.38	0.71
CH	0.39	0.54		0.61	0.67	0.74	0.45	0.45	0.65
D	0.54	0.61	0.63		0.80	0.69	0.13	0.34	0.49
FR	0.50	0.64	0.67	0.69		0.82	0.30	0.39	0.60
GB	0.69	0.76	0.57	0.60	0.75		0.29	0.46	0.69
HUN	0.51	0.63	0.50	0.44	0.45	0.47		0.27	0.28
JP	0.66	0.44	0.46	0.32	0.50	0.55	0.32		0.30
US	0.64	0.87	0.54	0.61	0.60	0.69	0.55	0.46	

	χ^2	dgf	prob.
Jennrich Stability-Test for correlation matrix	45.171	36	0.141
Jennrich Stability-Test for covariance matrix	65.017	45	0.027

Appendix B: The Invariance of the ERP to the *Bayes-Stein* transformation

Let $\mathbf{e}$ denote the vector of the expected return on the securities being considered, $\mathbf{V}$ the variance-covariance matrix, $\mathbf{1}$ a vector of ones and $\mathbf{x}$ the vector of portfolio weights. In the case of a strategy labeled by ERP, we are looking for a portfolio on the efficient frontier with the same risk (σ_0) as the benchmark (domestic) portfolio has. Formally, the ERP can be determined by solving the following maximization problem:

$$(\mathbf{B1}) \qquad \max \mathbf{x}'\mathbf{e} \qquad \text{subject to} \quad \mathbf{x}'\mathbf{V}\mathbf{x} = \sigma_0^2; \quad \mathbf{x}'\mathbf{1} = 1; \quad (x_i \geq 0,\ 1 = 1,\ \ldots,\ N).$$

Let us define a set $\mathbf{x}_0$ as

$$(\mathbf{B2}) \qquad \mathbf{x}_0 = \left\{\mathbf{x}\,|\,\mathbf{x}'\mathbf{V}\mathbf{x} = \sigma_0^2, \quad \mathbf{x}'\mathbf{1} = 1, \quad (x_i \geq 0,\ 1 = 1,\ \ldots,\ N)\right\},$$

so the maximization problem (B1) can be written in the following form:

$$(\mathbf{B3}) \qquad \max \mathbf{x}'\mathbf{e} \qquad \text{for} \qquad \mathbf{x} \in \mathbf{x}_0\,.$$

The *Bayes-Stein* estimator for the expected return vector is a linear combination of the sample mean return vector and a vector which can be created by multiplying a vector of ones by the mean return from the minimum variance portfolio. Formally: $\mathbf{e}^* = (1-w)\mathbf{e} + we_0\mathbf{1}$.

After applying the *Bayes-Stein* transformation for the expected return vector, the ERP can be identified by solving the following maximization problem:

$$(\mathbf{B4}) \qquad \max \mathbf{x}^{*\prime}\mathbf{e}^{*} \qquad \text{for} \qquad \mathbf{x} \in \mathbf{x}_0\,.$$

The $\mathbf{x}^{*\prime}\mathbf{e}^*$ expression can be written in the form as follows:

$$(\mathbf{B5}) \qquad \mathbf{x}^{*\prime}\mathbf{e}^* = (1-w)\,\mathbf{x}^{*\prime}\mathbf{e} + we_0\,\mathbf{x}^{*\prime}\mathbf{1} = (1-w)\,\mathbf{x}^{*\prime}\mathbf{e} + we_0\,.$$

This means that an $\mathbf{x}$ which maximizes $\mathbf{x}^{*\prime}\mathbf{e}^*$ will also maximize $\mathbf{x}^{*\prime}\mathbf{e}$. Therefore, the solutions of the maximization problems (B3) and (B4) result in the same portfolio weights, independently of whether the non-negativity constraints in parenthesis are fulfilled or not (i.e. short sales are excluded or not). In other words: the ERP is invariant to the *Bayes-Stein* transformation.

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Summary

Performance of International Portfolio Diversification Strategies: The Viewpoint of German and Hungarian Investors

In this paper, we study the benefits derived from international diversification of stock portfolios from the German as well as the Hungarian perspective. Seen from an ex post perspective the benefits for Hungarian investors from internationally diversified portfolios accrue in terms of reduction in risk while for German investors the benefits accrue also in terms of higher expected returns. By examining the performance of several ex ante strategies the paper also gives evidence of the benefits of international diversification for both countries. (JEL G11, G15)

Zusammenfassung

Die Performance internationaler Portfolio-Diversifikationsstrategien aus der Sicht deutscher und ungarischer Investoren

Diese Arbeit untersucht die Vorteilhaftigkeit der internationalen Diversifikation von Aktienportfolios aus der Sicht deutscher sowie ungarischer Investoren. Es wurden verschiedene Portfoliostrategien sowohl aus einer Ex-post- als auch Ex-ante-Perspektive betrachtet. Aus Sicht eines deutschen Investors kann die Ausweitung des Anlagespektrums auf internationale Aktienmärkte vor allem zu einer Steigerung der Rendite genutzt werden. Aus Sicht eines ungarischen Investors äußert sich eine internationale Diversifikation in einer Reduktion des Risikos.

Résumé

La performance de stratégies internationales de diversification de portefeuilles Point de vue des investisseurs allemands et hongrois

Cet article analyse les avantages de la diversification internationale des portefeuilles d'actions du point de vue des investisseurs allemands et hongrois. Différentes stratégies de portefeuilles y sont examinées, autant d'une perspective ex post qu'ex-ante. Pour un investisseur allemand, la diversification internationale du portefeuille aux marchés d'actions internationaux peut être avant tout utilisée pour accroître les rendements. Du point de vue de l'investisseur hongrois, une telle diversification se traduit par une réduction du risque.