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INVESTIGATING THE PROFITABILITY OF PAIRS TRADING ON THE ZIMBABWE STOCK EXCHANGE (2009-2016)

[1]Mazuruse Peter, [2]Lorreta Nyamadzawo, [3]Muvingi Jacob, [4]Chisunga David, [5]Gwarimbo Willard

[1,2,3,4,5] School of Business and Management Sciences, Department of Financial Engineering, Harare Institute of Technology, P.O.Box Be 277 Ganges Road Belvedere Harare.

Abstract: **The objective of this study was to investigate the profitability of pairs trading on the Zimbabwe Stock Exchange (ZSE). Pairs trading is an algorithmic trading strategy that aims to trade pairs based on cointegration between two stocks. Logarithmic stock prices for the top ten listed stocks were used in the study. Potential pairs were first identified by testing for cointegration using the Engle Granger (1988) and the Johansen test (1987). The selected pairs were modelled by the Vector Error Correction Model to produce the spread series. From the 45 pairs formed, four were found to be cointegrated. The four pairs were hypothetically traded based on historical performance of the spread. Pairs trading was implemented by monitoring the position of the spread relative to its long-run equilibrium. For each chosen pair, a short and long position is taken when the spread is significantly above and below zero respectively. A position is reversed when the spread reverts back to zero (0). One pair showed consistent returns from 2009 to 2016 whereas other pairs had varying profits. Returns from the strategy for all pairs ranged from 0.84% to 39% after deducting transaction costs, showing that the strategy is relatively profitable despite the declining returns being registered by the ZSE index.**

Keywords: **Zimbabwe Stock Exchange (ZSE), Pairs trading, Cointegration, Vector Correction Model (VECM), Engle Granger.**

1. INTRODUCTION

The Zimbabwe Stock Exchange has been underperforming as evidenced by the “softening” industrial index over the past two consecutive years .The declining returns resulted in low participation and low “appetite” for stocks on the local market. Foreign inflows on the market have reduced as well as restricting stock market growth. The deteriorating index is a true reflection of falling stock prices, and has seen many local and foreign investors exiting the market as a form of risk aversion. Investment returns on the front have been continuously going down, hence the need for new strategies to profit both investors and other participants. Pairs trading is a strategy that can benefit investors and increase commission for brokers and the Zimbabwe Stock Exchange. The research is therefore an endeavor to investigate the profitability of pairs trading on the exchange.

The Zimbabwe Stock Exchange adopted for the first time, the use of an Automated Trading system (ATS) in June 2015, after a lengthier period of manual trading. The ATS system upon adoption, showed significant improvements in trading volumes and liquidity on the bourse. The system’s benefits in the stock market were however swept away by the persistent economic challenges. The major challenges impacting performance on the local market include liquidity constraints, policy inconsistences, the unstable political arena as well as the absence of news to excite investors. The system is also still constrained in terms of automatic transfer of traded shares and cash between buyers and sellers.

Statistics show that from 2009 to 2016, the ZSE industrial index recorded a high of 231.21 points in August 2013, 114.14 points as at 31 December 2015 and 99.88 points as at 02 September 2016. The mining index on the other hand recorded a high of 272.2 points in June 2009, 21.51 points as at 31 December 2015 and improving to 26.32 points as at 02 September 2016. The figures clearly show that the bourse is under pressure and no longer exhibit favorable returns for the investors. Zimbabwean investor's trading behavior has been greatly characterized by buying and selling stocks when funds are in excess and in need of cash respectively. Figure 1 shows the ZSE performance from 2009 to 2016, measured by the trend of the industrial index.

Figure 1: ZSE Performance 2009-2016

Source: Bloomberg, MMC Capital

Apparent to the declining returns on the ZSE, pairs trading strategy is proposed to allow investors to exploit temporal deviations from an equilibrium price relationship between two stocks. The strategy for any two cointegrated stocks is buying one stock while short selling the other stock, when the spread is away from its mean. A trade is closed when the spread reverts back to its mean. The strategy signals investors when to buy and sell stocks to capitalize on market inefficiencies. It is possible for pair's traders to profit when the market goes up, down or sideways, and during periods of either low or high volatility. The study explore on how best the strategy can be implemented to be able to assess its profitability. Amongst the different approaches to pairs trading, the study will employ the Cointegration approach with the Vector Error correction model to pairs trading. Recent studies show that the use of trading strategies allows market participants to remain focused, amid the huge inflow of news and economic data that can seriously impede the analytical process. Moreover, trading strategies hold profound knowledge regarding the pricing characteristics of certain assets. The strategy uses technical analysis in addition, to set up the entry and exit points.

Huck and Afabuwo (2015) examined the superiority of cointegration approach among other approaches, on the components of the S&P 500 index. The study revealed that the minimum distance method produced the weakest returns.Trades initiated based on stationarity of the price ratio failed to generate significant excess returns after transaction costs. Pairs trading based on the cointegration approach showed high and robust returns after considering risk factors and transaction costs. During a period of more than 10 years, the least profitable parameterization dealing with cointegration delivered excess returns greater than 1.38% per month. The study concluded that cointegration methodology produces higher returns and significantly reduces non-convergence risk. Caldas et al. (2014) compared the pair's selection strategies and discovered that pairs formed with cointegration method have generally performed better on average than pairs formed with traditional distance method. For Brazil and main European stock markets from 1996 to 2012, the cointegration method had statistically significant higher average annual return with higher Sharpe ratio and generally a significantly lower volatility.

Bogomolov (2010), also examines the different approaches to pairs trading on the Australian market. The distance approach, cointegration approach and the stochastic spread method were used together with the daily closing prices for the period 1 Jan 1996 to 22 Nov 2010. Statistics show that the cointegration, distance and stochastic spread approach produce valid returns ranging from 5% to 12% per annum for the Australian equity market. Factoring in transaction costs, returns significantly diminished, living the minimum distance and stochastic approach in an unprofitable range. The cointegration approach remained profitable but with minimal proceeds. The study however did factor in the commissions and margin requirements. In practice, academic scholars prefer the distance approach due to its straightforward application while the cointegration approach remains a fairly unexplored field of interest.

Gatev, et al. (1998, 2006) evaluated the pairs trading on the United States of America Stock market using the pairs exhibiting historical co–movement in prices. Back-testing for the strategy was done on the daily closing prices data for the period 1962 to 2002. The study employed the minimum distance method on the normalized historical prices to formulate pairs. Findings show that the strategy produced excess returns close to 11% before transaction cost, on an annual basis for self-financing portfolio of pairs. Mirroring the top five pairs, long and short positions were taken at a standard deviation greater than 4.76%. The average excess returns of 0.75% for the period 1963 and 2002, were twice as large as of the S&P 500. The risk inherent as measured by the standard deviation is 2.1%. The Sharpe Ratio of 0.35 for pairs trading was close to four times larger than the market's.

Goetzman et al. (2002) found that Sharpe Ratios may be misleading if the return distributions are negatively skewed. The study found that profits obtained from the strategy decreased to 3.75% during the end of 1980. The decline was attributable to increased competition between hedge funds. Pairs trading returns over the period were steady, indicating that pairs trading makes profits from the temporary mispricing of close substitutes. Do and Faff (2010) extended the research done by Gatev et al. in 2006 to 2008. Findings reveal that pairs trading returns continued to decline at a faster rate. The decline was attributable to the concept of the law of one price that is evident when pairs can no longer converge after a notable divergence.

Engelberg et al. (2009), following the approach outlined by Gatev et al. (2006), examined further the factors affecting returns. Findings show that returns to a trade are sensitive to the period of time between divergence point and convergence point. Pair's profits were found to be closely related to news related to the company. Such news include information related to corporate structure and analyst coverage reports. If a pair of stocks are both owned and covered by the same institutional analyst, profits are likely to be reduced in case of any bad news.

Andrade et al. (2005) examined pairs trading strategy on the Taiwanese Stock Exchange. They examined the strategy over the period 1994 to 2002. The strategy was found to achieve excess returns of 10.2% per annum, a standard deviation of around 9% and the Sharpe ratio of 1.11. The returns failed to be explained with known sources of market risk resulting in systematic risk being insignificant. The study also highlighted that profitability of the strategy was mainly driven by the uninformed trading shocks in the market. The researchers however argue that profitability is based on the ability of the strategy to identify situations with stocks being temporarily mispriced. The study however implicitly introduces, but does not extend the possibility of exploring actual trades of arbitrageurs taking the other side of the transactions.

Excess returns for the study were slightly higher than those in Gatev et al. (2006). Pairs trading was found to be profitable after allowing for a one day delay in trade initiation after a signal. The study concluded that the annualized return can be as high as 15% on average and that returns are not related to market risk.

Since Gatev et al. (2006), Broussard and Vaihekoski (2012), replicated and tested the strategy on Finland's stock market. The study investigated the performance of pairs trading on the Finish stock market from 1987 to 2004. The market is characterized by low liquidity levels compared to other markets. Two interesting views on the significance of pairs trading in Finland were explored in the study. Firstly, the period 1987 to 2004 covers the global boom, bust in the technology sector and the financial crisis of 1990 that affected the Finish investors. Pairs trading would provide an alternative opportunity for investor as a risk management tool. Secondly, Finland has a unique characteristic regarding common and preferred shares. This allows for closer evaluation of the causes of price deviation in securities with access to the same cash flow source.

The study used daily stock prices for all the listed stocks on the Finish stock market for the period 1987 to 2004. The total number of stocks over the period varied from a 100 to 150 during the period of study. The analysis used stock returns adjusted for the dividends, new issues, stock splits as well as the monthly risk-free rates of returns. The monthly risk-free rates were generated from the monthly holding period returns. The returns were calculated from one month Helibor prior to 1998 and Euribor rates as suggested in Vaihekoski (2009). Results show that pairs trading was persistently profitable in the market despite the reduced liquidity. A maximum of 30.48% and 69.37% monthly return was obtained from the strategy for the five potential pairs chosen for the analysis. The average price deviation to trigger a long or short position in the market was 6.93%. The average number of times to opening a position in a pair was 15 over a 6 month period and an average holding period of 23 days. The results indicate that the strategy was actively employed and providing market participants with trading opportunities. The Finish stock market returns from 1991 forward were computed from the value-weighted OMXH yield index (previously HEX index). OMXH is the symbol for the Finish stock market index.

Significant profits were also generated by taking advantage of price deviations between common and preferred shares of the same firm. If the trader's assessment of fundamental value is highly uncertain, then prices may deviate persistently. Trader risk aversion behavior had potential effects on the profitability of the strategy. Findings showed that risk aversion would lead to lack of trading which may cause the asset prices in disequilibrium not to converge. The study notes that the notion that profits can be made from a price deviation between two assets with claims on the same cash flow source provides additional support for pairs trading.

Schurer and Lisev (2015), examine the profitability of pairs trading on the Swedish equity market based on cointegration approach. A comprehensive analysis of pairs trading strategy was performed by applying a long-term rolling window on the stock market. The study used a corresponding scenario analysis of the Swedish stock market which was analyzed on three different market environments. Findings from the study suggest that the trading technique is profitable and superior in return and risk relative to the set benchmarks. The ability of the trading algorithm to continuously generate abnormal returns was considered a loss protection and portfolio diversification mechanism. Outcomes also show that long-term back test confirms that the trading technique creates excess returns and is also exposed to less risk than the benchmark. A conclusion that pairs trading is a multi-criteria decision method that reports non-zero excess returns at 1% significance level for the S&P100 was made.

The study used Sharpe-Ratio ratios to select potential pairs on the Swedish stock market that can be used in examining the profitability of pairs trading. Findings also revealed that pairs trading was showing favorable returns as well as superior risk exposure throughout all markets. The research was informational as it explored the different methods to stock selection and their corresponding impact on the strategy. The use of risk measures allowed for the specification of the associated risk and return trade-offs. The researcher however pointed out that, their findings need to be interpreted with caution as results are based on a continuously re-balancing portfolio.

Haque and Haque (2014) explored the implementation and profitability of pairs trading on the Dhaka stock exchange. The research used the cointegration methodology on a sample of 20 stocks, and their daily prices. The main objective of the study was to develop a financial lucrative trading technique based on deviations from the long-run equilibrium of a given pair. The study from the 20 stocks, employed the cointegration approach to formulate pairs and came up with a total of three potential pairs. The research was carried out on the most actively traded stocks on the Bangladesh market. The Johansen's test of cointegration was implemented at 5% critical level, to identify pairs with a steady long-run equilibrium. After pair's formulation, the study employed the Vector Error Correction Model in Eviews to model the relationship between the pair of stocks.

To assess for profitability, the study used real data to hypothetically trade the pairs. Initial investments of $50,000 was made in each stock. The strategy generated more than 100% rate of return for all three pairs. From the three pairs, statistics show that the first pair had a return of 14.19% over a 22 day period and an annual return of 804%. The second and third pairs had a return of 9.32% and 9.5% over a 22 day period as well. The results showed that pairs trading is indeed lucrative on the Dhaka Stock exchange though transaction cost were not taken into account. The study to validate their returns, compared the pairs trading returns with those returns from conventional financial analysis. They found out that pairs trading yields higher returns than financial analysis returns. Restricted stock availability on the exchange, extreme historical volatility on the market as well liquidity risk were some of the limitations to the study. The analysis was carried out in the Bangladesh capital market during a pre-election year in 2013. The market was undergoing a lot of uncertainty and prolonged bear run due to domestic political violence. The timing of the study was considered perfect for pairs trading since the strategy is considered free from the market risks which were prevalent in Bangladesh during the period of study.

2. METHODOLOGY

A quantitative research design was employed in the study to investigate the profitability of pairs trading strategy at the ZSE. The study is a case study of the Zimbabwe stock exchange for the period 2009 to 2016 for a sample of ten stocks. Cointegration and other mathematical techniques were used in the study to identify potential pairs that can be traded on the Zimbabwe Stock exchange. The study aims to quantify the spread existing between two tradable pairs and model the spread using the Vector Error Correction Model. The study uses secondary data obtained from the Zimbabwe Stock Exchange through a stock broker, MMC Capital. The data collected include stock prices, market capitalization and sectorial information for each stock. Data validity and reliability was ensured by collecting information only from the source to ensure accuracy.

Daily stock prices for the top 10 listed counters over the period June 2009 to December 2016 was used in the study to select potential pairs that are tradable under the trading strategy. 250 working days will be used as the standard business year. Weekends and public holidays are excluded from the study because the ZSE will be closed. The study is divided into a formation period of one year (250 days) and a trading period of half a year (125 days). This means that pairs will be formed within a period of 250 days and good trades will be opened and closed within 125 days.

This study makes use of Microsoft-Excel, Eviews and the pairs trading algorithm in the analysis. Microsoft Excel was used for data capturing and partial analysis. Pairs Trading Algorithm is a system designed by the researcher in python to compute hypothetical pairs trading returns from different time periods and for different pairs. Results from the algorithm were presented using excel.

2.1 Pairs Trading Algorithm:

The study employs the cointegration approach to pairs trading for both the formation and trading period. Formation period focuses on the identification of potential pairs. The identified potential pairs are used in the trading period to analyse the performance of strategy on the Zimbabwe stock exchange. The algorithm also computes hypothetical returns from pairs trading. The steps that will be taken by algorithm are summarized below:

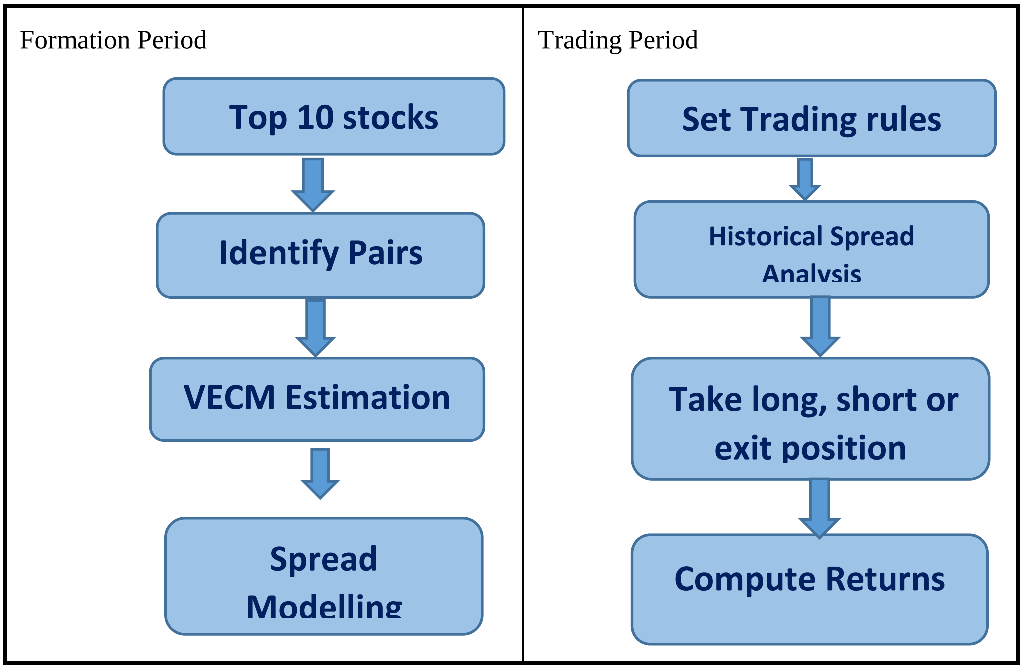

Figure 2: Pair Trading Algorithm

3. DATA ANALYSIS AND RESULTS

3.1 Engle Granger two step model to cointegration:

The top 10 stocks were paired onto 45 potential pairs. The first step of the Engle Granger regresses one log stock price on another stock and obtains the residual spread series. The residual series (spread) of each pair were then tested for unit root using the Augmented Dickey Fuller (ADF) at 5% significance level. Only 7 out of the 45 pairs had stationary residual series.

Table 1: Engle Granger two step results

	Stock Pair	t-statistic	5% Critical value
Pair 1	CBZ, BARCLAYS	-4.66985	-2.829
Pair 2	NATFOOD, BARC	-3.5475	-2.8629
Pair 4	ECO, CBZ	-3.2962	-2.8629
Pair 5	NATFOOD, CBZ	-3.4751	-2.8629
Pair 6	OML, CBZ	-3.3127	-2.8629
Pair 7	CBZ, BAT	-3.3164	-2.8629
Pair 7	ECO, DELTA	-3.077	-2.8629

Table 2: CBZ and BAT Cointegration Result

Hypothesized No. of CE(s)	None*	At most 1
Trace Statistic	23.867	4.666197
0.05 Critical Value	15.49471	3.841466
p-value	0.0022	0.0308
Normalized Cointegrating Coefficient	**CBZ**	**BARCLAYS**
	1	-1.03417

** denotes rejection of the hypothesis at the 0.05 level*

CBZ and BAT trace statistic of 23.867 is greater than the 5% critical value of 15.49471. The null hypothesis is that there is no cointegration between the stocks BAT and CBZ is rejected. From figures in table 4, we conclude that CBZ and BARCLAYS have two cointegrating equations at the 5% significant level. The pair is statically significant with a p-value of 3.08%. Haque (2013) notes that if both coefficients are positive, the two stocks will appreciate in the long run. The higher value of the two is to be chosen for long position and another for the short position. This is done on the premise that the long position will generate a higher return relative to the short position's losses. For this study, the normalized co-integrating coefficients show that a long position will be taken in CBZ stock and a short position in the BARCLAYS stock.

Table 3: CBZ and NATFOODS Cointegration Result

Hypothesized No. of CE(s)	**None***	**At most 1**
Trace Statistic	176.4987	5.841466
0.05 Critical Value	15.49471	3.841466
p-value	0.001	0.0193
	CBZ	**NATFOODS**
Normalized Cointegrating Coefficient	1	0.66024

The trace test statistic for CBZ and NATFOODS of 176.4987 is above the 0.05 critical level of 15.49471, thus rejecting the null hypothesis there is no cointegration between the stocks. The trace test statistic for the null hypothesis that there is also at most one cointegration equation between the two stocks is also rejected at the 5% level (second column). Findings lead to a conclusion that there exists at least two cointegrating equations for the pair of stocks. The pair is statistically significant at 1.93%. For the purpose of the study, a long position can be taken for CBZ stock with a higher coefficient while a short position can be taken for NATFOODS stock.

The null hypothesis that the pair (CBZ and DELTA) has no cointegration was rejected at 5% critical level. The null hypothesis that there exist at most one cointegrating equation is also rejected at the 5% critical level. The results point out that there exist two cointegrating equations for the pair and this is statistically significant given the 3.12% p-value. From the normalized coefficients, the study will take a long position in CBZ stock and a short position in DELTA stock.

Table 4: DELTA and CBZ Cointegration Results

Hypothesized No. of CE(s)	**None***	**At most 1**
Trace Statistic	38.70424	4.643346
0.05 Critical Value	15.49471	3.841466*
p-value	0	0.0312
	DELTA	**CBZ**
Normalized Cointegrating Coefficient	1	2.928672

Table 5: DELTA and ECONET Cointegration Results

Hypothesized No. of CE(s)	None*	At most 1
Trace Statistic	17.02946	1.075151
0.05 Critical Value	15.49471	3.844466
p-value	0.2998	0.02998
	DELTA	**ECO**
Normalized Cointegrating Coefficient	1	0.114939

For DELTA and ECONET, the null hypothesis that there is no cointegrating equation was rejected at the 5% critical level. The trace test for "at most 1" was 1.075 which is lower than the 5% critical value. This means that we do not reject the hypothesis that there is at most one equation for the two stocks. We therefore conclude that the two stocks are cointegrated and significant.

OML and CBZ, from table 7, shows a rejection of the null hypothesis that there exist at most one cointegrating equation for the pairs at the 5% critical level. The two pairs are the considered to be significant with a trace test of 3.16% that is less than 5% critical value. To use the pair in pairs trading, a long position is taken for the stock with a higher cointegrating coefficient, CBZ. Resultantly, a short position is taken for the stock with a lower cointegration coefficient, OML.

Table 6: OML and CBZ Cointegration results

Hypothesized No. of CE(s)	None*	At most 1
Trace Statistic	50.85908	4.617306
0.05 Critical Value	15.49471	3.841466
p-value	0	0.0316
	OML	**CBZ**
Normalized Cointegrating Coefficient	1	1.142584

The pairs found to be cointegrated and significant will then be modelled by the VECM Vector Error Correction Model as well as implemented in the hypothetical trading period. Table below shows a summary of pairs suitable for Pairs trading.

Table 7: ZSE potential Pairs

	Long Position	Short position
Pair 1	CBZ	BARCLAYS
Pair 2	BARCLAYS	NATFOODS
Pair 3	ECONET	DELTA
Pair 5	CBZ	OML

3.2 Modelling Pairs with VECM model:

VECM model for CBZ and BARCLAYS

Table 8: CBZ and BARCLAYS VECM

D(BARCLAYS) = C(7)*(CBZ(-1) - 0.388928637748*BARCLAYS(-1) - 0.839232237712) + C(8)*D(CBZ(-1)) + C(9)*D(CBZ(-2)) + C(10) *D(BARCLAYS(-1)) + C(11)*D(CBZ(-2)) + C(12)

	Coefficient	Std. Error	t-Statistic	Prob.
C(7)	0.006235	0.004002	1.558066	0.1194
C(8)	0.036758	0.023554	1.560554	0.1188
C(9)	0.006925	0.023588	0.293573	0.7691
C(10)	0.057828	0.022976	2.516848	0.0119
C(11)	0.065757	0.022965	2.863376	0.0042
C(12)	-0.000282	0.000356	-0.793439	0.4276

The VECM model for CBZ and BAT has two significant variables, C(10) with 1.19% and C(12) with 0.43%. A variable is considered significant when the p-value is less than 5%. In this analysis, statistics such as the goodness of fit R- squared and Adjusted R-squared, are not considered in the research because the study does not focus on the variation relationship between the two stocks. By considering only the significant variables, the VECM final model reduces to:

D (BARCLAYS) = C(10)*D(BARCLAYS(-1)) + C(11)*D(CBZ(-2))

Where C (10) = 0.057828

C (11) = 0.065757

Resultantly, the Spread series is modeled by:

$$S_{CB} = \mathrm{D\ (BARCLAYS)} - \mathrm{C(10)} * \mathrm{D(BARCLAYS(-1))} + \mathrm{C(11)} * \mathrm{D(CBZ(-2))}$$

BARCLAYS and NATFOODS VECM:

Table 9 BARCLAYS AND NATFOODS

D(BARCLAYS) = C(1)(BARCLAYS(-1) + 0.649227361147*NATFOODS(-1) -2.09791569712) + C(2)*D(BARCLAYS(-1)) + C(3)*D(BARCLAYS(-2)) + C(4)*D(NATFOODS(-1)) + C(5)*D(NATFOODS(-2)) + C(6)*

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.003342	0.002019	-1.655853	0.6645
C(2)	0.049151	0.023305	2.109067	N/A
C(3)	0.082893	0.023250	3.565235	0.0004
C(4)	0.069253	0.026564	2.606999	0.0092
C(5)	-0.042038	0.026597	-1.580544	0.1142
C(6)	-0.000235	0.000352	-0.667530	0.5045

The VECM model for CBZ and NATFOODS has two significant variables at C(3) and C(4) with their p-values less than 5%. By taking only the significant variables to model the long-run relationship between Barclays and Natfoods, the model reduces to

*D(BARCLAYS) = C(3)*D(BARCLAYS(-2)) + C(4)*D(NATFOODS(-1))*

And the resultant Spread Series is given by:

$$S_{BN} = D(BARCLAYS) - C(3) * D(BARCLAYS(-2)) + C(4) * D(NATFOODS(-1))$$

Where C(3)=0.082893

C(4)= 0.069253

VECM model for ECONET and DELTA

Table 10: ECONET and DELTA

D(ECONET) = C(7)(DELTA(-1) + 0.134504634959*ECONET(-1) -2.18774247687) + C(8)*D(DELTA(-1)) + C(9)*D(DELTA(-2)) + C(10) *D(ECONET(-1)) + C(11)*D(ECONET(-2)) + C(12)*

	Coefficient	Std. Error	t-Statistic	Prob.
C(7)	-0.012851	0.006171	-2.082400	0.0001
C(8)	0.100894	0.113454	0.889294	NA
C(9)	0.375487	0.113545	3.306936	0.0010
C(10)	-0.358632	0.022750	-15.76435	0.0001
C(11)	-0.117526	0.022747	-5.166668	0.0001
C(12)	-0.000734	0.000874	-0.839533	0.4013

The VECM model for one of the large cap listed entities, Delta and Econet has three significant variables. The model by elimination of the insignificant variables, gives and reduces to an equation that summarizes the long-run relationship between the two stocks, Delta and Econet. The resultant relationship between the two stocks is given by:

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D(ECONET) = C(7)(DELTA(-1) + 0.134504634959*ECONET(-1) -2.18774247687) +)) + C(9)*D(DELTA(-2)) + C(10) *D(ECONET(-1)) + C(11)*D(ECONET(-2))*

The derived residual series S_{DE} is given by:

S_{DE} *=C(7)*(DELTA(-1) + 0.134504634959*ECONET(-1) -2.18774247687) +)) + C(9)*D(DELTA(-2)) + C(10) *D(ECONET(-1)) + C(11)*D(ECONET(-2)) - D(ECONET)*

VECM Model for OML and CBZ

Table 11: VECM model for CBZ and OML

D(OLDM) = C(7)(CBZ(-1) + 0.0195047361191*OLDM(-1) - 16.8735502163) + C(8)*)*D(CBZ(-1)) + C(9)*D(CBZ(-2)) + C(10)*D(OLDM(-1)) + C(11)*D(OLDM(-2)) + C(12)*

	Coefficient	Std. Error	t-Statistic	Prob.
C(7)	-0.045999	0.063895	-0.719904	0.0468*
C(8)	0.540990	0.454209	1.191060	NA
C(9)	0.543672	0.454122	1.197192	0.2314
C(10)	-0.578431	0.022389	-25.83547	0.0000
C(11)	-0.259221	0.022430	-11.55663	0.0000
C(12)	0.210569	0.190128	1.107513	0.2682

The VECM model has one significant variable that has a p-value less than 5%. The model reduces to:

$$\mathrm{D(OLDM)} = \mathrm{C(7)} * (\mathrm{CBZ}(-1) + 0.0195047361191 * \mathrm{OLDM}(-1) - 16.8735502163)$$

And the residual spread model is shown as

$$S_{CN} = D\,(OLDM) - C\,(7) * (CBZ(-1) + 0.0195047361191 * OLDM(-1) - 16.8735502163)$$

The deduced residual series from the vector error correction was used to produce signals for when to take long and short positions in the market, assuming hypothetical trades.

CBZ and BARCLAYS Return Analysis:

The two companies in the same sector tend to be driven by almost the same factors. The residual spread series showed the strongest cointegration as shown by the trend of the spread figure 3.

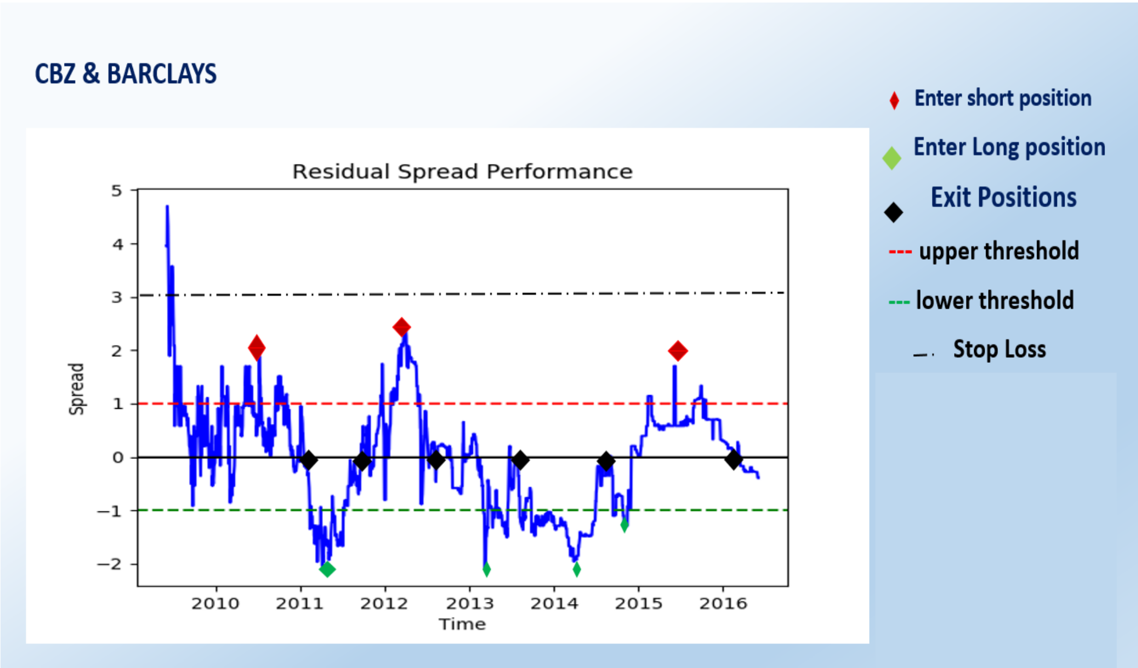

Figure 3: CBZ and Barclays Spread series

Over the years 2010 to 2016, the spread showed a mean reverting nature of the spread, especially around 2010. The table below shows an analysis of the pair's returns over the years with a hypothetical monetary investment of US$1000.

The pair CBZ and Barclays shows that in 2009, the pairs made a return of 0.8% after transaction cost over 102 days. The pair was opened on the 5th of June 2009 and closed on 6 July 2009 according to the trading rules. During 2010, the pair made a return of 12% over a 105 day period. A return of 29% and 30% were made during 2012 and 2016 over a 72 day and 79 day period respectively. The pairs trading strategy for 2016 was opened on the 3 November 2015 and closed on 21 January 2016. Findings reveal that pairs trading is able to hedge a trader from potentially realizing a loss from holding a certain security. In 2012, instead of realizing a loss of $125 from holding 12500 shares of Barclays, a trader could earn a net gain of $285 from simply trading the pair.

Table 12: CBZ and Barclays Returns

	2009		**2010**		**2012**		2016	
Stocks	**CBZ**	**BARCLAYS**	**CBZ**	**BARCLAYS**	**CBZ**	**BARCLAYS**	**CBZ**	**BARCLAYS**
Amount Invested	$500	$500.00	$500.	$500.00	$500.	$500.00	$500.	$500.00
Entry date		05/06/2009		7/7/2010		3/23/2012		11/3/2015
trading Price at entry	$0.54	$0.27	$0.11	$0.09	$0.05	$0.04	$0.07	$0.04
No of shares	926	1852	4545	5882	10000	12500	7143	12500
Exit Date		06/07-2009		10/20/2010		6/3/2012		1/21/2016
Selling Price at exit	$0.55	$0.27	$0.14	$0.08	$0.09	$0.03	$0.11	$0.04
Gain($)	$9.26	$ -	$136.36	($17.65)	$410.0	($125.00)	$285.71	$12.50
Net Gain $		$9.26		$118.72		$285.00		$298.21
Transaction cost		$0.83		$10.68		$25.65		$26.83
Net returns		$8.43		$108.68		$25.65		$26.83
Return %		0.84%		11%		26%		27%
Duration Days		31		105		72		79

Mirroring the spread's historical trend, there is reasonably a number of positions for which pairs trading could be applied. Compared to other markets, Zimbabwe stock exchange does not yet allow for daily trading of pairs or pairs trading within a short period of time. This is because of the frequency of divergence of the spread from its mean.

Natfoods and Barclays Return Analysis:

The residual spread for Barclays is described in figure 4 below.

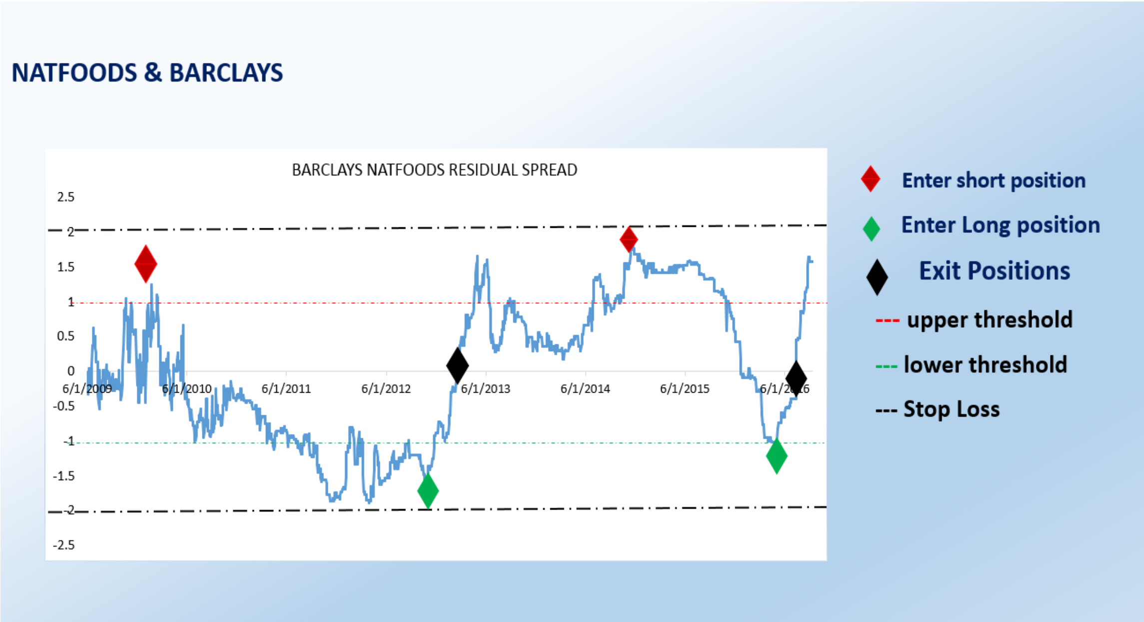

Figure 4: Natfoods and Barclays Residual Series

The results shows potential trading period for the pairs between the periods 2009-2012, 2011-2013, mid 2014-2016 as well as during 2016. The table below computes hypothetical trading returns for the prior period by investing equal amounts of $500 in each stock.

Table 13: Natfoods and BARCLAYS Return Analysis

	2012-2013		2014-2016	
Stocks	**Barclays**	**Natfoods**	**Barclays**	**Natfoods**
Amount Invested	$500.**00**	$500.00	$500.00	$500.00
Entry date		4/4/2012		11/19/2014
trading Price at entry (log)	**$0.86**	**$0.04**	**$0.02**	**$2.04**
No of shares	581.3953	11627.907	33333	245
Exit Date		**4/13/16**		**1/22/2016**
Selling Price at exit	$1.50	$0.03	$0.02	$2.20
Gain($)	$372.09	-104.65	$166.67	$39.22
Net Gain $		$267.44		$205.88
Transaction Cost		$24.05		$18.53
Return %		$243.33		$187.35
		24.30%		18%.74
Duration Days		1.25		1.72

The pair Natfoods and Barclays between 2012 and 2013 showed a return of 27% over 1.25 year and equivalent to 313 days. The pair was opened on the 4th of April 2012 and closed on the 6th of July 2013 according to the trading rules. During 2016, another potential trading period could be opened from 11/19/2014 to 01/22/2016 and giving a return of 21% over the 426 days. Findings reveal that pairs trading is able to hedge a trader from potentially realizing a loss from holding Natfoods security in 2012. Instead of realizing a loss of $104 from holding 11 600 shares of Natfoods, a trader could earn a net gain of $267 from simply trading the pair.

Mirroring the spread's historical trend, there are not much potential period for pairs trading. Pairs trading should enable traders to benefit also from term frictions in the market. From findings, the users. This is because of the frequency of divergence of the spread from its mean

Econet and Delta Return Analysis:

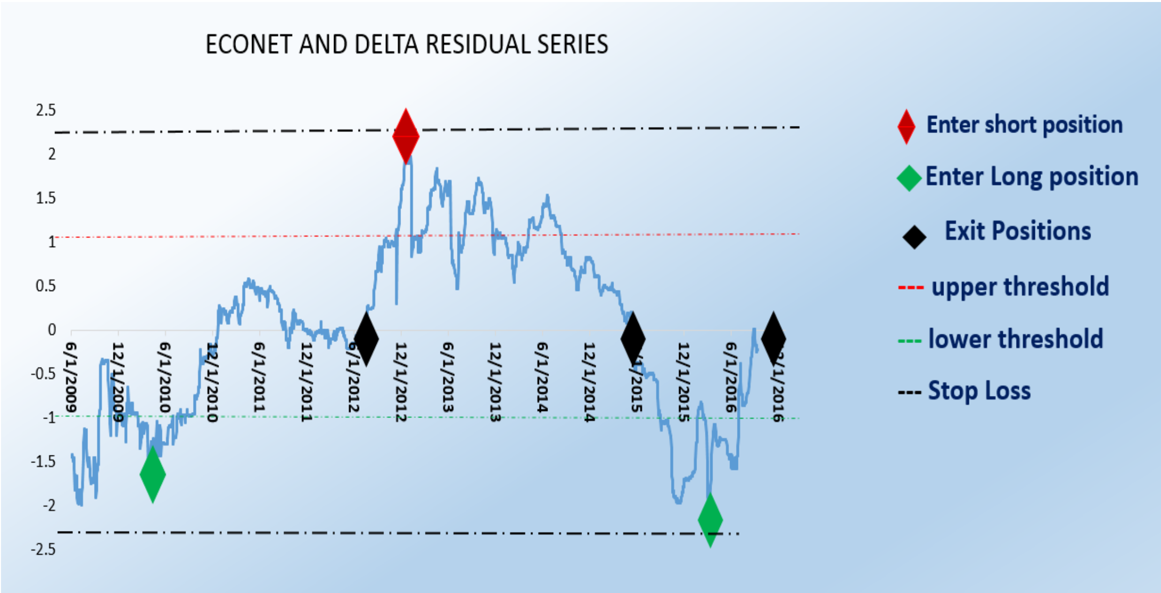

Figure 5: Econet and Delta Residual Series

CBZ and Econet hold very significant shares in the Zimbabwean market as measured by their market capitalization. The pair over the 2009 to 2010, as in figure 4, reveals that there's has been potential periods for pairs trading on the Zimbabwe Stock Exchange.

Three positions have been picked for the pair to test for profitability of the strategy. During 2010, the pair could open trades on 26 March 2010 and close the position at 17 December 2010 and realize a return of 2% over a 266 day period. The pair during 2013 and 2015 also could open a long position during the period 1 January 2013 to 15 May 2015. The lengthy period exhibited is unattractive to users as they intend to make profit by taking multiple positions in a pair of stocks over a reasonably short period of time. The pairs made a return of 19% between the year 2013-2015 and 5% during 2016.

Table 14 Econet and Delta Return Analysis

	2010		**2013-2015**		2016	
Stocks	**ECONET**	**DELTA**	**ECONET**	**DELTA**	**ECONET**	**DELTA**
Amount Invested	$500.00	$500.00	$500.00	$500.00	$500.00	$500.00
Entry date		3/26/2010		1/1/2013		3/4/2016
trading Price at entry	$4.40	$0.48	$0.62	$1.53	$0.31	$0.99
No of shares	114	1042	806	327	1613	505
Exit Date		40529		42139		9/1/2016
Selling Price at exit	$4.60	$0.48	$0.60	$1.17	$0.21	$0.98
Gain($)	$22.73	$ -	$10.00	180.1	$50.05	$4.85
Combined Gain $		$22.73		$190.10		$54.90
Transaction costs		$2.02		$17.10		$4.94
Net Return		$20.70		$172.90		$49.96
		2.00%		17.00%		5%
Duration Days		266		864		181

Though pairs trading gives returns, the trading period for the pairs is very lengthy and is not favorable. Pairs trading seeks to hedge an investor from adverse market conditions that may impede returns from investing in certain stocks. The Zimbabwe stock exchange has over the years been witnessing depressed performance. The strategy has therefore managed to show returns despite economic upheavals persistent in Zimbabwe.

4. CONCLUSIONS AND RECCOMENDATIONS

From the findings, we conclude that pairs trading is profitable on the stock exchange. Pairs trading is a market neutral strategy seeking to hedge market participants from diverse market movements. Historical performance of the trading strategy provides a clear view that investors have the opportunity to simultaneously purchase undervalued stocks and sell overvalued stocks at any given point in time as signaled by the trading algorithm. Mirroring the unstable economic environment in Zimbabwe evidenced by the performance of the industrial index from 2009 to 2016, pairs trading comes in handy for the investors. The methodology may result in improvements in the country's capital market and the financial sector as a whole. The investor bracket includes pension funds, asset managers, insurance companies, corporate investors and individual investors.

Zimbabwe Stock Exchange, also may realize increased activity and improvements in turnover revenue. The increase in activity makes the market attractive to other international investors. The regulator of the exchange, the Securities and Exchange Commission and the Zimbabwe Revenue authority will benefit from increased commission arising from the increased turnover. The study also adds to the body of knowledge related to the Zimbabwe stock market as well as providing an insight on alternative trading strategies.

Pairs trading involves making trades based on the concept of long-buying and short-selling of shares. Long-buying implies that an individual buys a share without any money whilst short selling implies borrowing shares and selling at the prevailing market price. The study therefore recommends for the adoption of the same concepts for the ZSE as the market does not at the moment support such trades.

Stockbrokers in the market will benefit from increased commission emanating from increased trades from pairs trading. The strategy provided will add to fundamental and technical analysis mainly used by stockbrokers on their day to day operations. The study therefore recommends that stockbrokers be able to hold shares that can be lent to investors wanting to borrow shares and short sell on the market. The broker may also provide a platform for investors to borrow shares from each other. This will increase on liquidity of the market and for the strategy itself. The brokers are also needed together with the main exchange to educate investors on the concepts of pairs trading.

Investors by implementing pairs trading can enjoy benefits derived such as risk neutral profits, absence of directional risk and self-funding trading. We therefore recommend that investors should explore more on pairs trading and its diverse benefits apart from just buying and holding stocks.

Pairs trading is a broad technique applied using different methodologies. Apart from cointegration, we recommend that other approaches such as the minimum distance method and the stochastic spread approach be examined on the Zimbabwe Stock Exchange. To provide a wide range of trading opportunities, other trading strategies like Equity hedging can also be explored. Pairs from the same industrial sector showed more cointegration during the study. We therefore recommend that a broader research be done by considering stocks from the same sector. Finally, more trading strategies like Equity hedging can be tested on the ZSE to assess if they can bring a new dimension of trading for investors.

REFERENCES

[1] Andrade, S. C., Pietro, V. d. & Seasholes, M. S., 2005. Understanding the Profitability of Pairs Trading.Economics Bulletin preprint.

[2] Bogomolov, T., 2010. Pairs trading in the land down under In Finance and. Melbourne, Australia, s.n.Finance and Corporate Governance Conference 2011 paper.

[3] Bogomolov, T., 2013. Pairs trading based on statistical variability of the spread process.. Journal of Quantitative Finance, Volume 13, p. 1411.

[4] Broussard, J. P. & Vaihekoski, M., 2012. Profitability of pairs trading strategy in an illiquid market with multiple share classes. Journal of International Financial Markets, Volume 22, p. 1188–1201..

[5] Caldas, et al., 2014. Is Pairs Trading Performance Sensitive to the Methodologies? A Comparison. Quantitative Finance, Issue paper_ANPEC, p. 2.

[6] Do, B. & Faff, R, 2012. Are Pairs Trading Profits Robust To Trading Costs? Business Source Premier, Journal of Financial Research, Volume 35, p. 261.

[7] Engelberg, J, Gao , P. & Jagannathan, R., 2009. An anatomy of pairs trading: The role of idiosyncratic news, common information and liquidity ,Singapore, s.n.Third Singapore.International Conference on Finance.

[8] Engle, R. & Granger, C., 1987. Cointegration and Error Correction: Representation, Estimation and Testing. Journal of Economics, Volume 55, p. 251.

[9] Gatev, E. G. e. W. a. R. K., 2006. Pairs Trading: Performance of a Relative Value Arbitrage Rule. The Review of Financial Studies, Volume 19, p. 797.

[10] Gatev, E., Goetzmann, W. N. & Rouwenhorst, K. G., 1999. Pairs trading: performance of a relative value arbitrage rule. Yale School of Management,, Volume NBER Working Paper, 7032.

[11] Goetzmann W, 2002. Sharpening Sharpe Ratios, working paper(Yale School of Management).

[12] Haque, S. M. & Haque, E. A. K., 2014. Pairs Trading Strategy in Dhaka Stock Exchange: Implementation and Profitability Analysis. Asian Economic and Financial Review, p. P. 1094..

[13] Marc Schurer and Pavel Lisev, 2015. Pairs Trading. Evaluation of profitability and risks on the Swedish stock market, Unpublished thesis (MSc), Lund University, Sweden.

APPENDICES

Appendix 1: Engle Granger Test Results:

Table A1: 1 CBZ and Barclays Engle Granger Test Results

Null Hypothesis: CBZBARC has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=24)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-4.669751	0.0001

Test critical values:	1% level	-3.433629
	5% level	-2.862875
	10% level	-2.567527

*MacKinnon (1996) one-sided p-values.

Table A1: 2 Natfoods and Barclays Engle Granger Test Results

Null Hypothesis: NB has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=24)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.547504	0.5093
Test critical values:	1% level	-3.433629	
	5% level	-2.862875	
	10% level	-2.567527	

*MacKinnon (1996) one-sided p-values.

Table A1: 3 Econet and delta Engle Granger Test Results

Null Hypothesis: ECOD has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=24)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.077045	0.2542
Test critical values:	1% level	-3.433631	
	5% level	-2.862876	
	10% level	-2.567528	

*MacKinnon (1996) one-sided p-values.

Table A1: 4 OLM and CBZ Engle Granger Test Results

Null Hypothesis: OMLC has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=24)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.312736	0.0145
Test critical values:	1% level	-3.433637	
	5% level	-2.862878	
	10% level	-2.567529	

*MacKinnon (1996) one-sided p-values.

Table A1: 5 CBZ and BAT Engle Granger Test Results

Null Hypothesis: CBB has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=24)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.316435	0.0143
Test critical values:	1% level	-3.433631	
	5% level	-2.862876	
	10% level	-2.567528	

*MacKinnon (1996) one-sided p-values.

Table A1: 6 CBZ and Natfoods Engle Granger Test Results

Null Hypothesis: CBZN has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=24)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.475125	0.0088
Test critical values:	1% level	-3.433631	
	5% level	-2.862876	
	10% level	-2.567528	

*MacKinnon (1996) one-sided p-values.

Table A1: 7 Econet and CBZ Engle Granger Test Results

Null Hypothesis: ECOC has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=24)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.296187	0.0152
Test critical values:	1% level	-3.433629	
	5% level	-2.862875	
	10% level	-2.567527	

*MacKinnon (1996) one-sided p-values.

Appendix 2: Johansen Cointegration Test results

Table A2: 1 CBZ and BAT Johansen test results

Date: 03/10/17 Time: 10:38
Sample (adjusted): 2/26/2009 6/30/2016
Included observations: 1916 after adjustments
Trend assumption: Linear deterministic trend
Series: BAT CBZ
Lags interval (in first differences): 1 to 4
Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.026428	52.43285	15.49471	0.0000
At most 1	0.000582	1.115697	3.841466	0.0298

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.026428	51.31715	14.26460	0.0000
At most 1	0.000582	1.115697	3.841466	0.0298

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values
Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

BAT	CBZ	
0.208882	2.789416	
D(BAT)	0.000240	-0.000782
D(CBZ)	-0.007410	5.90E-06

1 Cointegrating Equation(s): Log likelihood 7075.709

Normalized cointegrating coefficients (standard error in parentheses)

BAT	CBZ
1.000000	13.35404
	(1.89973)

Adjustment coefficients (standard error in parentheses)

D(BAT)	5.01E-05
	(0.00016)
D(CBZ)	-0.001548
	(0.00022)

Table A2: 2 CBZ and Natfoods Johansen test results

Date: 03/10/17 Time: 11:00
Sample (adjusted): 2/26/2009 6/30/2016
Included observations: 1916 after adjustments
Trend assumption: Linear deterministic trend
Series: CBZ NATFOOD
Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.085394	176.4987	15.49471	0.0001
At most 1 *	0.002852	5.472689	3.841466	0.0193

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.085394	171.0260	14.26460	0.0001
At most 1 *	0.002852	5.472689	3.841466	0.0193

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

CBZ	NATFOOD
-1.852806	-1.234012
2.377167	-1.364431

Unrestricted Adjustment Coefficients (alpha):

D(CBZ)	0.003939	-0.002446
D(NATFOOD)	0.015829	0.001726

1 Cointegrating Equation(s): Log likelihood 5832.254

Normalized cointegrating coefficients (standard error in parentheses)

CBZ	NATFOOD
1.000000	0.666024
	(0.07331)

Adjustment coefficients (standard error in parentheses)

D(CBZ)	-0.007299
	(0.00202)
D(NATFOOD)	-0.029328
	(0.00259)

Table A2: 3 CBZ and Old Mutual Johansen test results

Date: 03/10/17 Time: 11:02
Sample (adjusted): 2/26/2009 6/30/2016
Included observations: 1910 after adjustments
Trend assumption: Linear deterministic trend
Series: OML CBZ
Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.023920	50.85908	15.49471	0.0000
At most 1 *	0.002415	4.617306	3.841466	0.0316

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.023920	46.24177	14.26460	0.0000
At most 1 *	0.002415	4.617306	3.841466	0.0316

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

OML	CBZ

1.647875	1.882835
-2.809408	2.386291

Unrestricted Adjustment Coefficients (alpha):

D(OML)	-0.002299	0.000671
D(CBZ)	-0.005618	-0.001546

1 Cointegrating Equation(s): Log likelihood 7868.166

Normalized cointegrating coefficients (standard error in parentheses)

OML	CBZ
1.000000	1.142584
	(0.25181)

Adjustment coefficients (standard error in parentheses)

D(OML)	-0.003788
	(0.00076)
D(CBZ)	-0.009257
	(0.00180)

Table A2: 4 Delta and Econet Johansen test results

Date: 03/10/17 Time: 11:12
Sample (adjusted): 2/26/2009 6/30/2016
Included observations: 1916 after adjustments
Trend assumption: Linear deterministic trend
Series: DELTA ECO
Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.008292	17.02946	15.49471	0.0292
At most 1	0.000561	1.075151	3.841466	0.2998

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.008292	15.95431	14.26460	0.0268
At most 1	0.000561	1.075151	3.841466	0.2998

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

DELTA	ECO
-2.546765	-0.292724
0.007454	-0.839837

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Unrestricted Adjustment Coefficients (alpha):

D(DELTA)	0.001842	-0.000295
D(ECO)	0.004388	0.001728

1 Cointegrating Equation(s): Log likelihood 6406.033

Normalized cointegrating coefficients (standard error in parentheses)

DELTA	ECO
1.000000	0.114939
	(0.08269)

Adjustment coefficients (standard error in parentheses)

D(DELTA)	-0.004692
	(0.00138)
D(ECO)	-0.011175
	(0.00509)

Table A2: 5 Delta and CBZ Johansen test results

Date: 03/10/17 Time: 10:54
Sample (adjusted): 2/26/2009 6/30/2016
Included observations: 1916 after adjustments
Trend assumption: Linear deterministic trend
Series: DELTA CBZ
Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.017620	38.70424	15.49471	0.0000
At most 1 *	0.002421	4.643346	3.841466	0.0312

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.017620	34.06089	14.26460	0.0000
At most 1 *	0.002421	4.643346	3.841466	0.0312

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

DELTA	CBZ
0.813415	2.382226
2.413104	-1.775442

Unrestricted Adjustment Coefficients (alpha):

D(DELTA)	-0.001654	-0.000955
D(CBZ)	-0.005544	0.001082

1 Cointegrating Equation(s): Log likelihood 7658.297

Normalized cointegrating coefficients (standard error in parentheses)

DELTA	CBZ
1.000000	2.928672
	(0.59390)

Adjustment coefficients (standard error in parentheses)

D(DELTA)	-0.001346
	(0.00043)
D(CBZ)	-0.004510
	(0.00087)

Table A2: 6 CBZ and Barclays Johansen test results

Date: 05/10/17 Time: 20:06
Sample (adjusted): 7/07/2009 9/12/2016
Included observations: 1875 after adjustments
Trend assumption: Linear deterministic trend
Series: CBZ BARCLAYS
Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.010188	23.86740	15.49471	0.0022
At most 1 *	0.002486	4.666197	3.841466	0.0308

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.010188	19.20120	14.26460	0.0076
At most 1 *	0.002486	4.666197	3.841466	0.0308

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

CBZ	BARCLAYS
-0.419640	0.433982
0.148708	0.230184

Unrestricted Adjustment Coefficients (alpha):

D(CBZ)	0.034929	-0.011656

D(BARCLAYS)	-0.013454	-0.011126

1 Cointegrating Equation(s):	Log likelihood	-1145.114

Normalized cointegrating coefficients (standard error in parentheses)

CBZ	BARCLAYS
1.000000	-1.034176
	(0.19684)

Adjustment coefficients (standard error in parentheses)

D(CBZ)	-0.014658
	(0.00404)
D(BARCLAYS)	0.005646
	(0.00252)