Trading Strategies Series: Pair Trading (Part 1 of 6)

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Overview - Pair Trading

The unpredictable nature of the stock market can make it difficult for investors to decide on a direction (long or short) to trade and be consistently correct. Investors who trade without a sound strategy may find themselves expending time and effort without much gains and even losing money, making them victims, rather than exploiters, of stock market volatility.

"Pair trading", a *market neutral* strategy (meaning the direction of the overall market does not matter), can help reduce portfolio volatility and improve money-making opportunities in volatile markets. Developed in the mid-1980s by quantitative analysts (quants), the strategy involves selecting two highly correlated stocks and then matching a long position in one of the two stocks with a short position in the other. **Participation in the stock market carries risks. For more details on possible risks of using Extended Settlement contracts to execute the "pair trading" strategy, please click here. Risks are not limited to using ES but also the strategy itself, click here for more info.**

This article (first of six) aims to equip potential traders with a basic understanding of pair trading by breaking the strategy down into 4 simple steps.

Guide - 4 Simple Steps to Pair Trading

Step 1: Pair Formation

First and foremost, pairs trading (as the name suggest) relies on the correct selection of a pair of stocks that are highly correlated. To achieve this, potential investors need to identify pairs through a correlation test. For beginners, the Pearson's Correlation test (available in Microsoft Excel) is sufficient. Statistically, stocks with correlations above 80% are considered to be highly correlated.

As a start, one may wish to begin with stocks in the same industry. For illustration purposes, let us look at UOB and OCBC (two local banks in Singapore) whose closing prices from 31/12/07 to 31/08/09 had a high correlation of approximately 95.8%[1]. Diagram 1 below provides a visual confirmation of the correlated movements. (Note: Stock prices of OCBC have been multiplied by a factor of 1.75 to make comparison easier).

Once the pair has been selected, the price ratio (Step 2) is calculated.

Note: These stocks are selected solely for illustration purposes. SGX and its affiliates do not recommend any stocks in particular.

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[1] Correlation between the pairs based on percentage returns is approximately 80% for the same period.

Diagram 1: Movement Correlation between UOB and OCBC (1 - 1.75 Spread Ratio)
(31/12/07 - 31/08/09)
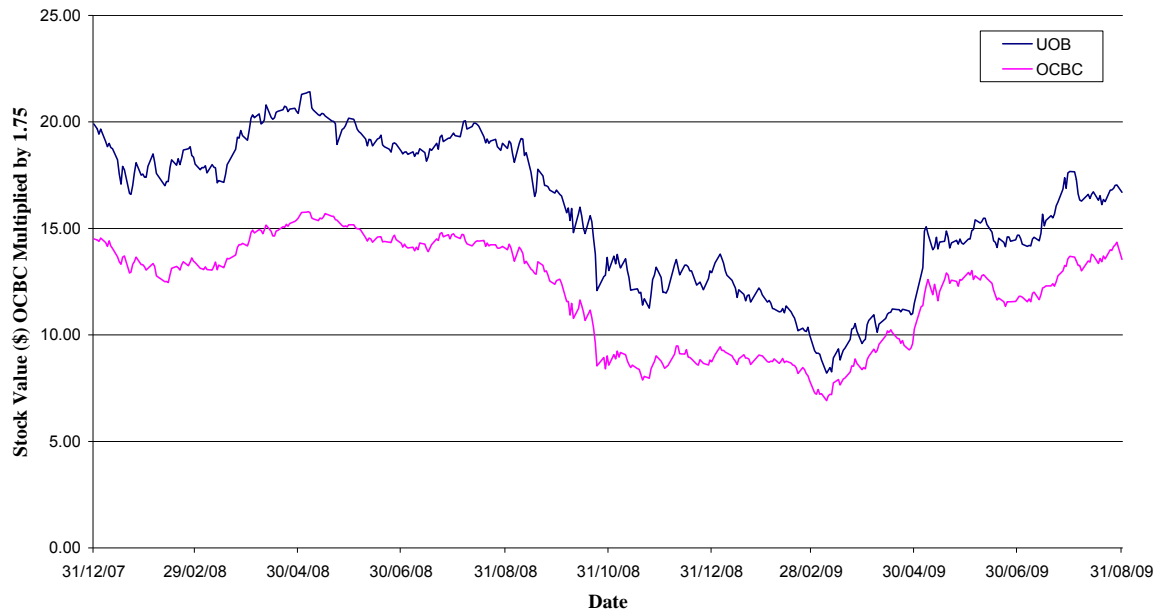
Step 2: Create a Price-Ratio

The price ratio (sometimes known as the relative performance line) is computed by dividing the price of one stock by that of the corresponding pair[2]. Hence, in our example, the stock price of UOB (numerator) is divided by that of OCBC (denominator) to derive the UOB-OCBC price ratio.

This ratio represents the average "spread" (or relative performance) between the two stocks in the pair. Deviations from the mean (or normal average) range, as indicated by "spikes" (can be upwards or downwards) suggest trading opportunities. The price ratio and examples of spikes for the UOB-OCBC pair are presented in Diagram 2.

After the price ratio has been charted, the next step (Step 3) is to spot which "spikes" to trade, i.e. the breakout (entry) points.

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[2] It does not matter which stock price is the numerator or denominator. To be consistent, the author of this article prefers to divide the higher price stock by the lower price stock so that the ratio is greater than 1.

Diagram 2: UOB-OCBC Price Ratio for the period 31/12/07 to 31/08/09

Diagram 2: UOB-OCBC Price Ratio (31/12/07 to 31/08/09)
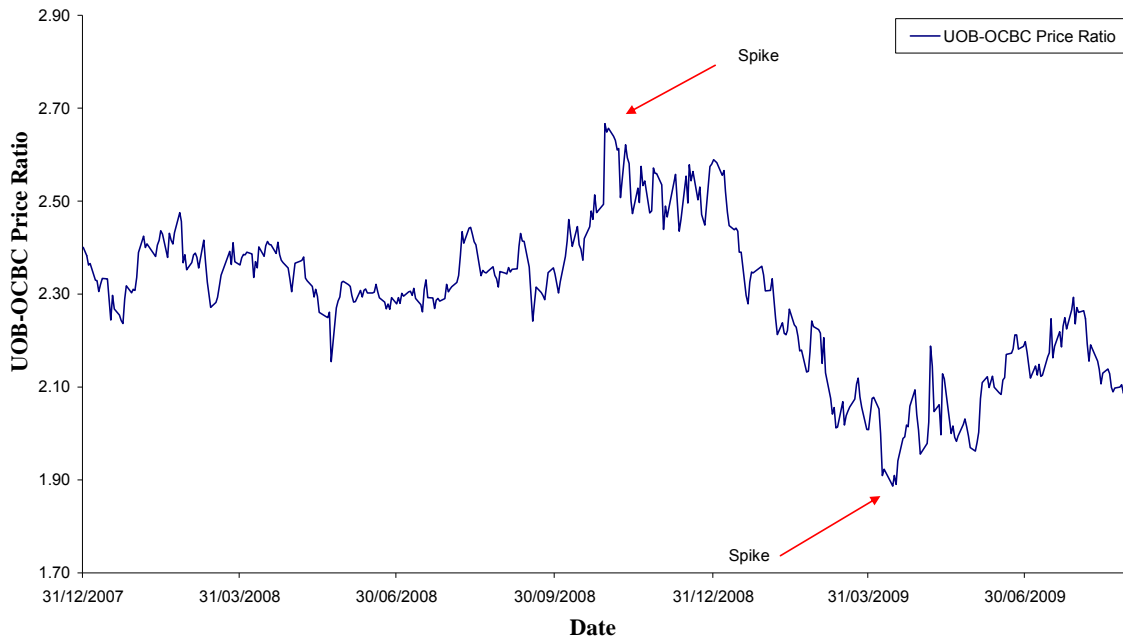
Step 3: Spotting the Breakout (entry) points and planning an exit strategy

In Step 3, we need to determine which "spikes" to trade on and when to exit (either profit-take or limit-losses). Having derived the price ratio line, the next question is: when does one trade? To assist us in making a scientifically calculated choice, an entry (breakout point) is estimated using the standard deviation (*SD*) of the UOB-OCBC price ratio. Based on historical prices, the entry points are set at + (-) 2 *SD* from the *one-year moving average*. This implies that when the price ratio is above (below) 2 *SD*, there are profitable opportunities to trade when we short (long) the numerator (UOB) and long (short) the denominator (OCBC). These factors are represented in Diagram 3 below[3].

While there are various methods to close the position, the successful trader always incorporates a stop-loss limit in his strategy. For illustration purposes, the trading rule for exiting a position is set at a 1:3 (stop-loss limit to gross profit) ratio. This implies that if we decide to set our stop-loss limit at 20% of capital outlay, we will set the profit taking exit point

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[3] The entry and exit points can be adjusted to the trader's preference. For example, traders who wish to trade more may wish to reduce the entry point from 2 to 1.5 *SD*. This creates more entry points but can also potentially reduce profits.

at 60% (see Table 1 for examples)[4]. Once these steps are set, it is possible to start trading using the pair trading strategy (Step 4).

Note: After stop loss: All breaks are ignored until price ratio reverts back to within 2 SD.

Diagram 3: UOB-OCBC Breakout and Exit Points for the period
31/12/07 to 31/08/09

Diagram 3: UOB-OCBC Breakout Points (31/12/07 - 31/08/09)

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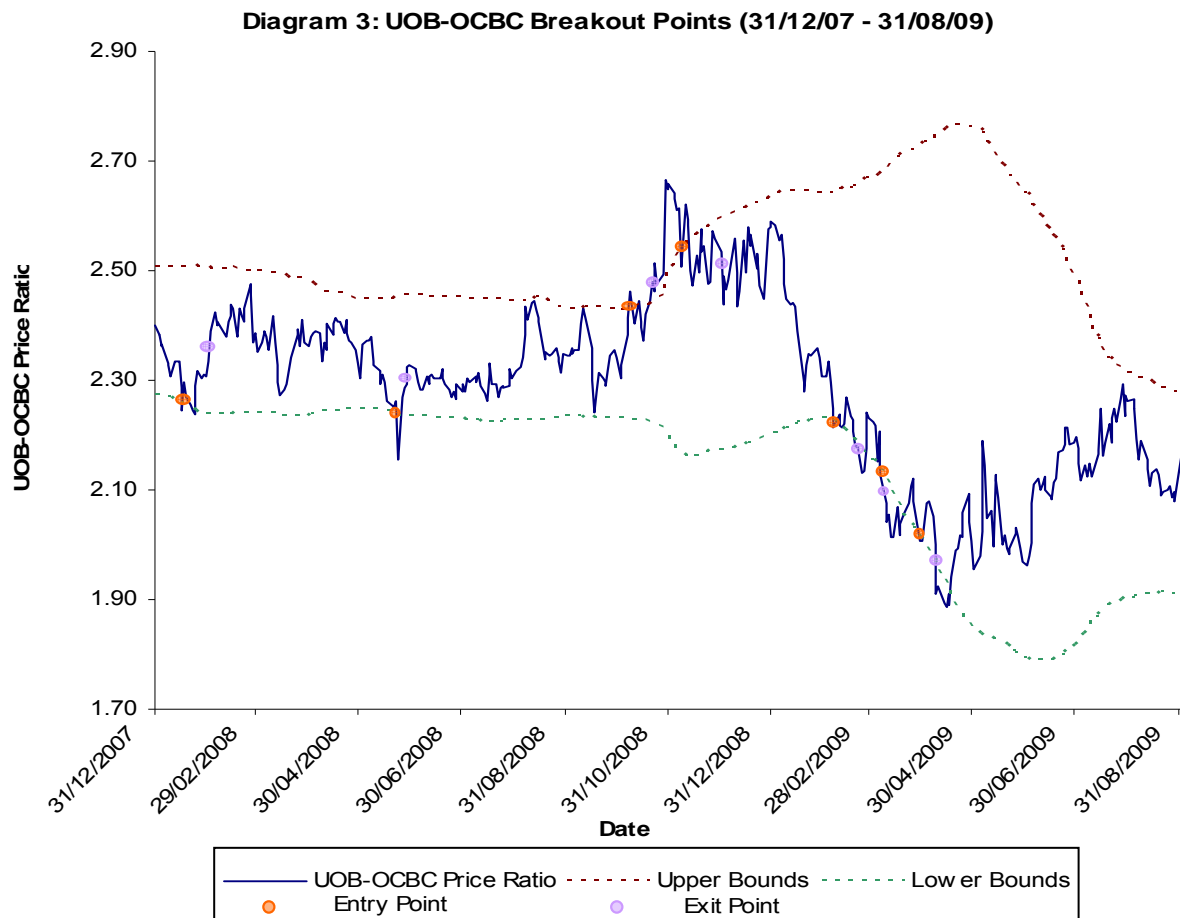
[4] Stop-loss limit to gross profit ratio and stop-loss limits / profit taking points can all be customize according to the traders preferences. E.g. investors with higher risk appetite may wish to increase the stop-loss limit above 20% or profit ratio above 60%.

Step 4: Trading on the Breakout points

Prior to actual trading, potential investors may wish to simulate the entries and exits (stop-loss) scenarios using historical prices to get a "feel" of the strategy. Using historical data, it is possible to emulate the trading environment and determine your own preferred entry and exit rules (Step 1 – 3). Once you are comfortable and familiar with the execution of this strategy, you can commence trading using pair trading.

To demonstrate this, Table 1 below presents a selected list of the breakout and exit points for the period from 31/12/07 to 31/08/09. The potential profit (loss) from trading is simulated below from these trades.

Note: These returns are based on the assumption that we use the Extended Settlement (ES) contracts[5] to leverage our position for profit maximization. The initial margin requirement is assumed to be 10% of contract value. For more information on ES contracts, click here[6]. There are risks associated with ES contracts, click here to understand these risks.

(SEE APPENDIX FOR A PRACTICAL STEP-BY-STEP GUIDE TO THIS)

(POTENTIAL INVESTORS SHOULD ALSO BE AWARE OF THE RISKS ASSOCIATED WITH THE STRATEGY. CLICK HERE OR REFER TO APPENDIX FOR DETAILS)

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[5] SGX prescribes different levels of maintenance margin requirements. Outright and spread margins will be set in simple tiers depending on stock volatility. For example, the margin rate can be in tiers of 5%, 10%, 15% and 20%. However, Members are permitted to set margin requirements higher than that prescribed by SGX.

[6] Refer to http://www.sgx.com/wps/portal/marketplace/mp-en/products/securities_products/extended_settlement

Table 1: List of Tradable Opportunities and Potential Profit (Selected)

Date	UOB Stock Price	OCBC Stock Price	UOB-OCBC Price Ratio	Upper Break (Sell 4,000 UOB, Buy 9,000 OCBC)	Lower Break (Buy 4,000 UOB, Sell 9,000 OCBC)	Exit Trigger (Profit-Take)	Stop Loss Trigger	Business Days Between Trades	*Cost of Entry (Stocks)	**Profit (Stocks)	*Cost of Entry (ES)	**Profit (ES)
16/01/08 (Entry)	17.08	7.61	2.24	≥ 2.51	≤ 2.26 (Trigger)	≥ 2.38	≤ 2.20	13	$102,565	$4,350 (4.24%)	$13,681	$4,350 (31.8%)
01/02/08 (Exit)	17.92	7.50	2.39	-	-	≥ 2.38 (Trigger)	≤ 2.20					
23/05/08 (Entry)	18.94	8.79	2.15	≥ 2.45	≤ 2.23 (Trigger)	≥ 2.28	≤ 2.11	2	$115,315	$4,570 (3.96%)	$15,487	$4,570 (29.5%)
27/05/08 (Exit)	19.70	8.62	2.29	-	-	≥ 2.28 (Trigger)	≤ 2.11					
08/10/08 (Entry)	15.38	6.25	2.46	≥ 2.43 (Trigger)	≤ 2.23	≤ 2.31	≥ 2.51	11	$87,010	-$520 (-0.60%)	$11,777	-$520 (-4.4%)
23/10/08 (Stop)	13.80	5.49	2.51	-	-	≤ 2.31	≥ 2.51 (Trigger)					
10/11/08 (Entry)	13.58	5.18	2.62	≥ 2.55 (Trigger)	≤ 2.16	≤ 2.46	≥ 2.67	16	$73,780	$3,980 (5.39%)	$10,094	$3,980 (39.4%)
02/12/08 (Exit)	12.00	4.92	2.44	-	-	≤ 2.46 (Trigger)	≥ 2.67					
06/0309 (Entry)	8.82	4.14	2.13	≥ 2.68	≤ 2.14 (Trigger)	≥ 2.26	≤ 2.09	1	$53,910	-$770 (-1.43%)	$7,254	-$770 (-10.6%)
09/03/09 (Stop)	8.20	3.95	2.08	-	-	≥ 2.26	≤ 2.09 (Trigger)					

* Assume Extended Settlement (ES) contracts are used and a 10% initial margin is imposed.

**Transaction costs have not been included in the computation of these returns.

Appendix

Detailed example of how to implement a pair trading strategy using ES contracts

Assuming that today is 10/11/2008, a trader has decided to implement a pair trading strategy using UOB and OCBC stocks.

Step 1: Calculate the price ratio, upper and lower breaks

From the stock price collected, the trader will calculate the price ratio, and upper and lower breaks on a daily basis as documented in the paper.[7] [8]

Date	UOB Stock Price	OCBC Stock Price	UOB-OCBC Price Ratio	Upper Break (Sell UOB, Buy OCBC)	Lower Break (Buy UOB, Sell OCBC)
10/11/2008	$13.58	$5.18	2.62	≥ 2.55	≤ 2.16

Calculation of Price Ratio

$$Price\ Ratio_t = \frac{Price_{UOB,i}}{Price_{OCBC,i}}$$

(where i = 10/11/2008)

$2.62 = 13.58 / 5.18$

Calculation of Upper Break

*Upper Break = 1 year Moving Average of UOB-OCBC Price Ratio + (2 * SD of 1 year Moving Average of Price Ratio)*

$= 2.355 + 0.195$

Calculation of Lower Break

*Lower Break = 1 year Moving Average of UOB-OCBC Price Ratio - (2 * SD of 1 year Moving Average of Price Ratio)*

$= 2.355 - 0.195$

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[7] SD represents standard deviation in the formulas above. A standard deviation of ±2 is selected as statistically 95% of observations will reside within the bands (assume normal distribution). It is possible for investors to adjust the entry standard deviation to their liking.
[8] A 1-year moving average price ratio is simply the average price ratio over 1 calendar year that is adjusted forward at the end of each trading day. It is calculated by summing all price ratios for 1 calendar year and dividing this total by the number of trading days in that year.

Step 2: Entry into the market once the upper or lower break is hit, and calculation of the exit and stop-loss trigger points

Once the calculated price ratio crosses the upper or lower breaks, the trader will enter the market. If the price ratio exceeds the upper (lower) break, the trader will sell (buy) 4,000 UOB stocks/ES contracts and buy (sell) 9,000 OCBC stocks/ES contracts. Following the table below, the price ratio has exceeded the upper break on 10/11/2008 and therefore the trader will sell 4,000 UOB stocks at $13.58 and buy 9,000 OCBC stocks at $5.18. In addition, the trader will also have to calculate the exit and stop-loss triggers every time he enters the market. A detailed explanation is discussed below:-

Identification of the price ratio exceeding the upper break

Date	UOB Stock Price	OCBC Stock Price	UOB-OCBC Price Ratio	Upper Break (Sell UOB, Buy OCBC)	Lower Break (Buy UOB, Sell OCBC)
10/11/2008	$13.58	$5.18	2.62	≥ 2.55	≤ 2.16

Alert!!
The price ratio has exceeded the upper break.
[2.62 (price ratio) ≥ 2.55 (upper break)]

Execution of the upper break strategy

Date	UOB Stock Price	OCBC Stock Price
10/11/2008	$13.58	$5.18

The trader will then buy 9,000 OCBC stocks at $5.18 and sell 4,000 UOB stocks at $13.58. Therefore,

$$Capital\ Outlay = (9,000 * \$5.18) * 0.10 + (4,000 * \$13.58) * 0.10$$
$$= \$10,094$$

Calculation of exit and stop-loss trigger points[9]

Date	Exit Trigger (Profit Take)	Stop-Loss Trigger
10/11/2008	≤ 2.46	≥ 2.67

$$\left[\begin{array}{c} \textit{\underline{Calculation of Exit Trigger}} \\ \textit{\underline{(Profit-Take)}} \\[6pt] \textit{Exit Trigger} \\ \textit{= Price Ratio * (1 - 0.06)} \\[6pt] \textit{= 2.62 * 0.94 = 2.46} \end{array} \right] \quad \left[\begin{array}{c} \textit{\underline{Calculation of}} \\ \textit{\underline{Stop loss Trigger}} \\[6pt] \textit{Stop-loss Trigger} \\ \textit{= Price Ratio * (1 + 0.02)} \\[6pt] \textit{= 2.62 * 1.02 = 2.67} \end{array} \right]$$

Note: Exit and Stop-loss Triggers are calculated based on a target stop-loss and gross profit ratio of 20% to 60%. As the illustration is done using ES contracts, the stop-loss trigger will be set at 2% above (below) the upper (lower) break instance and the take-profit trigger at 6% below (above) the upper (lower) break instance. This is due to the margin requirements (assume 10%) which reduce initial capital by 10 times (i.e. the investment outlay is decreased from 100% to 10% of stock value).

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[9] Assume trader is using Extended Settlement (ES) contracts and the target stop-loss and gross profit ratio is 20% to 60%. This implies that the stop-loss trigger will be set at 2% above (below) the upper (lower) break instance and the take-profit trigger at 6% below (above) the upper (lower) break instance. Note: Traders can adjust the exit (stop-loss) % based on their risk preference.

Step 3: Exit from the market once the exit or stop-loss trigger is hit

After 10/11/2008, the trader will continue to calculate the price ratio on a daily basis as shown in Step 1. Following the exit and stop-loss trigger points calculated on that day, the trader will compare them with the daily calculated price ratio. In this case, the current price ratio is compared with the trigger points calculated on 10/11/2008. On 02/12/2008, the price ratio is found to have crossed the exit trigger; therefore the trader will now close out all positions. As a result, he will sell 9,000 OCBC stocks and buy 4,000 UOB stocks at the current market price.

Identification of the price ratio crossing the exit point

Date	UOB Stock Price	OCBC Stock Price	UOB-OCBC Price Ratio	Exit Trigger	Stop-Loss Trigger
02/12/2008	$12.00	$4.92	**2.44**	**≤ 2.46**	≥2.67

Alert!!
The price ratio has crossed the exit trigger.
[2.44 (price ratio) ≤ 2.46 (exit trigger)]

Closing out of all positions

Date	UOB Stock Price	OCBC Stock Price
02/12/2008	$12.00	$4.92

The investor will now close off the position by selling 9,000 OCBC stocks at $4.92 and buying 4,000 UOB stocks at $12.00. Therefore,

*Total Profits = [4,000 * ($13.58 - $12.00)] – [9,000 *($5.18 - $4.92)]*
*=$3,980*

Step 4: Repeat Step 1 to Step 3 to identify new entry and exit points

Once the trader has closed all positions and realised his profits, he will continue to calculate the price ratio and the upper and lower breaks. The trader will then look to identify the trading day when the price ratio exceeds the upper or lower breaks again. In such an event, the trader will implement the strategy as documented in Step 2 (remember to calculate the exit and stop-loss trigger points) and continue to calculate the price ratio after that. As mentioned in Step 3, the trader will then look to identify the trading day when the price ratio crosses the trigger points (either exit/stop-loss) that are calculated on the day of entry into the market. When this occurs, the trader will close all remaining open positions and realise his profits (or limit-loss). These steps will then be repeated across the investment horizon as determined by the trader.

Intraday Trading Opportunities

To provide further empirical evidence that pair trading opportunities exist, the intraday price ratio and the entry/exit breaks were plotted on a minute-by-minute interval[10]. Diagram 4 illustrates the entry breaks (price ratios ≥ 2.55) that occurred on the 10/11/08 and Diagram 5 demonstrates the exit breaks (price ratios ≤ 2.46) for the 02/12/08. From the diagrams, it can be observed that there are numerous instances where the price ratio is above (below) the break lines (exit triggers) which indicate trading opportunities.

Diagram 4: Intraday (Entry) Breaks for 10/11/08 (UOB – OCBC)

Diagram 4: Intraday (Entry) Breaks for 10/11/08 (UOB - OCBC)

Diagram 5: Intraday (Exit) Breaks for 02/12/08 (UOB - OCBC)
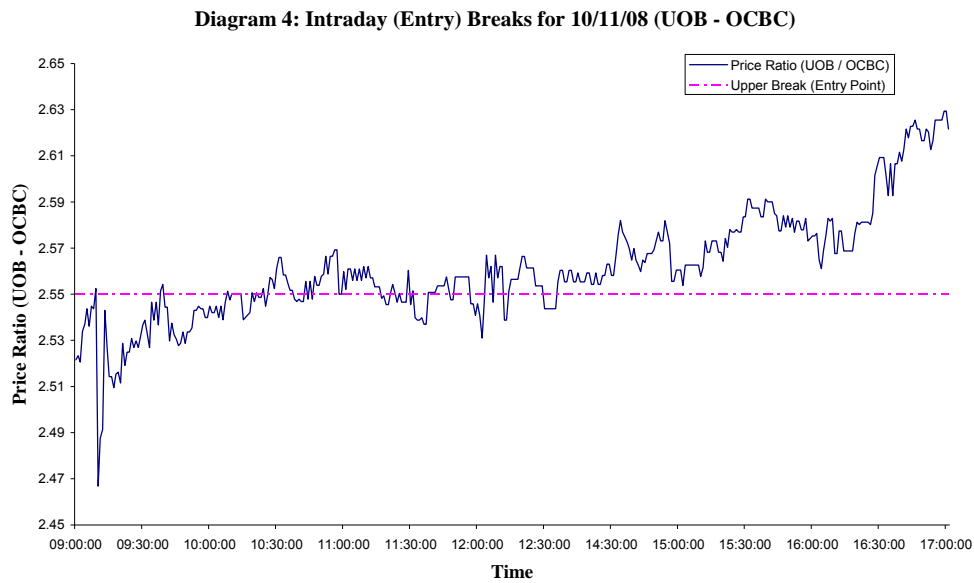
Diagram 5: Intraday (Exit) Breaks for 02/12/08 (UOB - OCBC)
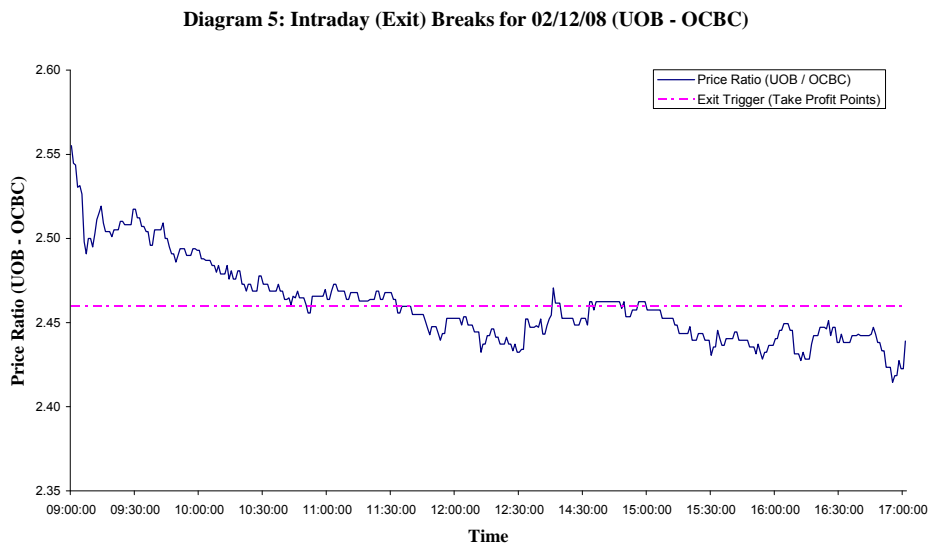
[10] The last traded price within each minute was used.

Extension of the Sample Period

Diagram 6 presents an extension of the period examined in Diagram 3. It also provides a theoretical line which is the average of the price ratio for the period 31/05/06 to 31/08/2009. This diagram attempts to provide some visual reference of the mean reverting tendency of UOB and OCBC prior to the volatile period caused by the global financial crisis.

Diagram 6: Extension of the UOB-OCBC Breakout and Exit Points
for the period 31/05/06 to 31/08/2009

Diagram 6: UOB-OCBC Breakout Points (31/05/06 - 31/08/09)
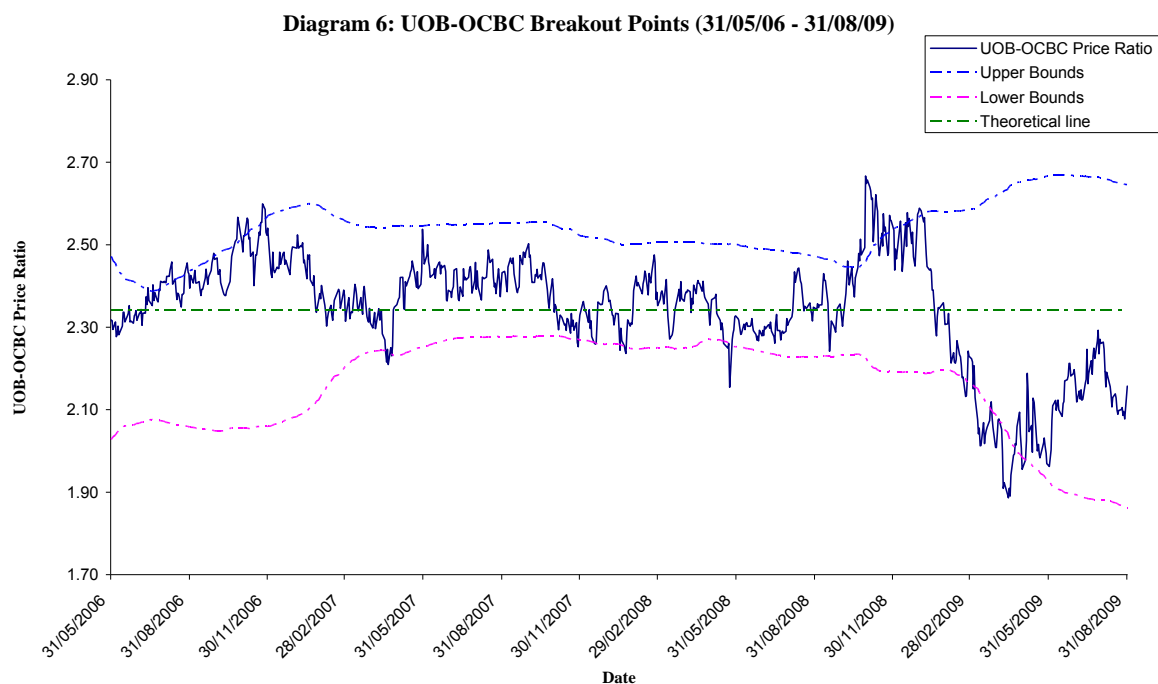
Why use Extended Settlement (ES) contracts for "Pairs Trading"?

Leverage - When an investor enters into an ES contract, he only needs to put up a margin, which is a small fraction of the full contract value. This allows the trader to leverage his positions and maximise the returns of the initial capital outlay.

Increase the holding period – One of the factors that potential traders need to take note of when using pair trading is the length of time they need to hold on for the pair to converge. ES allows the holders a maximum of approximately 35 calendar days compared to 3 days for contra trading and 30 calendar days for Contracts for Differences (CFDs).

Ease of Taking Short Positions - ES contracts provide traders the ease of taking short positions with minimum costs. The transactional costs are reduced substantially compared to borrowing shares or CFDs for gaining a short exposure as it has no financing costs (unless you hold your position until settlement).

Risk Awareness

(i) Risks of trading ES contracts

a) Leveraging

The leverage exposure provided by ES contracts can lead to substantial losses. If the market moves against the investor, the losses suffered from trading ES contracts will be greater as a percentage of the initial cost or capital outlay needed to enter into an ES contract position, i.e. the margin deposit, than if an investor had invested the same amount in the underlying assets.

b) Overexposure and overtrading

Investors tend to look only at the margin required and often fail to appreciate and take into account the full contract value. As such, they may trade a large number of contracts, significantly beyond their financial resources, resulting in overexposure

c) Margin calls

If the market moves against the investor, the losses will be debited from the margin account. This is done on a daily basis. If the margin account falls below the required margin, a margin call will be initiated which requires a top–up back to the initial margin + variable margin, or to reduce the number of open contracts. Failing this, the broker may force–liquidate the position.

d) Buy–in

Should an investor hold a short ES contract position till expiration, he is obliged to physically deliver the stock for settlement. If an investor does not have the required shares in his account on the due date (the third market day following the expiration date), CDP will buy–in shares on the market to satisfy the delivery obligation.

Buy–in starts the day after the settlement day, which is four days after the last trading day (LTD+4). The buy-in bid price, as determined by CDP, will be 2 minimum bids above the highest of the closing price of the previous day, the reference transacted price or the reference bid price. The reference transacted price and the reference bid price will be any of the last transacted prices and bid prices in the 1 hour preceding the commencement of buying-in, as determined by CDP. In addition to the current processing fee for buying-in, there will be a penalty of 5% of the value of the failed trade subject to a minimum of $1,000.

(ii) Strategy risks

Similar to other investments, there are risks to "pair trading". Hence, it is important for the investor to understand the risks/constraints of this strategy to better profit from it. Some of these include:

Mean Reversion - Pair trading is based on the expectation that the two stocks will *mean revert*, this is derived based on historical data. However, in the event of a significant change in company's fundamentals, the mean reverting relationship may no longer exist. Investors wishing to exploit pair trading should be mindful of any such changes before trading.

Market Neutrality - Complete market neutrality will only occur when the dollar values of the paired stocks are *perfectly matched* at the time of trade. For example, the UOB-OCBC price ratio ranges from 1.89 to 2.67; this implies that for every share of UOB that is traded, 1.89 to 2.67 OCBC equivalent shares should be traded for the portfolio to be completely market neutral. In reality, this may not always be possible.

Holding Period - Occasionally, the holding periods for the pair of stocks to mean revert can be lengthy.

*Note: The risk awareness section contains the key risks associated with the strategy, they are however not exhaustive.