



**Pairs Trading: A Cointegration Approach
(An Empirical Study in Stock Exchange of Thailand)**

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ABSTRACT

Pairs trading is an speculative investment strategy based on relative mispricing between a pair of stocks. Though, it is relatively a new trading strategy, which has only been used during a couple of decades but it is an investment strategy used by many Hedge Funds. The study made on several major stock markets has shown that the strategy has generated a positive result. The purpose of this paper is to investigate whether pairs trading has been able to generate a positive return on the Stock Exchange of Thailand during the study period of 2001-2005.

Pairs trading involves two stages – formation and trading periods. The pairs were identified during a period of 12 months. During this period an adjusted closing-price series was constructed and a cointegration procedure was applied to these series. Then, these pairs were used in the next six-month trading period.

Trading simulations show that the strategy is able to make consistent profits during rising, falling and sideways markets. Besides, after risk-adjusted return, Sharpe ratio of this strategy is outperformed an index, except during the bull market.

I. Introduction

The traditional focus of equity investing has been on finding stocks to buy that offer opportunity for appreciation. This strategy would give an impressive result to investor, especially in the uptrend market. However, during other market trends, bearish or sideways, this traditional investment style may not be successful to create a profit. More recently, a growing number of investors have begun holding both long and short stock positions in their equity portfolio. Long/short equity investing provides benefit and investment opportunities that is unavailable for traditional style. For example, suppose you expect that stock A will go up and stock B is likely to go down. According to this condition, you would certainly not just bet on stock A to win. You would also short stock B. Long/short equity style shows you that why bet on winner only? Profits can be earned from both winning and losing stocks simultaneously, earning the full performance.

Being as one of a branch of long/short trading style, pairs trading is a popular strategy in the market-neutral-funds sector of hedge funds. It is particularly powerful when markets are volatile and do not show an overall trend. The idea behind pairs trading is relative pricing; that is, if two stocks that have shown a high correlation in the past, then they are expected to continue to do so in the near future. Note that the specific price between two stocks is not importance. We only concern with the relative price between two stocks. If the prices happen to be different, it could be that one of the stocks is overpriced, the other stock is underpriced, or the mispricing is a combination of both. As a strategy, it is fairly easy to conceptualize. Find two securities that have moved together in price space. Monitor the spread between them. When the spread widens, buy the loser and short the winner. If the two securities have a stable relationship, the spread will narrow to its normal historical levels. At that time, reverse the trade and take the profit. This strategy offers traders two important advantages: firstly, profit regardless of the direction of the stock, and secondly, lower risk by avoiding a positional trade, with one stock providing a hedge for the other

stock. The task of trader is to find the potential stock pair, identify abnormally large gaps between share prices and bet on the securities reverting to normal trading patterns established in the past. Statistical methods can be used to establish whether or not a relationship between the two stocks is likely to hold over the duration of a particular trade.

The paper explains and analyzes a trading strategy, popularly known as Pairs trading. We begin by introducing what a pair trading strategy is in section 1 and examine the literature review in section 2 and explain the theoretical background in section 3. Since there are various ways of implementing the strategy, we describe the methodology selected for this study in section 4. Thereafter, we examine the returns from the strategy and benchmark it to the SET50 index in section 5. Finally, we make a conclusion in section 6 with comments on whether we would implement the strategy in real life and if so, with what limitations and concerns we need to be aware of.

Research Questions:

- Is pairs trading strategy able to generate an abnormal return in the Stock Exchange of Thailand?
- Which market conditions will pairs trading provide the best result, comparing with the market index?
- What are the key factors determining the success of pairs trading strategy?

Objectives:

- To study the determinants of trading pairs
- To examine the result of applying pairs trading strategy to the Stock Exchange of Thailand

Scope of Study:

- In this study, I have limited the database to stocks in the SET 50 index. These are very liquid stocks, which is an important factor to keep in mind when executing the trades. Obviously, you will want to get in and out of these trades quickly and at the prices you want.
- Period of study will be tested during 2003-2005 which will be categorized into 3 separate periods:
 - 1) July 2003 – December 2003 (Bullish period)
 - 2) January 2004 – June 2004 (Bearish period)
 - 3) January 2005 – June 2005 (Sideway period)

This would answer the question that whether pairs trading strategy is able to generate abnormal profit in the different market situation.

Limitation of Study:

Due to applying the daily closing price, instead of bid-ask price, for pairs trading strategy, this will be likely to give us the higher reward than it should be. Nevertheless, only focusing on securities in the SET 50 Index, assuming to have a high liquidity, the bid-ask spread should be narrow. Thus, an effect from this should not be significantly.

II. Literature Review

This section describes four main methods to implement pairs trading, which we label: the distance method, the cointegration method, the wavelet correlation method and the stochastic spread method.

2.1 The Distance Method

In [Gatev et al \(1999\)](#), the pairs are selected by choosing, for each stock, a matching partner that minimizes the distance. They show that this strategy is profitable after an allowance for trading costs, and that these profits are inherently different from a pure mean-reversion strategy. [Patanapol \(2001\)](#) implemented the model and method of [Gatev et al \(1999\)](#) to test the Stock Exchange of Thailand during 2001-2002. The study confirms that this strategy is able to generate abnormal profit, exceeding the market return in Thai market. [Nath \(2003\)](#), with more concerned on risk control, adopts a stop-loss trigger to close the position whenever the distance widens further to hit the 5 percentile. The additional measure is able to improve the portfolio performance relative to various benchmarks.

Actually, the distance approach mainly employs the statistical relationship between two stocks. Since the approach is economic model-free, it has the advantage of not being exposed to model mis-specification and mis-estimation. Conversely, being non-parametric means that the strategy lacks forecasting ability regarding the convergence time or expected holding period.

2.2 The Cointegration Method

Given that all pairs are cointegrated, they are logical choice for pairs-trading. [Lin, Mccrae and Gulati \(2003\)](#) tested this strategy on daily closing price data for Australia

Stock Exchange over the period of January 2, 2001 to August 30, 2002. The results show that trading strategy is able to generate substantial return and is not unduly constrained by adding a reasonable minimum profit condition to protect against losses. [Hong and Susmel \(2003\)](#) study pairs-trading strategies for 64 Asian shares listed in their local market and the listed in the U.S. as ADRs. They find that pairs-trading in this market delivers significant profits. The results are robust to different profit measures and different holding periods. [Vidyamurthy \(2004\)](#) provides detail on an implementation strategy based on a cointegration framework without empirical results.

This approach may be exposed to errors arising from the econometric techniques employed such as, mis-specification and mis-estimation. Moreover, Vidyamurthy's approach may also be exposed to errors arising from the econometric techniques. The 2-step cointegration procedure, Engle-Granger method, raises a question about how to select the variables, which one should be independent and dependent variables in the equation.

2.3 The Wavelet Correlation Method

[Zapart \(2004\)](#) introduces an approach in which pairs of stocks from the same sector are selected according to their wavelet correlation measure. For a pair of stocks a correlation between their time-series would be calculated using a highly optimized wavelet correlation measure with help of artificial neural networks and genetic algorithms. The models trade using a set of twenty-five NYSE stocks. Trading simulations show that models are able to make consistent profit during rising and falling markets even when a typical established long-short arbitrage strategy remains flat. Comparing between two measures, the static wavelet correlation measure outperforms a trading system that uses a dynamic version. Besides, a direct comparison to the traditional statistical arbitrage fund managers found that static wavelet model outperformed during the test period 2000-2004 whereas the dynamic models performed in line with an average statistical arbitrage fund manager.

2.4 The Stochastic Spread Method

Elliott, Van der Hoek and Malcolm (2005), apply a Kalman filter to estimating a parametric model of the spread. The result shows that this method provides a consistent and robust to predict the spread for making an investment decisions.

The model offers major advantages from the empirical perspective. First, it exploits mean reversion that underlies pairs trading. Second, being continuous time model, it is convenient for forecasting purposes. Despite the several advantages, this approach does have a fundamental issue is that the model restricts the long run relationship between the two stocks to one of return parity, i.e. in the long run, the two stocks chosen must provide the same return such that any departure from it will be expected to be corrected in the future. This is a big restriction as in practice it is rare to find such two stocks with identical returns.

This study extends the work on the cointegration procedure, the Engle-Granger two-step method, in pairs trading by Vidyamurthy (2004) to integrate the risk control measures and fundamental consideration by selecting only stocks that come from the same industry categorized by the Stock Exchange of Thailand. Although pairs trading has been originally premised on pure statistical results, economic and/or fundamental theory considerations are necessary in verify the strategy as the trader should not lose sight of fundamental driving the values of the assets. Adding this condition to the model, it is believed that the systematic risk, market and sector risks, will be mitigated.

III. Theoretical Framework

First, the concept of Unit Root, Granger causality and Cointegration will be introduced. Then, how to apply this concept to pairs trading strategy will be explained.

3.1 Unit Root Test

In time series models in econometrics a unit root is present if the autoregressive representation of a variable y_t , the coefficient $|\beta|$ is equal to 1 in $y_t = \beta y_{t-1} + \varepsilon_t$, where y_t is the variable of interest at time t , β is the slope coefficient, and ε_t is an error component. Whenever a unit root is present, the time series is said to be non-stationary or integrated of order one or $I(1)$ according to Engle terminology. A unit root test tests whether a time series variable is non-stationary.

Consider the autoregressive model

$$y_t = \alpha + \beta y_{t-1} + \varepsilon_t \quad (1)$$

where we assume that $y_0 = 0$, β is a real number, and ε_t is a sequence of independent normal random variables with mean zero and a constant variance, and $t = 1, 2, \dots, T$. We want to test whether $\beta = 1$, if we cannot reject the null hypothesis then y_t contains a unit root and is not stationary. However, the test is best implemented by subtracting y_{t-1} to both sides, it then becomes:

$$\Delta y_t = \alpha + \gamma y_{t-1} + \varepsilon_t \quad (2)$$

where $\gamma = \beta - 1$.

$$H_0: \gamma = 0$$

$$H_1: \gamma < 0$$

The OLS t-stat testing $\gamma = 0$ is called the Dickey-Fuller statistics. Note that acceptance of the null, $\gamma = 0$, or equivalently with $\beta = 1$, implied that the time series carries unit root and is not stationary. Rejection of the null, $\gamma < 0$, implies that $\beta < 1$, means that the time series converges to a stationary time series.

3.2 Granger Causality Test

A question that frequently is frequently arised in time series analysis is whether one economic variable can forecast another economic variable. One way to answer this question was proposed by [Granger \(1969\)](#). Testing causality, in the Granger sense, involves using F-tests to test whether lagged information on a variable x provides any statistically significant information about a variable y in the presence of lagged y . If not, then “ x does not Granger-cause y .”

To implement a test of Granger causality, we use the autoregressive specification of a bivariate vector autoregression. Assume a particular autoregressive lag length p , and estimate the following equation by ordinary least squares (OLS):

$$y_t = C + \sum_{i=1}^p \alpha_i y_{t-i} + \sum_{i=1}^p \beta_i x_{t-i} + \mu_t \quad (3)$$

$$H_0: \beta_i = 0 \quad \text{for all } i$$

$$H_1: \beta_i \neq 0$$

Then we conduct an F-test of the null hypothesis by estimating the following equation by OLS:

$$y_t = C + \sum_{i=1}^p \gamma_i y_{t-i} + \varepsilon_t \quad (4)$$

Compare their respective sum of squared residuals.

$$RSS\mu = \sum_{t=1}^T \mu_t^2 \quad , \quad RSS\varepsilon = \sum_{t=1}^T \varepsilon_t^2$$

If the test statistic

$$S = \frac{(RSS\varepsilon - RSS\mu)/p}{RSS\mu/(T-2p-1)} \quad (5)$$

is greater than the specified critical value, then reject the null hypothesis that x_t does not Granger-cause y_t .

3.3 Cointegration Test

It is an economic technique for testing the correlation between non-stationary time series variables. If two or more series are themselves non-stationary, but a linear combination of them is stationary, then the series are said to be cointegrated.

In regression model

$$y_t = \alpha + \beta y_{t-1} + \varepsilon_t \quad (6)$$

where y_t and x_t are both nonstationary and $I(1)$ processes. The difference between them tends to be increasing, not stable as time passing. Unless there is some relationship between y_t and x_t , then there should be α and β such that

$$\varepsilon_t = y_t - \alpha + \beta x_t \quad (7)$$

is $I(0)$ or stationary. Intuitively, if two series are both $I(1)$, then this partial difference between them might be stable around a fixed mean. Two series that satisfy this requirement are said to be cointegrated. In such a case, we can estimate a long-run relationship between y_t and x_t .

The most well known test, suggested by Engle and [Granger \(1987\)](#) is to run a static regression (after first having verified that y_t and x_t are both $I(1)$). In the single equation approach, the test of cointegration can be conducted in the following

manner. First, we regress y_t on x_t by ordinary least squares method, and obtain the OLS residuals ε_t

$$\varepsilon_t = y_t - \alpha + \beta x_t \quad (8)$$

where α and β denote the OLS estimates.

$$H_0: \beta = 0$$

$$H_1: \beta < 0$$

Note that acceptance of the null, $\beta = 0$, implied that the residual contains unit root and is not stationary. Rejection of the null, $\beta < 0$, means that the residual converges to the long-term mean or being a stationary time series.

3.4 Applying Cointegration Concept to Pairs Trading

Stock prices move through time, each roughly following random walk. Testing the hypothesis that there is a statistically significant connection between two series of stock price can be done by testing a cointegration procedure. Once, we get the following formula

$$\bar{\alpha} = y_t - \bar{\beta} x_t \quad (9)$$

where $\bar{\alpha}$: estimated mean spread of stock x and y

$\bar{\beta}$: estimated cointegration coefficient

y_t : price of stock y at time t

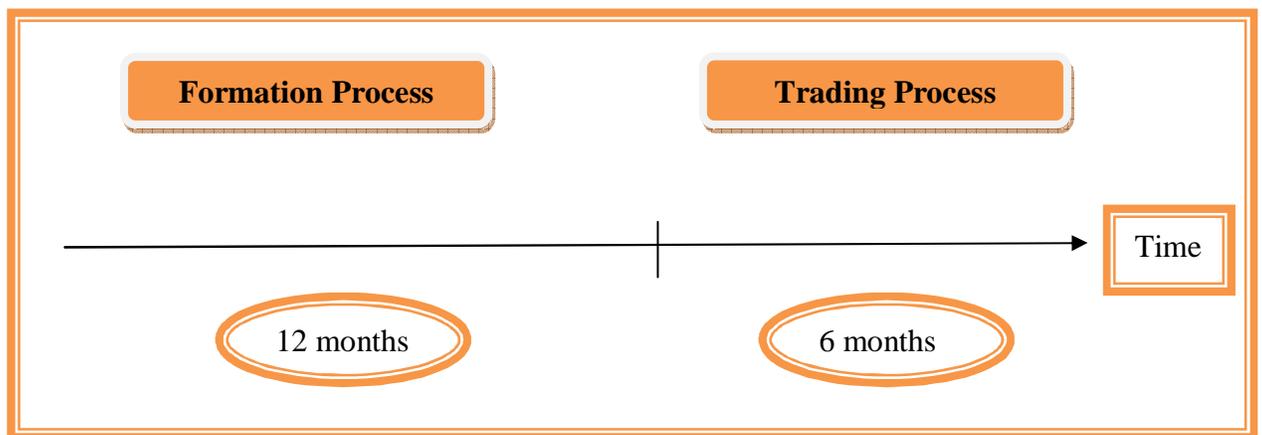
x_t : price of stock x at time t

From this formula, when we get the buy signal from the trading program, we will enter the position by long 1 share of y and simultaneously short $\bar{\beta}$ share of x, and vice versa for the short signal.

IV. Research Methodology

We selected to implement pairs trading based on cointegration approach. Such an approach involves two main processes – forming process for 12 months period and trading process for the next 6 months.

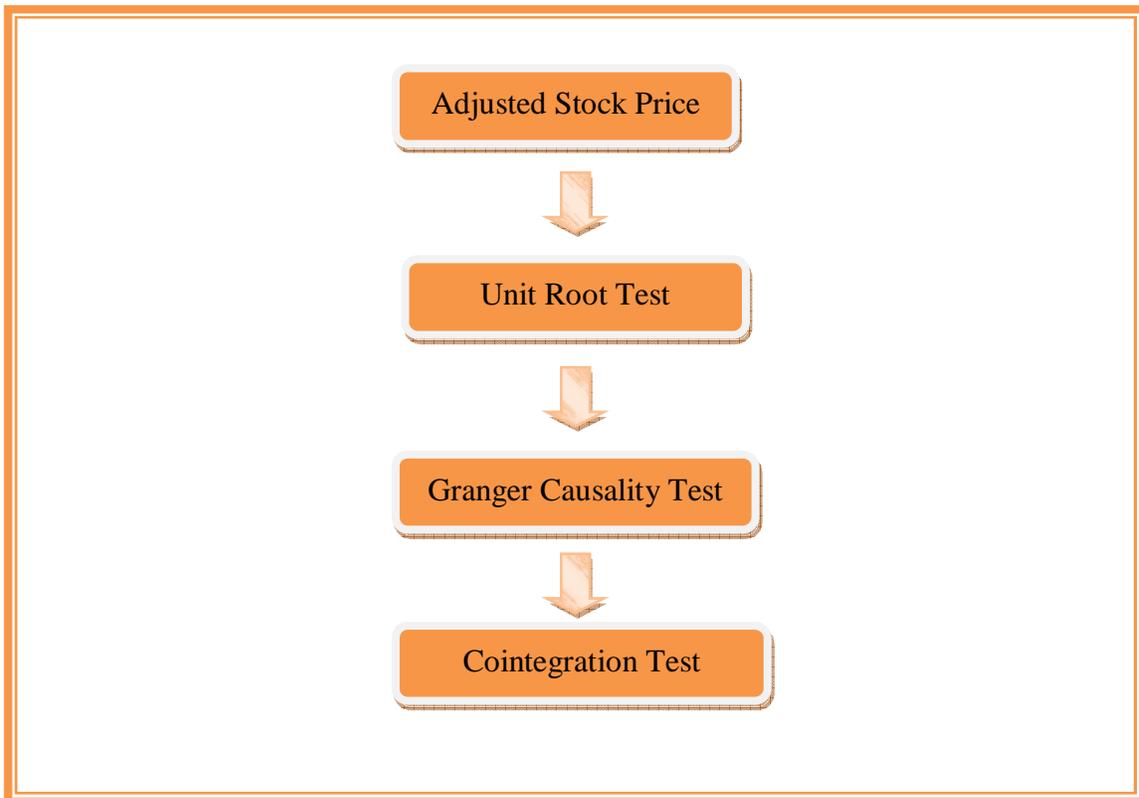
Figure1: Study Process



4.1 Pairs Formation Process

The dataset consists of daily closing price series during 2001-2005 of stock in the SET50 Index. After adjusting stock price, we first examine the stationarity of daily closing price of stock in the SET50 Index for 12 months using the Dickey-Fuller unit root test. Next, the Granger Causality test will be applied to identify which variables might be independent or dependent variables. We then investigate the relation between stock prices over the entire sample period, 12 months, using cointegration test suggested by [Engle-Granger \(1987\)](#). After this process, we could know which pairs of stock are cointegrated and their mean spread, standard deviation of mean spread, which will be used in the next process, trading process.

Figure2: Flow of Pairs Formation Process



4.1.1 Adjusted stock price series

Due to a dividend payment and a par split directly affects to the stock price and each stock may differently pay dividend to the shareholders in each period of time, thus, We need to adjust the dataset by adding back an amount of dividend payment for the formation period and also recalculate the stock price in case of a split in order to know the actual trend of stock price.

$$P_t = P_0 + \sum_{s=0}^t d_s \quad (10)$$

where:

P_t is stock's price at period t

P_0 is stock's price at period 0

d_s is amount of dividend payment at period s

4.1.2 Unit Root Test

A unit root test examines whether a time series variable is non-stationary. If the stock price series is considered to be non-stationary or integrated of order one or I(1) according to Engle terminology, then it is regarded as one of the candidate stocks and will be continually tested in the next process. But, if it is not, that series will be ignored. In this paper, we employ so-called the AUGMENTED Dickey-Fuller test, which seems to be the most popular procedure in applied econometric works.

4.1.3 Granger Causality Test

In the Engle and Granger framework, there are only two steps, Unit Root Test and Cointegration Test, for estimating cointegration relationship. However, for this study, we add one more test, Granger Causality Test, because this test will help to identify that between two variables that need to be regressed which one might be independent and dependent variables.

A time series, X , is said to cause another time series, Y , if present Y can be predicted better by using the value of X . Between two stocks, the stock that causes other one will be selected as an independent variable, while the rest will be dependent variable. However, in case that Granger Causality Test is unable to identify, we will select by considering on market capitalization of stock. Stock with larger market capitalization will be classified as an independent variable and the smaller one will be dependent variable.

4.1.4 Cointegration Test

Cointegration is an econometric property of time series variables. Suppose each of two stock price series x_t and y_t is judged to have a unit root according to the procedure described in the previous section. It means that both x_t and y_t are non-stationary processes. The next step of the procedure is to test whether two given stocks are cointegrated or not.

An ideal situation for pairs trading is when the residual series of two stocks exhibit the characteristics of stationary series. Since pairs trading is a bet that the residual series will revert to its mean or equilibrium value. In other words, deviations from the mean are corrected by the series moving back toward the mean. If the error term of stock pair appears to be stationary, it will indicate that these two stocks are cointegrated. Conversely, if the error term is nonstationary, that pair is not cointegrated.

We check for cointegration of stock prices over the entire sample period with Engle-Granger's cointegration test (1987). For the pair that cointegrated, we will get mean spread, standard deviation of mean spread and price spread of stock pair that is tradable. The pair of stock that is cointegrated will be used to simulate with the real data during the trading process.

4.2 Trading Process

The dataset used in simulation is daily closing price of the next 6 months following the formation period.

4.2.1 Trading by Period

We test Pairs Trading strategy for three kinds of market environment, bullish, bearish and sideways market. The study in the first category is to test performance of pairs trading when the whole market is uptrend. Conversely, the second category is to evaluate the strategy during the market is in downtrend. And, the last, we test the strategy performance in sideways period where market moves in the narrow range. An objective of this is to investigate whether this strategy is able to generate abnormal return in different market situation and to determine the kinds of market environment that Pairs Trading strategy would give the best investment result comparing with several benchmarks.

We define the characteristic of each period as following

- A bull market is a prolonged period of time when market index is rising faster than their historical average.
- A bear market is a prolonged period of time when market index is falling faster than their historical average.
- A sideways market is a situation in which the index moves within a narrow range, showing only small changes up or down.

4.2.2 Trading by Sector

In actual trading, we take the position by choosing stocks only from the same industrial sector, categorized by the Stock Exchange of Thailand because when your position is to long and short stocks in the same industry implied that your position stays as a sector neutral. This means that investor is protected against adverse movements affecting any particular industry.

Besides, we would like to investigate whether different sector will provide the same investment return to investors, if not, what is the factors that can explain the different performance.

4.2.3 Adjusted stock price series

There are two cases about this issue.

- XD date is in the holding period

If we open the position at t_0 and the XD date of one or both stocks that we hold have reached before we are able to close the position. It is necessary to adjust the price of stocks by adding back an amount of dividend payment in order to eliminate the effect of dividend payment to stock price.

- XD date is not in the holding period

If we open the position and are able to close it before an XD date or open the position after an XD date, in this case, it is unnecessary to adjust the stock price since the dividend payment has no effect on our position.

4.2.4 Amount of Invested Capital

In every trade, we will put the position (long & short) with the same amount of money at THB 100 in order to equally weight each position.

4.2.5 Trading Rules

The screening process described gives us a large set of pairs, which can be used to take positions. This should not be done randomly, since timing is an important issue. In order to execute the strategy we need a couple of trading rules to follow, i.e. to clarify when to open and when to close a position. The basic rule will be opened when the price spread of two share prices hits the 2 standard deviation and close it when the spread return to its mean. But, we do not want to open the position in a pair with a price spread is wide and getting wider. Thus, the position is not opened when the spread breaks the two-standard-deviations limit for the first time, but rather when it crosses to revert to the mean again. In other words, we will open the position when the pair is on the way back again. However, the good trading rules might consist of three parts, entry point, profit taking point and stop loss point. The point of stop loss in trading is also necessary in order to limit any loss from a single trade in an acceptable level. We select to close the position when the price spread hits the 4 standard deviation. The reason behind this number is due to we prefer the reward/risk ratio to stay at 1 (2 standard deviation/2 standard deviation) (see the figure 3). And, in the last case that the price spread has neither hit the mean nor stop loss point until the last trading day, we will automatically close the position by using the closing price of the last trading day.

Summary of Trading Rules

Open Trade Condition (OTC)

- Open position when the spread hits the 2 standard deviation band for two consecutive times

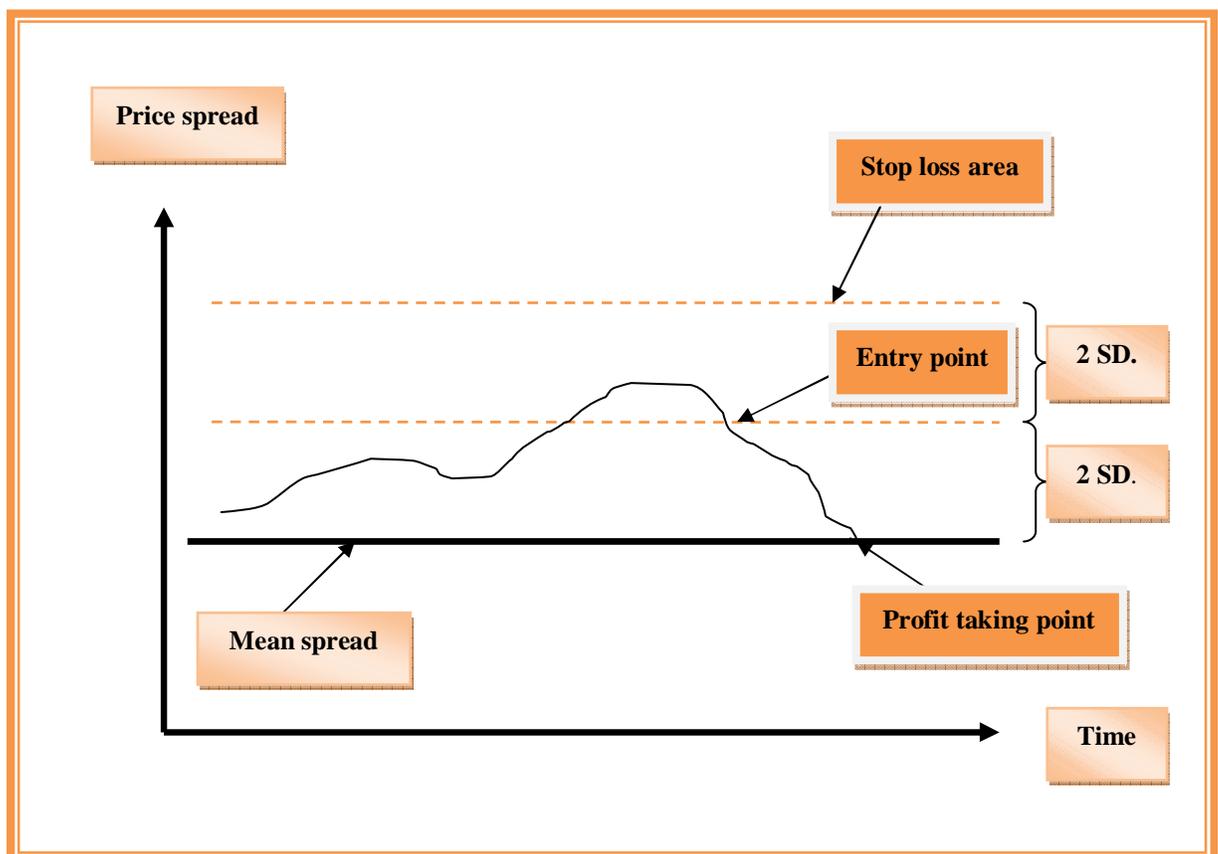
Close Trade Condition (CTC)

- Close position when the spread hits the mean (profit taking)
- Close position when the spread hits the 4 standard deviation band (stop loss)
- Close position at any closing price of the last trading day

Remarks:

- After getting a signal to open the position on one day, we will take the position by buying and simultaneous selling the stock pair in the next trading day at the opening prices and, vice versa for the close signal.
- Due to this paper involves several decision choices in calculation and analysis of quantitative data, we therefore apply Visual Basic for Application (VBA) in helping to calculate and provide the trading signal. The VBA code will be presented in Appendix E.

Figure3: Trading Rules of Pairs Trading Strategy



4.3 Implementation of Pairs Trading Strategy

In theoretical world, investor might receive cash from short selling. But in reality, particularly in Thailand, we need to deposit cash when we borrow stock for short selling. Since an objective of this paper is to study the Pairs Trading strategy in the Stock Exchange of Thailand, we decide to comply with this restriction by depositing 100% of margin when making a short selling. For a better understanding of how to trade with this strategy, we will show the numerical example below,

Consider two stocks, DELTA and HANA that are cointegrated with the following data:

$$\text{HANA} = 5.82 + 0.83 \text{ DELTA}$$

Price spread= 5.82

Cointegration Coefficient= 0.83

Price of HANA at time t_1 = 21

Price of DELTA at time t_1 = 19.90

Price of HANA at time t_3 = 22.60

Price of DELTA at time t_3 = 20.10

- Getting the buying signal of HANA-DELTA at time t_0 , we first need to calculate the number of share for long and short.

Ratio of share number= 1 : 0.83

Amount of invested capital= THB 100

$$\begin{aligned} \text{Multiplier} &= \text{Invested Capital} / [(\text{ratio of share number of stock A} * \text{price of stock A at} \\ &\quad \text{time } t_1) + (\text{ratio of share number of stock B} * \text{price of stock B at time } t_1)] \\ &= 100 / [(1 * 21) + (0.83 * 19.90)] \\ &= 2.67 \end{aligned}$$

Remark: Stock A is for long position and stock B is for short.

We then buy $(2.67*1)$ shares of HANA and simultaneously short $(2.67*0.83)$ shares of DELTA in the next trading day (t_1) at the opening price.

$$\begin{aligned}\text{Cash outflow} &= (\text{share number of stock A} * \text{price of stock A at time } t_1) + \\ &\quad (\text{share number of Stock B} * \text{price of stock B at time } t_1) \\ &= (2.67*21) + (2.22*19.90) \\ &= 100.25\end{aligned}$$

Remark: Cash outflow composes by two parts, one is THB 56.07 for buying 2.67 shares of HANA and other is deposit margin of THB 44.18 for short selling of 2.22 shares of DELTA.

- Getting the closing signal of HANA-DELTA at time t_2 , we then unwind the position by buying back 2.22 shares of DELTA and sell 2.67 shares of HANA in the next trading day (t_3) at the opening price.

$$\begin{aligned}\text{Cash inflow} &= (\text{share number of stock A} * \text{price of stock A at time } t_3) - \\ &\quad (\text{share number of Stock B} * \text{price of stock B at time } t_3) \\ &= (2.67*22.60) - (2.22*20.10) \\ &= 15.72\end{aligned}$$

Plus with deposit margin of THB 44.18 and cash from short selling of DELTA at 44.18

$$\begin{aligned}\text{Total cash inflow} &= \text{Cash inflow} + \text{Deposit margin of stock B at time } t_1 + \text{Cash from} \\ &\quad \text{short selling of stock B at time } t_1 \\ &= 15.72 + 44.18 + 44.18 \\ &= 104.08\end{aligned}$$

$$\begin{aligned}\text{Investment Return} &= (\text{Total cash inflow} - \text{Cash outflow})/\text{Invested capital} \\ &= [(104.08-100.25)/100.25] \\ &= 0.0382 \text{ or } 3.82\% \text{ per month or } 45.84\% \text{ per year}\end{aligned}$$

4.4 Profit & Return Calculation

The profit & loss calculation will be taken monthly. However, in case of CTC is not met, the profit & loss will be calculated by mark to market method.

The next step is to calculate investment return by dividing profit by invested capital, consisting of money that is spent for long position and is also deposited for short position.

$$R_P = \frac{\sum_{i=0}^t (\text{Total cash inflow}_i - \text{Cash outflow}_i)}{\sum_{i=0}^t \text{Invested capital}_i} \quad (8)$$

4.5 Risk-adjusted Return Calculation

To evaluate the strategy performance by only regarding on return might not give the whole picture of that investment. It is more appropriate to concern about investment risk along with the return. This enables the full picture of the investment. Thus, we will apply Sharpe ratio as a measure to compare among investments that which one is the best.

$$S = \frac{R_P - R_f}{\sigma} \quad (9)$$

where:

S is Sharpe ratio

R_P is portfolio return

R_f is risk-free rate, using Treasury Bill 6-months

σ is standard deviation of portfolio return

V. Empirical Results and Analysis

5.1 Statistical Results

5.1.1 Unit Root Test

The procedure begins with checking if a stock price series is an integrated process or not. In this paper, we use so-called the Augmented Dickey-Fuller test.

During bull period, there are 42 securities that are $I(1)$ and 6 securities are $I(0)$, while these figures during the bear market are 45 securities for $I(1)$ and only 2 securities for $I(0)$. The number of $I(0)$ securities is 14 during sideways market, the number of $I(1)$ securities drops to only 34. And during the sector sideways period, the number of $I(1)$ securities moves to 38, while $I(0)$ is only 2 (for more detail see Appendix B).

5.1.2 Granger Causality Test

We need to run regression between two variables in the process of cointegration test, therefore, it is necessary to identify which variable are independent and dependent variables. Granger Causality test is selected for this process. However, in case that Granger Causality test is unable to identify, we will choose the independent and dependent variables by looking at market capitalization. The larger will be selected as an independent variable, while the smaller will be dependent variable. The reason why we select by consideration on market capitalization is due to the large stocks are likely to be the leader in their sectors.

We apply this test for every pair of stock in each sector. Results and details of Granger causality test will be shown in Appendix C.

5.1.3 Cointegration Test

For the process of Cointegration test, we select to use the Engle-Granger test, suggested by Eagle and Granger (1987) to run a regression (after having verified the Unit Root test and Granger Causality test).

According to this test, we find that, during the bull period, from the total number of pair stock of 82 pairs, there are 19 pairs that are cointegrated. For during bear market, total pair of 98, it is considered to be cointegrated only 20. And, 18 pairs are cointegrated from the total of 55 pairs during sideways market. More detail will be shown in Appendix D.

5.2 Performance Analysis

After making a trade according to the trading rules during 6 months of trading period, performance of pairs trading strategy will be shown you below.

5.2.1 Performance by Period

In this study, we divide the study periods into three categories, bull, bear and sideways markets. The study in the first category is to test performance of pairs trading when the whole market is uptrend. Conversely, the second category is to evaluate the strategy during the market is in downtrend. And, the last, we test the strategy performance in sideways period where market moves in the narrow range. An objective of this is to answer the question whether pairs trading strategy is able to provide the abnormal returns in any kinds of market and what kinds of market environment that this strategy shows the best performance, comparing with other benchmarks.

Table 1 presents the annualized mean returns and other information of the pairs trading strategy for the three different trading periods: bullish, bearish, and sideways. For all the trading periods, the pairs trading-profits are positive. Return during bearish and bullish market stand at around 12% annually, while drop to only 5.89% during the sideways period.

The strategy has a number of positions at most in bearish market at 84, and 64 and 58 during sideways and bullish, respectively. However, an accuracy rate seems to be stable at the reliable level, more than 70%, for the study period.

Consider on an average holding period, these numbers stay at around 12.52, 13.62 and 28 days during the three periods. Based on this information, there are two interesting points. First, this implies that pairs trading – implemented according to the particular rules – is a short-term investment strategy. Second, it appears that the market environment affects the length of holding period. During the market seems to be volatile or trending, bullish and bearish market, the length of holding period will be shorter than the sideways period where the market is regarded to have only a few movement.

Table 1 Performance by Period

	Bullish	Bearish	Sideway
Mean Return (%)	12.79	12.84	5.89
Total number of positions	58	84	64
No. of winning trade	43	66	47
No. of losing trade	15	18	17
Accuracy (%)	74.14	78.57	73.44
Average Holding Period (day)	12.52	13.62	28.00

Remark: Definition of each item in table

Item	Definition
Total number of position	Total number of position during the study period
No. of wining trade	Position that is closed with profit
No. of losing trade	Position that is closed with loss
Accuracy	No. of winning trade/total number of position
Average holding period	Total number of holding day during the study period /total number of position during the study period

5.2.2 Performance by Sector

In the previous part, we consider performance of pairs trading strategy by the whole market. Thus, there is a question about what is the performance of this strategy if we trade by sector. When we consider the performance by sector, this may give a better understanding of pairs trading strategy about success factor of the strategy.

Consider on sector trading, it is clearly seen that pairs of stock from finance and electronic sectors relatively perform well. Especially, pairs of financial stock that is able to generate consecutive positive returns for all three periods. On the other hand, pairs from property sector tend to give the poorer result by realizing investment loss during bullish and sideway periods by -28.22% and -3.52%, respectively.

Factor that determines the success of investment result could be business nature of each firm. For example, based on table 2, pair of stock from property sector shows the poorest results. This is mainly due to core business of firms which are characterized in Property sector are different. Though LH, AMATA and, ITD are ranked in the same sector, property, but their core businesses are considered to be quite different. LH business concerns about housing, while ITD is a contractor and industrial park is a major business of AMATA. Thus, factor exposures of these stocks will not be the same. Making a pair from stock like these, investor is unable to hedge any industry risk. This may lead to unflavorable investment result. On the other hand, looking at financial sector which is considered to give the best result, pair of stock from this

sector could generate positive returns for all kinds of market environment and the accuracy rate is very high. We can explain this by considering business nature of stock like KK, TISCO and KGI that are similar and also compete in the same market. Therefore, these kinds of stock are likely to have same factor exposure.

Table 2 Bullish Period (2 July – 31 Dec 03)

	Bank	Construction	Communication	Electronics	Entertainment	Finance	Property
Mean Return (%)	25.75	-17.93	1.44	11.00	15.68	3.46	-28.22
Total No. of Position	20	5	4	9	5	8	7
No. of Winning Trade	20	1	4	7	5	6	0
No. of Losing Trade	0	4	0	2	0	2	7
Accuracy (%)	100.00	20.00	100.00	77.78	100.00	75.00	0.00
Average Holding Period	16.00	9.40	12.75	7.78	4.40	19.88	8.14

Remark: Sectors are categorized according to the Stock Exchange of Thailand.

Definition of each item in table

Item	Definition
Total number of position	Total number of position during the study period
No. of wining trade	Position that is closed with profit
No. of losing trade	Position that is closed with loss
Accuracy	No. of winning trade/total number of position
Average holding period	Total number of holding day during the study period /total number of position during the study period

Table 3 Bearish Period (5 Jan – 30 June 04)

	Bank	Construction	Chemicals	Energy	Entertainment	Finance	Property
Mean Return (%)	-2.58	1.48	6.94	14.86	17.13	13.70	10.00
Total No. of Position	8	20	4	17	7	16	12
No. of Winning Trade	4	14	3	16	6	13	10
No. of Losing Trade	4	6	1	1	1	3	2
Accuracy (%)	50.00	70.00	75.00	94.12	85.71	81.25	83.33
Average Holding Period	3.75	21.30	12.00	6.88	3.86	25.05	7.92

Remark: Definition of each item in table

Item	Definition
Total number of position	Total number of position during the study period
No. of wining trade	Position that is closed with profit
No. of losing trade	Position that is closed with loss
Accuracy	No. of winning trade/total number of position
Average holding period	Total number of holding day during the study period /total number of position during the study period

Table 4 Sideway Period (4 Jan – 30 June 05)

	Construction	Communication	Electronics	Energy	Finance	Property	Transportation
Mean Return (%)	-17.70	2.70	9.91	-3.63	10.92	-3.52	-4.69
Total No. of Position	2	7	8	5	23	17	2
No. of Winning Trade	0	5	8	3	22	9	0
No. of Losing Trade	2	2	0	2	1	8	2
Accuracy (%)	0.00	71.43	100.00	60.00	95.65	52.94	0.00
Average Holding Period	45.00	41.14	16.38	21.40	44.43	8.12	8.00

Remark: Definition of each item in table

Item	Definition
Total number of position	Total number of position during the study period
No. of wining trade	Position that is closed with profit
No. of losing trade	Position that is closed with loss
Accuracy	No. of winning trade/total number of position
Average holding period	Total number of holding day during the study period /total number of position during the study period

At this point, it appears that the similarity of business plays the key role in determining the success or failure of pairs trading strategy. However, what will happen to the performance of strategy, if there are fundamental changes in the stocks.

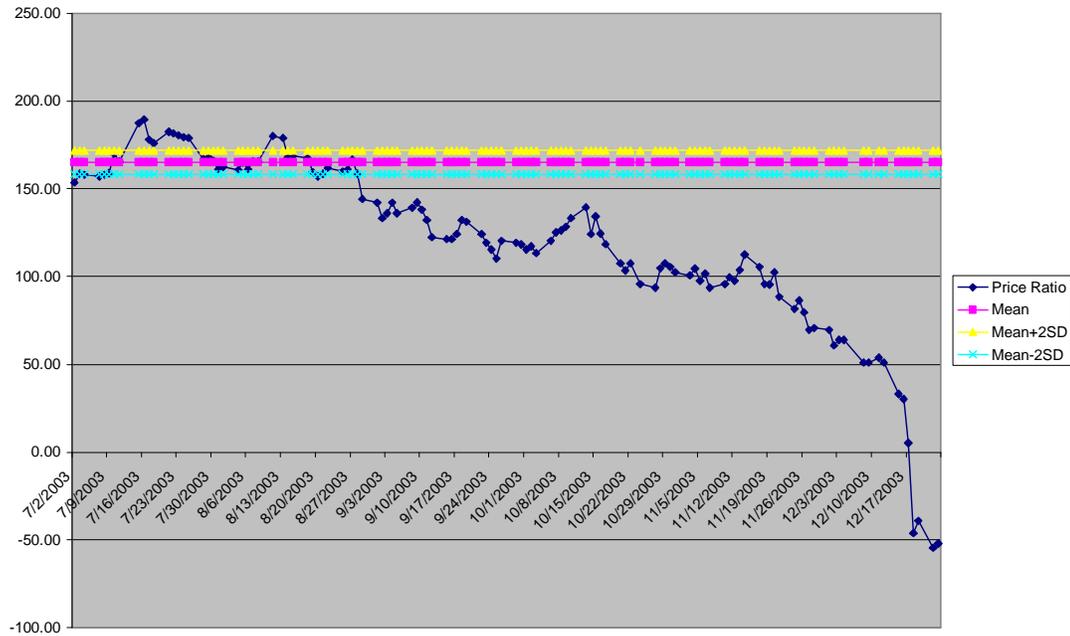
5.2.3 Case study of ITV: When fundamental has changed

BEC-ITV is a pair in entertainment sector and both of them operate in the same business. We raise this case in order to show what will happen to the stock pair if fundamental of one of security making the pair has changed.

During the second half of 2003, ITV requested to the court for the reduction of concession payment from THB 1,000 Million per year to THB 320 Million per year. If this request of ITV were successful, it would significantly increase the company's value. Market responds to this news by buying ITV stock because they totally believe that ITV will win. Thus, ITV stock price rapidly moved from THB 9.35 to THB 29.75, up by 218% within 6 months.

About this case, no matter what the request of ITV will succeed or not. But, this news directly affects and also changes the relationship between pair of ITV and BEC. Figure 4 represents that the price ratio of this pair has moved away from its long-term mean, 165, since the late of August and never come back to this mean.

Figure 4 Movements of BEC-ITV Pair



From this case, we can conclude that not only the similarity of business determining the success of the strategy, but also the fundamental change or just the common believe of market participant that fundamental will change would affect the performance of pairs trading strategy. In the trading world, when it occurs like this, we need to stop trading on that pairs since the relationship between those stocks might change.

5.2.4 Performance after Risk-adjusted Returns

Table 5 Performance by period after risk-adjusted returns

	Bullish	Bearish	Sideway
Mean Return (%)	12.79	12.84	5.89
Standard Deviation	16.92	17.96	11.36
Sharpe Ratio	0.68	0.65	0.33
SET50 Index Return (%)	112.81	-26.88	1.22
Standard Deviation	119.12	59.58	68.20
Sharpe Ratio of SET50	0.94	-0.47	-0.01

To evaluate the strategy performance by only regarding on return might not give the whole picture of that investment. It is more appropriate to concern about investment risk along with the return. We use Sharpe ratio, developed by Nobel Laureate Bill Sharpe to measure risk-adjusted performance. It can tell us whether the returns of a portfolio are due to smart investment decisions or a result of excess risk.

Based on table 5, consider performance of portfolio after adjusted risk by considering Sharpe ratio, we find that pairs trading is able to give the better result than SET50 Index for during bearish and sideway market. Sharpe ratio of the strategy during bearish and sideway are 0.65 and 0.33, while Sharpe ratio of SET50 Index are -0.47 and -0.01, respectively. But, this strategy is regarded to be underperformed during bullish market where Sharpe ratio of SET50 is 0.94 larger than 0.68 of pairs trading strategy. The result indicates that pairs trading strategy is suitable for the timing of market sideway, not bullish.

Consider on sector trading, the below tables confirm that sectors including the company with similar characteristic would give the good performance such as

finance, electronics or entertainment sector. Sharpe ratios of these sectors seem to be stable for both bullish and bearish period. Meanwhile, these numbers of property and construction sectors are poorer than sector number, except in bearish period because sector return during this period is negative.

Table 6 Bullish Period by Sector (2 July – 31 Dec 03)

	Bank	Construction	Communication	Electronics	Entertainment	Finance	Property
Mean Return (%)	25.75	-17.93	1.44	11.00	15.68	3.46	-28.22
Standard Deviation	19.80	32.57	4.51	19.78	22.57	9.63	32.20
Sharpe Ratio	1.24	-0.59	0.04	0.49	0.64	0.26	-0.92
Sector Index Return (%)	104.29	104.85	91.85	17.55	50.57	96.85	142.45
Standard Deviation	144.36	65.73	139.17	86.07	90.47	134.23	143.67
Sharpe Ratio	0.71	1.58	0.65	0.19	0.54	0.71	0.98

Table 7 Bearish Period by Sector (5 Jan – 30 June 04)

	Bank	Construction	Chemicals	Energy	Entertainment	Finance	Property
Mean Return (%)	-2.58	1.48	6.94	14.86	17.13	13.70	10.00
Standard Deviation	17.76	31.40	28.74	17.30	23.42	43.39	21.84
Sharpe Ratio	-0.21	0.01	0.20	0.79	0.68	0.29	0.40
Sector Index Return (%)	-32.18	-28.90	-42.85	-26.51	-73.24	-35.35	-82.73
Standard Deviation	71.12	59.37	121.24	77.60	81.26	64.64	62.54
Sharpe Ratio	-0.47	-0.51	-0.36	-0.36	-0.92	-0.57	-1.34

Table 8 Sideway Period by Sector (4 Jan – 30 June 05)

	Construction	Communication	Electronics	Energy	Finance	Property	Transportation
Mean Return (%)	-17.70	2.70	9.91	-3.63	10.92	-3.52	-4.69
Standard Deviation	20.81	16.51	14.35	28.32	15.96	26.40	11.49
Sharpe Ratio	-0.96	0.03	0.54	-0.21	0.55	-0.22	-0.60
Sector Index Return (%)	-19.22	-14.34	18.14	42.23	-27.48	-19.11	-19.20
Standard Deviation	78.65	76.35	92.24	102.33	80.19	96.68	46.35
Sharpe Ratio	-0.27	-0.22	0.17	0.39	-0.37	-0.22	-0.46

Based on table 8, most of sectors show the negative return, there are only electronics and energy sector having positive result, offsetting the whole market go sideway. Thus, we need to make a further study by sector selecting only the sideway period. The result will show in table 9. Pairs of bank, energy and finance sector present the positive return and their Sharpe ratio are greater than their sector numbers. Communication sector oppositely shows the negative return and Sharpe performance is also less than sector.

These results comply with the prior conclusion that pairs of stock in sector having similar business tends to produce the better investment result than sector having different business nature. Besides, during the sideway market, this strategy can beat the index by giving the higher return.

Table 9 Sectors Sideway Period

	Bank	Communication	Energy	Finance
	(July 04 - Dec 04)	(Nov 01 - Apr 02)	(Feb 04 - July 04)	(July 05 - Dec 05)
Mean Return (%)	4.55	-7.13	4.64	13.79
Standard Deviation	14.29	41.91	14.43	25.68
Sharpe Ratio	0.22	-0.23	0.24	0.43
Total number of positions	27	23	14	17
No. of winning trade	22	12	10	14
No. of losing trade	5	11	4	3
Accuracy (%)	81.48	52.17	71.43	82.35
Average Holding Period (day)	26.81	14.39	14.20	47.18
Sector Index Return (%)	3.64	2.75	0.27	-0.83
Standard Deviation	76.47	75.56	60.67	92.50
Sharpe Ratio	0.03	0.01	-0.01	-0.04

Remark: Definition of each item in table

Item	Definition
Total number of position	Total number of position during the study period
No. of wining trade	Position that is closed with profit
No. of losing trade	Position that is closed with loss
Accuracy	No. of winning trade/total number of position
Average holding period	Total number of holding day during the study period /total number of position during the study period

VI. Conclusion and Further Development

This paper examines the performance of pairs trading strategy in the Stock Exchange of Thailand over the sample period of July 2003 to December 2003, January 2004 to June 2004 and January 2005 to June 2005, which these periods are defined as a bull, bear and sideways market, respectively.

We find that over the entire sample period, pairs trading strategy is able to continuously make a positive return and the return is also greater than risk-free rate, generating an excess return to the investor. This result complies with other works those implemented this strategy in the many countries, such as United State, Australia, Sweden. Performance after risk-adjusted return measured by Sharpe ratio during 2004-2005 is outperformed compared with SET50 Index return since it is in the bearish and sideways period. However, performance of pairs trading strategy during the 2nd half of 2003 is regarded to be underperformed compared to SET50 Index return since it is bull period where most stock prices tend to considerably increase. This implies that if an investor believes that the market in the next period is likely to be bullish, an appropriate strategy might be a long strategy because an investor will get the full benefit of rising market. On the other hand, during bearish market, the best strategy is short strategy. According to the results, it may conclude that **pairs trading strategy should be used for two reasons.**

- **Firstly, during the sideways period, the market only moves in the narrow range.**
- **Secondly, when an investor has no idea about the market trend, since pairs trading is able to provide excess return in every market environment.**

One key factor determining the success of pairs trading strategy; **one is the similarity of business nature.** Although pairs trading has been originally premised on pure statistical results, but fundamental considerations are still necessary, especially in the

pair selection process. **Another factor is whether it has an individual shock.** During the 6-month trading period, pairs of stock whose business is considered to be similar will hedge each other in case of industrial or economic shocks. But, in case of individual shock whose effect is permanent, i.e. ITV case, this will change the relationship between two stocks, making the spread price diverge and not converge to the old level, which may lead to the loss result.

Since the basic concept of pairs trading strategy is to take a long-short position when they diverge, the problem is how do we identify stocks that move together? How far do they have to diverge before a position is put on? When is a position unwound? The Cointegration procedure, suggested by Engle-Granger (1987) can help in answering these questions by estimating long-run relationship of the pair. However, the Engle-Granger method still has a question about how to select the variables, which one should be independent and dependent variables in the equation. Results are sensitive to the ordering of the variables, i.e. if instead x is regressed against y , a different set of price spread, cointegration coefficient and their standard errors will be found from the same sample. Thus, practitioner who would like to apply this method in real life need to concern on this point.

For further development, there are some interesting points that should be considered. Firstly, commission charge should be included into the model due to this is a major cost of the strategy. The second point is to change the length of formation and/or trading periods or some trading rules, such as reward/risk ratio, which may give the better investment result. Another interesting point is to apply this strategy to other financial products or commodity since cointegration is a general economic concept which can be widely applied to determine long-run relationship.

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Online Database

<http://www.set.or.th>

<http://www.wikipedia.com>

<http://www.answer.com>

Appendix A List of Securities in The SET50 Index

- **Bullish Period**

For calculating the index during July 1, 2003 - December 31, 2003

No.	Sector	Securities Name	
1	Agribusiness	CHAROEN POKPHAND FOODS PUBLIC COMPANY LIMITED	CPF
2	Banking	BANK OF AYUDHYA PUBLIC COMPANY LIMITED	BAY
3		BANGKOK BANK PUBLIC COMPANY LIMITED	BBL
4		KASIKORNBANK PUBLIC COMPANY LIMITED	KBANK
5		KRUNG THAI BANK PUBLIC COMPANY LIMITED	KTB
6		THE SIAM COMMERCIAL BANK PUBLIC COMPANY LIMITED	SCB
7		BANK OF ASIA PUBLIC COMPANY LIMITED	BOA
8		BANK THAI PUBLIC COMPANY LIMITED	BT
9		THAI DANU BANK PUBLIC COMPANY LIMITED	DTDB
10		THE THAI MILITARY BANK PUBLIC COMPANY LIMITED	TMB
11		Finance and Securities	ADKINSON SECURITIES PUBLIC COMPANY LIMITED
12	SIAM PANICH LEASING PUBLIC COMPANY LIMITED		SPL
13	KGI SECURITIES (THAILAND) PUBLIC COMPANY LIMITED		KGI
14	KIATNAKIN FINANCE PUBLIC COMPANY LIMITED		KK
15	NATIONAL FINANCE PUBLIC COMPANY LIMITED		NFS
16	TISCO FINANCE PUBLIC COMPANY LIMITED		TISCO
17	Petrochemicals & Chemicals	THE AROMATICS (THAILAND) PUBLIC COMPANY LIMITED	ATC
18		VINYTHAI PUBLIC COMPANY LIMITED	VNT
19	Construction Materials	THE SIAM CEMENT PUBLIC COMPANY LIMITED	SCC
20		SIAM CITY CEMENT PUBLIC COMPANY LIMITED	SCCC
21		SAHAVIRIYA STEEL INDUSTRIES PUBLIC COMPANY LIMITED	SSI
22		TPI POLENE PUBLIC COMPANY LIMITED	TPIPL
23	Property Development	ASIAN PROPERTY DEVELOPMENT PUBLIC COMPANY LIMITED	AP
24		QUALITY HOUSE PUBLIC COMPANY LIMITED	QH
25		ITALIAN-THAI DEVELOPMENT PUBLIC COMPANY LIMITED	ITD
26		LAND AND HOUSES PUBLIC COMPANY LIMITED	LH
27		GOLDEN LAND PROPERTY DEVELOPMENT PUBLIC COMPANY LIMITED	GOLD

28		SANSIRI PUBLIC COMPANY LIMITED	SIRI
29		LALIN PUBLIC COMPANY LIMITED	LALIN
30		AMATA CORPORATION PUBLIC CO.,LTD.	AMATA
31	Energy & Utilities	BANPU PUBLIC COMPANY LIMITED	BANPU
32		ELECTRICITY GENERATING PUBLIC COMPANY LIMITED	EGCOMP
33		PTT PUBLIC COMPANY LIMITED	PTT
34		PTT EXPLORATION AND PRODUCTION PUBLIC COMPANY	PTTEP
35		RATCHABURI ELECTRICITY GENERATING HOLDING PUBLIC CO.,LTD.	RATCH
36	Entertainment and Recreation	BEC WORLD PUBLIC COMPANY LIMITED	BEC
37		ITV PUBLIC COMPANY LIMITED	ITV
38		GMM GRAMMY PUBLIC COMPANY LIMITED	GRAMMY
39		MAJOR CINEPLEX GROUP PUBLIC COMPANY LIMITED	MAJOR
40		UNITED BROADCASTING CORPORATION PUBLIC CO., LTD.	UBC
41	Food & Beverage	THAI UNION FROZEN PRODUCTS PUBLIC COMPANY LIMITED	TUF
42	Transportation & Logistics	BANGKOK EXPRESSWAY PUBLIC COMPANY LIMITED	BECL
43		THAI AIRWAYS INTERNATIONAL PUBLIC COMPANY LIMITED	THAI
44	Communication	ADVANCED INFO SERVICE PUBLIC COMPANY LIMITED	ADVANC
45		SHIN SATELLITE PUBLIC COMPANY LIMITED	SATTEL
46		SHIN CORPORATION PUBLIC COMPANY LIMITED	SHIN
47		TELECOM ASIA PUBLIC COMPANY LIMITED	TA
48	Companies Under Rehabilitation	MILLIONIUM STEEL PUBLIC COMPANY LIMITED	MS
49	Electronic Components	HANA MICROELECTRONICS PUBLIC COMPANY LIMITED	HANA
50		DELTA ELECTRONICS PUBLIC COMPANY LIMITED	DELTA

- **Bearish Period**

For calculating the index during January 1, 2004 - June 30, 2004

No.	Sector	Securities Name	
1	Agribusiness	CHAROEN POKPHAND FOODS PUBLIC COMPANY LIMITED	CPF
2	Banking	BANK OF AYUDHYA PUBLIC COMPANY LIMITED	BAY
3		BANGKOK BANK PUBLIC COMPANY LIMITED	BBL
4		KASIKORNBANK PUBLIC COMPANY LIMITED	KBANK
5		KRUNG THAI BANK PUBLIC COMPANY LIMITED	KTB
6		THE SIAM COMMERCIAL BANK PUBLIC COMPANY LIMITED	SCB
7		BANK OF ASIA PUBLIC COMPANY LIMITED	BOA
8		BANK THAI PUBLIC COMPANY LIMITED	BT
9		THAI DANU BANK PUBLIC COMPANY LIMITED	DTDB
10		THE THAI MILITARY BANK PUBLIC COMPANY LIMITED	TMB
11		Finance and Securities	KGI SECURITIES (THAILAND) PUBLIC COMPANY LIMITED
12	SIAM PANICH LEASING PUBLIC COMPANY LIMITED		SPL
13	KIATNAKIN FINANCE PUBLIC COMPANY LIMITED		KK
14	NATIONAL FINANCE PUBLIC COMPANY LIMITED		NFS
15	TISCO FINANCE PUBLIC COMPANY LIMITED		TISCO
16	Petrochemicals & Chemicals	THE AROMATICS (THAILAND) PUBLIC COMPANY LIMITED	ATC
17		VINYTHAI PUBLIC COMPANY LIMITED	VNT
18	Construction Materials	THE SIAM CEMENT PUBLIC COMPANY LIMITED	SCC
19		SIAM CITY CEMENT PUBLIC COMPANY LIMITED	SCCC
20		SAHAVIRIYA STEEL INDUSTRIES PUBLIC COMPANY LIMITED	SSI
21		VANACHAI GROUP PUBLIC COMPANY LIMITED	VNG
22		TPI POLENE PUBLIC COMPANY LIMITED	TPIPL
23	Property Development	ASIAN PROPERTY DEVELOPMENT PUBLIC COMPANY LIMITED	AP
24		QUALITY HOUSE PUBLIC COMPANY LIMITED	QH
25		ITALIAN-THAI DEVELOPMENT PUBLIC COMPANY LIMITED	ITD
26		LAND AND HOUSES PUBLIC COMPANY LIMITED	LH
27		GOLDEN LAND PROPERTY DEVELOPMENT PUBLIC COMPANY LIMITED	GOLD
28		SANSIRI PUBLIC COMPANY LIMITED	SIRI
29		AMATA CORPORATION PUBLIC CO.,LTD.	AMATA

30	Energy & Utilities	BANPU PUBLIC COMPANY LIMITED	BANPU
31		ELECTRICITY GENERATING PUBLIC COMPANY LIMITED	EGCOMP
32		PTT PUBLIC COMPANY LIMITED	PTT
33		PTT EXPLORATION AND PRODUCTION PUBLIC COMPANY	PTTEP
34		RATCHABURI ELECTRICITY GENERATING HOLDING PUBLIC CO.,LTD.	RATCH
35	Entertainment and Recreation	BEC WORLD PUBLIC COMPANY LIMITED	BEC
36		ITV PUBLIC COMPANY LIMITED	ITV
37		GMM GRAMMY PUBLIC COMPANY LIMITED	GRAMMY
38		MAJOR CINEPLEX GROUP PUBLIC COMPANY LIMITED	MAJOR
39		UNITED BROADCASTING CORPORATION PUBLIC CO., LTD.	UBC
40	Food & Beverage	THAI UNION FROZEN PRODUCTS PUBLIC COMPANY LIMITED	TUF
41	Transportation & Logistics	BANGKOK EXPRESSWAY PUBLIC COMPANY LIMITED	BECL
42		THAI AIRWAYS INTERNATIONAL PUBLIC COMPANY LIMITED	THAI
43	Communication	ADVANCED INFO SERVICE PUBLIC COMPANY LIMITED	ADVANC
44		SHIN SATELLITE PUBLIC COMPANY LIMITED	SATTEL
45		SHIN CORPORATION PUBLIC COMPANY LIMITED	SHIN
46		TT&T PUBLIC COMPANY LIMITED	TT&T
47		TELECOM ASIA PUBLIC COMPANY LIMITED	TA
48	Companies Under Rehabilitation	MILLIONIUM STEEL PUBLIC COMPANY LIMITED	MS
49	Electronic Components	HANA MICROELECTRONICS PUBLIC COMPANY LIMITED	HANA
50		DELTA ELECTRONICS PUBLIC COMPANY LIMITED	DELTA

- **Sideway Period**

For calculating the index during January 1, 2005 - June 30, 2005

No.	Sector	Securities Name	
1	Banking	BANK OF AYUDHYA PUBLIC COMPANY LIMITED	BAY
2		BANGKOK BANK PUBLIC COMPANY LIMITED	BBL
3		KASIKORNBANK PUBLIC COMPANY LIMITED	KBANK
4		KRUNG THAI BANK PUBLIC COMPANY LIMITED	KTB
5		THE SIAM COMMERCIAL BANK PUBLIC COMPANY LIMITED	SCB
6		SIAM CITY BANK PUBLIC COMPANY LIMITED	SCIB
7		THE THAI MILITARY BANK PUBLIC COMPANY LIMITED	TMB
8	Finance and Securities	ASIA PLUS SECURITIES PUBLIC COMPANY LIMITED	ASP
9		KIM ENG SECURITIES (THAILAND) PUBLIC COMPANY LIMITED	KEST
10		KGI SECURITIES (THAILAND) PUBLIC COMPANY LIMITED	KGI
11		KIATNAKIN FINANCE PUBLIC COMPANY LIMITED	KK
12		NATIONAL FINANCE PUBLIC COMPANY LIMITED	NFS
13		TISCO FINANCE PUBLIC COMPANY LIMITED	TISCO
14	Petrochemicals & Chemicals	THE AROMATICS (THAILAND) PUBLIC COMPANY LIMITED	ATC
15		NATIONAL PETROCHEMICAL PUBLIC COMPANY LIMITED	NPC
16		THAI OLEFINS PUBLIC COMPANY LIMITED	TOC
17		THAI PLASTIC AND CHEMICALS PUBLIC COMPANY LIMITED	TPC
18		VINYTHAI PUBLIC COMPANY LIMITED	VNT
19	Construction Materials	MILLENNIUM STEEL PUBLIC COMPANY LIMITED	MS
20		THE SIAM CEMENT PUBLIC COMPANY LIMITED	SCC
21		SIAM CITY CEMENT PUBLIC COMPANY LIMITED	SCCC
22		SAHAVIRIYA STEEL INDUSTRIES PUBLIC COMPANY LIMITED	SSI
23		TPI POLENE PUBLIC COMPANY LIMITED	TPIPL
24		VANACHAI GROUP PUBLIC COMPANY LIMITED	VNG
25	Property Development	ASIAN PROPERTY DEVELOPMENT PUBLIC COMPANY LIMITED	AP
26		CH.KARNCHANG PUBLIC COMPANY LIMITED	CK
27		ITALIAN-THAI DEVELOPMENT PUBLIC COMPANY LIMITED	ITD
28		LAND AND HOUSES PUBLIC COMPANY LIMITED	LH
29		SINO-THAI ENGINEERING AND CONSTRUCTION PUBLIC CO.,LTD.	STEC
30	Energy & Utilities	BANPU PUBLIC COMPANY LIMITED	BANPU

31		ELECTRICITY GENERATING PUBLIC COMPANY LIMITED	EGCOMP
32		PTT PUBLIC COMPANY LIMITED	PTT
33		PTT EXPLORATION AND PRODUCTION PUBLIC COMPANY	PTTEP
34		RATCHABURI ELECTRICITY GENERATING HOLDING PUBLIC CO.,LTD.	RATCH
35	Entertainment and Recreation	BEC WORLD PUBLIC COMPANY LIMITED	BEC
36		ITV PUBLIC COMPANY LIMITED	ITV
37		UNITED BROADCASTING CORPORATION PUBLIC CO., LTD.	UBC
38	Transportation & Logistics	AIRPORTS OF THAILAND PUBLIC COMPANY LIMITED	AOT
39		BANGKOK EXPRESSWAY PUBLIC COMPANY LIMITED	BECL
40		PRECIOUS SHIPPING PUBLIC COMPANY LIMITED	PSL
41		THAI AIRWAYS INTERNATIONAL PUBLIC COMPANY LIMITED	THAI
42		THORESEN THAI AGENCIES PUBLIC COMPANY LIMITED	TTA
43	Communication	ADVANCED INFO SERVICE PUBLIC COMPANY LIMITED	ADVANC
44		SHIN SATELLITE PUBLIC COMPANY LIMITED	SATTEL
45		SHIN CORPORATION PUBLIC COMPANY LIMITED	SHIN
46		TT&T PUBLIC COMPANY LIMITED	TT&T
47		UNITED COMMUNICATION INDUSTRY PUBLIC COMPANY LIMITED	UCOM
48		TRUE CORPORATION PUBLIC COMPANY LIMITED	TRUE
49	Electronic Components	HANA MICROELECTRONICS PUBLIC COMPANY LIMITED	HANA
50		DELTA ELECTRONICS (THAILAND) PUBLIC COMPANY LIMITED	DELTA

Appendix B Unit Root Test

- Bullish Period**

Stock Code	Level of Integration
KTB	I (1)
BBL	I (1)
KBANK	I (1)
SCB	I (1)
BAY	I (1)
TMB	I (1)
DTDB	I (1)
BT	I (0)
BOA	I (0)
SCC	I (1)
SCCC	I (1)
TPIPL	I (0)
SSI	I (1)
VNG	I (1)
ATC	I (1)
VNT	I (1)
ADVANC	I (1)
SHIN	I (1)
SATTEL	I (1)
TRUE	I (1)
DELTA	I (1)
HANA	I (1)
PTT	I (1)
PTTEP	I (1)
RATCH	I (1)
EGCOMP	I (1)
BANPU	I (1)

Stock Code	Level of Integration
BEC	I (1)
GRAMMY	I (1)
UBC	I (1)
MAJOR	I (0)
ITV	I (1)
ASL	I (1)
KGI	I (1)
KK	I (1)
NFS	I (1)
SPL	I (1)
TISCO	I (1)
LH	I (1)
QH	I (1)
GOLD	I (1)
ITD	I (1)
AP	I (0)
SIRI	I (1)
AMATA	I (1)
LALIN	I (0)
THAI	I (1)
BECL	I (1)

- **Bearish Period**

Stock Code	Level of Integration
KTB	I (1)
BBL	I (1)
KBANK	I (1)
SCB	I (1)
BAY	I (1)
TMB	I (1)
DTDB	I (1)
BT	I (1)
BOA	I (0)
SCC	I (1)
SCCC	I (0)
TPIPL	I (1)
SSI	I (1)
VNG	I (1)
ATC	I (1)
VNT	I (1)
ADVANC	I (1)
SHIN	I (1)
SATTEL	I (1)
TRUE	I (1)
TT&T	I (1)

Stock Code	Level of Integration
DELTA	I (1)
HANA	I (1)
PTT	I (1)
PTTEP	I (1)
RATCH	I (1)
EGCOMP	I (1)
BANPU	I (1)
BEC	I (1)
GRAMMY	I (1)
UBC	I (1)
MAJOR	I (1)
ITV	I (1)
KGI	I (1)
KK	I (1)
NFS	I (1)
SPL	I (1)
TISCO	I (1)
LH	I (1)
QH	I (1)
GOLD	I (1)
ITD	I (1)
AP	I (1)
SIRI	I (1)
AMATA	I (1)
THAI	I (1)
BECL	I (1)

- **Sideway Period**

Stock Code	Level of Integration
KTB	I (1)
BBL	I (1)
KBANK	I (0)
SCB	I (0)
BAY	I (0)
TMB	I (0)
SCIB	I (0)
SCC	I (1)
SCCC	I (1)
TPIPL	I (1)
SSI	I (1)
VNG	I (1)
ATC	I (1)
VNT	I (1)
TOC	I (1)
TPC	I (0)
NPC	I (0)
ADVANC	I (1)
SHIN	I (1)
SATTEL	I (1)
TRUE	I (1)
TT&T	I (1)
UCOM	I (1)

Stock Code	Level of Integration
DELTA	I (1)
HANA	I (1)
PTT	I (1)
PTTEP	I (1)
RATCH	I (0)
EGCOMP	I (0)
BANPU	I (1)
BEC	I (0)
UBC	I (1)
ITV	I (0)
KGI	I (1)
KK	I (1)
KEST	I (1)
NFS	I (0)
TISCO	I (0)
LH	I (1)
AP	I (1)
ITD	I (1)
CK	I (1)
STEC	I (1)
THAI	I (1)
BECL	I (1)
AOT	I (0)
PSL	I (1)
TTA	I (1)

- **Sector Sideway Period**

Stock Code	Level of Integration
KTB	I (1)
BBL	I (1)
KBANK	I (1)
SCB	I (1)
BAY	I (1)
TMB	I (0)
SCC	I (1)
SCCC	I (1)
TPIPL	I (0)
SSI	I (1)
MS	I (1)
VNG	I (1)
ATC	I (1)
VNT	I (1)
NPC	I (1)



Stock Code	Level of Integration
ADVANC	I (1)
SHIN	I (1)
SATTEL	I (1)
TRUE	I (1)
TT&T	I (1)
JASMIN	I (1)
UCOM	I (1)
DELTA	I (1)
HANA	I (1)
PTT	I (1)
PTTEP	I (1)
RATCH	I (1)
EGCOMP	I (1)
BANPU	I (1)
BEC	I (1)
UBC	I (1)
GRAMMY	I (1)
KGI	I (1)
KK	I (1)
KEST	I (1)
NFS	I (1)
TISCO	I (1)
LH	I (1)
QH	I (1)
GOLD	I (1)

Appendix C Granger Causality Test

- Bullish Period**

Pairs of Stock	Test Result		
	Dependent	Independent	No Result
KTB-BBL	BBL	KTB	
KTB-KBANK	KBANK	KTB	
KTB-SCB	SCB	KTB	
KTB-BAY			X
KTB-TMB			X
KTB-DTDB			X
BBL-KBANK			X
BBL-SCB			X
BBL-BAY			X
BBL-TMB			X
BBL-DTDB			X
KBANK-SCB	KBANK	SCB	
KBANK-BAY	BAY	KBANK	
KBANK-TMB	KBANK	TMB	
KBANK-DTDB	KBANK	DTDB	
SCB-BAY	BAY	SCB	
SCB-TMB	SCB	TMB	
SCB-DTDB	SCB	DTDB	
BAY-TMB	BAY	TMB	
BAY-DTDB	BAY	DTDB	
TMB-DTDB	DTDB	TMB	
SCC-SCCC	SCCC	SCC	
SCC-SSI	SSI	SCC	
SCC-VNG			X
SCCC-SSI	SCCC	SSI	
SCCC-VNG			X
SSI-VNG			X
ATC-VNT			X
ADVANC-SHIN	SHIN	ADVANC	
ADVANC-SATTEL	SATTEL	ADVANC	
ADVANC-TRUE	TRUE	ADVANC	
SHIN-TRUE			X
SHIN-SATTEL			X
SATTEL-TRUE	TRUE	SATTEL	
DELTA-HANA			X

Pairs of Stock	Test Result		
	Dependent	Independent	No Result
PTT-PTTEP	PTTEP	PTT	
PTT-RATCH	PTT	RATCH	
PTT-EGCOMP	EGCOMP	PTT	
PTT-BANPU	BANPU	PTT	
PTTEP-RATCH	PTTEP	RATCH	
PTTEP-EGCOMP	PTTEP	EGCOMP	
PTTEP-BANPU	BANPU	PTTEP	
RATCH-EGCOMP	EGCOMP	RATCH	
RATCH-BANPU	BANPU	RATCH	
EGCOMP-BANPU	BANPU	EGCOMP	
BEC-GRAMMY			X
BEC-UBC	BEC	UBC	
BEC-ITV	BEC	ITV	
GRAMMY-UBC			X
GRAMMY-ITV			X
UBC-ITV			X
ASL-KGI			X
ASL-KK	ASL	KK	
ASL-NFS	NFS	ASL	
ASL-SPL			X
ASL-TISCO			X
KGI-KK			X
KGI-NFS	KGI	NFS	
KGI-SPL			X
KGI-TISCO			X
KK-NFS			X
KK-SPL			X
KK-TISCO			X
NFS-SPL			X
NFS-TISCO	NFS	TISCO	
SPL-TISCO			X
LH-QH	LH	QH	
LH-GOLD			X
LH-ITD			X
LH-SIRI			X
LH-AMATA			X
QH-GOLD			X

Pairs of Stock	Test Result		
	Dependent	Independent	No Result
QH-ITD	QH	ITD	
QH-SIRI			X
QH-AMATA			X
GOLD-ITD	GOLD	ITD	
GOLD-SIRI			X
GOLD-AMATA			X
ITD-SIRI			X
ITD-AMATA			X
SIRI-AMATA			X
THAI-BECL	THAI	BECL	

- **Bearish Period**

Pairs of Stock	Test Result		
	Dependent	Independent	No Result
KTB-BBL			X
KTB-KBANK			X
KTB-SCB	KTB	SCB	
KTB-BAY	KTB	BAY	
KTB-TMB			X
KTB-DTDB			X
KTB-BT			X
BBL-KBANK			X
BBL-SCB	BBL	SCB	
BBL-BAY			X
BBL-TMB			X
BBL-DTDB			X
BBL-BT	BT	BBL	
KBANK-SCB	SCB	KBANK	
KBANK-BAY			X
KBANK-TMB			X
KBANK-DTDB	KBANK	DTDB	
KBANK-BT			X
SCB-BAY	SCB	BAY	
SCB-TMB			X
SCB-DTDB	SCB	DTDB	
SCB-BT			X
BAY-TMB			X
BAY-DTDB			X
BAY-BT			X
TMB-DTDB			X
TMB-BT			X
DTDB-BT			X
SCC-TPIPL	TPIPL	SCC	
SCC-SSI			X
SCC-VNG	VNG	SCC	
TPIPL-SSI	TPIPL	SSI	
TPIPL-VNG	TPIPL	VNG	
SSI-VNG			X
ATC-VNT	VNT	ATC	

Pairs of Stock	Test Result		
	Dependent	Independent	No Result
ADVANC-SHIN	ADVANC	SHIN	
ADVANC-SATTEL	SATTEL	ADVANC	
ADVANC-TRUE	TRUE	ADVANC	
ADVANC-TT&T	TT&T	ADVANC	
SHIN-TRUE			X
SHIN-SATTEL	SATTEL	SHIN	
SHIN-TT&T	TT&T	SHIN	
SATTEL-TRUE	TRUE	SATTEL	
SATTEL-TT&T			X
TRUE-TT&T			X
DELTA-HANA			X
PTT-PTTEP	PTTEP	PTT	
PTT-RATCH	RATCH	PTT	
PTT-EGCOMP			X
PTT-BANPU			X
PTTEP-RATCH	PTTEP	RATCH	
PTTEP-EGCOMP	EGCOMP	PTTEP	
PTTEP-BANPU	PTTEP	BANPU	
RATCH-EGCOMP	EGCOMP	RATCH	
RATCH-BANPU	RATCH	BANPU	
EGCOMP-BANPU	EGCOMP	BANPU	
BEC-GRAMMY			X
BEC-UBC			X
BEC-ITV			X
BEC-MAJOR	MAJOR	BEC	
GRAMMY-UBC			X
GRAMMY-ITV			X
GRAMMY-MAJOR			X
UBC-ITV	UBC	ITV	
UBC-MAJOR	UBC	MAJOR	
ITV-MAJOR			X
KGI-KK	KK	KGI	
KGI-NFS			X
KGI-SPL			X
KGI-TISCO			X
KK-NFS	NFS	KK	
KK-SPL			X
KK-TISCO			X
NFS-SPL			X

Pairs of Stock	Test Result		
	Dependent	Independent	No Result
NFS-TISCO	NFS	TISCO	
SPL-TISCO	SPL	TISCO	
LH-QH			X
LH-GOLD			X
LH-ITD			X
LH-SIRI	LH	SIRI	
LH-AMATA	AMATA	LH	
LH-AP	LH	AP	
QH-GOLD			X
QH-ITD			X
QH-SIRI			X
QH-AMATA			X
QH-AP			X
GOLD-ITD			X
GOLD-SIRI			X
GOLD-AMATA	AMATA	GOLD	
GOLD-AP	AP	GOLD	
ITD-SIRI			X
ITD-AMATA	ITD	AMATA	
ITD-AP			X
SIRI-AMATA	AMATA	SIRI	
SIRI-AP	AP	SIRI	
AMATA-AP	AMATA	AP	
THAI-BECL	THAI	BECL	

- Sideway Period

Pairs of Stock	Test Result		
	Dependent	Independent	No Result
KTB-BBL			X
SCC-SCCC			X
SCC-TPIPL			X
SCC-SSI			X
SCC-VNG			X
SCC-MS			X
SCCC-TPIPL			X
SCCC-SSI			X
SCCC-VNG			X
SCCC-MS			X
TPIPL-SSI			X
TPIPL-VNG			X
TPIPL-MS			X
SSI-VNG			X
SSI-MS	MS	SSI	
VNG-MS			X
ATC-VNT			X
ADVANC-SHIN	SHIN	ADVANC	
ADVANC-SATTEL	ADVANC	SATTEL	
ADVANC-TRUE			X
ADVANC-TT&T			X
ADVANC-UCOM			X
SHIN-TRUE			X
SHIN-SATTEL			X
SHIN-TT&T			X
SHIN-UCOM			X
SATTEL-TRUE			X
SATTEL-TT&T			X
SATTEL-UCOM			X
TRUE-TT&T	TT&T	TRUE	
TRUE-UCOM			X
TT&T-UCOM			X

Pairs of Stock	Test Result		
	Dependent	Independent	No Result
DELTA-HANA	HANA	DELTA	
PTT-PTTEP			X
PTT-BANPU			X
PTTEP-BANPU	PTTEP	BANPU	
KGI-KK			X
KGI-KEST	KEST	KGI	
KK-KEST	KK	KEST	
LH-AP			X
LH-ITD			X
LH-CK	LH	CK	
LH-STECC			X
AP-ITD	ITD	AP	
AP-CK	AP	CK	
AP-STECC	AP	STECC	
ITD-CK			X
ITD-STECC			X
CK-STECC			X
THAI-BECL			X
THAI-PSL	PSL	THAI	
THAI-TTA	TTA	THAI	
BECL-PSL			X
BECL-TTA			X
PSL-TTA	PSL	TTA	

- Sector Sideway Period

Pairs of Stock	Test Result		
	Dependent	Independent	No Result
KTB-BBL	BBL	KTB	
KTB-KBANK			X
KTB-SCB	KTB	SCB	
KTB-BAY			X
BBL-KBANK			X
BBL-SCB	SCB	BBL	
BBL-BAY			X
KBANK-SCB	SCB	KBANK	
KBANK-BAY			X
SCB-BAY	SCB	BAY	
SCC-SCCC			X
SCC-SSI	SCC	SSI	
SCC-MS			X
SCC-VNG	VNG	SCC	
SCCC-SSI			X
SCCC-MS			X
SCCC-VNG			X
SSI-MS			X
SSI-VNG			X
MS-VNG			X
ATC-VNT	VNT	ATC	
ATC-NPC	ATC	NPC	
VNT-NPC			X
ADVANC-SHIN			X
ADVANC-SATTEL			X
ADVANC-TRUE			X
ADVANC-TT&T			X
ADVANC-JASMIN			X
ADVANC-UCOM	UCOM	ADVANC	
SHIN-TRUE			X
SHIN-SATTEL			X
SHIN-TT&T	SHIN	TT&T	
SHIN-JASMIN			X
SHIN-UCOM			X

Pairs of Stock	Test Result		
	Dependent	Independent	No Result
SATTEL-TRUE			X
SATTEL-TT&T			X
SATTEL-JASMIN			X
SATTEL-UCOM			X
TRUE-TT&T	TT&T	TRUE	
TRUE-JASMIN	TRUE	JASMIN	
TRUE-UCOM	TRUE	UCOM	
TT&T-JASMIN	TT&T	JASMIN	
TT&T-UCOM	TT&T	UCOM	
JASMIN-UCOM	UCOM	JASMIN	
DELTA-HANA			X
PTT-PTTEP			X
PTT-RATCH			X
PTT-EGCOMP			X
PTT-BANPU			X
PTTEP-RATCH			X
PTTEP-EGCOMP			X
PTTEP-BANPU			X
RATCH-EGCOMP			X
RATCH-BANPU			X
EGCOMP-BANPU			X
BEC-GRAMMY			X
BEC-UBC			X
GRAMMY-UBC	UBC	GRAMMY	
KGI-KEST	KGI	KEST	
KGI-KK			X
KGI-NFS			X
KGI-TISCO			X
KEST-KK			X
KEST-NFS			X
KEST-TISCO	KEST	TISCO	
KK-NFS			X
KK-TISCO			X
TISCO-NFS			X
LH-QH			X
LH-GOLD			X
QH-GOLD	QH	GOLD	

Appendix D Cointegration Test

- **Bullish Period**

Pairs of Stock	Test Result					
	Cointegration	No Cointegration	Price Spread	Standard Deviation	Cointegration Coefficient	Standard Deviation
BBL-KTB		X				
KBANK-KTB		X				
SCB-KTB		X				
BAY-KTB		X				
TMB-KTB		X				
DTDB-KTB	X		2.977542	0.08662	0.300397	0.009932
KBANK-BBL		X				
SCB-BBL		X				
BAY-BBL		X				
TMB-BBL		X				
DTDB-BBL		X				
KBANK-SCB	X		6.533793	0.343267	0.730614	0.011219
BAY-KBANK	X		-0.75997	0.256132	0.290611	0.00888
KBANK-TMB		X				
KBANK-DTDB		X				
BAY-SCB		X				
SCB-TMB		X				
SCB-DTDB		X				
BAY-TMB		X				
BAY-DTDB		X				
DTDB-TMB	X		3.097396	0.074619	0.540195	0.016104
SCCC-SCC	X		140.2437	3.968865	0.588156	0.034998
SSI-SCC	X		3.088307	0.169707	0.043473	0.001496
VNG-SCC		X				
SCCC-SSI	X		123.2084	6.410898	10.41704	0.80093
VNG-SSI		X				
VNG-SCCC		X				
VNT-ATC		X				
SHIN-ADVANC	X		0.224204	0.249122	0.318151	0.006248
SATTEL-ADVANC		X				

TRUE-ADVANC		X				
TRUE-SHIN		X				
SATTEL-SHIN		X				
TRUE-SATTEL		X				
DELTA-HANA	X		21.26975	0.535037	0.099587	0.007047
PTTEP-PTT		X				
PTT-RATCH		X				
EGCOMP-PTT	X		12.85216	0.605518	0.646226	0.013682
BANPU-PTT		X				
PTTEP-RATCH		X				
PTTEP-EGCOMP		X				
BANPU-PTTEP		X				
EGCOMP-RATCH		X				
BANPU-RATCH		X				
BANPU-EGCOMP		X				
GRAMMY-BEC		X				
BEC-UBC	X		111.7762	6.580755	6.764806	0.420899
BEC-ITV	X		165.0965	3.393809	9.887401	0.634047
GRAMMY-UBC		X				
GRAMMY-ITV	X		14.24336	0.436853	1.245292	0.081615
UBC-ITV		X				
ASL-KGI		X				
ASL-KK	X		-20.0206	1.147014	0.938113	0.034996
NFS-ASL		X				
ASL-SPL		X				
ASL-TISCO	X		-17.2556	1.071234	1.26016	0.048219
KGI-KK		X				
KGI-NFS		X				
KGI-SPL		X				
KGI-TISCO		X				
KK-NFS		X				
SPL-KK		X				
KK-TISCO	X		4.490315	0.647804	1.273413	0.02916

SPL-NFS		X				
NFS-TISCO		X				
SPL-TISCO		X				
LH-QH		X				
GOLD-LH		X				
ITD-LH		X				
SIRI-LH		X				
AMATA-LH		X				
GOLD-QH	X		-3.73054	0.366632	1.814241	0.048489
QH-ITD		X				
SIRI-QH		X				
AMATA-QH		X				
GOLD-ITD	X		2.512818	0.264015	0.288561	0.010109
GOLD-SIRI		X				
GOLD-AMATA	X		-0.79253	1.622436	2.618973	0.39687
SIRI-ITD		X				
ITD-AMATA		X				
SIRI-AMATA		X				
THAI-BECL		X				

- **Bearish Period**

Pairs of Stock	Test Result					
	Cointegration	No Cointegration	Price Spread	Standard Deviation	Cointegration Coefficient	Standard Deviation
BBL-KTB		X				
KBANK-KTB		X				
KTB-SCB		X				
KTB-BAY		X				
TMB-KTB		X				
DTDB-KTB		X				
BT-KTB		X				
KBANK-BBL		X				
BBL-SCB		X				
BAY-BBL	X		2.263588	0.233434	0.115234	0.003486
TMB-BBL		X				
DTDB-BBL		X				
BT-BBL		X				
SCB-KBANK	X		14.9416	0.41919	0.604415	0.011175
BAY-KBANK		X				
TMB-KBANK		X				
KBANK-DTDB		X				
BT-KBANK		X				
SCB-BAY		X				
TMB-SCB		X				
SCB-DTDB		X				
BT-SCB		X				
TMB-BAY		X				
DTDB-BAY		X				
BT-BAY		X				
DTDB-TMB		X				
BT-TMB		X				
DTDB-BT		X				
TPIPL-SCC	X		-20.7595	1.492292	0.286479	0.009157
SSI-SCC		X				
VNG-SCC	X		2.160718	0.454394	0.048715	0.002788
TPIPL-SSI	X		10.07078	0.657624	0.867701	0.032093
TPIPL-VNG	X		-7.08623	2.401968	3.216694	0.235951

VNG-SSI		X				
VNT-ATC	X		9.21534	0.11275	0.135037	0.004271
ADVANC-SHIN		X				
SATTEL-ADVANC		X				
TRUE-ADVANC		X				
TT&T-ADVANC		X				
TRUE-SHIN		X				
SATTEL-SHIN		X				
TT&T-SHIN		X				
TRUE-SATTEL		X				
TT&T-SATTEL		X				
TT&T-TRUE		X				
HANA-DELTA		X				
PTTEP-PTT	X		86.78393	1.32191	1.013942	0.016938
RATCH-PTT		X				
EGCOMP-PTT		X				
BANPU-PTT		X				
PTTEP-RATCH	X		44.67573	2.303682	3.993311	0.077226
EGCOMP-PTTEP	X		-12.1924	1.197207	0.414774	0.007344
PTTEP-BANPU		X				
EGCOMP-RATCH	X		3.691674	0.785067	1.747875	0.026318
RATCH-BANPU		X				
EGCOMP-BANPU		X				
GRAMMY-BEC		X				
UBC-BEC		X				
ITV-BEC		X				
MAJOR-BEC		X				
GRAMMY-UBC		X				
GRAMMY-MAJOR		X				

GRAMMY-ITV		X				
UBC-ITV	X		12.6445	0.175983	0.550972	0.016232
UBC-MAJOR		X				
ITV-MAJOR		X				
KK-KGI	X		19.01416	0.366943	2.758016	0.059663
KGI-NFS		X				
KGI-SPL		X				
KGI-TISCO	X		-2.09098	0.190426	0.309444	0.007234
NFS-KK	X		7.8552	0.36544	0.127359	0.010263
SPL-KK		X				
KK-TISCO	X		11.9789	0.546621	0.902746	0.020766
NFS-SPL		X				
NFS-TISCO		X				
SPL-TISCO	X		25.39849	0.529227	0.477242	0.020105
QH-LH		X				
GOLD-LH		X				
ITD-LH		X				
LH-SIRI		X				
AMATA-LH		X				
LH-AP	X		0.135199	0.187812	1.893203	0.037115
GOLD-QH		X				
ITD-QH		X				
SIRI-QH		X				
QH-AMATA		X				
AP-QH		X				
GOLD-ITD		X				
GOLD-SIRI		X				
AMATA-GOLD		X				
AP-GOLD	X		0.980841	0.111363	0.362307	0.00988
ITD-SIRI		X				
ITD-AMATA		X				
ITD-AP		X				
AMATA-SIRI		X				
AP-SIRI	X		2.598068	0.060384	0.232206	0.00554
AMATA-AP		X				
THAI-BECL		X				

- **Sideway Period**

Pairs of Stock	Test Result					
	Cointegration	No Cointegration	Price Spread	Standard Deviation	Cointegration Coefficient	Standard Deviation
BBL-KTB		X				
SCCC-SCC		X				
SSI-SCC		X				
TPIPL-SCC		X				
VNG-SCC		X				
MS-SCC		X				
TPIPL-SCCC		X				
SSI-SCCC	X		-1.263474	0.297448	0.017858	0.001304
VNG-SCCC		X				
MS-SCCC		X				
SSI-TPIPL		X				
VNG-TPIPL		X				
MS-TPIPL		X				
VNG-SSI		X				
MS-SSI		X				
VNG-MS		X				
VNT-ATC		X				
SHIN-ADVANC	X		18.02609	1.169488	0.209841	0.012356
ADVANC-SATEL		X				
TRUE-ADVANC		X				
TT&T-ADVANC		X				
UCOM-ADVANC	X		-41.71237	3.510443	0.997729	0.03709
TRUE-SHIN		X				
SATEL-SHIN		X				
UCOM-SHIN	X		-54.77277	7.026817	2.833667	0.18548
TT&T-SHIN		X				
SATEL-TRUE		X				
SATEL-UCOM		X				
TT&T-SATEL	X		2.576065	0.067961	0.091052	0.002889
TT&T-TRUE		X				

TRUE-UCOM		X				
TT&T-UCOM		X				
HANA-DELTA	X		5.817625	0.410203	0.829078	0.018117
PTT-PTTEP	X		70.01016	6.701944	0.328541	0.023542
BANPU-PTT	X		-66.7525	9.330502	1.275324	0.057029
PTTEP-BANPU	X		137.8236	7.303755	1.032524	0.051295
KGI-KK	X		-1.144208	0.148672	0.134138	0.003834
KEST-KGI	X		-7.121097	0.744825	12.64814	0.182449
KK-KEST	X		16.92478	0.518884	0.49314	0.011605
AP-LH		X				
ITD-LH	X		-2.097128	0.555758	1.122527	0.051887
LH-CK	X		7.315516	0.130157	0.228983	0.008615
STEC-LH		X				
ITD-AP	X		2.095439	0.245775	1.725767	0.053839
AP-CK	X		1.940505	0.073969	0.175516	0.004896
AP-STEC	X		2.541656	0.061005	0.154837	0.004555
CK-ITD		X				
STEC-ITD		X				
STEC-CK		X				
BECL-THAI		X				
PSL-THAI		X				
TTA-THAI		X				
PSL-BECL		X				
TTA-BECL		X				
PSL-TTA	X		4.111057	0.749584	0.917451	0.019716

- Sector Sideway Period

Pairs of Stock	Test Result					
	Cointegration	No Cointegration	Price Spread	Standard Deviation	Cointegration Coefficient	Standard Deviation
BBL-KTB		X				
KBANK-KTB		X				
KTB-SCB		X				
BAY-KTB		X				
KBANK-BBL		X				
SCB-BBL	X		14.84598	0.759402	0.34056	0.0088
BAY-BBL	X		5.401703	0.26185	0.072771	0.003034
SCB-KBANK	X		11.45432	0.614375	0.694014	0.013013
BAY-KBANK	X		5.263982	0.314427	0.135727	0.00666
SCB-BAY		X				
SCCC-SCC		X				
SCC-SSI		X				
MS-SCC		X				
VNG-SCC		X				
SSI-SCCC		X				
MS-SCCC		X				
VNG-SCCC		X				
MS-SSI		X				
VNG-SSI		X				
VNG-MS		X				
VNT-ATC		X				
ATC-NPC		X				
VNT-NPC		X				
SHIN-ADVANC		X				
SATTEL-ADVANC		X				
TRUE-ADVANC		X				
TT&T-ADVANC		X				
JASMIN-ADVANC		X				
UCOM-ADVANC		X				
SATTEL-SHIN	X		13.92869	0.874295	0.973022	0.051446

TRUE-SHIN		X				
SHIN-TT&T	X		9.992948	0.462977	1.646157	0.108629
JASMIN-SHIN		X				
UCOM-SHIN		X				
SATTEL-TRUE	X		25.80793	0.414805	0.24644	0.021565
TT&T-SATTEL	X		-4.18714	0.370361	0.27617	0.01216
JASMIN-SATTEL		X				
SATTEL-UCOM		X				
TT&T-TRUE		X				
TRUE-JASMIN	X		3.194025	0.332589	2.158197	0.044588
TRUE-UCOM	X		0.178418	0.547834	0.588867	0.017021
TT&T-JASMIN		X				
TT&T-UCOM		X				
UCOM-JASMIN	X		7.270843	0.479096	3.363478	0.064229
HANA-DELTA		X				
PTTEP-PTT	X		78.25058	1.436678	1.135247	0.015741
RATCH-PTT		X				
EGCOMP-PTT		X				
BANPU-PTT	X		-2.87076	1.090966	0.828259	0.011953
RATCH-PTTEP		X				
EGCOMP-PTTEP		X				
BANPU-PTTEP		X				
EGCOMP-RATCH	X		0.656796	0.906444	1.846437	0.028348
BANPU-RATCH		X				
BANPU-EGCOMP		X				
UBC-BEC		X				
BEC-GRAMMY		X				
UBC-GRAMMY		X				

KGI-KEST		X				
KGI-KK		X				
KGI-NFS	X		-2.19252	0.523345	0.54158	0.051948
KGI-TISCO		X				
KEST-KK		X				
KEST-NFS		X				
KEST-TISCO		X				
NFS-KK		X				
TISCO-KK	X		10.80299	0.885354	0.442119	0.026422
NFS-TISCO		X				
QH-LH		X				
GOLD-LH		X				
QH-GOLD		X				

Appendix E VBA Code for Pairs Trading

Function SignalOTC use to check the signal for Open Trade Condition (OTC)

Option Base 1

Function SignalOTC(Price1, Price2, mu, Mean, SD)

Dim i, j, numRows, flag

numRows = Price1.Rows.Count

Dim SignalColOTC()

ReDim SignalColOTC(numRows, 1)

Dim Price1Col()

ReDim Price1Col(numRows)

Dim Price2Col()

ReDim Price2Col(numRows)

Dim P_Ratio()

ReDim P_Ratio(numRows)

For i = 1 To numRows

P_Ratio(i) = Price1(i) - (mu * Price2(i))

Next i

UpperLim = Mean + (2 * SD)

LowerLim = Mean - (2 * SD)

Count = 0

flag = 0

For i = 1 To numRows

If (Count = 0 And (P_Ratio(i) < UpperLim) And (P_Ratio(i) > LowerLim)) Then

Count = 0

flag = 0

SignalColOTC(i, 1) = "Wait&See"

ElseIf (Count = 0 And (P_Ratio(i) > UpperLim)) Then

Count = 1

```

flag = 1
SignalColOTC(i, 1) = "Wait&See"
ElseIf (Count = 0 And (P_Ratio(i) < LowerLim)) Then
    Count = 1
    flag = -1
    SignalColOTC(i, 1) = "Wait&See"
    ElseIf (Count = 1 And flag = 1 And (P_Ratio(i) < UpperLim) And (P_Ratio(i)
> Mean)) Then
        Count = 0
        flag = 0
        SignalColOTC(i, 1) = "OTC_Sell"
        ElseIf (Count = 1 And flag = -1 And (P_Ratio(i) > LowerLim) And
(P_Ratio(i) < Mean)) Then
            Count = 0
            flag = 0
            SignalColOTC(i, 1) = "OTC_Buy"
            Else: SignalColOTC(i, 1) = "Wait&See"
    End If
Next i
SignalOTC = SignalColOTC
End Function

```

Function SignalCTC use to check the signal for Close Trade Condition (CTC)

```
Function SignalCTC(Price1, Price2, mu, Mean, SD, StopLoss)
Dim i, j, k, m, n, o, p, numRows, numOTC, order, list, flag, finish
numRows = Price1.Rows.Count
Dim SignalColOTC()
ReDim SignalColOTC(numRows, 1)
Dim Price1Col()
ReDim Price1Col(numRows)
Dim Price2Col()
ReDim Price2Col(numRows)
Dim P_Ratio()
ReDim P_Ratio(numRows)
For i = 1 To numRows
P_Ratio(i) = Price1(i) - (mu * Price2(i))
Next i
UpperLim = Mean + (2 * SD)
LowerLim = Mean - (2 * SD)
Count = 0
flag = 0
For i = 1 To numRows
    If (Count = 0 And (P_Ratio(i) < UpperLim) And (P_Ratio(i) > LowerLim)) Then
        Count = 0
        flag = 0
        SignalColOTC(i, 1) = "Wait&See"
    ElseIf (Count = 0 And (P_Ratio(i) > UpperLim)) Then
        Count = 1
        flag = 1
        SignalColOTC(i, 1) = "Wait&See"
    ElseIf (Count = 0 And (P_Ratio(i) < LowerLim)) Then
        Count = 1
```

```

        flag = -1
        SignalColOTC(i, 1) = "Wait&See"
        ElseIf (Count = 1 And flag = 1 And (P_Ratio(i) < UpperLim) And (P_Ratio(i)
> Mean)) Then
            Count = 0
            flag = 0
            SignalColOTC(i, 1) = "OTC_Sell"
            ElseIf (Count = 1 And flag = -1 And (P_Ratio(i) > LowerLim) And
(P_Ratio(i) < Mean)) Then
                Count = 0
                flag = 0
                SignalColOTC(i, 1) = "OTC_Buy"
                Else: SignalColOTC(i, 1) = "Wait&See"
        End If
    Next i
    numOTC = 0
    order = 0
    list = 0
    For i = 1 To numRows
        If (SignalColOTC(i, 1) = "OTC_Sell") Or (SignalColOTC(i, 1) = "OTC_Buy")
Then
            numOTC = numOTC + 1
            Else: numOTC = numOTC
        End If
    Next i
    Dim SignalColCTC()
    ReDim SignalColCTC(numRows, numOTC)
    For n = 1 To numRows
        If (SignalColOTC(n, 1) = "OTC_Sell") Then
            list = list + 1
            SignalColCTC(n, list) = "OTC_Sell"

```

```

For j = n + 1 To numRows
    If ((P_Ratio(j) < Mean) Or (Abs(P_Ratio(j)) > (1 + StopLoss) *
Abs(P_Ratio(n))) Or (j = numRows)) Then
        SignalColCTC(j, list) = "CTC_Buy"
        Else: SignalColCTC(j, list) = "Wait&See"
    End If
Next j
ElseIf (SignalColOTC(n, 1) = "OTC_Buy") Then
    list = list + 1
    SignalColCTC(n, list) = "OTC_Buy"
    For k = n + 1 To numRows
        If ((P_Ratio(k) > Mean) Or (Abs(P_Ratio(k)) < (1 - StopLoss) *
Abs(P_Ratio(n))) Or (k = numRows)) Then
            SignalColCTC(k, list) = "CTC_Sell"
            Else: SignalColCTC(k, list) = "Wait&See"
        End If
    Next k
End If
Next n
For o = 1 To numRows
    For list = 1 To numOTC
        If (SignalColCTC(o, list) = "CTC_Buy") Or (SignalColCTC(o, list) = "CTC_Sell")
Then
            For p = o + 1 To numRows
                SignalColCTC(p, list) = "0"
            Next p
        End If
    Next list
Next o
SignalCTC = SignalColCTC
End Function

```