Pairs Trading Arbitrage Strategy in the Old and New EU Member States

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Abstract
We analyze the return gained by pairs trading arbitrage strategy in Western and Eastern European capital markets and we find contrarian evidence to the weak form of market efficiency. The portfolios established during 250 day long test periods based on the cointegration selection of the pairs and traded for 125 days on out-of-sample data. The return between 1993 and 2013 are 16.98% and 20.74% in the Western end Eastern European markets respectively. We also evaluate the standard deviations of returns achieved by the strategy and the portfolios' correlations to the MSCI Europe, S&P 500 and the risk free rate and found low correlation. The portfolios' Sharpe-ratios for the full sample period are 0.57 (western) and 0.92 (eastern), but 1.89 and 1.39 in the last 10 years.

Keywords: pairs trading, asset pricing, cointegration, statistical arbitrage, market neutral
JEL codes: C53, G17

1. Introduction

Our paper is intended to study profitability on the European stock market using pairs trading strategy. Pairs trading is a market neutral statistical arbitrage strategy based on the convergence of stock prices. Stock pairs which present significant cointegration are selected, and then by adding equivalent long and short positions we create zero-investment portfolios; when the stock pairs abnormally deviate for a short period excess return can be gained. Based on previous studies (e.g. Gatev et al., 2003.), the strategy results in abnormal return. In our work, the portfolio profits of stocks traded on the European market are compared to the return of the MSCI Europe, S&P500 and the risk free rate. We use 20 years of market data and we divide the European sample into Western and Eastern European countries. As a result of our empirical study, we argue that the strategy yields an average annual return of 16.89% in Western Europe and 20.74% in Eastern Europe in the recent 20 years. In Western Europe, the standard deviation is 24.17%, and the Sharpe-ratio is 0.57. In Eastern Europe, the standard deviation is 19.12%, and the Sharpe-ratio is 0.92. Annual returns are calculated as simple arithmetic averages contrary to the proposition of Andor and Dülk (2013).

The applied pairs trading method is an investment strategy developed by Gerry Bamberger and Nunzio Tartaglia quantitative analyzers of Morgan Stanley against the perfect market of the Black-Scholes-Merton model appearing in the 1970s, which relies on the correction of market mispricing based on the convergence of prices and return to the historical trend.

In fact, the method is a relative pricing mechanism based on the Law-of-One-Price. In accordance with the definition by Ingersoll (1987), if different investments generate the same risk adjusted cash flow then they should be marketed at the same price. This observation was further developed by Chen and Knez (1995) by stating that two similar stocks that might not guarantee identical payments must be marketed also at similar prices. This concept was further developed by Elliott (2005) by replacing two different businesses with a single one and modeling the correlation between its internal value process and its market price with stochastic methods.

In the1980s, pair trading was one of the most successful investment strategies, and in accordance with Gatev et al. (2006), Morgan Stanley achieved a profit of $ 50 million by using the strategy still in 1987, then its efficiency reduced as a result of the intensifying spread of the method, and therefore the group of Tartalgia was dissolved by 1989.

One of the most comprehensive study of the profitability of the strategy was performed by Gatev et al. (2006) who made an analysis on the basis of daily figures available from July 1963 to December 2002 in their paper. The portfolio containing the twenty best pairs of the period covered by them generated an average monthly gross profit of approximately 1.44 percent (t-statistics=11.56), and their research also explored the significant differences between profits before and after the 1980s. While on the basis of data before the 80s the cost and risk adjusted average monthly net profit was 67 basis points, this reduced to 42 basis points in the period between 1988 and 2002.

In our opinion, the difference is explained not only by the extensive use of the strategy but also by the growth of stock market profits. They prove that pair trading has a better performance with low market prices than with high ones, and therefore the growth of stock market prices also significantly reduced the profitability of the strategy by the end of the 80s. In their scholarly paper Gatev et al. (2006) also prove that the portfolio is sensitive to parallel yield curve movements, and it results in higher profits in the case of a rising yield curve.

The study on the composition of the portfolio demonstrates that a portfolio with a higher number of components is more diversified, i.e. it has less standard deviation. While in the case of the best five pairs 124 out of the 474 months covered by the study resulted in losses, in the case of the best twenty pairs this number was only 71. During the back test, the yield generated by the strategy is double the yield of S&P 500 with less standard deviation. We note that this is a completely market neutral investment strategy since the portfolio is hardly sensitive to the systematic risk factors.

Following the article of Gatev et al. (2006), an analysis was made also on the daily stock ex-change index data of Taiwan in view of the pair trading strategy in 2005. Sandro (2005) examines the time series of 647 various companies of Taiwan between 4 January 1994 and 29 August 2002. The portfolio used during the back test contains the best twenty pairs with even weights. The results obtained during the research are significantly similar to the results obtained by Gatev et al. (2006). The average excess return of the portfolio built during the analysis of the prices of the TSEC is10.18% per year against the portfolio of the Taiwanese market, while the excess return is11.28% in the case of Gatev et al. (2006). On an average, 19.69 out of the best twenty pairs of the Taiwanese portfolio has on open position, whole in accordance with the analysis by Gatev et al. (2006) 19.30 out of the twenty pairs of the portfolio used by them could obtain a position.

The quantitative method used by the two analyses is based on the normalized daily returns:

$$\hat{P}_t^A := \prod_{\tau}^{t} 1 + r_\tau^A \tag{1}$$

The periods covered are divided into half-years (125 day) periods. Each half-year trading period is preceded by a 250 day observation period, and therefore the portfolio is adjusted on the basis of the new data every half year.

After calculating the $\hat{P}_t^A$ values of each company involved in the index, their standard deviations are calculated (i.e. the standard deviation of 127,750 time series for 500 listed stocks, and of 208,981 time series for 647 listed stocks), then the pairs are ranked on the basis of the standard deviations of the differences, and the twenty pairs with the least standard deviations are chosen for further examination. For the determination of the difference between two stocks

$$Cloeseness^{AB} := \sum_{t=1}^{250} \left(\hat{P}_t^A - \hat{P}_t^B\right)^2 \tag{2}$$

is introduced as an index number.

The opening times of the position are determined with a so-called trigger value

$$Trigger^{AB} = \pm 2\sigma\left(\hat{P}_t^A - \hat{P}_t^B\right) \tag{3}$$

The return on the pair containing stocks (A, B) is determined with the method of

$$I_t^{AB} = \begin{cases} 0 & closed\ position \\ 1 & short\ A, long\ B \\ -1 & long\ A, short\ B \end{cases}$$

$$r_t^{AB} = I_t^{AB}(r_t^B - r_t^A) \tag{4}$$

In the creation of the portfolio, each pair is taken into consideration with the same weight, and therefore the portfolio yield is:

$$r_t^{port} = \frac{1}{20}\sum_{i=1}^{20} r_t^{AB,i} \tag{5}$$

The strategy is further developed by Vidyamurthy (2006) who determine his portfolio by introducing another significant already existing concept. He considers short term deviations from the long term balance as a stationary noise, and this approach lead to the cointegration and the study of the cointegrity of the stock pairs. The study of Caladeira, Moura (2013) is run on the basis of this approach in which data of BM&FBOVESPA between Jan 2005 and Oct 2012 is examined. The portfolio determined by means of the VAR(p) model applied during the research results in an excess return of16.38% return against the given market portfolio. In our research, the study of the model described in the article of Caladeira, Moura (2013) using the Kernel Density Estimation method specified by Silverman (1982) based on the results of Vidyamurthy (2006) is performed in relation to the European markets.

2. Pairs Trading Strategy Model

The following concepts are defined for the description of our study. Operator **S** is called a back step if process$Y_t = X_{t-1}$ *is* assigned to process X_t .Process X_t is called ARMA(p,q) composite autoregressive moving average process if back step operator **S** has such

$$A(\mathbf{S})X_t = X_t - a_1X_{t-1} - \ ... - a_p\ X_{t-p} \tag{6}$$

$$B(\mathbf{S})X_t = b_0 + \ b_1\mathbf{S} + \ ... + b_q\mathbf{S}^q \tag{7}$$

polynomial elements where $n_0 \neq 0$and

$$A(\mathbf{S})X_t = \ B(\mathbf{S})\varepsilon_t \tag{8}$$

where$\varepsilon_t$is a white noise process.

Always A(**S**), B(**S**) polynomial elements with the lowest degrees are taken into consideration in the definition, which means also that A(**S**), B(**S**) polynomial elements have no common radical.

- If the radicals of A(**S**) polynomial member are beyond the unit circle then there is a stationary X_tARMA(p, q) process where

$$X_t = \sum_{i=1}^{p} a_iX_{t-i} + \sum_{j=1}^{q} b_j\ \varepsilon_{t-j} \tag{9}$$

is met, and it has MA(∞) form.

- If the radicals of B(**S**) polynomial element are beyond the unit circle then X_t has AR(∞) form, i.e. the process can be inverted.

Be d∈N, and X_t a stochastic process without a deterministic process and if it is differentiated d times then it has a stationary and invertible ARMA representation. Then X_t is d-th integrated process, and is marked as $X_t \sim$ I (d).
The X_t , $Y_t \sim$ I (d) time series are cointegrated if β, so thatX_t + β$Y_t \sim$ I (d − k) where 0 ≤ k ≤ d, k = d is an important special case of the above definition where here there is a perfect cointegration. It is a generator function of X_t ARMA process Ψ(**S**) = A(**S**)/B(**S**).

Be $X_1, X_2, \dots, X_n$the given time series and indicated as

$$A(\lambda) = \sqrt{\frac{2}{n}} \sum_{k=1}^{n} x_k \cos(\lambda k) \qquad B(\lambda) = \sqrt{\frac{2}{n}} \sum_{k=1}^{n} x_k \sin(\lambda k) \tag{10}$$

where

$$I_n(\lambda) = A^2(\lambda) + B^2(\lambda) \qquad -\pi \le \lambda \le \pi \tag{11}$$

function is a periodogram.

$$\left| \sqrt{\frac{2}{n}} \sum_{k=1}^{n} x_k \cos(\lambda k) + \sqrt{\frac{2}{n}} \sum_{k=1}^{n} x_k \sin(\lambda k) \right| = \frac{2}{n} \left| \sum_{k=1}^{n} x_k \mathrm{e}^{i\lambda k} \right|^2 \tag{12}$$

i.e. the periodogram is simply the 2/n-th the square of the Fourier transformed absolute value. Be X_t a Gauss white noise process where

$$\mathbf{E} I_n(\lambda_j) = 2\sigma_\varepsilon^2$$

$$\mathbf{D^2} I_n(\lambda_j) \begin{cases} 4\sigma_\varepsilon^4 & if\ 0 < j < n/2 \\ 8\sigma_\varepsilon^4 & if\ j = 0\ or\ n/2 \end{cases} \tag{13}$$

$$I_n(\lambda_j) \sim \begin{cases} \sigma_\varepsilon^2 \chi_2^2 & if\ 0 < j < n/2 \\ 2\sigma_\varepsilon^2 \chi_1^2 & if\ j = 0\ or\ n/2 \end{cases}$$

The empirical characteristic function of a probability variable with X unknown background distribution.

$$\hat{\varphi}(t) = \frac{1}{n} \sum_{j=1}^{n} e^{itx_j} \tag{14}$$

where$X_1, X_2, \dots, X_n$ is the statistical pattern.
It is reasonable to estimate the X background distribution with the inverse Fourier transform of a $\hat{\varphi}(t)$ empirical characteristic function, however, in the case of high *t* the inversion formula diverges due to the instability of a $\hat{\varphi}(t)$To keep the stability of $\hat{\varphi}(t)$the function is multiplied at each point by a $\Psi_h(t)$= Ψ(ht), Ψ(0) = 1 $\lim_{n\to\infty} \Psi(n) = 0$ attenuation function, and therefore the density function of*X* can be already estimated with the inverse Fourier transform of $\hat{\varphi}(t)\Psi_h(t)$ attenuated function.

$$\hat{f}_h(x) = \frac{1}{2}\int_{-\infty}^{\infty} \hat{\varphi}\Psi_h(t)e^{-itx}dt = \frac{1}{2\pi}\int_{-\infty}^{\infty}\frac{1}{n}\sum_{j=1}^{n} e^{-it(x_j-x)}\,\Psi(ht)dt =$$

$$\frac{1}{nh}\sum_{j=1}^{n}\frac{1}{2\pi}\int_{-\infty}^{\infty} e^{-it\frac{(x_j-x)}{h}}\Psi(ht)\,d(ht) = \frac{1}{nh}\sum_{j=1}^{n}\mathbf{F}_{\Psi}^{-1}\left(\frac{x-x_j}{h}\right)$$

A symmetric function K is called a core function if

$$K_h(x) = \frac{1}{h}K\left(\frac{x}{h}\right) \tag{15}$$

and ∃ such a Ψ function where $\mathbf{F}_{\Psi}^{-1}$(x) = K (x) is derived in note.

The approach of a density function of a variable with an unknown X background distribution by means of $X_1, X_2, \ldots, X_n$ independent realisation:

$$\hat{f}_h(x) = \frac{1}{n}\sum_{i=1}^{n} K_h(x - x_i) = \frac{1}{nh}\sum_{i=1}^{n} K\left(\frac{x - x_i}{h}\right)$$

where h is a scale parameter, K is a core function.
In the choice of h scale parameter, our aim is to minimize the expected square deviation: Z

$$h \coloneqq \arg\min_{h\in\mathbb{R}} \mathbf{E}\int \left(\hat{f}_h(x) - f(x)\right)^2 dx \tag{16}$$

If a standard normal core function is used the optimal scale parameter is

$$h = \left(\frac{4\hat{\sigma}^5}{3n}\right)^{\frac{1}{5}} \tag{17}$$

where$\hat{\sigma}$ is the empirical standard deviation.
The process defined with the following SDE is an Ornstein Uhlenbeck process:

$$dR(t) = \left(\alpha - \beta R(t)\right)dt - \sigma dW(t) \tag{18}$$

where α, β, σ > 0.

The closely interpreted solution of the Ornstein Uhlenbeck process:

$$R(t) \sim \mathcal{N}\left(e^{-\beta t}R(0) + \frac{\alpha}{\beta}\left(1 - e^{-\beta t}\right), \int_0^t \sigma e^{-2(t-s)\beta}\;\; ds\right) \tag{19}$$

and*R(t)* has a boundary distribution

$$\lim_{t\to\infty} R(t) \sim\ \mathcal{N}\left(\frac{\alpha}{\beta}, \frac{\sigma^2}{2\beta}\right) \tag{20}$$

Sharpe-ratios are calculated by the following equation:

$$\frac{\mathbf{E}(r_p) - r_f}{\sigma_f} \quad (21)$$

3. Applied Pairs Trading Strategy

Our aim is to find an investment strategy since our $X_t$portfolio value process submartingales. The pair trading strategy is constituted by two steps:

3.1. Selection of pairs

Our study covers 649 stocks which represents $\binom{649}{2}$potential pairs. We want to choose n pieces from these pairs so that the stock prices per pair viewed on the logarithmic can perfectly cointegrate .i.e. by pair $\exists \beta_i$so that

$$\ln S_t^{i,1} = \mu_i + \beta_i \ln S_t^{i,2} + \varepsilon_t^i \quad (22)$$

$$\ln S_t^{i,1} \sim I(d) \quad and \quad \ln S_t^{i,2} \sim I(d) \quad (23)$$

where d ∈ N, ε_t^i white noise ∀i∈ [0, n].

The study is performed for each possible pairs, the relevant linear regressions and the u_t^idifference processes are calculated (values β_i specified on the logarithmic scale is considered),

$$u_t^i = \ln S_t^{i,1} - \mu_i - \beta_i \ln S_t^{i,2} \quad (24)$$

then the stationarity of processes $u_t^i$is characterized with the ADF test statistics and the study of the periodogram. n pieces of stock pairs belonging to the strongest test statistics are considered in the next steps. The pairs are created after a 250 study period which is followed by a 125 day trading period.

3.2. Trading

We are about to create a market neutral portfolio with the cointegrating pairs determined in the above methodology. In the next step of the strategy is to calculate the value of$Z^{(i)}$, applying the Gauss core function$Z^{(i)}$, i ∈ {1, 2, . . . , n} density function estimations, and the periodograms are studied.

$$Z_t^{(i)} = \frac{S_t^{i,1} - \beta_i S_t^{i,2} - \mathbf{E}(S_t^{i,1} - \beta_i S_t^{i,2})}{\sigma(S_t^{i,1} - \beta_i S_t^{i,2})} \quad (25)$$

The opening and closing points of the position are determined by means of $Z_t^{(i)}$ values;

- If in the case of i. pairs at t time $Z_t^{(i)} > 2$, then a position is opened and a short position is added to $S_t^{i,1}$stock and a long position to $S_t^{i,2}$stock. If in the case ofi. pairs at t time $Z_t^{(i)} < -2$, then a position is opened and a long position is added to $S_t^{i,1}$stock and a short position to $S_t^{i,2}$ stock.

- If in the case of i. pairs and at t time $0.5 > Z_t^{(i)} > -0.5$, then the position is closed.

- In addition, stop-loss terms must be also integrated since an extremely high $Z_t^{(i)}$value cannot be considered accidental, and therefore the prices of i. stock pairs might not be perfectly cointegrated in the new larger data set. Besides, the approach to the average might slow down (the β(t) parameter of the modeling Ornstein Uhlenbeck process significantly reduces) thus we can stuck in a position for a very long time which is undesirable.

During the creation of the portfolio, the methodology of Caladeira, Moura (2013) is followed, and therefore certain stock pairs are taken into consideration identically in the case of several open positions. When the portfolio is changed we try to achieve a preliminarily set (m) total value. If a position is opened on a new pair then a sufficient part of the already existing positions is closed to obtain the same amount on each pair in the position, and if a position is closed then the weight of the other open positions is increased proportionally to the weight of the closed position and the number of the open positions. Our portfolio contains a maximum of 20 cointegrating stock pairs and the null hypothesis of the ADF statistics used for their stationarity study can be accepted with 95% safety. In our study, data of 250 days are followed, and these data are used to determine the pairs to be traded in the next 125 days. During the management of the portfolio, 125 day moving averaging is used to determine Z values in addition to4 stop loss levels, i.e. if $|Z_t| > 4$ then the position is closed.

In addition to the stop loss level, time limits are also integrated in accordance with the indexes which are 85 days for the Eastern European stocks, and 70 days for the Western European stocks. To determine the time limit, the time lines calculated from the Z values are approached with Ornstein Uhlenbeck processes, and the expected cutting time of these processes are taken into consideration.

4. Data

We use daily closing prices from 30.08.1993 to 30.08.2013. The stock prices are corrected with dividends and expressed in USD, they are available from Thomson Reuters Data Stream database. The stocks covered by the study contain the components of the main European indexes as of 6 September 2013 (see Table 1). These are 649 stocks at the end of the period. As the stock indexes reflects the actual content thus the data series is exposed to survivorship bias. The stocks has various lengths of time series, thus significantly less stocks were involved in the analysis at the beginning of the research than towards the end of the research. The inefficiency resulting from the decreasing number of stocks back to the starting periods can be observed on the yield curves.

Table 1: Variety of Stocks

Country	Nr. of Stocks	Country	Nr. of Stocks
England	100	Baltic nations	9
Austria	20	Cyprus	100
Belgium	20	Czech	50
Denmark	20	Poland	20
Finland	25	Hungary	13
France	40	Malta	20
Greece	20	Slovakia	5
Netherlands	25	Slovenia	7
Ireland	20		
Germany	30		
Italy	40		
Spain	35		
Sweden	30		

We do not make restrictions that the stock must to belong to similar industries, we base the generation of pairs only on cointegration results.

5. Results

5.1. Absolute and excess returns

During the analyses, the above strategy is applied to study the Eastern and Western European stock market prices. In the Western European stock markets in the recent 20 years, 338% cumulative return is achieved by the strategy, thus an average gross return of 16.98% per year. The standard deviation of the annual returns is 24%. The average length of the positions is 35 days with a standard deviation of 33 days. During the study of the Eastern European stocks in the recent 20 years, 414% cumulative return is achieved, and this results an average annual gross return of 21%. The standard deviation of the annual returns is 19% and the average length of the positions is 39 days with a standard deviation of 45.8 days. The annual results and the standard deviations of the annual returns are presented in Table 2.

Table 2: Annual returns of the strategy

Year	W. Europe P. T.	E. Europe P. T.	W. Europe Excess MSCI	E. Europe Excess MSCI	W. Europe Exc. Risk Free	E. Europe Exc. Risk Free
1993	-0.01	0.30	-0.16	-0.03	-0.03	0.27
1994	-0.07	0.86	-0.12	-0.11	-0.11	0.82
1995	0.25	0.14	-0.06	0.19	0.19	0.08
1996	0.33	0.40	0.02	0.28	0.28	0.34
1997	-0.23	0.17	-0.24	-0.29	-0.29	0.12
1998	0.79	0.22	0.67	0.74	0.74	0.16
1999	0.30	-0.08	0.44	0.25	0.25	-0.13
2000	-0.06	0.19	0.09	-0.12	-0.12	0.13
2001	0.34	0.27	0.59	0.30	0.30	0.23
2002	0.70	0.07	0.21	0.69	0.69	0.05
2003	0.11	0.08	-0.12	0.10	0.10	0.07
2004	0.07	0.20	-0.02	0.05	0.05	0.19
2005	0.06	0.14	-0.17	0.03	0.03	0.11
2006	0.15	0.09	0.09	0.10	0.10	0.04
2007	0.11	0.13	0.59	0.06	0.06	0.08
2008	0.03	0.27	-0.27	0.01	0.01	0.25
2009	0.14	0.03	0.17	0.14	0.14	0.03
2010	0.10	0.18	0.14	0.10	0.10	0.18
2011	0.18	0.11	0.11	0.18	0.18	0.11
2012	0.09	0.38	0.02	0.09	0.09	0.38
Avg.:	16.98	20.74	9.89	13.77	13.77	17.54
Std.:	24.17	19.12	27.79	24.17	24.17	19.05

We calculate the excess returns as each year's pairs trading portfolio return minus the actual year's market return. The returns show excess above MSCI Europe by 9.89% and 13.77% for the Western and Eastern European portfolio respectively. The average annual excess returns above the risk free rate are 13.77% and 17.54%. We prefer to use the risk free rate as a benchmark, as we can see in Section 5.3. the very low correlation to market returns, which imply the market neutrality of the portfolio.

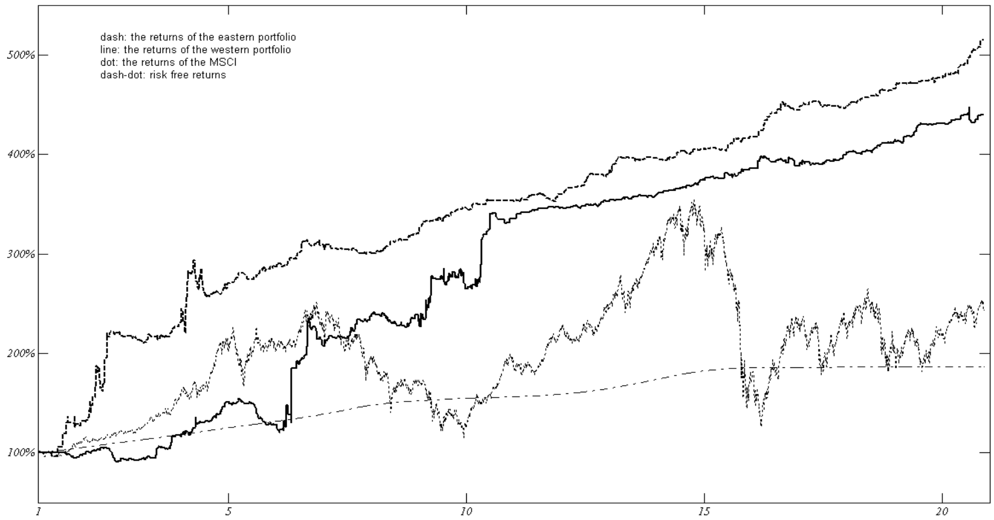
It is also worth to study the results in sub-periods, especially to have an idea about the standard deviation of the process. Our results show for Western Europe a 23.53% return for the first 10 years and 10.43% returns for the second 10 years. The standard deviations are 33.43 and 4.54for the Eastern and the Western European market respectively. If we examine the Eastern European portfolio than the returns are 25.34% in the first 10 years and 16.15% in the second 10 years. The standard deviations are 24.89 and 10.27.

This difference in the standard deviation is due to the smaller number of same-time-traded stocks in the first period. The amount of money in the portfolio is always equal to the total amount of investment, even if there is only one open position. When the numbers of open positions are just few than the standard deviation of the portfolio is higher. The second period of the study reflects better a real-life portfolio as the numbers of open positions are higher, the equity is better distributed and the diversification effect produces less standard deviation.

We can examine the above process by Figure1. The returns are above the benchmark levels and there is visually less standard deviation in the second part of the period.

Figure 1: Plot of returns

(bold: western portfolio return, plain: eastern p. r., light: MSCI returns, dash: risk-free rate)



5.2. Risk and risk adjusted returns

We are not only interested in the absolute and relative returns but also in the risk adjusted return of the portfolio. We measure the risk as the standard deviation of the portfolio and so we use the Sharpe-ratio to compare the risk adjusted return to different portfolios.

3. Table: Sharpe-ratios of the portfolio

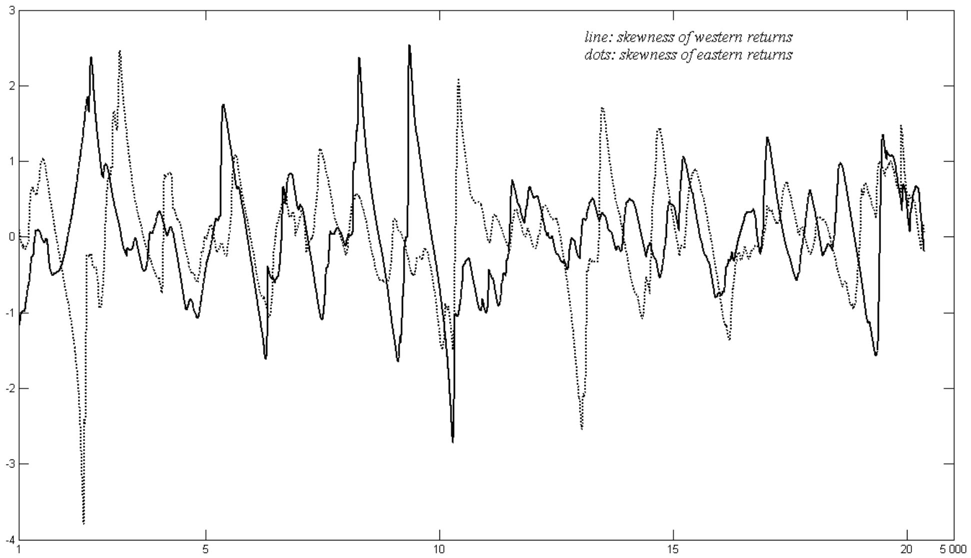
	1993-2003	2004-2013	1993-2013
Western Europe Sharpe-ratio	0.56	1.89	0.57
Eastern Europe Sharpe-ratio	0.83	1.39	0.92
MSCI Europe Sharpe-ratio	0.21	0.15	0.18

As the Table 3 shows, the Sharpe ratio of the investigated portfolios in the two sub-periods are significantly different. This is due to the above expressed difference in the standard deviations. In the second sub-period we find 1.89 and 1.39 ratios which result shows a very high value compared to the market proxy. In the first period these ratios are just slightly above the ratios which are observable on the market; however in the second period significantly higher than the average ratios on the stock market.

Gatev et al. (2006) shows that Sharpe-ratios can be misleading when considering risk adjusted returns, as the negatively skewed return distribution can increase the Sharpe-ratios. We find in both European regions positive skewness which indicates lower than reasonable Sharpe-ratios.

4. Table: Plot of skewnesses

(bold: skewness of western returns, plain: skewness of eastern returns)



5.3. Correlation of the portfolio

The above figure clearly indicates that the pairs trading portfolios resulted in higher returns and have less standard deviations in case of both stock indexes. The correlation between the yield curves are indicated in the following table.

5. Table: Covariance matrix

	Western Europe P.T.	Eastern Europe P.T.	MSCI Europe	S&P500	Risk Free
Western Europe P. T.	1	0.003	-0.01	0.019	0.003
Eastern Europe P. T.	0.003	1	-0.02	0.012	0.02
MSCI	-0.01	-0.02	1	0.276	0.032
S&P500	-0.019	-0.012	0.276	1	0.18
Risk Free	0.003	-0.02	0-032	0-018	1

One of our aims is to prove the strategies market neutrality as defined by Alexander and Dimitriu (2002). Returns were set against the MSCI Europe, S&P 500 and the risk free rate and show low correlations against them as presented in the Table 5. This result means that the portfolio is not dependent on market movements and so it is market neutral.

5.4 Biases and constrains

The results show upwards biases in relation to bid-ask spreads, trading costs and short selling cost. The database and the return are exposed to survivorship bias.

6. Conclusion

In this paper we examine the Eastern and Western European stock market based on the pairs trading statistical arbitrage strategy. Our aim was to explore the mean reversion nature of the highly cointegrated pairs and establish a trading strategy, with predefined entry and exit points. The database includes 20 years of European stock prices. The results show excess return above the MSCI Europe index by 9.89 and 13.77. Sharpe-ratios were 0.56 and 0.83 for the entire twenty years, but 1.89 and 1.39 in the recent ten years. We also examined the correlation between our results and the market return. We found low correlation to the MSCI Europe, S&P 500 and to the risk free rate, confirming the strategies market neutrality.

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