DOES SIMPLE PAIR TRADING STILL WORK WITHIN THAILAND?

BY

MISS SAINUM TANGSOMBATVISIT

AN INDEPENDENT STUDY SUBMITTED IN PARTIAL
FULFILLMENT OF THE REQUIREMENTS FOR
THE DEGREE OF MASTER OF SCIENCE
PROGRAM IN FINANCE (INTERNATIONAL PROGRAM)
FACULTY OF COMMERCE AND ACCOUNTANCY
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Chairman

(Assistant Professor Chaiyuth Padungsaksawasdi, Ph.D.)

Member and Advisor

(Associate Professor Tatre Jantarakolica, Ph.D.)

Dean

(Professor Siriluck Rotchanakitumnuai, Ph.D.)

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ABSTRACT

Pair trading strategy gains prominence heavily in 2000s as many research papers evidence of extraordinary return by implementing price spread method and ratio selection method, this study on pair trading additionally focuses on single-business company and diversified company in order to investigate whether single business's stock provides higher return than diversified one or not. As well as, most of companies currently change their business strategy to be operating in more than one single business specifically over the past decade, therefore companies with same business or high similarities should be influenced by the same fundamentals and their stock piece should be also. In a nutshell, after having 6 major industries studied in Thailand, pair trading return from single-business companies is abnormal and higher that the diversified-business companies.

Keywords: Pair Trading, Distance Approach, Stochastic Spread Approach, Cointegration Approach, Unit Root Test, Stationarity Test, Zivot Test

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CHAPTER 1
INTRODUCTION

Investors today are in search for new methods, tools and instruments to accelerate their wealth against increasing turbulence and market volatility. Many structured products have been invented and too sophisticated for general investors to approach such as Synthetic Options and Knock-In Knock-Out options, as well as the rising of derivatives products. On the other hand, one of the investment strategies widely used for decades that is Pair Trading, this investment strategy may be on the downtrend, it has never been disappeared from columns of papers since the day it was developed.

Pair trading is a market neutral trading strategy allowing traders to exploit benefit from different market movements. As it acts like a statistical arbitrage and convergence trading, quantitative group at Morgan Stanley explored this pair trading strategy in 1980s. To perform a pair trading strategy, pairs of correlated stock prices are kept record, when their correlation is short-term weaken due to news or earning announcement, one stock climbs up and another one shrinks, the strategy is to short an overperforming one and long underperforming one, risking that the price spread between two stocks would return to the mean. This short-run movement is said to be caused by changing in demand and supply, large buy or sell volume as well as market response to the company's news or earning announcement etc. Therefore, pair trading is a convergence trading strategy (Stander, Marias &Botha, 2013).

In spite of the pair trading strategy on its declining trend, as mainly substituted by derivatives, many studies (Do and Faff, 2010) investigated that pair trading within four major industries still provided excess return during turbulence and market volatility; these industries are utilities, financials, transportation and industrials. Because operating in the same single business are similarly influenced by the same fundamental and these same fundamental has had influenced the business earning, therefore their stock price should be the same. As a consequence when there is a temporary weak in price spread between these two, we trades on that short term

volatile relationship betting on the price movement that they will come back to the mean price.

To the extent, utilities business faces rather stable demand, their products have low differentiation, and power plants are generally subjected to legal and regulation. Likewise, Financials are sensitive to such banking factors such as central bank's interest rate, non-performing loans and bank fees. Having the same fundamental, hence, helps to match stocks within the same business and diminish the out-of-group company to ensure close substitution by class and lessen divergence risk, which could have avoided the share price to move together. In Thailand's telecommunication industry, four big players are ADVANC, DTAC, TRUE, and JAS. Only ADVANC, DTAC and TRUE are mobile operators with voice and non-voice services, whilst JAS is the fixed line operator providing internet broadband with neither voice or non-voice services. So to avoid price divergence, JAS should be excluded out of the group main business. Later on, TRUE is not only a mobile operator, but also owns hundreds of coffee shops around Thailand, television services and fixed line broadband, since TRUE operates in multiple businesses and largely diversified itself from ADVANC and DTAC, it is considered that TRUE is out-of-the group main business. For trading pair, there is now only one match of ADVANC and DTAC that is in the same single business (voice and non-voice services).

On the other hand, many authors (Nath 2003, Gatev, Goetzman and Rouwenhorst 2006, Do and Faff 2006, Do and Faff 2010) studied about pair trading return and found that pair trading performed worst than the historical, specifically 1990s. However, in recent years, pair trading strategy has been shifted to focus only within the same industry with similar business pattern as mentioned in Do and Faff (2010), the authors documented that pair trading still provide abnormal return, as well as Srisakwichai (2007) pointed out that similar nature of business is one of the key determinants of the pair trading success.

Furthermore, for the success of pair trading within Thailand, Srisakwichai (2007) found that pair trading is able to enhance the portfolio return compared with SET50 index between 2003 and 2005, bearish and sideway markets provides the satisfied result rather than bullish market, which is 12.84% and 5.89% respectively,

while SET50 index provided -26.88% and 1.22% respectively. Panyagometh (2013) also added more result to support this success, the pooled data is during 2002 to 2012, he found that pair trading strategy provides abnormal return rather than long-only portfolio, and over the period he documented that pair trading portfolio had 50 times of return larger than long-only portfolio return as well as 500 times of return larger than SET index return.

This study will criticize on pair trading strategy focusing and comparing the same business groups against diversified business groups that operate in more than one single industry. The data is taken from 6 major industries in Thailand during January 2013 to September 215, as well as using SET100 index as a measurement of market movements. To Begin with, pair trading strategy and examples are already shown in chapter I, stepping through theoretical framework in chapter II, then provide research design in chapter III. After that, we will discuss the result in chapter IV, then conclude and provide some recommendation in chapter V.

Research Questions

1. Comparing single business with diversified business, does pair trading strategy generate higher return in single business rather than diversified business?
2. In which market condition does pair trading strategy produce the outstanding return comparing with SET 100 index?
3. What are the key determinants for pair trading strategy to achieve abnormal return?

Objectives

1. To study and investigate whether single business pair trading generate higher return than diversified business pair trading
2. To examine the results for applying pair trading strategy along the trends of Thailand's stock index

CHAPTER 2
THEORETICAL FRAMEWORK

The beginning of pair trading's concept is traced back to 1999 when Gatev (1999) put a record of historical price spread between 2 potential stocks, and decided to do a back test before it was found that an extraordinary return could be made. The success of pair trading in early age, one major explanation comes from the business fundamentals between high potential pairs in trading, business that were allocated under the same industry is exactly the same, and relative to one another as mentioned by Hong(2003) and Gatev(2006). It can be concluded that same business fundamentals contribute to same movement in stock price because these stocks have shared many fundamentals together, for example interest rates, labor productivity and technology.

During the mid-age of pair trading, most of the same-business companies have been more excited to environmental factors and trying to reduce external risks by changing business strategy, they have diversified themselves to be allocated in more-than-one business sectors over the past decade, these companies are known as conducting diversified business. Therefore, if one happens to pair single business stock with diversified one, weakness in relationship is highlighted within the pair, this becomes problematic as well as the rising of derivative market that its concept is more simple to follow and many papers proved it successfully (Kanamura 2008, Donaldson 2012, Ungever 2015). For example, buy one stock while short sell its future stock, which is under the same underlying asset. Unsurprisingly, it follows by a declining trend in simple pair trading.

As a consequence, pair trading over the past decade was not recommended compared to its early age. This is because the focus error, instead of focusing in similar business pair but confusingly trade the single business stock with the diversified business stock and in doing so, many people choose to buy the stocks with its underlying asset. This research paper aims to shed some lights by studying the simple pair trading among single business pairs, and single business against with diversified business stock.

Many companies who concentrate in one single business still exists, under the market pressure they are less in number. As these single-business players within the same industry share the same fundamental, their stock prices reflect in the same way, leads to our theoretical framework that their stock prices should have moved together in the similar trend. This is called relationship among same business fundamental. Pair trading strategy monitors the relationship, and once its long-term relationship is temporarily broken, pair trading steps in to long an underperforming stock and short an overperforming stock. Before covering off the position by sell an underperform one and purchase back an overperform one at the mean reverting position. Therefore, pair trading plays on their temporary weakness of relationship. Rule that is used to identify the price break is previously 10 per cent of price spread, later it is developed to 2 standard deviations of price spread.

In a nutshell, the buyer is able to obtain 2 ways of price spread from one time of pair trading, which is the return from buying the underperform stock as well as the return from selling the overperforming stock. As we have realized, these two stocks are in a long-term relationship, once its relationship is temporarily broken, they will find the way back to its mean reverting price. This concept acts as a weapon to test the relationship among companies, single business to single business, and single business to diversified business, it aims to check whether the single business pair trading provides more abnormal return that diversified pairs or not. The widely accepted fact by Do (2010) is companies with homogeneity or operating in the same single business provides works very well and provide abnormal return, he mentioned that single business pair trading of Financials, Transportation, Utliities and Industries were highly outstanding.

As a so-called distance approach, one of the well known pair trading approaches in the early age, was named after the success of pair trading in early age. Later on, the stochastic spread method, the more advanced stochastic residual spread method and the Cointegration method are developed. For the distance approach, a non-parametric method, is embraced by Gatev, Goetzman and Rouwenhorst (1999) and Nath (2003) with database testing. The stochastic spread method and stochastic spread approach are recently presented Elliot, Van Der Hoek and Malcolm (2005) and

Do, Faff and Hamza (2006), respectively. Lastly, the Cointegration approach with an attempt of Vidyamurthy (2004), he successfully described pair trading by precisely modeling the mean-reversion process.

2.1 The Distance Approach

As being one of the generally known pair trading strategies, Gatev, Goetzman and Rouwenhorst (2006) pioneered this well-known strategy of pair trading, their studies was conducted in the US during 1962 and 2002 evidencing that the portfolio's return was enhanced greater than 10 per cent. Gatev (2006) conducted their trading based on the distance method, which is considered as uncomplicated tool assisting on screening the securities based on historical price spread of the time series. The study brought out 20 trading pairs of the portfolio based on their trading rules, and to contrast with the portfolio that contains only 5 trading pairs, whereas the result demonstrated that the portfolio risk significantly decreased and profit accelerated. In contrast, the actual portfolio's return itself shrinks during the 1990s.

In Gatev (1999, 2006), their trading strategy exercises a back test and pairs are chosen from their historical price movement. Honestly speaking, trading pairs with smallest price spread over the historical are considered as a high potential pair. This method is late on known as the distance approach. The authors also reported that a remarkable return of up to 11% per annum before cost deducted from the chosen pairs. This is because the pairs are consisted of high correlation degree, while unknown systematic risk has not been described. After that Gatev (1999) revealed that their trading rules are examined from total return index with dividends reinvest included over the specified period by using the rule that minimizes the sum of squared deviations between the two stock prices. Likewise, their trading rules are based on numbers of standard deviation measurement, if the pair is deviated for 2 standard deviations (SD) the trade is entered into a position.

As same as Gatev (1999, 2006), Nath (2003) put a record of historical price spread between the pair and decided to enter a position when the pair spread hit 15 percentile. Regardless to the outcome, Nath (2003) prepares a stop loss position for

his pair trade in order to limit the risk that might occur if the pair doesn't revert back to its mean, therefore his cut-loss point is another 5 percentile further from the entered position. In general, the distance approach brings out the statistical price spread of the pair and by using historical data to identify the price spread of when to enter into a position and when to cut loss, it advantages are then not being exposed to model misspecification and miscalculation.

On the face of it, this distance approach as regarded as non-parametric is purely based on statistical movement between trading pair, as same as Do (2006) studied, this non-parametric approach is unable to forecast the trading pair in a longer term, although its advantage is economic model free and no misspecification. The limitation of the distant approach is that it only works for a certain stocks, not any stocks can be paired, and the successful pair must be contained of similar risk.

Furthermore, researchers like Do and Faff (2010) substantially illustrated that pair trading return have been worst in the US during the mid-1990. On the other hand, the strategy still works and does provide abnormal return during the long-term bearish market movement. They criticize that a large amount of pair trading leads to an extraordinary profitability and enhance market effectiveness. In term of high frequency and intraday trading, using the pair trading strategy has been examined to provide even higher return.

2.2 The Stochastic Spread Approach

Elliot (2005) designed a model that captures behavior of price spread between the paired stocks in spontaneous time setting, the price spread is identified as the difference between two stock prices and this price spread is motivated by a time series X, according to Vasicek process as follow:

$$dx_t = \kappa(\theta - x_t)dt + \sigma dB_t$$

As dB_t is a standard Brownian motion in probability space, the time series is recognized to revert back to its mean θ at the speed of κ turning the price spread equivalent to the time series plus a Gaussian noise.

There are three advantages associated with this model. On top of the list, this model is able to catch mean reverting behavior that is an important part of pair trading. For time series X as being negative is not a concern, this is because the price spread is already designed to have a negative value. Well, it is obviously not clearly described from Elliot (2005), however it should be confirm that the spread is calculated from the difference in logarithms of the price. Therefore, the mean of price spread over the long term should not be one fixed number, but increasing as the pair is widen and decreasing as the pair is narrowed. One exclusion is that a pair is traded at a similar price in term, using the price spread from logarithms is not an issue. Secondly, continuous rolling in time setting, this is necessary for forecasting objectives. So that general investors can compute the expected time when the price spread could revert back to its mean level, also the concern is now shifted toward the appropriated holding period as well as how much the return should be. Finally, this model is easy to use, and absolutely manageable with the parameters developed from Kalman Filtering in a state space form. In the sense of minimum mean square error, the estimator is a maximum estimator and optimal.

Although this model is highly advantageous, some drawbacks are remained as it restricts the long-term relationships between the pair as Do (2006) mentioned. In longer term, the chosen pair must provide the return as same as earlier, while any divergence from the previous return will soon be adjusted and return to the starting price. This drawback causes many analysts to find the good pair between two stocks, which two stocks are eventually returned to the opening price. In some extent, risky asset pricing models such as Arbitrage Pricing Theory (APT) and Capital Asset Pricing Model (CAPM) have indicated that any two equities with identical risks should have undifferentiated return, whereas practically, each firm is subjected to specific internal risks that deviates its share price from one another within industry homogeneity.

2.3 The Stochastic Residual Spread Approach

Do, Faff and Hamza (2006) pioneered a pair trading strategy that contrast itself from Elliot (2005) model, by targeting the mispricing calculation on top of the return level instead of price level. This model utilizes the prior literature for long-run relationship in order to get rid of the unrelated trading rules, which are existed over the past literatures. To begin with, this residual approach assumes that there is equilibrium in relative parameter co-exists between two stocks, and this equilibrium can be told by some spread. Mispricing is an outcome from the disequilibrium, which arises from residual spread function where external vector is determined in formulating process of the equilibrium.

By the definition of residual spread, it emphasized that the process is capable of measure any surplus above the long-run spread and probably not a zero values up on the formation spread. Also, company fundamental is considered to influence the stock price movement whether their stock can be headed back to the mean level or not. As the literature discussed, when the disequilibrium occurs, that time we should enter into a pair trade position and close out the position when the disequilibrium is dissolved.

Across the model, an adoption and modification are made from Elliot (2005) in the stochastic spread model, this model employs one parameter from Elliot to improve the mispricing and misspecification, and allow noise to be mixed with the above parameter. As you can see, X is the state of mispricing or residual spread regarding to a counterbalance correlation, whose power is employed by a Vasicek process, as shown below:

$$dx_t = \kappa(\theta - x_t)dt + \sigma dB_t$$

In addition, this formation lets the change between the mispricing dynamics and vector of exposure factor to be continuously determined by engaging in Kalman Filtering, and this avoid the estimation error from the 2-step process. Below are the transition equation and measurement equation that comprise of stochastic residual spread for a pair trading. It is widely recognized as linear Gaussian model that can be

evaluated from maximum likelihood estimation, where an error prediction decomposition form is the key interest in this function.

Transition equation

$$x_k = \theta(1 - e^{-K\Delta}) + e^{-K\Delta}x_{k-1} + \varepsilon_k$$

Measurement equation

$$y_k = x_k + \Gamma r_k^m + H\omega_k$$

To conclude, Do (2006) developed a mean reverting behavior in related to the pricing model between two assets, while pricing model is obtained from Arbitrage Pricing Theory known as APT framework. Along to this framework, the proposed estimation is similar to Elliot (2005). Although this model doesn't make any conclusion from the APT availability, it only duplicates APT framework to derive the relative pricing that the traded pair should have. Likewise, APT framework may define the long-run mispricing of the relative stocks or θ, which almost has a zero value, this non-zero value does not impair APT framework or the pair trading strategy in general.

2.4 The Cointegration Approach

Vidyamurthy (2004) attempts to describe the parameters in the pair trading strategy by accessorizing the Cointegration methodology as firstly developed by Eager and Granger (1987). Cointegration is a relationship between two time series that are co-integrated by a linear combination. For the application to pair trading, time series are integrated with degree of 1 to become stationary, while integration with degree of zero to become a complete time series. This Cointegration characteristic is the most want property for forecasting objectives since being non-stationary is resulted in spurious problem, according to Lim and Martin (1995) studies. Cointegration also embeds a mean reverting behavior into pair trading strategy, which is highly required to make a perfect forecast bases on historical data. If the pair is oscillated around its equilibrium level, then when the pair starts to clearly deviated the pair trade position can be entered again. Likewise, Vector Error Correction model, in

which the power of one time series is functioned of its own lags, is also equivalent to cointegrated time series, with an error-correction component that correct off the deviation in the earlier period to the equilibrium level. Both of them are advantageous at its forecasting capability.

In order to test the Cointegration property, Vidyamurthy (2004) applied Engle and Granger's 2-step framework (Engle and Granger, 1987), that stock X is regressed again stock Y, as a Cointegration equation so called:

$$\log(p_t^X) - \gamma \log(p_t^Y) = \mu + \varepsilon_t$$

Let's assume that γ is equal to cointegration coefficient and the fixed term μ is the premium of stock X over stock Y. The rest is the error term that has to be test for stationary by Augmented Dicky-Fuller test (ADF).

In practice, the above equation suggests that long 1 unit of stock X and short γ unit of stock Y with a long run mean reverting of μ, and any price spread or ε_t will finally come back to the mean reverting level. In the longer term, this pair will always come back to it equilibrium price since ε_t is known as being stationary. Vidyamurthy (2004) explained that the conceptual trading is to long an underperforming stock when the price is lower than its equilibrium level, and as same short an overperforming stock when the price is higher than its equilibrium level. Immediately when the pair returns to hit the equilibrium value, the position is closed out and profit is taken. The key concern is how many shares those stocks should be entered into in order to achieve profit maximization. Vidyamurthy (2004) then came up with both parametric and non-parametric empirical approach to find out the profit maximization method. The first parametric approach with the ARMA process incorporated and then uses Rice's methodology (Rice, 1945) to estimate the amount of two stocks (Δ) that should be put on transaction, the value of Δ is chosen as trading amount. Whilst the non-parametric approach is built on empirical distribution of zero and level crossing, which is based on the historical data. After the value of Δ is recognized, then it is directly applied to the actual transaction.

Furthermore, econometrics that outlines how the pair trading works is explained below. It is classified into 4 categories, which are Unit Root and

Stationarity, Unit Root with Structural Break, Granger Causality test, and Johansen's Cointegration test. These econometric framework will be discussed in the next chapter.

CHAPTER 3
RESEARCH DESIGN

In this study, the stock data are chosen from 6 major industries, each industry is contained of 2 similar-business pairs and 2 diversified-business pairs that totally makes up to 24 trading pairs. These 6 major industries are Technology, Financials, Services, Property, Resources and Agriculture, the purpose of testing these 6 industries is to investigate whether pair trading play roles in a wide variety of Thailand's stock exchange as well as testify the successful industries that were chosen by Do (2010) in the US market, he acclaimed that pair trading in only 4 industries works. The studied data is based on daily closing price of each stock accounted from January 2013 to September 2015, statistically 671 observations for each stock.

3.1 Data Selection

Data is separated into 2 windows, which is forming window, and trading window. For the forming window, the data is 12-month period prior to the trading period as to check causality relationship and obtain the cointegration ratio. After the ratio is derived from the trading window, it is now ready to be use as a multiplier of stocks number in the trading period. For the trading period, data is derived from Stock Exchange of Thailand during January 2013 to September 2015. After the trading periods are ended, market conditions are then analyzed and identified as bearish, bullish and sideways movements depended on its returns. The periods of 3 market conditions are shown below

- Bearish Period: June 2013- Nov 2013 accounted for -14.75%
- Bullish Period: January 2014- June 2014 accounted for 20.78%
- Sideway Period: January 2015- June 2015 accounted for -0.28%

Likewise, the reason this study is interested on pair trading over the last 3 years is most of the listed companies is excited to the environmental factors, they have been trying to reduce the external risks by diversifying themselves and playing heavily on more-than-one business sectors. As can be clearly seen, a large number of

companies focus on changing business strategy in the early of 2010 instead of engaging in one single business.

The purpose is to answer the question of which market condition pair trading strategy produces the outstanding return compared with Stock Exchange of Thailand Index. After the return is calculated from an individual pair, the result will be compared with those related stocks's holding period return and Sharp ratio as well. All information is sourced from SET Smart and Bank of Thailand.

In this section, the methodology is categorized into 2 processes. Firstly, portfolio selection, this approach is advantageous for the stock screening procedure and to test they are being Non-Stationary , before testing their primary structural break if there exists one, causality relationship and finally checking whether two stocks within the same pair are being cointegrated or not. If any individual stocks demonstrates that it is Stationary, it will be removed from our data pool. As well as, if the pair is not causally related to each other, they will be omitted from the pair trading,

Then, pair trading algorithm, which is literally the pair trading rules guiding about price spread and when to open and close out the position. Lastly, implementation of pair trading strategy, profit and return calculation and risk-adjusted return calculation will be illustrated and discussed.

3.2 Trading Period

Since the data is taken from SET100, which contains high daily trading liquidity and volume, our focus is in 6 major industries while the forming window contains daily closing prices series between 2011 and 2015. Likewise, portfolio selection is made during the formation window and then being traded in the trading window stating on the next trading day after the prior day of the forming window. Choosing SET 100 as to ensure that no stock has missing values during any trading days in the forming window, according to Gatev's studies (2006), he cleaned up every stocks that were not showing up during each day as well as consisting lower trading volume than any another day within the period. However, since this study focuses on SET100, there is no concern associating with those being either nil or trading volume.

Subsequently, after adjusting the stock prices, Augmented Dicky-Fuller unit root test is occupied to examine that those stocks chosen from 6 industries are Non-Stationary. Then proceed to Granger Causality test to examine whether each paired stock is a dependent or independent variable. Cointegration test as suggested by Johansen (1988) will investigate their relationship over the studied period. As a result, the test will reveal the cointegration characteristics as well as mean spread, standard deviation that we are able to use in the trading algorithm process.

3.2.1 Stock price alteration

It is undeniable that dividend payout, stock split and par split has no effect upon stock prices, these corporate's various actions adversely impact investors in many different forms. Therefore, it is necessary to have the data set added back by the dividend amount that paid out during forming window, and we must revisit the stock in case of stock split and par split in order to know its actual value.

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

Let, P_t = stock's price at time t

P_0 = stock's price at time 0

d_s = amount of dividend pay out

3.2.2 Testing Unit Root Characteristics and Find Cointegration Ratio

1) Unit Root and Stationarity

To begin with, it is demanded to check whether variables from the data set are stationary or non-stationary, and our aim is to have the variables that are non-stationary. This is because, being non-stationary confirms that variables are contained with trends and seasonality and it is perfect to proceed to causality relationship check. However, in term of arbitrage, if the data set is non-stationary, the right treatment is prerequisite as Brooks (2008) mentioned.

Normally, if the first two moment conditions and auto-covariance are constant, then that time series are identified as being Stationarity. Besides, if the time

series are not depended on time based on mean and volatility, the process is considered as covariance Stationarity or weak, Veerbek (2004) pointed out.

In fact, a unit root test is to test whether a time series variable is non-stationary using an autoregressive model. A widely-known test that is used in large data set is the Augmented Dicky Fuller test (ADF test), and another test is Phillips-Perron test. However these tests use the existence of a unit root as the null hypothesis. Time series can be identified as a unit root or not if the autoregressive presents a variable of y_t, the coefficient |β| 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 term. If there is a unit root, the time series is always a non-stationary or integrated of first moment known as I(1) regarding to Engle terminology.

Following is the autoregressive model:

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

It's assumed that $y_0 = 0$, β is a real number, and ε_t is a randomized error term with mean of zero and constant variance, while t = 1,2, .., T. To test whether β is equal to 1 or not, it the null hypothesis is rejected, then y_t is unit root and non-stationary. Likewise, it is the best to minus y_{t-1} on both sides, then it becomes as follow:

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

where, $\gamma = \beta - 1$

$$H_0 : \gamma = 0$$

$$H_1 : \gamma < 1$$

The ordinary least square t-stat test $\gamma = 0$ is know as Dicky-Fuller statistics. It is remarked that when $\gamma = 0$ making $\beta = 1$ and implying times series is unit root and non-stationary, while rejecting null hypothesis implying that $\beta < 1$ and it is a stationary time series.

2) Unit Root with Structural Break

In this section, Unit Root test is going forward to examine if there is such a case that major structural break destroys Cointegration ability in the time series, and it's universally known that Augmented Dicky-Fuller test fails to detect this structural break because of misspecification bias and exogenous data size, also lead to the non-rejection of unit root null hypothesis. Zivot and Andrews (1992) tackled this problem by allowing a structural break data endogenously under the null hypothesis of a first order integrated variable. Zivot and Andrews test is carried out using the following equations:

(4) Model A or Crash Model-

$$y_t = \mu + \beta t + \theta DU_t + \alpha y_{t-1} + \sum_{i=1}^{k} C_i \Delta y_{t-1} + \varepsilon_t$$

(5) Model B or Changing Growth Model-

$$y_t = \mu + \beta t + \gamma DT_t + \alpha y_{t-1} + \sum_{i=1}^{k} C_i \Delta y_{t-1} + \varepsilon_t$$

(6) Model C or Mixed Model-

$$y_t = \mu + \beta t + \theta DU_t + \gamma DT_t + \alpha y_{t-1} + \sum_{i=1}^{k} C_i \Delta y_{t-1} + \varepsilon_t$$

Where; TB = the date of endogenously determined break

DU_t is equal to 1 when t > TB,0, otherwise DT_t = t- TB when t > TB,0. Model A, known as the crash model, allows for a one-time adjustment in the intercept of the trend function, model B as known as the changing growth model, it is quite similar to model A while it allows for a one-time adjustment in the slope of the trend function without any changes throughout the system. Model C is the best model since the model incorporates a change in the intercept as well as a trend break, its advantage is its least restrictive compared to the intercept only in model A and trend only in model B, therefore model C is being used in our examination. For the null hypothesis, if α is statistically significant, null hypothesis is rejected.

$$H_0 : \alpha = 0$$

$$H_1 : \alpha \neq 0$$

3) Granger Causality Test

Granger Causality test is a statistical hypothesis test for determining the ability of one time series being able to predict a later time series, this concept was proposed by Granger (1969). Generally, regressions represent a minor correlation, but Granger argued that testing the ability to forecast the future value of a time series and using the previous values of that time series could identify causality relationship in econometrics.

A time series X is mentioned to Granger-cause Y if it can be demonstrated, while test is normally conducted as a t-test or f-test on lagged values of X as well as lagged valued of Y is included, and those X values provide statistically significant prediction about future values of Y.

In order to apply Granger Causality test, the autoregressive specification of a bivariate vector Autoregression is introduced. It's accepted that a particular autoregressive lag length p and the following equation by ordinary least squares is measured.

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

$$H_0 : \beta_i = 0$$
$$H_1 : \beta_i \neq 0 \text{ , for all i}$$

After that, F-test of null hypothesis is implemented in order to measure the following equation by ordinary least square:

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

Consider their sum of squared residuals

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

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

When the t-test is larger than the specified critical value, then the null hypothesis is rejected that x_t is not able to predict the future value of y_t.

4) Johansen's Cointegration Test

Cointegration test is a tool to measure statistical property of a time series variables. Firstly, the times series have to be integrated with moment of 1 or non-Stationary as a so called. If their linear combination is integrated with moment of zero, then the series are considered as Cointegration. For example, if a series of X, Y, Z are integrated with moment of 1, and their existed coefficients are α, β, γ making that $\alpha X + \beta Y + \gamma Z$ is integrated with moment of zero, hence X, Y, Z are completely integrated. In recent years, Cointegration becomes an important tool using in a wide variety of time series analysis, which is usually attached with trends whether determinable or randomized.

According to regression model

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

Since y_t and x_t are non-Stationary with moment of 1, also their difference seems to be accelerating, which is not constant as time goes by. Otherwise, the relationship between y_t and x_t would make the equation look like below

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

With moment of zero, the linear combination is Stationary. While two time series happened to be moment of 1, it means that their difference already has a fixed mean satisfying the Cointegration prerequisite, therefore a long-term relationship can be now estimated.

After having tested that y_t and x_t are non-Stationary with moment of 1, Eagle and Granger (1987) suggested to run a static regression, however Engle-Granger's Cointegration faces several drawbacks (Schmidt, 2008) for example, the test heavily relies on a 2-step estimators model and it uses residuals from one of the equilibrium equations. That's why this study makes use of Johansen's Cointegration test (1988). Johansen's test, as can be seen, it illustrates the relationship between time series by utilizing maximum likelihood estimators in order to avoid the problems arising from

2-step estimators like in the Engle and Granger. Also, Johansen emphasizes between a matrix ran and its characteristics roots, according to regression equation (8-11). Initially, error term will be acquired through ordinary least square method that y_t regress on x_t.

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

In which α and β remark the ordinary least square measure.

$$H_0 : \beta = 0$$

$$H_1 : \beta < 0$$

The null hypothesis is accepted only when $\beta = 0$ meaning that an error term comprises of unit root and being non-Stationary. Whereas, a rejection of null hypothesis meaning that error term converges in a long run and being Stationary.

Implementing Cointegration Concept to Pair Trading

Since stock prices move together through time, each may or may not follow a random walk model, however after testing the non-Stationarity, Granger Causality test and Cointegration test, the statistical significance is derived and now ready to pursue the following formula in order to complete the cointegration.

(13) $\hat{\alpha} = y_t - \hat{\beta} x_t$

in which; $\hat{\alpha}$ = estimated mean spread between stock x and stock y

$\hat{\beta}$ = estimated cointegration coefficient

y_t = price of stock y at time t

x_t = price of stock x at time t

According to the formula, investor can open a position to long one share of stock Y and short $\bar{\beta}$ share stock X when signal triggers, as well as to short one share of stock Y and long $\bar{\beta}$ share stock X.

3.2.3 Trading Process

Trading by Period

To examine the ability of pair trading strategy whether they can generate excess return or not and in which market conditions they outperform the market. In this section, we will check 3 market conditions that are uptrend, downtrend and sideways. Due to of market insecurity, it is better to invest in the pair trading strategy in a specific market condition that gives out the best return.

Market behaviors are described as following:

- Uptrend market, or Bull market is attributed to the market that sharply increases compared to the previous period
- Downtrend market, or Bear market is attributed to the market that critically drops compared to the previous period
- Sideway market, or no trend market is attributed to the market that contains no uptrend or downtrend, but slightly fluctuates within a narrowed window making the market condition overall stays at the same level.

Trading by Single Business

Most investors learn that a pair trading strategy is about to choose 2 stocks within the same industry as they have been informed by analyst papers, however this misperception makes a big mistake and may cause a big loss. On the company's side , in doing business today, management feels the need to diversify their business and maximize profit, that's why business patterns has been changing from single business model to multiple business model, therefore the company's risk to specific environmental factor can be diversified.

For instance, Telecommunication sector (Technology industry), there are 4 main players that are Advanced Info Service Public Company Limited ("ADVANC"), Total Access Communication Public Company Limited ("DTAC"), True Corporation Public Company Limited ("TRUE"), Jasmine International Public Company Limited ("JAS"), Intuch Holdings Plublic Company Limited ("INTUCH)", a holding company of ADVANC and other technology companies, is excluded. Although every players

operates in Telecommunication business, only ADVANC and DTAC is purely mobile operators, who share the same fundamental and their business is not diversified from being voice and non-voice providers. TRUE is not only a mobile operator, but also join media sector as they are an important television provider as known as 'TrueVision', 'TrueInternet' for home fixed-line internet provider, and 'TrueCoffee' in food and beverage store. JAS, the only telecom player who has neither voice nor non-voice service, however JAS's business is only home fixed-line Internet known as '3BB' trademark, the table is summarized below.

As a result, there is only ADVANC and DTAC operating in the single business with INTUCH added as a holding company of ADVANC, therefore they undoubtedly share the relevant fundamental, whereas TRUE and JAS are in a diversified business of telecom industry. Nature of operation is also one of the key determinants that help to identify the success of pair trading strategy (Do and Faff, 2010, Srisakwichai 2007), 2 pairs in the same single business are ADVANC-DTAC, ADVANC-INTUCH, while 2 diversified pairs are DTAC-TRUE, and ADVANC-JAS.

Table 3.1 Business Classification

Company	**Single Business**		**Diversified Businesses**		
	Voice	*Mobile Data*	*Home Wifi*	*Food &Beverage*	*TV service*
ADVANC	X	X			
DTAC	X	X			
INTUCH	X	X			
JAS		X	X		
TRUE	X	X	X	X	X

Adjusted stock price series

There can be 2 scenarios about dividend pay out

1.) Dividend is paid out during the holding period

2.) Dividend is paid our outside the holding period.

For the first scenario, since dividend is paid out during the holding period. Hence, amount of paid-out dividend must be calculated back to the stock price as to get rid of the dividend impact. Nevertheless, it is not necessary for the later scenario, since we may have opened the position after dividend date (XD) or closed the position before dividend date (XD)

Amount of Invested Capital

To begin with, one of the paired stock (overperforming stock) will be shorted for an amount of 1,000THB, then we will get number of shares as 'X'. After that multiply 'X' with the ratio to get number of shares to buy another paired stock (underperforming stock) as 'Y'. These ratios are obtained from Cointegration test, which is run earlier. When we closed out the position, we will buy back 'X' shares of the overperforming one and sell 'Y' shares of the underperforming one.

3.2.4 Trading Rules

There are several trading rules to start a pair trade. On top of the list, we start to take the position at time t_0, which is to long one underperforming stock and short one overperforming stock, at the price spread of 2 standard deviations (SD) of time t_1. If the price spread goes beyond 4SD, it is to cut loss and close out the position, but if not beyond 4SD, we will take the profit and close out the position when each of them revert back the mean price at time t_2.

For example, for the underperforming stock, we long it at its negative standard deviation and sell out when it climbs back to mean reverting position, and for the overperforming stock, we will short it at its positive standard deviation before purchased it back when it returns to the mean reverting position.

In contrast, stop loss is when the spread further move for another 2SD to beyond 4SD from the mean price at time t_0. As well, we will close the position when the price spread moves back to the mean reverting price whether they are exactly at the mean reverting price, or slightly goes over that original price level.

For instance, we will cut loss when the underperforming stock keep going down steadily for another 2SD, as well as when the overperforming keep climbing of another 2SD instead of returning to mean reverting level. The objective of setting cut-loss point is to control the loss and be protected against the price risk. After both stocks reverts back to the mean level and resume their abnormal behavior, we will once again consider to start a new pair trade when the underperforming stock hit -2SD and overperforming stock hit +2SD.

At the end of the day, we are able to gain 2SD in price differentiation from trading 2 stocks from this pair trading strategy.

Trading rules in brief:

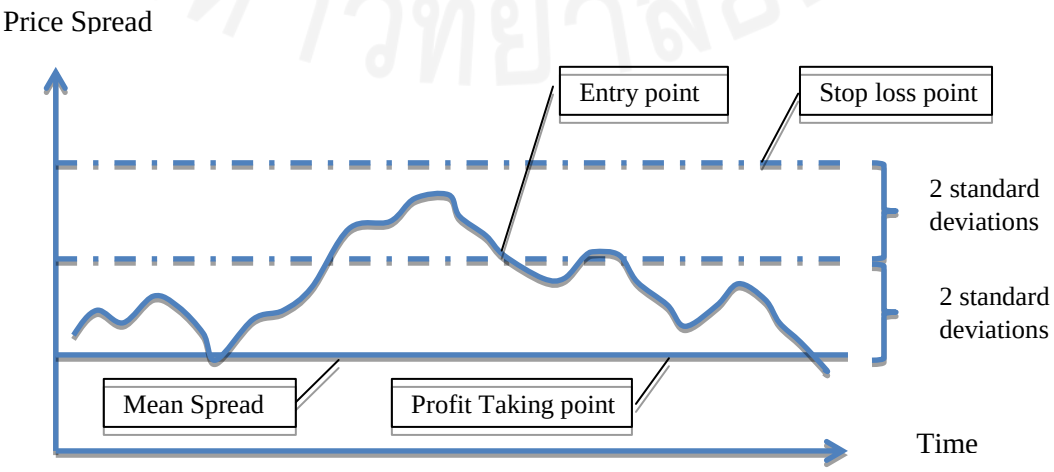
When to open the position

- Price spread between two stocks climbs up to 2 standard deviations.

When to close out the position

- Close out the position when the price spread back to the mean
- Close out the position when the price spread climbs up to 4SD
- Close out the position at any price spread during the last trading day

Figure 3.1 Pair Trading Graph



3.2.5 Implementation of Pair Trading Strategy

Ideally it requires no deposit to do short selling, nonetheless Securities and Exchange Commission of Thailand requires investors to put up a minimum margin for a short sell in order to protect against prepayment risk. As an objective of this paper to examine of applying pair trading strategy along the trends of Thailand's stock index, we consider to put up 100% of margin requirement along with this strategy.

For example, DTAC and ADVANC they are Cointegrated with the following data.

$$\text{DTAC} = 0.4791484 * \text{ADVANC} - 11.77811$$

Where, Price differentiation = -11.77811

Cointegration Coefficient = 0.4791484

Price of DTAC at time t_1 = 119

Price of ADVANC at time t_1 = 290

Price of DTAC at time t_2 = 117.5

Price of ADVANC at time t_2 = 294

The buying signal of DTAC-ADVANC at time t_0, number of share for long and short are calculated as follow.

Ratio of share number = 1:0.4791484

Amount of invested capital = THB 1,000

Ratio of short unit = Invested Capital / price of short unit at time t_t
= 1,000/ 119
= 8.40

Ratio of long unit = Ratio of short unit * Cointegration coefficient
= 8.40 * 0.4791484
= 4.03

Note: DTAC is on short position and ADVANC is on long position

Then we are going to short 8.40 shares of DTAC, then long 4.03 shares of ADVANC at time t_1 at its closing price.

Cash outflow = (no. of ADVANC shares * price of ADVANC at t_1) - (no. of DTAC shares * price of DTAC at t_1)
= (4.03 * 290) - (8.40 * 119)
= 167.673 THB

Closing position of DTAC-ADVANC at time t_2, we purchase back 8.40 shares of DTAC and sell 4.03 shares of ADVANC in the next trading day (t_2) at closing price.

Cash inflow = (no. of ADVANC shares * price of ADVANC at t_2) - (no. of DTAC shares * price of DTAC at t_2)
= (4.03 * 294) - (8.40 * 117.5)
= 196.38

Total cash inflow = Cash inflow – Cash outflow
= 196.38 – 167.67
= 28.71

Investment Return = (Total cash inflow – Cash outflow)/Invested capital
= (196.38 – 167.67) / 1,000.00
= 2.87 %

At the end of the day, we are able to gain 2.87% from one time of pair trade.

3.2.6 Profit and Return Calculation

As to recognize profit and loss, transactions that are regularly made will be calculated monthly. Although we may have to cut loss, the profit and loss will be continuously calculated by mark to market method. Finally, the return is calculated in per cent from the beginning of capital invested, and to measure our portfolio performance we can simply compare our portfolio performance to the market index or SET100 index.

(14) $R_p = \sum_{i=0}^{t}(\text{Total cash inflow}_i - \text{Total cash outflow}_i) / \sum_{i=0}^{t} \text{Invested capital}_i$

3.2.7 Performance Evaluation

In order to evaluate Pair Trading's performance, there is 2 approaches that are comparing with weighted average return of portfolio and comparing with its industry's Total Return Index (TRI). For weighted average return, the method is relied on the purchase-only portfolio by the cointegrated ratio as obtained from the Granger's Cointegation Test. With TRI, dividend paid out has been added back to Industry's index transforming it to TRI, and we find TRI during the period by

(15) $(C_x * R_x) + (C_y * R_y) = Weighted\ average\ return\ during\ the\ period$

C_x , C_y = Cointegrated Ratio of Stock X and Stock Y

R_x , R_y = Return of Stock X and Stock Y during the period

(16) $\frac{(TRI_{t1} - TRI_{t0})}{TRI_{t0}} = Industry's\ TRI\ during\ the\ period$

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Trading Pairs

The study is conducted in 6 major industries, each industry is divided into 2 pairs of single business and 2 pairs of diversified business that is totally made up of 24 pairs. In these 24 pairs are also classified by 3 market conditions in order to find which market condition is best for pair trading.

Table 4.1 Trading pairs by industry and by business

No.	Industry	Business	Trading Pair
1	Technology/Information	Single	ADVANC : DTAC
2	& Communication Technology	Single	ADVANC : INTUCH
3		Diversified	ADVANC : TRUE
4		Diversified	ADVANC : JAS
5	Financials/Banking	Single	KBANK : BBL
6		Single	KBANK : SCB
7		Diversified	KBANK : TCAP
8		Diversified	KBANK : TMB
9	Services/Commerce	Single	MAKRO : BIGC
10		Single	MAKRO : CPALL
11		Diversified	MAKRO : CPN
12		Diversified	MAKRO : BJC
13	Property & Construction	Single	QH : LH
14	/Property Development	Single	QH : PS
15		Diversified	QH : SIRI
16		Diversified	QH : SPALI
17	Agro & Food Industry	Single	TU : CFRESH
18	/Food & Beverage	Single	TU : GFPT
19		Diversified	TU : CPF
20		Diversified	TU : ASIAN
21	Industrials/Petrochemicals	Single	PTTGC : IRPC
22	& Chemicals	Single	PTTGC : IVL
23		Diversified	PTTGC : SCC
24		Diversified	PTTGC : TOP

**Detail of company's nature business can be found in Appendix B*

4.2 Results from implementation of pair trading

Note that these stock prices are matched by nature of business, then classified by market condition.

Table 4.2 Result from Technology & Communication Technology Industry

No.	Business	Trading Pair	Market Condition	Weighted average return without Pair Trading	Pair Trading return	Industry's Total Return Index	Number of Pair Trading (Total, Neg returns, Pos returns)		
1	Single	ADVANC DTAC	Bearish	-7.78%	2.20%*	-6.43%	12	3	9
2			Bullish	22.00%	0.33%	21.82%	10	2	8
3			Sideways	-13.42%	1.09%*	1.09%	14	3	11
4		ADVANC INTUCH	Bearish	-9.84%	0.92%*	-6.43%	7	2	5
5			Bullish	18.39%	-0.12%	21.82%	8	5	3
6			Sideways	2.24%	-0.19%	1.09%	13	6	7
7	Diversified	ADVANC TRUE	Bearish	-14.23%	-3.47%	-6.43%	8	4	4
8			Bullish	40.15%	-0.43%	21.82%	11	6	5
9			Sideways	-1.07%	-8.41%	1.09%	12	6	6
10		ADVANC JAS	Bearish	-9.47%	-3.22%	-6.43%	11	4	7
11			Bullish	37.49%	2.20%	21.82%	10	5	5
12			Sideways	-2.91%	0.79%	1.09%	13	6	7

(*) Pairs that are proven successful when compared to the weighted average return and industry's TRI. See Appendix C for cointegration ratio and trading pairs' result

Table 4.3 Result from Financials/Banking Industry

No.	Business	Trading Pair	Market Condition	Weighted average return without Pair Trading	Pair Trading return	Industry's Total Return Index	Number of Pair Trading (Total, Neg returns, Pos returns)		
1	Single	KBANK BBL	Bearish	-11.11%	-0.92%	3.62%	14	9	5
2			Bullish	28.61%	0.55%	33.16%	18	6	12
3			Sideways	-6.56%	0.19%*	-8.11%	17	8	9
4		KBANK SCB	Bearish	-11.49%	0.49%*	3.62%	19	9	10
5			Bullish	29.04%	0.56%	33.16%	19	6	13
6			Sideways	-11.85%	0.28%*	-8.11%	11	5	6
7	Diversified	KBANK TCAP	Bearish	-21.46%	-0.46%	3.62%	10	6	4
8			Bullish	21.89%	0.00%	33.16%	8	3	5
9			Sideways	6.79%	1.68%	-8.11%	8	3	5
10		KBANK TMB	Bearish	-13.30%	2.87%	3.62%	8	2	6
11			Bullish	36.40%	0.67%	33.16%	6	2	4
12			Sideways	-12.60%	1.12%	-8.11%	16	13	3

(*) Pairs that are proven successful when compared to the weighted average return and industry's TRI. See Appendix C for cointegration ratio and trading pairs' result

Table 4.4 Result from Services/Commerce Industry

No.	Business	Trading Pair	Market Condition	Weighted average return without Pair Trading	Pair Trading return	Industry's Total Return Index	Number of Pair Trading (Total, Neg returns, Pos returns)		
1	Single	MAKRO BIGC	Bearish	-17.15%	-0.07%	0.17%	7	3	4
2			Bullish	21.56%	-1.27%	28.27%	8	5	3
3			Sideways	4.04%	0.68%	4.40%	17	6	11
4		MAKRO CPALL	Bearish	-3.20%	-73%	0.17%	3	3	0
5			Bullish	27.64%	-1.4%	28.27%	16	12	4
6			Sideways	10.72%	0.0%	4.40%	12	6	6
7	Diversified	MAKRO CPN	Bearish	-37.77%	-0.41%	0.17%	11	6	5
8			Bullish	33.28%	-0.94%	28.27%	9	7	2
9			Sideways	10.34%	-1.76%	4.40%	7	2	5
10		MAKRO BJC	Bearish	-38.34%	0.84%	0.17%	5	2	3
11			Bullish	8.69%	-0.81%	28.27%	17	10	7
12			Sideways	8.73%	-2.10%	4.40%	15	9	6

Due to major change in CPALL, BIGC, and MAKRO's company structure, which are par separation in MAKRO in Aug 2013, BJC's acquisition of BIGC in March 2015 and CPALL sold partial stake of MAKRO in May 2015 , these tested periods are not able to show actual pair trading's performance. See Appendix C for cointegration ratio and trading pairs' result

Table 4.5 Result from Property & Construction/Property Development Industry

No.	Business	Trading Pair	Market Condition	Weighted average return without Pair Trading	Pair Trading return	Industry's Total Return Index	Number of Pair Trading (Total, Neg returns, Pos returns)		
1	Single	QH LH	Bearish	-22.01%	0.87%*	-5.23%	10	5	5
2			Bullish	35.13%	0.87%	27.44%	14	6	8
3			Sideways	31.33%	-0.12%	9.08%	17	8	9
4		QH PS	Bearish	-27.80%	0.54%*	-5.23%	12	5	7
5			Bullish	48.30%	0.10%	27.44%	14	7	7
6			Sideways	64.10%	12.37%*	9.08%	9	4	5
7	Diversified	QH SIRI	Bearish	-39.55%	-0.05%	-5.23%	12	6	6
8			Bullish	39.40%	-0.45%	27.44%	8	3	5
9			Sideways	18.29%	-0.58%	9.08%	10	6	4
10		QH SPALI	Bearish	-26.67%	-1.11%	-5.23%	19	12	7
11			Bullish	47.06%	0.85%	27.44%	14	8	6
12			Sideways	60.93%	-0.29%	9.08%	8	5	3

(*) Pairs that are proven successful when compared to the weighted average return and industry's TRI. See Appendix C for cointegration ratio and trading pairs' result

Table 4.6 Result from Agro & Food Industry/Food & Beverage Industry

No.	Business	Trading Pair	Market Condition	Weighted average return without Pair Trading	Pair Trading return	Industry's Total Return Index	Number of Pair Trading (Total, Neg returns, Pos returns)		
1	Single	TU CFRESH	Bearish	-11.62%	-0.87%	2.18%	12	6	6
2			Bullish	4.78%	0.30%	11.24%	10	6	4
3			Sideways	-4.09%	-0.78%*	-1.41%	7	5	2
4		TU GFPT	Bearish	14.33%	-0.27%	2.18%	10	5	5
5			Bullish	4.30%	3.08%	11.24%	6	1	5
6			Sideways	-18.88%	1.99%*	-1.41%	7	4	3
7	Diversified	TU CPF	Bearish	3.08%	-1.26%	2.18%	11	7	4
8			Bullish	-7.45%	-0.99%	11.24%	17	10	7
9			Sideways	-7.44%	-43.81%	-1.41%	6	5	1
10		TU ASIAN	Bearish	-33.19%	2.13%	2.18%	4	1	3
11			Bullish	-1.94%	-20.73%	11.24%	8	7	1
12			Sideways	20.46%	-0.01%	-1.41%	2	1	1

(*) Pairs that are proven successful when compared to the weighted average return and industry's TRI. See Appendix C for cointegration ratio and trading pairs' result

Table 4.7 Result from Industrials/Petrochemicals & Chemicals Industry

No.	Business	Trading Pair	Market Condition	Weighted average return without Pair Trading	Pair Trading return	Industry's Total Return Index	Number of Pair Trading (Total, Neg returns, Pos returns)		
1	Single	PTTGC IRPC	Bearish	-1.58%	6.02%*	4.25%	14	6	8
2			Bullish	2.87%	0.18%	15.44%	12	6	6
3			Sideways	47.86%	-0.02%	11.44%	5	2	3
4		PTTGC IVL	Bearish	10.01%	0.84%	4.25%	13	7	6
5			Bullish	10.81%	-0.06%	15.44%	10	5	5
6			Sideways	40.18%	-0.53%	11.44%	13	6	7
7	Diversified	PTTGC SCC	Bearish	6.47%	0.31%	4.25%	9	4	5
8			Bullish	-5.60%	0.51%	15.44%	5	1	4
9			Sideways	31.83%	2.96%	11.44%	8	3	5
10		PTTGC TOP	Bearish	4.76%	-1.19%	4.25%	9	6	3
11			Bullish	-3.62%	1.25%	15.44%	7	2	5
12			Sideways	33.81%	-1.89%	11.44%	10	7	3

(*) Pairs that are proven successful when compared to the weighted average return and industry's TRI. See Appendix C for cointegration ratio and trading pairs' result

As a result, among 6 major industries there are 5 industries proven successful in Pair Trading, which are 1) Technology/Information & Communication Technology 2) Financials/Banking 3) Property & Construction/Property Development 4) Agro & Food Industry/Food & Beverage and 5) Industrials/Petrochemicals. In order to be successful, the trading pairs have to provide higher return than the weighted average return or the return from purchasing both stocks at the same Cointegration ratio, as well as higher return than its industry's total return index.

In Services/Commerce industry, according to table IV, due to several major changes in industry's structure for example, BJC's acquisition of BIGC in March 2016, CPALL's acquisition of MAKRO in June 2013 as well as MAKRO's share split in Aug 2013. Therefore, during our studied periods, pair trading is not able to provide abnormal return, and this industry is the only one that is not successful in pair trading.

Pair trading in single business absolutely provides extraordinary return rather than diversified business's pairs. In diversified business, some trading pairs may provide higher return than weighted average return, most of these diversified pairs somehow show negative result when compared to the industry's total return index. As we have mentioned, companies with same fundamental seem to have similar stock prices, and their returns move along with each other. For example, being mobile operator in telecommunication industry distinguishes JAS and TRUE out of the industry, being major banks in commercial banking excludes TMB and TCAP, being retail stores excludes CPN and BJC, being townhouse and condominium developer excludes SIRI and SUPALAI, being food exporters excludes CPF and ASIAN, finally focusing in only petrochemicals business excludes SCC and TOP out of the single business as SCC they began from being the major cement producer before diversified and focusing at Petrochemicals business and TOP they are not only petrochemical player but also energy explorer and producer.

When comes to market conditions, there are only bearish and sideways periods that show significant result, and sideways periods are more preferable than bearish periods. In bullish periods, the pair trading shows worst return when compared to both weighted average return and industry's total return index, since the

profit taking is limited by the timeframe and when one of the stocks comes back to the mean reverting position it brings price spread back to the start point. On the other hand, in sideways movement, the price between 2 stocks are around the mean reverting position, moving slightly up and down giving more chance in finding timing for pair trade. Therefore, only bullish condition is not appropriate for pair trading.

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

Pair trading concept using in this research paper, pair trading concept is overall remained as same as Morgan Stanley's concept in 1980s that is to long an underperforming stock and short an overperforming stock at the same time, so investors are able to enjoy 2-way price spread from this pair trading when both stock return to its mean price. Also, the rules implied for this concept was previously ± 10% of price level in order to long and short the underperforming and overperforming stocks respectively before we sell and purchase back those stocks as they return to its mean price. The ± 10% rule has been developed and now become ±2 standard deviation, this research paper as well adopted ±2 standard deviation for pair trading calculation.

To calculate return from pair trading, many research papers, including to Srisakwichai (2007), start with a specific amount of money, and separate that amount into 2 proportions for long and short the stocks. On the other hand, this research paper use different method. We begin with no cash on hand, short an overperforming stock in order to get a specific amount of money, take this received money to purchase an underperforming stock. With this method, it allows us to fully benefit from the long/short strategy that doesn't require any capital, after that the net profit made will be our return. Furthermore, this method is not only advantageous for low capital investment strategy, but also increase the amount of profit that will be made in the future instead of the previous method separating one amount of money to long and short at the same time.

This research paper extends the scope of study in pair trading to investigate the stock's return between single business and diversified business, whilst none of previous studies highlights on this business characteristics. Srisakwichai (2007) focuses pair trading's return based on industries and market circumstances, and he found that pair trading generates higher return specifically bearish and sideways market, which is similar to this research paper. Furthermore, he mentioned that only electronics and energy sectors could generate higher return, while the latest data from

6 studies industries all generate abnormal return excluded Services/ Commerce industry. Also, Hong (2003) evidenced that pair trading is able to deliver 33% annualized profit among local Asian markets

According to Gatev (1999), Hong (2003) and Engelberg (2008), in which stock's performance has been evidenced based on the relative characteristics specifically the company's business strategy, the company with similar fundamentals their stock prices tend to move with each other as well as in this research paper. Among 6 industries that are shown, single business strategy within that industries provides abnormal return than its industry's Total Return Index or weighted average performance.

Compare to Panyagometh's study (2013), the data was chosen from Stock Exchange of Thailand during 2002-2012, he demonstrates that pair trading generates 500 times larger than SET index based on his methodology. Nevertheless, Panyagometh (2013) didn't choose the stock based on specific industry, he selected the pair from P/E and P/B ratio, by purchasing underperform P/E and P/B and selling overperform P/E and P/B. Similarly, Do (2010) shows that 4 industries that are Utilities, Financials, Transportation, and Industrials works well in US stock market. The idea from similarity of business natures within the same industry was then taken and applied to Stock Exchange of Thailand, this research paper therefore adds the concept of business nature to narrow down the matching pairs in order to increase the return from normal pair trading.

As can be seen, the result illustrates that single business pairs provide higher return than the diversified pairs, where the diversified pairs mixes up the businesses and fundamental in industry wide. Diversified pairs rarely provide positive return, however single business pairs all provide positive return, which is a clear cut that single business pairs generate abnormal return rather than diversified pairs. Also to argue that pair trading strategy still works very well in turbulence market, if investors know how to choose and construct the pair by nature of business, not by industry wide.

In further development, it would be interested to conduct pair trading within the group company by trading one company with its holding, or its listed subsidiaries since the trend is moving towards mergers and acquisition. As the companies with closely-related fundamental, their prices should move within a narrow range. For instance, BIGC, CPF and BJC, all of them is under Charoen Phokapan Group (CPF), their prices probably move together. As well as PTT Group, they have several subsidiaries listed in the stock exchange of Thailand, which are PTTGC, PTTEP, TOP, and IRPC. It could be beneficial to investigate the relationships among the group companies.

Limitation

For the limitation, since this paper studies on 6 major industries but one of six industries that is Services /Commerce had been involving in significant structural change during 2013-2016. This structural change is mainly caused by mergers and acquisition, for example CPALL (CP ALL PUBLIC COMPANY LIMITED) won the deal over BIGC (SIAM MAKRO PUBLIC COMPANY LIMITED) and acquired 64.00% of MAKRO (SIAM MAKRO PUBLIC COMPANY LIMITED) in June 2013, this deal made the largest record in Thai Companies. After that, MAKRO's share split from 10THB to 0.50THB in October 2013. However, BIGC as a Thailand's subsidiary of Casino Group, after acquired Carrefour in 2010, BIGC is now acquired by TCC Corporation who is owned by CP Group in 2016. As a consequence, CPALL and MAKRO's stock prices rapidly accelerate from the successful acquisition and share split during 2013-2014.

Situation of hypermarkets in Thailand will be more competitive and accompanied by series of acquisitions, it is suggested to avoid studying in this Service/ Commerce industry in aspect of stock prices until the industry is firmly structured. This is because studying in its stock prices probably provides researchers with the contradict result like this case's pair trading in Services/ Commerce industry.

REFERENCES

1. Brooks, C., 2008. Introductory Econometrics for Finance. Cambridge: Cambridge University Press.

2. Do, B., R. Faff & K. Hamza, 2006. "A new approach to modeling and estimation for pairs trading". http://www.finanzaonline.com/forum/attachments/econometria-e-modelli-di-trading-operativo/1048428-spread-e-pair-trading-pairstrading_binhdo.pdf 2006 . [Accessed 12 Sep 2015].

3. Do, B. & R. Faff, 2010. "Does Simple Pairs Trading Still Work?", Financial Analysts Journal 66(4), 83–95.

4. Donaldson, J., F. Donald & N. Ashley, 2012. Pair Trading with Options, SSRN Electronic Journal SSRN Journal.

5. Elliott, R., J. Van der Hoe & W. Malcolm, 2005. "Pairs Trading", *Quantitative Finance* 5(3), 271-276.

6. Engelberg, J., P. Gao & R. Jagannathan, 2008. "An Anatomy of Pairs Trading: The Role of Idiosyncratic News, Common Information and Liquidity", SSRN Electronic Journal SSRN Journal.

7. Engle, R.F. & C.W.J. Granger, 1987. "Co-Integration and Error Correction: Representation, Estimation, and Testing", Econometrica 55(2), 251.

8. Gatev, E.G., W.N. Goetzmann & K.G. Rouwenhorst, 1999. Pairs Trading: Performance of a Relative Value Arbitrage Rule. Cambridge, MA: National Bureau of Economic Research.

9. Gatev, E., W.N. Goetzmann & K.G. Rouwenhorst, 2006. "Pairs Trading: Performance of a Relative-Value Arbitrage Rule", Rev. Financ. Stud. Review of Financial Studies 19(3), 797–827.

10. Godfrey, K., 2013. "Empirical Inference of Related Trading between Two Securities: Detecting Pairs Trading, Merger Arbitrage, and Strategy Rules", SSRN Electronic Journal SSRN Journal.

11. Granger, C.W.J., 1969. "Investigating Causal Relations by Econometric Models and Cross-spectral Methods", Econometrica 37(3), 424.

12. Hong, G. & S. Raul, 2003. "Pairs-Trading in the Asian ADR Market", SSRN Electronic Journal SSRN Journal.

13. Johansen, S., 1988. “Statistical analysis of cointegration vectors”, Journal of Economic Dynamics and Control 12(2-3), 231–54.

14. Kanamura, T., S.T. Rachev & F. Fabozzi, 2008. “The Application of Pairs Trading to Energy Futures Markets”, SSRN Electronic Journal SSRN Journal.

15. Lim, G. & V.L. Martin, 1995. “Regression-based cointegration estimators with applications”, Journal of Economic Studies 22(1), 3–22.

16. Miao, G.J., 2014. “High Frequency and Dynamic Pairs Trading Based on Statistical Arbitrage Using a Two-Stage Correlation and Cointegration Approach”, International Journal of Economics and Finance IJEF 6(3).

17. Nath, P., 2003. “High Frequency Pairs Trading with U.S. Treasury Securities: Risks and Rewards for Hedge Funds”, SSRN Electronic Journal SSRN Journal.

18. Panyagometh, K., 2013. “Pairs trading and value investing strategies”, International Journal Of Business And Economics Perspectives (IJBEP) 2, 119.

19. Rice, S.O., 1945. “Mathematical Analysis of Random Noise”, Bell System Technical Journal 24, 146-156.

20. Schmidt, A.D., 2008. “Pairs Trading: A Cointegration Approach”. http://ses.library.usyd.edu.au/bitstream/2123/4072/1/Thesis_Schmidt.pdf 2008 . [Accessed 19 Sep 2016].

21. Srisakwichai, A., 2007. “Pairs Trading: a Cointegration Approach (an Empirical Study in Stock Exchange of Thailand)”. Bangkok: Faculty of Commerce and Accountancy, Thammasat University.

22. Stander, Y., D. Marais & I. Botha, 2013. “Trading strategies with Copulas” Journal of Economic and Financial Sciences 6(1), 83-107

23. Ungever, C., 2015. “Pairs Trading to the commodities futures market using cointegration method”, International Journal of Commerce and Finance 1(1), 25–38.

24. Veerbek, M., 2004. A Guide to Modern Econometrics, NJ: J.Wiley

25. Vidyamurthy, G., 2004. Pairs Trading: Quantitative Methods and Analysis. Hoboken, NJ: J. Wiley.

26. Zhang, M., 2012. “Research on Modern Implications of Pairs Trading”, *SSRN Electronic Journal SSRN Journal*.

27. Zivot, E. & D.W.K. Andrews, 1992. “Further Evidence on the Great Crash, the Oil-Price Shock, and the Unit-Root Hypothesis”, Journal of Business & Economic Statistics 10(3), 251–70.

APPENDICES

APPENDIX A
STATA CODE FOR PAIR TRADING

1. Unit Root Test with Stationary

```
. g t=_n
. tsset t
. dfuller X, lags(0) regress
. dfuller X, trend lags(0) regress
. dfuller X, nocon lags(0) regress
. dfuller d.X, nocon lags(0) regress
. dfuller Y, lags(0) regress
. dfuller Y, trend lags(0) regress
. dfuller Y, nocon lags(0) regress
. dfuller d.Y, nocon lags(0) regress
```

2. Unit Root Test with Structural Break

```
. zandrews X, graph
. zandrews X, break(trend)
. zandrews X, break(both) trim(0.10)
. zandrews X, lagmethod(BIC)
. zandrews Y, graph
. zandrews Y, break(trend)
. zandrews Y, break(both) trim(0.10)
. zandrews Y, lagmethod(BIC)
```

3. Engle Granger's Causality Test

```
. var X Y, lags(1/2) small dfk
. vargranger
```

4. Johansen's Cointegration Test

```
. vecrank X Y, trend(constant)
. vec X Y
```

APPENDIX B

NATURE OF COMPANY'S BUSINESS

Table B.1 Technology/Information & Communication Technology Industry

Abbreviation in SET	Company's name	Nature of business	Single Business
ADVANC	ADVANCED INFO SERVICE PUBLIC COMPANY LIMITED	The Company operates cellular mobile telephone network in the 900 megahertz (MHz) frequency.	YES
DTAC	TOTAL ACCESS COMMUNICATION PUBLIC COMPANY LIMITED	The Company, operating under DTAC brand, provides wireless telecommunication service in 800 megahertz and 1800 megahertz frequency bands.	YES
INTUCH	INTOUCH HOLDINGS PUBLIC COMPANY LIMITED	Intouch is a holding company with investments in the telecommunications, media, information technology and digital content business. There are presently three principal business units: Wireless Telecommunications, Satellite and International Businesses, and Other Businesses.	YES
JAS	JASMINE INTERNATIONAL PUBLIC COMPANY LIMITED	The businesses are grouped into 4 categories : 1. Broadband Business 2. Telecom Network & Service Provider Business 3. System Integration Business 4. Other Businesses	NO
TRUE	TRUE CORPORATION PUBLIC COMPANY LIMITED	True Group's core businesses have been organized into the three following categories: (1) Online business under TrueOnline, comprising fixed-line phone and value-added services, business data services, Internet and broadband Internet services and WiFi; (2) Cellular business under True Mobile Group, offering a full range of mobile services through 4G, 3G and 2G networks nationwide under the brand TrueMove H and TrueMove; (3) Pay TV and Digital TV business under TrueVisions.	NO

Table B.2 Financials/Banking Industry

Abbreviation in SET	Company's name	Nature of business	Single Business
BBL	BANGKOK BANK PUBLIC COMPANY LIMITED	The Bank provides full commercial banking services in corporate SME including retail customer with nationwide network. The Bank's overseas branch network spans economies zone.	YES
SCB	THE SIAM COMMERCIAL BANK PUBLIC COMPANY LIMITED	The Company is the commercial bank providing a full range of financial services, including corporate and personal lending, retail and wholesale banking, foreign currency operations, international trade financing, cash management, custodial services, credit and charge card services and investment banking services.	YES
KBANK	KASIKORNBANK PUBLIC COMPANY LIMITED	KASIKORNBANK PCL (KBank) conducts commercial banking, securities and other related businesses per the Financial Institutions Business Act, Securities and Exchange Act and other regulations. KBank primarily provides financial services via an extensive branch network nationwide.	YES
TCAP	THANACHART CAPITAL PUBLIC COMPANY LIMITED	Thanachart Financial Conglomerate. The companies under Thanachart Financial Conglomerate are classified by their types of business into two groups; (1) financial business group, consisting of commercial banking business, asset management business, securities business, insurance business, hire purchase business, and leasing business and (2) supporting business group consisting of brokerage business, service business, and training business.	NO
TMB	TMB BANK PUBLIC COMPANY LIMITED	The Bank engages in universal banking business to serve corporate, SME, and retail customers. ING Bank B.V., a financial group in the Netherland, is its strategic partner and a major shareholder as well as Ministry of Finance.	NO

Table B.3 Services/Commerce Industry

Abbreviation in SET	Company's name	Nature of business	Single Business
BIGC	BIG C SUPERCENTER PUBLIC COMPANY LIMITED	Big C and its subsidiaries are one of the leading modern retailer in Thailand, a successful combination between retail business and property business under Dual retail-property model concept.	YES
MAKRO	SIAM MAKRO PUBLIC COMPANY LIMITED	The principal business of the Company is the operation of Cash and Carry Trade Centres throughout Thailand, under the name "Makro", selling food and non-food products to registered member, predominantly small and medium size business, retailers, caterers, professional sectors and institutions.	YES
CPALL	CP ALL PUBLIC COMPANY LIMITED	The Company operates the convenience store business under the 7-Eleven trademark and franchises to other retailers in the territory of Thailand and has invested in supporting businesses such as manufacturing facility of food & bakery products, bill payment services and so on.	YES
CPN	CENTRAL PATTANA PUBLIC COMPANY LIMITED	The Company operates in retail property for rent, which comprises of large-scale shopping complexes and other supportive businesses. Its portfolio comprises of shopping centers, offices, hotels, residential buildings and recreational parks.	NO
BJC	BERLI JUCKER PUBLIC COMPANY LIMITED	1. Manufacturing, marketing and distributing packaging products, consumer products and household products 2. Importing and distributing (1) healthcare products (2) technical supplies (3) books, magazine, stationery products, and office supplies. 3. Design, sourcing and distribution of tools, automatic control system, industry tools, warehouse and transportation equipment and galvanized steel towers. 4. Providing logistics services: custom clearing, warehouse and transportation services.	NO

Table B.4 Property & Construction/Property Development Industry

Abbreviation in SET	Company's name	Nature of business	Single Business
QH	QUALITY HOUSES PUBLIC COMPANY LIMITED	The Company engages in the residential and commercial property development businesses. Its businesses include land and house projects, residential projects, service apartment for rent,hotel,office building for rent, residential and commercial buildings management services, investment business and others.	YES
LH	LAND AND HOUSES PUBLIC COMPANY LIMITED	The Company engages in the development of commercial buildings and residential housing. The Company develops detached houses, townhouses and condominiums in Bangkok and the surrounding areas. It also has projects in Chiang Mai, Nakhon Ratchasima, Khon Kaen and Phuket.	YES
PS	PRUKSA REAL ESTATE PUBLIC COMPANY LIMITED	Real estate developer for residential purposes, including townhouses, single detached houses, and condominiums in Thailand and Asia region such as the Republic of India	YES
SIRI	SANSIRI PUBLIC COMPANY LIMITED	The Core businesses are 1. Property development consists of: 1.1 For sale includes landed property - single detached house, detached house, townhouse, and high-rise property - condominium projects 1.2 For rent includes office buildings and leasehold commercial building and 2. Property services : Providing property and asset management, property brokerage services, property sales management, property development consultancy, and property management 3. Hotel business in provincial areas	NO
SPALI	SUPALAI PUBLIC COMPANY LIMITED	The Company engages in the operation of real estate development projects include 1) detached houses, duplex houses, townhouses, and condominiums projects in a variety of areas throughout Bangkok and provincial 2) office buildings for rent in the commercial districts and 3) hotel business in the provincial	NO

Table B.5 Agro & Food Industry/Food & Beverage Industry

Abbreviation in SET	Company's name	Nature of business	Single Business
TU	THAI UNION GROUP PUBLIC COMPANY LIMITED	The Company engages in the manufacture and export of frozen and canned seafood. Its comprehensive business is completed with snack foods such as canned food, frozen food and snacks of various types especially seafood. Also, its businesses include packaging and publishing business, domestic market business, animal feed and development of shrimp species for sale business and commercial shrimp hatchery and nursery.	YES
CFRESH	SEAFRESH INDUSTRY PUBLIC COMPANY LIMITED	The Company is principally engaged in manufacture and distribution of frozen shrimp including cooked shrimp, raw, shrimp, breaded shrimp, and sushi. Seafresh has exported the majority of products under its own brands (Seafresh, Sea AngelI, Phoenix ,Thai Chia, Go-Go) with the remainder under customers' brands.	YES
GFPT	GFPT PUBLIC COMPANY LIMITED	The Group operates integrated poultry business including feed mill, breeder farm, hatchery farm, broiler farm, chicken evisceration and processed food. Main products of the group are cooked chicken products, fresh and frozen chicken meat, processed food, land animal feed, and aquatic animal feed.	YES
CPF	CHAROEN POKPHAND FOODS PUBLIC COMPANY LIMITED	The Company engages in agro-industrial and food conglomerate with 3 product catagories : 1) Feed business involving in production and sale of anminal feed, 2) Farm business involving in breeding, farming and basic meat processing, 3) Food business involving in production of semi-cooked and cooked meat.	NO
ASIAN	ASIAN SEAFOODS COLDSTORAGE PUBLIC COMPANY LIMITED	The Company produces processed frozen seafood under the company brands : TCC, ASS, SAKURA, ASIAN SEAFOODS BRAND and provides coldstorage services.	NO

Table B.6 Industrials/Petrochemicals & Chemicals Industry

Abbreviation in SET	Company's name	Nature of business	Single Business
PTTGC	PTT GLOBAL CHEMICAL PUBLIC COMPANY LIMITED	PTT Global Chemical Public Company Limited was founded on 19th October 2011 through the amalgamation of PTT Chemical Public Company Limited and PTT Aromatics and Refining Public Company Limited to be the chemical flagship of PTT Group.	YES
IRPC	IRPC PUBLIC COMPANY LIMITED	The Group's core businesses are 1) Refinery business; its refinery is situated in Rayong province and its pretroleum products from the refinery consisted of various kinds of refined oil, diesel, gasoline, lube base oil, fuel oil etc. 2) Petrochemical business, 3) Port and tankfarm business. 4) Asset management business, provides asset management services based on its empty plots of land.	YES
IVL	INDORAMA VENTURES PUBLIC COMPANY LIMITED	Indorama Ventures Public Company Limited, a holding company conducting its business through investment in subsidiaries and affiliates engaged in the manufacture of integrated petrochemical products both domestic and overseas. These companies manufacture and distribute Ethylene Oxide and Ethylene Glycol, Purified Terephthalic Acid, Polyethylene Terephthalate, Polyester Fiber and Yarn and Wool products.	YES
TOP	THAI OIL PUBLIC COMPANY LIMITED	Thaioil is Thailand's largest refinery and supplier of petroleum products. To complement our core oil refining business, we engage through our subsidiary companies in related businesses of aromatics, LAB: an intermediate in the production of surfactants such as detergents, lube base oil refinery, power generation, marine and pipeline transportation of crude, petroleum and petrochemical products, ship management, alternative energy, solvents and chemical products, as well as recruitment services for Thaioil Group.	NO

Abbreviation in SET	Company's name	Nature of business	Single Business
SCC	THE SIAM CEMENT PUBLIC COMPANY LIMITED	The Company operates as holding company engaging in the industrial supplies and construction industries. The Company operates 3 core businesses consists of investments in the Cement-Building Materials business, chemicals business and packaging business.	NO

APPENDIX C
RESULTS FROM STATA

Table C.1 Estimated Result of Pair Trading in Technology/Information &Communication Technology Industry

Market Condition		Equation (Forming Window)	LONG	SHORT	Cointegration Ratio		2SD (Forming Window)	Pair Trading Return
					ADVANC	DTAC		
BEARISH	DTAC1	= 0.4791484 ADVANC1 - 11.77811	ADVANC	DTAC	0.48	1.00	2.20	2.20%
BULLISH	DTAC2	= 0.3920989 ADVANC2 + 9.487825	ADVANC	DTAC	0.39	1.00	2.50	0.33%
SIDEWAYS	DTAC3	= -0.3258335 ADVANC3 +189.0099	ADVANC	DTAC	0.33	1.00	2.00	1.09%
					ADVANC	INTUCH		
BEARISH	INTUCH1	= 0.34896 ADVANC1 -7.622146	ADVANC	INTUCH	0.35	1.00	2.50	0.92%
BULLISH	INTUCH2	= 0.240953 ADVANC2 +21.38276	ADVANC	INTUCH	0.24	1.00	3.00	-0.12%
SIDEWAYS	INTUCH3	= 0.1779673 ADVANC3 + 35.85014	ADVANC	INTUCH	0.18	1.00	1.50	-0.19%
					ADVANC	TRUE		
BEARISH	TRUE1	= 0.1246946 ADVANC1 -25.07916	ADVANC	TRUE	0.12	1.00	3.50	-3.47%
BULLISH	TRUE2	= 0.0151335 ADVANC2 +4.130202	ADVANC	TRUE	0.02	1.00	4.00	-0.43%
SIDEWAYS	TRUE3	= 1.256183 ADVANC3 -294.8622	ADVANC	TRUE	1.26	1.00	2.00	-8.41%
					ADVANC	JAS		
BEARISH	JAS1	= 0.104988 ADVANC1 - 29.7221	ADVANC	JAS	0.10	1.00	3.00	-3.22%
BULLISH	JAS2	= 0.024631 ADVANC2 + 14.0225	ADVANC	JAS	0.02	1.00	3.50	2.20%
SIDEWAYS	JAS3	= 1.49823 ADVANC3 - 205.5581	ADVANC	JAS	1.50	1.00	2.00	0.79%

Table C.2 Estimated Result of Pair Trading in Financials/ Banking Industry

Market Condition		Equation (Forming Window)	LONG	SHORT	Cointegration Ratio		2SD (Forming Window)	Pair Trading Return
					KBANK	BBL		
BEARISH	BBL1	= 1.616053 KBANK1 - 113.159	KBANK	BBL	1.62	1.00	1.5	-0.92%
BULLISH	BBL2	= 0.7052452 KBANK2 +73.5053	KBANK	BBL	0.71	1.00	1	0.55%
SIDEWAYS	BBL3	= 0.4401399 KBANK3 + 103.2645	KBANK	BBL	0.44	1.00	2	0.19%
					KBANK	SCB		
BEARISH	KBANK1	= 1.494998 SCB1 - 66.43529	SCB	KBANK	1.00	1.49	1	0.49%
BULLISH	SCB2	= 0.6845055 KBANK2 + 37.66551	KBANK	SCB	0.68	1.00	1	0.56%
SIDEWAYS	SCB3	= 0.5224593 KBANK3 + 68.92634	KBANK	SCB	0.52	1.00	1.5	0.28%
					KBANK	TCAP		
BEARISH	TCAP1	= 0.3550871 KBANK1 - 29.59866	KBANK	TCAP	0.36	1.00	2	-0.46%
BULLISH	KBANK2	= 2.846702 TCAP2 + 79.06127	TCAP	KBANK	1.00	2.85	1.5	0.00%
SIDEWAYS	KBANK3	= -17.7537 TCAP3 + 902.2518	TCAP	KBANK	1.00	17.75	3.5	1.68%
					KBANK	TMB		
BEARISH	KBANK1	= 44.23134 TMB1 +14.22237	KBANK	TMB	1.00	44.23	0.6	2.87%
BULLISH	TMB2	= -0.0006331 KBANK2 +2.427745	TMB	KBANK	0.00	1.00	0.4	0.67%
SIDEWAYS	KBANK3	= -39.8461 TMB3 + 8.21379	KBANK	TMB	1.00	39.85	0.2	1.12%

Table C.3 Estimated Result of Pair Trading in Services/ Commerce Industry

Market Condition	Equation (Forming Window)		LONG	SHORT	Cointegration Ratio		2SD (Forming Window)	Pair Trading Return
					MAKRO	BIGC		
BEARISH	BIGC1	= 0.0583751 MAKRO1 + 184.3892	MAKRO	BIGC	0.06	1.00	14.26	-0.07%
BULLISH	BIGC2	= -0.0322101 MAKRO2 + 220.2889	MAKRO	BIGC	0.03	1.00	2.42	-1.27%
SIDEWAYS	BIGC3	= 3.48626 MAKRO3 + 93.43687	MAKRO	BIGC	3.46	1.00	3.18	0.68%
					MAKRO	CPALL		
BEARISH	MAKRO1	= -418.054 CPALL1 + 11758.8	CPALL	MAKRO	1.00	418.05	15.05	-73.26%
BULLISH	CPALL2	= -0.303964 MAKRO2 + 65.75442	MAKRO	CPALL	0.30	1.00	0.76	-1.41%
SIDEWAYS	MAKRO3	= 1.268909 CPALL3 - 19.04226	CPALL	CPALL	1.00	1.27	0.81	-0.01%
					MAKRO	CPN		
BEARISH	CPN1	= -0.35411877 MAKRO1 +99.7801	MAKRO	CPN	0.35	1.00	14.16	-0.41%
BULLISH	CPN2	= -0.0944 MAKRO2 +55.5638	MAKRO	CPN	0.09	1.00	0.69	-0.94%
SIDEWAYS	CPN3	= -5.2790 MAKRO3 +451.8972	MAKRO	CPN	5.28	1.00	0.72	-1.76%
					MAKRO	BJC		
BEARISH	BJC1	= - 0.2979588 MAKRO1 + 102.8605	MAKRO	BJC	0.30	1.00	14.42	0.84%
BULLISH	BJC2	= - 0.184096 MAKRO2 + 184.8336	MAKRO	BJC	0.18	1.00	0.72	-0.81%
SIDEWAYS	BJC3	= - 7.994972 MAKRO3 + 353.8987	MAKRO	BJC	7.99	1.00	0.64	-2.10%

Table C.4 Estimated Result of Pair Trading in Property &Construction /Property Development Industry

Market Condition		Equation (Forming Window)	LONG	SHORT	Cointegration Ratio		2SD (Forming Window)	Pair Trading Return
					QH	LH		
BEARISH	QH1	= 0.5550688 LH1 - 3.095689	LH	QH	1.00	0.56	0.14	0.87%
BULLISH	LH2	= 1.596498 QH2 + 5.823681	QH	LH	1.60	1.00	0.08	0.87%
SIDEWAYS	LH3	= 0.7287508 QH3 + 7.437104	QH	LH	0.73	1.00	0.06	-0.12%
					QH	PS		
BEARISH	QH1	= 0.2311407 PS1 - 3.438938	PS	QH	1.00	0.23	0.61	0.54%
BULLISH	QH2	= 0.0938796 PS2 + 1.078542	PS	QH	1.00	0.09	0.53	0.10%
SIDEWAYS	QH3	= 0.0922719 PS3 + 1.266783	PS	QH	1.00	0.09	0.75	12.37%
					QH	SIRI		
BEARISH	QH1	= 1.148477 SIRI1 - 0.852421	SIRI	QH	1.00	1.15	0.05	-0.05%
BULLISH	QH2	= 0.4157753 SIRI2 + 1.984189	SIRI	QH	1.00	0.42	0.10	-0.45%
SIDEWAYS	SIRI3	= 0.048476 QH3 + 1.932808	QH	SIRI	0.05	1.00	0.07	-0.58%
					QH	SPALI		
BEARISH	QH1	= 0.27224 SPALI1 -4.17044	SPALI	QH	1.00	0.27	0.55	-1.11%
BULLISH	QH2	= 0.12761 SPALI2 +1.181724	SPALI	QH	1.00	0.13	0.53	0.85%
SIDEWAYS	QH3	= 0.11947SPALI3 + 1.94681	SPALI	QH	1.00	0.12	0.85	-0.29%

Table C.5 Estimated Result of Pair Trading in Agro &Food Industry/ Food &Beverage Industry

Market Condition		Equation (Forming Window)	LONG	SHORT	Cointegration Ratio		2SD (Forming Window)	Pair Trading Return
					TU	CFRESH		
BEARISH	TU1	=-5.215689 CFRESH1 + 117.8184	CFRESH	TU	1.00	5.22	0.70	-0.87%
BULLISH	CFRESH2	=0.4572797 TU2 - 19.62438	TU	CFRESH	0.46	1.00	0.60	0.30%
SIDEWAYS	CFRESH3	=-0.0531828 TU3 +10.37392	TU	CFRESH	0.05	1.00	1.00	-0.78%
					TU	GFPT		
BEARISH	GFPT1	=-0.1525439 TU1 +18.72637	TU	GFPT	0.15	1.00	0.60	-0.27%
BULLISH	GFPT2	=0.374864 TU2 - 14.14887	TU	GFPT	0.37	1.00	0.80	3.08%
SIDEWAYS	GFPT3	=-0.319137 TU3 + 34.89985	TU	GFPT	0.32	1.00	0.80	1.99%
					TU	CPF		
BEARISH	TU1	=3.813742 CPF1 - 60.28904	CPF	TU	1.00	3.81	0.50	-1.26%
BULLISH	CPF2	=0.6428437 TU2 - 10.71426	TU	CPF	0.64	1.00	0.50	-0.99%
SIDEWAYS	TU3	=-14.50514 CPF3 + 473.391	CPF	TU	1.00	14.51	1.00	-43.81%
					TU	ASIAN		
BEARISH	TU1	=25.89141 ASIAN1 -28.26012	ASIAN	TU	1.00	25.89	0.60	2.13%
BULLISH	ASIAN2	=-0.8523108 TU2 +55.97581	TU	ASIAN	0.85	1.00	0.70	-20.73%
SIDEWAYS	ASIAN3	=-0.0078998 TU3 + 4.276089	TU	ASIAN	0.01	1.00	1.00	-0.01%

Table C.6 Estimated Result of Pair Trading in Industrials/ Petrochemicals &Chemicals Industry

Market Condition		Equation (Forming Window)	LONG	SHORT	Cointegration Ratio		2SD (Forming Window)	Pair Trading Return
					PTTGC	IRPC		
BEARISH	PTTGC1	= -110.6732 IRPC1 +535.8693	IRPC	PTTGC	1.00	110.67	1.00	6.02%
BULLISH	PTTGC2	= -1.304195 IRPC2 +81.99465	IRPC	IRPC	1.00	1.30	0.50	0.18%
SIDEWAYS	IRPC3	= 0.0170669 PTTGC3 +1.993439	PTTGC	IRPC	0.02	1.00	0.60	-0.02%
					PTTGC	IVL		
BEARISH	IVL1	= -0.3394015 PTTGC1 +50.19896	PTTGC	IVL	0.34	1.00	1.25	0.84%
BULLISH	PTTGC2	= 0.6710624 IVL2 + 61.79264	IVL	PTTGC	1.00	0.67	0.50	-0.06%
SIDEWAYS	IVL3	= 0.8227345 PTTGC3 - 30.86738	PTTGC	IVL	0.82	1.00	0.75	-0.53%
					PTTGC	SCCC		
BEARISH	PTTGC1	= 0.1109653 SCC1 +18.74231	SCC	PTTGC	1.00	0.11	7.25	0.31%
BULLISH	PTTGC2	= -0.181013 SCC2 + 157.5883	SCC	PTTGC	1.00	0.18	3.00	0.51%
SIDEWAYS	PTTGC3	= -0.3108798 SCC3 +208.02	SCC	PTTGC	1.00	0.31	3.50	2.96%
					PTTGC	TOP		
BEARISH	PTTGC1	= 1.2214TOP1 - 9.9284	PTTGC	TOP	1.00	1.22	0.75	-1.19%
BULLISH	PTTGC2	=2.4887TOP2 +11.7498	PTTGC	TOP	1.00	2.49	0.50	1.25%
SIDEWAYS	PTTGC3	=0.6914 TOP3 + 9.7924	PTTGC	TOP	1.00	0.69	0.50	-1.89%

BIOGRAPHY

Name	Miss Sainum Tangsombatvisit
Date of Birth	April 12, 1988
Work Position	Investor Relations Manager, SAMART Corporation Public Company Limited
Education	2014- 2016 M.Sc. Finance, Thammasat University 2008- 2011 B.BA. International Business, Macquarie University
Work Experiences	June 2016 - now Investor Relations Manager, SAMART Corporation Plc. June 2015 – June 2016 Finance Manager, Total Access Communication Plc. June 2014 – May 2015 Senior Consultant at PricewaterhouseCoopers Thailand February 2012 – May 2014 Business Financial Analyst, Siam City Cement Plc.