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PAIRS TRADING STRATEGY IN DHAKA STOCK EXCHANGE: IMPLEMENTATION AND PROFITABILITY ANALYSIS

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ABSTRACT

The objective of this study is to develop a financially profitable Pairs trading model for trading in Dhaka Stock Exchange. Pairs Trade is a statistical arbitrage investment strategy. The study used daily stock prices of a sample of 20 stocks listed in Dhaka Stock Exchange. The research first identified a pair of stocks whose prices have a long-run equilibrium using Johansen's test for cointegration. The cointegrated stock pair is then modeled using a Vector Error Correction Model. The residual obtained from the estimated model serves as the guide to implementing Pairs Trading Strategy. The research finally identified three pairs of stocks which have general long-run equilibriums. Based on the residual series of these pairs, we implemented pairs trading strategy for a period of one to two months using real time data but doing hypothetical trading. It generated significant returns for all trades carried out using both in-sample and out-of-sample data. Given that Bangladesh stock market is frequently subjected to unprecedented volatility, a market-neutral investment strategy like Pairs Trading can be a valuable option to retail and institutional investors. We recommend undertaking policy initiatives required to allow investors to utilize this strategy in Bangladesh.

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Keywords: Pairs trading, Cointegration, Vector error correction model, Statistical arbitrage, Mean reversion, Market neutral strategy, Profitability analysis, Dhaka stock exchange.

JEL Classification: C32; C52; G10.

Contribution/ Originality

Previous studies on Pairs Trading Strategy focused on developed stock markets. To the best of our knowledge, current literature does not cover profitability of Pairs Trading Strategy in a developing stock market, which poses additional risks like illiquidity, fewer choices of stocks etc.

This study is the first to empirically confirm the profitability of the strategy in a developing stock market – Dhaka Stock Exchange.

1. INTRODUCTION

Pairs Trading strategy is an investment strategy pioneered by Gerry Bamberger and quantitative analyst Nunzio Tartaglia of global investment bank, Morgan Stanley in the 1980s. They teamed up with a set of physicists, computer scientists and mathematicians in order to develop statistical rules to find ways to implement arbitrage trades and take the "skill" out of trading according to Gatev (2006).

Pairs trading strategy works by taking the arbitrage opportunity of temporary irregularities between prices of related assets which generally have a long-run equilibrium. Gatev (2006) explained that when such an event occurs, one asset will be overvalued compared to the other asset. A trader can then create a two-asset portfolio or a "Pair" where a short position[1] is taken in the over-valued asset and a long position[2] is taken on the under-valued one. The trade is completed or closed by taking an exit strategy in each of the positions when the two assets have returned to their original or long run equilibrium path – therefore this strategy utilizes the concept of "mean reversion" as stated by Hillebrand (2003). The profit is thus captured from the short-term or temporary anomaly that arises in a pair of asset prices. Vidyamurthy (2004) stated that because this movement to and away from the long-run equilibrium relationship between a pair of financial assets does not depend on the movement of the overall market, pairs trading strategy is a market-neutral investment strategy. The objective of this research is to develop a financially profitable Pairs trading model with pairs of stocks in Dhaka Stock Exchange (DSE). Since Bangladesh stock market has historically experienced extreme volatility, a market-neutral investment strategy can be a valuable option to retail and institutional investors. The study first identifies pairs of stocks for pairs trading using Johansen's Test for cointegration. The pair of stocks is then modeled using a Vector Error Correction Model (VECM). The estimated VECM will then give a residual series which will act as the primary guide for implementing a Pairs Trade.

This paper is divided into five sections. Section one gives the introduction while the second section discusses literature review on Pairs trading and relevant estimation methods. The third section explains rationale of data classification and methodology used in this study. Section four presents empirical results of this research and the final chapter draws relevant conclusions.

[1] Going short implies selling financial securities that are not owned, with the goal of eventually re-purchasing them at a lower price in future.

[2] A long position in an asset is an investment concept of a person or entity owning a security, such as a stock or a bond, to make profit if the price of the asset appreciates.

2. REVIEW OF LITERATURE

2.1. Key Concepts in Pairs Trading Strategy

The concept of market-neutrality is critical to the benefits of Pairs trading. Nicholas (2000) stated that these strategies seek to neutralize certain market risks by taking offsetting long and short positions in instruments which have an actual relationship. This means that these approaches actually limit exposure to systematic risk[3] in asset prices due to fundamental drivers like macroeconomic changes, industry-specific shifts, investor sentiment etc.

Because one position is taken considering another position to reduce directional risk exposure, these strategies hedge against market risk. In other words, exposure to market is replaced by exposure to association between the long and short calls. One must be clear about the fact that this does not mean that pairs trading is a risk-free strategy. There are several risks associated with it also[4]. However, Fung (1999) determined that such risks are different than traditional risks that are associated with only long investing. Pairs trading strategy reduces the directional risk by going long on one stock and short on another. The value of both investments must be equal in order to equally divide dependence on long and short calls. Since, it does not matter whether the market goes on a bear[5] or a bull run[6], directional risk is removed. Profits ultimately depend on the difference in price changes between the two stocks, regardless of market movement.

We now explain the relevance of mean reversion in this research. Schmidt (2008) stated that mean reversion in stock prices is the assumption that a stock's highs and lows are temporary and a stock's price will tend to move to an average price over long-run. When the price is less than its average price, the stock is considered attractive for buying and when the price is above its average, it is considered suitable for selling. Pairs trading strategy depends largely on long-run equilibrium or cointegration between two variables. Cointegration incorporates mean reversion into a pairs trading framework. If the value of a portfolio is known to move around its mean, than the deviations from this equilibrium can be capitalized upon. Cointegrated time-series variables can be modeled in a Vector Error Correction Model according to the Granger Representation Theory introduced by Granger (1987).

2.2. Estimation Methods and Profitability of Pairs Trading Strategy

Muslumov (2009) used the distance-approach, to test Pairs trade in Istanbul Stock Exchange (ISE). To implement this method, he first computed the normalized series of prices using the following formula:

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[3] Systematic risk is a type of risk inherent in an entire market.

[4] Major risks in Pairs Trading include necessity of proper market-timing and lack of desired volume.

[5] Bear run is a market condition in which the prices of securities are falling, and widespread pessimism causes the negative sentiment to be self-sustaining.

[6] Bull run is a financial market of a group of securities in which prices are rising or are expected to rise.

$$P*_{it} = \frac{P_{it} - E(P_{it})}{\sigma_i} \qquad (2.1)$$

P* is the normalized price of asset i at time t. E(P) is the expectation of P and σ is the standard deviation of respective stock price. Distance between the main asset and the pair assets were generated by the following formula:

$$D = PA - MA \qquad (2.2)$$

Where D is the distance between the normalized series of prices of PA and MA; PA is the Pairs asset and MA is the main asset. From equation 2.2, one can get the sum of the squares of distances as shown in equation 2.3.

$$DS = \sum_{i=1}^{n} (PA_i - MA_i)^2 \qquad (2.3)$$

In the 12 months pair formation (training) period all stocks traded on the ISE are selected, except those with more than five non-traded days. In the pairs formation process, no restriction (such as industry, size etc.) was imposed. By considering only minimum distance criteria, any stock could be paired with any other stock. The distance-based pairs trading methodology gave an average excess return of 5.4% for the top 20 best pairs trading portfolio.

Gatev (2006) also used the distance-based approach to test Pairs trade using daily data from the period 1962 to December 2002. They constructed a cumulative total returns index for each stock over the formation period and then chose a matching partner for each stock by finding the security that minimized the sum of squared deviations between the two normalized price series. Stock pairs were formed by exhaustive matching in normalized daily "price" space, where price included reinvested dividends. In addition to "unrestricted" pairs, the study also provided results by sector, where they restricted stocks to belong to the same broad industry categories defined by S&P. This acted as a test for robustness of any net profits identified using the unrestricted sample of pair trades. Average annualized excess returns were found to be as high as 11% for self-financing portfolios of pairs. Broussard (2012) investigated the practical issues of implementing the self-financing pairs portfolio trading strategy presented by Gatev (2006). They provided new evidence on the profitability of pairs trading under different weighting structures and trade initiation conditions. Using data from the Finnish stock market over the period 1987–2008, they found pairs trading to be profitable even after allowing for a one day delay in the trade initiation after the signal. On average, the annualized return was as high as 12.5%.

Schmidt (2008) carried out a study on pairs trade in the Australian Stock Market where he used cointegration tests to identify pairs of stocks and then modeled the residual as a Vector Error Correction Model. However, he did not aim to produce a profitable portfolio of a pairs stock. Instead, he focused on a theoretically sound model which could be applied to a practical scenario. The plots of the residual series from his study identified a high rate of zero crossing and large deviations around the mean. This implied profitable Pairs Trading was possible with his model.

Unlike Vidyamurthy (2004), who used the 2-step Engle-Granger method for cointegration, Schmidt (2008) used a different test for identifying cointegrated stocks. This is because he identified that apart from being rather ad hoc, Vidyamurthy's approach may be exposed to errors arising from the econometric techniques employed. Firstly, the 2-step Engle-Granger procedure used by Vidyamurthy (2004), rendered results sensitive to the ordering of variables; therefore the residuals may have different sets of statistical properties. Secondly, if the bivariate series is not cointegrated, the end result may turn out to be a set of spurious regressions. Consequently, he used Johansen's Cointegration approach. Puspaningrum (2009) attempted to identify the optimal pre-set boundaries for Pairs Trading Strategy using cointegration technique. The objective was to develop a numerical algorithm to estimate the average trade duration, the average inter-trade interval, and the average number of trades and then use them to find the optimal pre-set boundaries that would maximize the minimum total profit for cointegration error following an AR(1) process.

Finally, Bogomolov (2010) compared profitability of the strategy in the Australian stock market using three estimation techniques – distance method, cointegration method and stochastic spread method used by Elliott (2005). All approaches showed statistically significant monthly excess returns on committed capital before transaction costs. However, transaction costs badly affected all three strategies – especially the method based on stochastic spread.

3. DATA AND METHODOLOGY

Data used in this study was from DSE. It comprised of daily prices of 20 stocks (see Table 11 in Appendix) listed in DSE. A total of 243 days of observations were used for estimation[7]. The sample used for estimating the model was one year's time period starting from 24/9/2012 to 30/9/2013. The weekends and public holidays were omitted as the stock market was closed.

Two major considerations were taken into account when organizing the dataset. First, the research was restricted to highly traded stocks in the market. The study searched and identified 20 of the most liquid[8] stocks and used them for this study. This was done by taking the daily volume[9] of all stocks listed in DSE, and then sorting according to highest average volume for the period concerned. This is because Pairs trading depends on perfect market timing for buy-sell decisions. However, many stocks in Dhaka Stock Exchange are illiquid, meaning their shares are much tougher to obtain at the desired quantity. If such shares are included in trading, additional risk arises because one may not be able to buy (or sell) desired number of stocks when indicated by the model. The second step in data classification was organization of stocks according to the same sector or industry. By restricting trading pairs to stocks from within the same industry it was assumed that these stocks would have similar exposures to systematic risk, or beta. Thus the resulting portfolio should have a beta close to zero. Estimation methodology used in this study is divided into two parts. First part was the process of identifying a pair of stocks using Johansen's test for Cointegration. The second part introduces the VECM and illustrates why it is necessary to

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[7] Observations were converted to first difference form to ensure stationarity.

[8] Liquid stocks are defined as those with daily average volume of 100,000 traded in DSE. Liquidity of all twenty stocks in the sample is shown in Table 11 in Appendix.

[9] This is the number of stocks of particular company traded in a day. The information is available in the website of DSE.

model cointegrated pairs of stocks. Once the VECM is estimated, the study obtained a series of residuals and used that as the necessary guide to implementing the strategy.

3.1. Testing for Cointegration: Johansen's Test approach

We used Johansen (1988) test for cointegration to identify stock pairs with long-run equilibrium. This test estimates the VECM using maximum likelihood under several assumptions about the trend or intercepts, parameters, and the number of cointegrating vectors, denoted by r, and then conducts likelihood ratio tests. One test proposed by Johansen (1988) for the vector r is the Trace-statistic test. This test is based on the log-likelihood ratio ln[Lmax(r)/Lmax(k)], and is conducted sequentially for r = k-1,...,1,0. The name comes from the fact that the test statistic involved is the trace (= the sum of the diagonal elements) of a diagonal matrix of generalized Eigen-values. This test investigates the null hypothesis that the cointegration rank is equal to r against the alternative that the cointegration rank is k. The latter implies that X_t is trend stationary.

Johansen's test was implemented using daily data of stock price with an acceptable occurrence of type-1[10] errors set at 5%. Trace statistic was used to identify presence of cointegration between stock pairs. A trace statistic greater than the 5% critical value indicated a cointegrating relationship between the two variables. Trading pairs were retained if their p-values were less than 5%. Lastly, Johansen's test also generated "normalized cointegrating coefficients" which gave the necessary information on which stock to long, and which one to short. The higher of the two cointegrating coefficients will imply suitability for a long position, while the other for short position.

3.2. Estimation Using VECM

Rather than using the general Vector autoregression (VAR) model, we used the VECM for estimation since it includes an error-correction component which considers the presence of a cointegrated relationship between two time-series variables. The error terms in the model reflect that part of the variables that are unrelated to its lagged values. This is the "unpredictability" in each variable. This "unpredictability" is generally correlated with each other due to perhaps a causal relationship according to Davidson (1978). To illustrate the VECM, as shown by Schmidt (2008), consider two stock prices denoted by y_t and x_t:

$$\Delta y_t = \alpha_1(\beta_1 x_{t-1} + \beta_2 y_{t-1}) + c_{11}\Delta y_{t-1} + c_{12}\Delta x_{t-1} + u_t + v_t \quad (3.3a)$$

$$\Delta x_t = \alpha_2(\beta_1 x_{t-1} + \beta_2 y_{t-1}) + c_{21}\Delta x_{t-1} + c_{22}\Delta y_{t-1} + \varepsilon_t + v_t \quad (3.3b)$$

Where, α = speed of adjustment to equilibrium

β = cointegrating co-efficient

Equation 3.3a and 3.3b illustrates the VECM. The error correction comes from the cointegrating relationship. The betas contain the cointegrating equation and the alphas the speeds of

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[10] A type I error (or error of the first kind) is the incorrect rejection of a true null hypothesis. It is a false positive. Usually a type I error leads one to conclude that a supposed effect or relationship exists when in fact it doesn't as defined by Sheskin (2004).

adjustment. If y_t and x_t are far from their equilibrium relationship, either y_t or x_t or both must change in order to restore the equilibrium relationship between the two variables. One significant aspect of understanding and implementing a VECM is between the “unpredictability” terms “v” and underlying exogenous, orthogonal shocks to each variable, which we shall call “ε” and “u” respectively for each variable. The “unpredictability” in y_t is that part of the variable which cannot be predicted by lagged values of y or x. A portion of this unpredictability in y_t may be caused due to ε_{ty} , an exogenous shock to y_t that is completely unrelated or independent of any behavior exhibited by variables x_t, y_t or in fact any other variable if it were to be included in the system. Finally, the estimated VECM was rearranged to obtain the residual series as shown in equation 3.4.

$$E_t = \alpha y_t - \beta x_t + c \qquad (3.4)$$

Where, E_t= Residual

When the value of the residual is significantly below 0, the trader will take a long position on the under-performing stock and when it is significantly higher than 0, the trader takes a short position on the out-performing stock. Finally, the trader closes the positions when the residual is at or nears 0 (See Figure 1 below).

4. EMPIRICAL RESULTS

We now present the findings from the study. First, the output from cointegration test is shown in Table 1 below. Then, for cointegrated pairs, the estimated VECM and corresponding residual series are shown. The study then uses real-time data and conducts hypothetical trading to test profitability of Pairs Trading.

Figure-1. Illustration of Pairs Trade Strategy using Residual Series Values

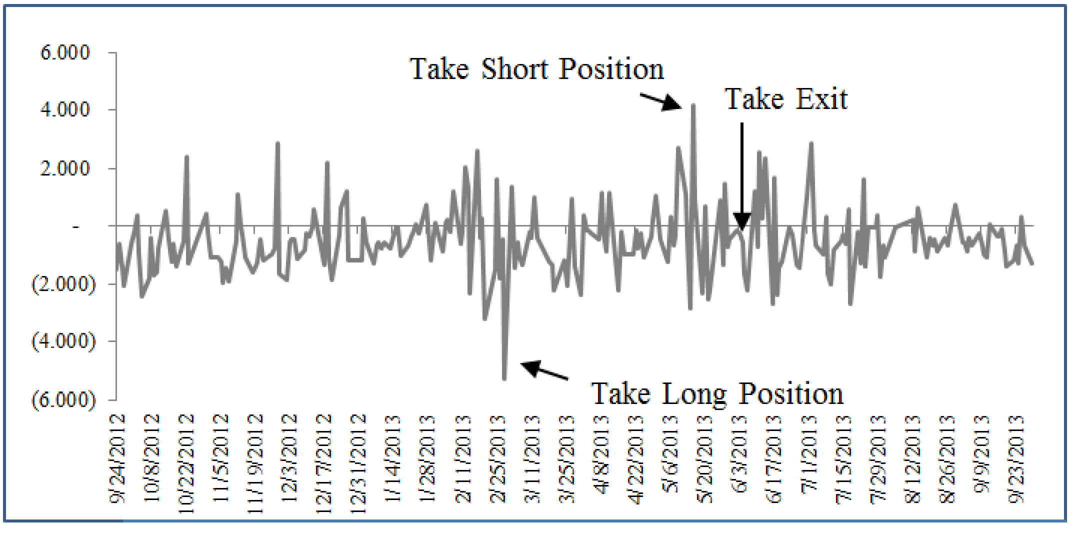

Table-1. Johansen's Co-Integration Test Results

	Stock Ticker	Trace Statistic	5% Critical Value	p-value	Normalized Co-integrating Coefficients
Pair 1	Activefine	18.15406	15.49471	0.0194	1.000000
	Pharmaid				-0.519327
Pair 2	Gbbpower	15.53677	15.49471	0.0493	1.000000
	Kpcl				2.192939
Pair 3	Titasgas	15.95171	15.49471	0.0427	1.000000
	Bdwelding				10.64156

Table 1 shows positive results for cointegration between two stock prices based on trace statistics. All three cointegration results are statistically significant at 95% confidence level. For each pair, the stock with the higher cointegrating coefficient was used for long position[11], and the one with lower value was used for taking short position.

Each of these stock pairs was modeled using a VECM to obtain the residual series. The model estimated for Pair 1 is shown in equation 4.1[12].

$$D\,(ACTIVEFINE) = C(1) * \left(ACTIVEFINE(-1) - 0.479960438913 * PHARMAID(-1) + 2.5423410255\right) + C(2) * D\left(ACTIVEFINE(-1)\right) + C(3) * D\left(ACTIVEFINE(-2)\right) + C(4) * D\left(PHARMAID(-1)\right) + C(5) * D\left(PHARMAID(-2)\right) + C(6) \quad (4.1)$$

Table-2. VECM estimates for Pair 1

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.033926	0.012894	-2.6312	0.0091
C(2)	0.03831	0.069693	0.549699	0.5831
C(3)	0.013942	0.069555	0.20044	0.8413
C(4)	0.009267	0.023303	0.397671	0.6912
C(5)	-0.030545	0.022997	-1.3282	0.1854
C(6)	0.070446	0.135079	0.521517	0.6025
S.E. of regression	2.08959		Akaike info criterion	4.3365
Sum squared residuals	1021.735		Schwarz criterion	4.42351
Log likelihood	-514.3795		Hannan-Quinn criter.	4.37156
Durbin-Watson stat	1.986967			

Assessing statistical significance from table 2, and rearranging according to equation 3.4, the residual series for Pair 1 is shown below.

$$R_{AP} = D(ACTIVEFINE) - (-0.033926 * \left(ACTIVEFINE(-1)\right) \quad (4.2)$$

The model for Pair 2 is shown in equation 4.3.

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[11] Because the higher cointegrating coefficient implied its price will appreciate in the long-run relative to the other asset; the lower cointegrating coefficient implied its price will fall in the long-run relative to the other asset.

[12] In equation 4.1 to 4.6, “D” denotes first-difference form and the expression Variable(-1)/(-2) denotes lagged values to first or second period of a particular variable.

$$D(KPCL) = C(7) * (GBBPOWER(-1) + 3.05040807582 * KPCL(-1) - 186.008031019) + C(8) * D(GBBPOWER(-1)) + C(9) * D(GBBPOWER(-2)) + C(10) * D(KPCL(-1)) + C(11) * D(KPCL(-2)) + C(12) \quad (4.3)$$

Table-3. VECM estimates for Pair 2

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.014164	0.005767	-2.45619	0.0004
C(2)	-0.019181	0.101811	-0.1884	NA
C(3)	0.107924	0.100618	1.072615	0.2845
C(4)	-0.064485	0.088615	-0.7277	0.4675
C(5)	-0.008241	0.087581	-0.09409	0.9251
C(6)	-0.043633	0.073884	-0.59057	0.5554
S.E. of regression	1.138945		Akaike info criterion	3.12276
Sum squared residuals	303.5437		Schwarz criterion	3.20978
Log likelihood	-368.7316		Hannan-Quinn criter.	3.15783
Durbin-Watson stat	1.996477			

Residual series for Pair 2 is shown in equation 4.4.

$$R_{KG} = D(KPCL) - (-0.014164 * (GBBPOWER(-1)) \quad (4.4)$$

The model for Pair 3 is shown in equation 4.5.

$$D(TITASGAS) = C(1) * (TITASGAS(-1) + 10.5335364118 * BDWELDING(-1) - 313.426704686) + C(2) * D(TITASGAS(-1)) + C(3) * D(TITASGAS(-2)) + C(4) * D(BDWELDING(-1)) + C(5) * D(BDWELDING(-2)) + C(6) \quad (4.5)$$

Table-4. VECM estimates for Pair 3

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.007158	0.002815	-2.54285	0.0004
C(2)	-0.08475	0.067269	-1.25987	NA
C(3)	-0.014946	0.067039	-0.22294	0.8238
C(4)	0.180603	0.138835	1.300849	0.1946
C(5)	-0.079583	0.140888	-0.56487	0.5727
C(6)	-0.037374	0.108118	-0.34567	0.7299
S.E. of regression	1.671128		Akaike info criterion	3.88956
Sum squared residuals	653.4844		Schwarz criterion	3.97657
Log likelihood	-460.7468		Hannan-Quinn criter.	3.92462
Durbin-Watson stat	1.993417			

Residual series for Pair 3 is shown in equation 4.6.

$$R_{TB} = D(TITASGAS) - (-0.007158 * (TITASGAS(-1)) \quad (4.6)$$

Using the equations for the residual series and real-time data, Pairs Trading Strategy was carried out to test for profitability. To illustrate the profitability of this strategy, the study used real-time data and assigned a hypothetical monetary investment of BDT 100,000 invested equally between long and short positions. Since the returns generated from each pair were in varying time-periods, they were annualized using a common mathematical formula called Annualized Return as outlined by Strong (2008):

$$Annualized\ Return = (1 + Percentage\ return)^{\left(\frac{1}{Number\ of\ Years}\right)} - 1$$

Profitability analysis was carried out using both in-sample and out-of-sample data using each pair.

Table-5. Pairs Trading with Pair 1 using in-sample data

Stock Name	**Pharmaid**	**Activefine**
Monetary Amount (BDT)	50,000	50,000
Entry Date	9/25/2012	10/17/2012
Residual Value (At entry date)	19.77	-16.47
Trading Price (At entry date)	205.0	74.0
No of Shares at Trading price[13]	244	676
Exit price (When residual returns to or nears 0)	164.00	75.00
Gain (BDT)	10,000	-676
Net Gain from Pairs Trade (BDT)	9,324.3	
Return (%)[14]	9.32%	
Date of Exit	10/17/2012	
Duration (Days)	22	
Annualized Return (%)	*339%*	

Table-6. Profitability Analysis for Pair 1 using out -sample data

Stock Name	**Pharmaid**	**Activefine**
Monetary Amount (BDT)	50,000	50,000
Entry Date	1/11/2011	1/18/2011
Residual Value (At entry date)	3,805	-372
Trading Price (At entry date)	3,990.0	92.0
No of Shares at Trading price	13	543
Exit price (When residual returns to or nears 0)	2,684.00	88.00
Gain (BDT)	16,366	-2,174
Net Gain from Pairs Trade (BDT)	14,192	
Return (%)	14.19%	
Date of Exit	2/2/2011	
Duration (Days)	22	
Annualized Return (%)	804%	

Table 5 and Table 6 show details of Pairs Trading Strategy with Pair 1 (ACTIVEFINE & PHARMAID). We assumed that the out-sample data holds the same cointegrating relationship as the in-sample data so that pairs trading strategy could be applied to both datasets in exactly the same manner. Long and short positions were taken according to trading guidelines discussed before. The strategy yields net profit of 9.3% for in-sample data and 14.2% for out-sample data. Duration of the strategy is 22 days for both trades, resulting in annualized returns in excess of

[13] No of Shares = Monetary Amount/Trading price

[14] Net Gain from Pairs trade/Total Initial investment

300% and 800% respectively[15]. Note that the trader has not gained from both the long and short positions. Rather, the gain from one position is greater than the loss from the other, resulting in a net gain.

Table-7. Pairs Trading with Pair 2 using in-sample data

Stock Name	**Kpcl**	**Gbbpower**
Monetary Amount (BDT)	50,000	50,000
Entry Date	11/11/2012	10/23/2012
Residual Value (At entry date)	-1.92	2.40
Trading Price (At entry date)	49.0	43.0
No of Shares at Trading price	1,020	1,163
Exit price (When residual returns to or nears 0)	51.00	34.0
Gain (BDT)	2,041	10,465
Net Gain from Pairs Trade (BDT)	12,505	
Return (%)	12.5%	
Date of Exit	7/22/2012	
Duration (Days)	22	
Annualized Return (%)	606%	

Table-8. Pairs Trading with Pair 2 using out -sample data

Stock Name	**KPCL**	**GBBPOWER**
Monetary Amount (BDT)	50,000	50,000
Entry Date	7/4/2012	7/18/2012
Residual Value (At entry date)	-2.05	2.52
Trading Price (At entry date)	50.0	28.0
No of Shares at Trading price	1,000	1,786
Exit price (When residual returns to or nears 0)	50.00	27.0
Gain (BDT)	0	1,786
Net Gain from Pairs Trade (BDT)	1,786	
Return (%)	1.79%	
Date of Exit	7/22/2012	
Duration (Days)	20	
Annualized Return (%)	38%	

Table 7 and Table 8 show details of Pairs Trading Strategy with Pair 2 (KPCL & GBBPOWER). As before, both in-sample and out-of sample data yield net profits. Net profit was generated from both short and long positions using in-sample data. For the out-sample data, the long position did not yield any profit when the equilibrium was restored. Only the short position yielded a net profit when the residual returned to 0. While the in-sample trade yielded net return of 12.5%, the out-sample data generated net return of only 1.79%. The duration of the in-sample and out-sample trades were 22 and 20 days respectively.

[15] One must remember that the annualized return is simply a tool we used to standardize the returns. Such returns are only possible if two asset prices experience exactly the same disequilibrium and return to equilibrium as shown in the trade, once every 22 days.

Table-9. Pairs Trading with Pair 3 using in-sample data

Stock Name	**Titasgas**	**Bdwelding**
Monetary Amount (BDT)	50,000	50,000
Entry Date	10/2/2012	11/28/2012
Residual Value (At entry date)	6.22	-7.29
Trading Price (At entry date)	92.7	23.8
No of Shares at Trading price	539	2,101
Exit price (When residual returns to or nears 0)	63.8	23.7
Gain (BDT)	15,588	-210
Net Gain from Pairs Trade (BDT)	15,378	
Return (%)	15.38%	
Date of Exit	12/05/2012	
Duration (Days)	64	
Annualized Return (%)	126%	

Table-10. Pairs Trading with Pair 3 using out- sample data

Stock Name	**Titasgas**	**Bdwelding**
Monetary Amount (BDT)	50,000	50,000
Entry Date	1/9/2011	1/11/2011
Residual Value (At entry date)	131.1	-52.2
Trading Price (At entry date)	979	218
No of Shares at Trading price	51	229
Exit price (When residual returns to or nears 0)	917.0	228.0
Gain (BDT)	3,166	2,294
Net Gain from Pairs Trade (BDT)	5,460	
Return (%)	5.46%	
Date of Exit	02/02/2011	
Duration (Days)	24	
Annualized Return (%)	124%	

Table 9 and Table 10 show details of Pairs Trading Strategy with Pair 3 (TITASGAS & BDWELDING). While, the net gain generated from the in-sample trade is the greatest in absolute terms, it also takes the highest period of time (64 days). This suggests that time required for the equilibrium to be restored between these two variables is the longest. The out-sample data yields a net return of 5.38% in 24 days. Annualized returns for the two trades using Pair 3 are 126% (in-sample data) and 124% (out-sample data).

Our findings confirming the profitability of pairs trading corroborates with previous researches in the topic, such as those carried out by Broussard (2012), Gatev (2006) and Nath (2003).

Finally, in terms of limitation of the study, it must be noted that we did not take transaction costs (of executing each trade) in our calculations. Frequent trading is likely to increase transaction costs and reduce net profit of the strategy. However, our objective was to design a pairs trading strategy for DSE and test profitability to validate the model. Further research may investigate profitability of this strategy compared to profitability of stock trading strategies based on financial analysis only, for instance taking long and short positions based on fair value of a stock.

5. CONCLUSION

We attempted to develop a financially profitable Pairs trading strategy for DSE. The strategy aimed to gain from the short-term movements away from the general long-run equilibrium that occur between two asset prices by taking short positions in the over-valued asset and long positions in the under-valued one. Given that Bangladesh stock market is often subjected to extreme volatility due to macroeconomic factors, this strategy can be a valuable hedge for both retail and institutional investors since it is market-neutral.

The study identified three pairs, from our sample, which had long-run equilibriums and thus suitable for Pairs Trading. Profitability analysis was carried out for Pairs trade. The study revealed that the three stock pairs generated positive returns for both in-sample and out-of-sample data. Actual returns reached as high as 15.38% using out-sample data. We can thus conclude that Pairs trading strategy has the potential of delivering greater risk-adjusted return since the strategy is market-neutral. Given its potential for generating profits through short-term trading, it can serve as a powerful investment strategy for local and foreign investors looking to invest in Bangladesh stock market. We therefore recommend taking all policy initiatives required to allow investors to utilize pairs trading strategy in Bangladesh stock market.

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Appendix

Table-11. Sample stocks (according to DSE ticker) used and Daily Average Volume

Ticker	Sector	Daily Average Volume
ENVOYTEX	Textile	982,667
RNSPIN	Textile	2,459,300
SQUARETEXT	Textile	137,049
MALEKSPIN	Textile	1,101,980
SAIHAMCOT	Textile	1,209,684
ARGONDENIM	Textile	1,184,346
ACTIVEFINE	Pharmaceuticals	636,624
KEYACOSMET	Pharmaceuticals	1,296,103
SQURPHARMA	Pharmaceuticals	333,054
PHARMAID	Pharmaceuticals	147,250
EBL	Bank	290,516
CITYBANK	Bank	769,379
ISLAMIBANK	Bank	573,877
EXIMBANK	Bank	1,023,417
NBL	Bank	2,207,772
TITASGAS	Fuel & Power	1,427,706
KPCL	Fuel & Power	571,336
BDWELDING	Fuel & Power	282,928
MPETROLEUM	Fuel & Power	471,460
GBBPOWER	Fuel & Power	673,598