CURVE TENS TENS STRATEGY

DESMOND HO

Abstract. This is an account of promising quantitave research done on a three-legged bond futures spread trading strategy. We discuss several results, limitation and potential improvements to the strategy at hand.

1. Introduction

1.1. **Structure.** Commonly known as the *Curve Tens Tens*, this three-legged spread (butterfly) involves the following outright futures.

(1) 3-Year Australian Treasury Bond Futures (YT)
(2) 10-Year Australian Treasury Bond Futures (XT)
(3) 10-Year U.S. Treasury Note Futures (TYA)

The price of one unit is calculated as follows

$$P = 1 * YT - 2 * XT + 0.125 * TYA$$

And one unit of trade consists of

$$U = 3 * YT - 2 * XT + 1 * TYA$$

1.2. **Strategy.** The strategy is based on mean reversion principles. Hourly bar periods are observed, and all entries and exits are taken on the following bar after a signal has been generated. Moreover this strategy holds a maximum position of one unit at any point of time.

1.2.1. *Entry.* Entry signals are based on Relative Strength Index (RSI)[1] values only. Note that the parameters L_{entry} and S_{entry} are values to be determined.

- Enter a long trade if the current bar RSI falls below L_{entry}.
- Enter a short trade if the current bar RSI rises above S_{entry}.
- No entry is to be made if there is a jump[2] between bars as well as during the Sydney Futures Exchange (SFE) Futures rollover period[3].
- If a stop loss (below) has been triggered, no subsequent trades are allowed unless the RSI has returned to the no entry range at least once.

1.2.2. *Exit.* Exit signals are employed based on RSI values and risk management in mind. Note that the parameters L_{exit}, S_{exit} and X_{stop} are values to be determined.

- Exit a long trade if the RSI rises above L_{exit}.
- Exit a short trade if the RSI falls below S_{exit}.
- Define a stop loss of X_{stop} basis points relative to the close price.

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[1]Relative Strength Index calculations are provided by CQG Integrated Client.

[2]A jump is defined as a minimum gap of 2 basis points between the ranges of consecutive bars.

[3]We take the rollover period to be the second week of March, June, September and December.

2. Backtesting and Optimisation

The behaviour of the strategy with respect to historical data[4] is studied using backtest and optimization modules developed in Python[5] were performed.

2.1. **Backtesting.** In order to maintain a proper level of rigour and remain conservative in the backtest results, a few basic assumptions are made.

2.1.1. *Assumptions.* Below is a list of important assumptions made.

(1) There is sufficient liquidity to fill all trades.
(2) The data provided from vendor is accurate.
(3) To account for slippage[6], we assume a loss of 0.5 basis points per side[7] for every trade.

2.1.2. *Historical Data.* The data was sampled from 25/02/2012 to 18/02/2015 inclusive. This amounts to approximately 2.6 years worth of data.

2.2. **Optimisation.** Initial trial backtests signalled that this was a profitable strategy in general. To study the effect of changes in parameters used in our model, several exhaustive (brute-force) optimisations were carried out.

The range of parameter values run-through in the optimisation process is shown in Table 1 below. This adds up to a total of $61,952$ backtest iterations per optimisation.

Table 1. Range of Parameters Tested

L_{entry}	L_{exit}	S_{entry}	S_{exit}	X_{stop}
25 to 35	44 to 59	60 to 70	41 to 56	4.0 to 5.0

[4]Open, High, Low, Close and RSI hourly bar quotes of the butterfly structure. Provided by CQG Integrated Client.
[5]Optimisation and backtest algorithms/computations were all run via scripts written in Python 2.7.9.
[6]Section 3 of this paper discusses more about the issue of slippage.
[7]A round trip (entry and exit), would therefore amount to a total slippage of 1.0 basis point.

2.2.1. *Optimising for Best Realised Basis Points.* The first optimisation was carried out with the goal of maximising the total realised basis points.

The set of parameters found to return the best total realised basis points was given to be:

$$L_{entry} = 31,\ L_{exit} = 53,\ S_{entry} = 60,\ S_{exit} = 41,\ X_{stop} = 5.0$$

A detailed backtest for this set of parameters was carried out. The trade statistics for this case is provided for reference in Table 2 below.

Table 2. Statistics for Best Basis Points Case

Total Realised BP	467.0
Win/Loss Mean	$2.67/-4.34$
Win/Loss Variance	3.16/6.87
Win/Loss Median	$2.5/-5.35$
Largest Win/Loss	$11.9/-13.4$
Trades Won/Lost/Break-Even	406 (73.95%) / 142 (25.87%) / 1 (0.18%)
Average Duration of Trade	19.93 hours
Maximal Drawdown (Duration)	-33.4 (245.67 hours)
Maximal Draw-up (Duration)	69.7 (1006.0 hours)
Maximum Consecutive Wins/Losses	17/5

Figure 1 below shows a plot of performance with time.

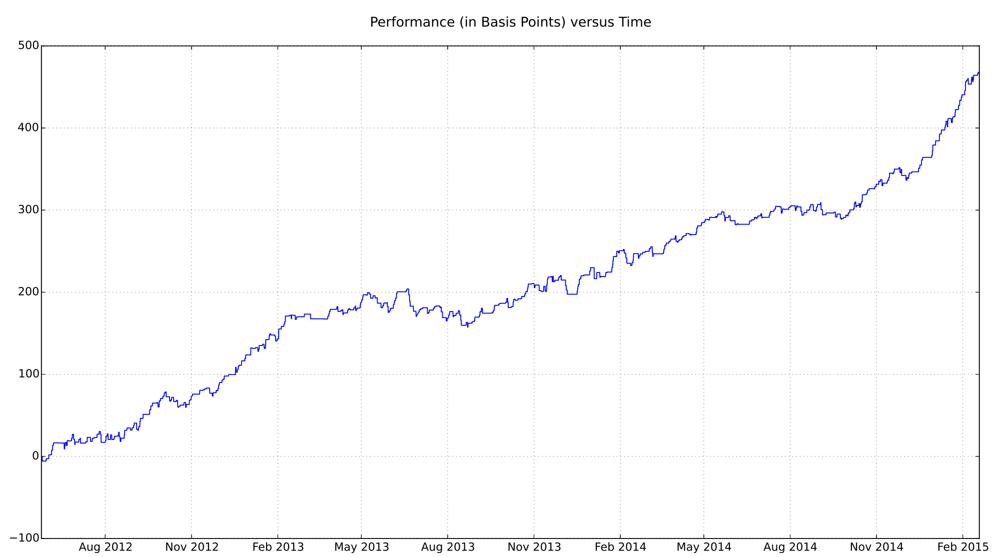

Figure 1. Best Realised Basis Points Performance.

2.2.2. *Optimising for Best Sortino Ratio.* With the motivation to capitalize on periodic returns whilst minimising downside risk, optimisation based on Sortino Ratio[8] was carried out.

The optimal set of parameters in this case was found to be:

$$L_{entry} = 32,\ L_{exit} = 53,\ S_{entry} = 63,\ S_{exit} = 49,\ X_{stop} = 5.0$$

A detailed backtest for this set of parameters was carried out. Statistics for this case is provided for reference in Table 3 below.

TABLE 3. Statistics for Best Sortino Ratio Case

Total Realised BP	424.7
Win/Loss Mean	$2.13/-2.84$
Win/Loss Variance	3.03/6.94
Win/Loss Median	$1.8/-1.4$
Largest Win/Loss	$15.2/-10.8$
Trades Won/Lost/Break-Even	411 (72.11%) / 158 (27.72%) / 1 (0.18%)
Average Duration of Trade	12.81 hours
Maximal Drawdown (Duration)	-18.4 (128.33 hours)
Maximal Draw-up (Duration)	62.6 (1006.0 hours)
Maximum Consecutive Wins/Losses	20/3

Figure 2 below shows a plot of performance with time. Notice the slight difference in slope compared to Figure 1.

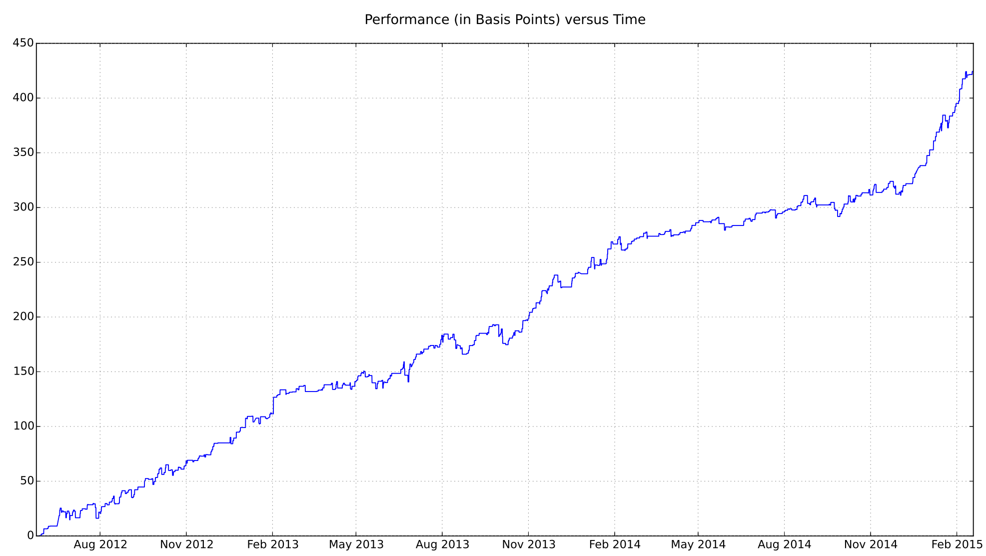

FIGURE 2. Best Sortino Ratio Performance.

[8]Sortino Ratio is calculated over 30-day periods, by taking the periodic returns (adjusted against a 0.25% benchmark) divided by the downside risk (standard deviation). In the case where the downrisk risk is zero, we choose the best periodic returns (adjusted against a 0.25% benchmark) given that the downside risk is zero.

2.2.3. *Optimising for Lowest Maximal Drawdown.* With the motivation to capitalize on periodic returns whilst minimising downside risk, optimisation based on Maximal Drawdown[9] was carried out.

The optimal set of parameters in this case was found to be:

$$L_{entry} = 25,\ L_{exit} = 44,\ S_{entry} = 70,\ S_{exit} = 50,\ X_{stop} = 4.0$$

A detailed backtest for this set of parameters was carried out. Statistics for this case is provided for reference in Table 4 below.

Table 4. Statistics for Lowest Maximal Drawdown Case

Total Realised BP	116.5
Win/Loss Mean	$2.37/-2.75$
Win/Loss Variance	4.07/5.65
Win/Loss Median	$2.05/-1.65$
Largest Win/Loss	$15.2/-7.9$
Trades Won/Lost/Break-Even	114 (67.06%) / 56 (32.94%) / 0 (0.00%)
Average Duration of Trade	12.13 hours
Maximal Drawdown (Duration)	-12.1 (264.0 hours)
Maximal Draw-up (Duration)	30.4 (1868.0 hours)
Maximum Consecutive Wins/Losses	10/4

Figure 3 below shows a plot of performance with time.

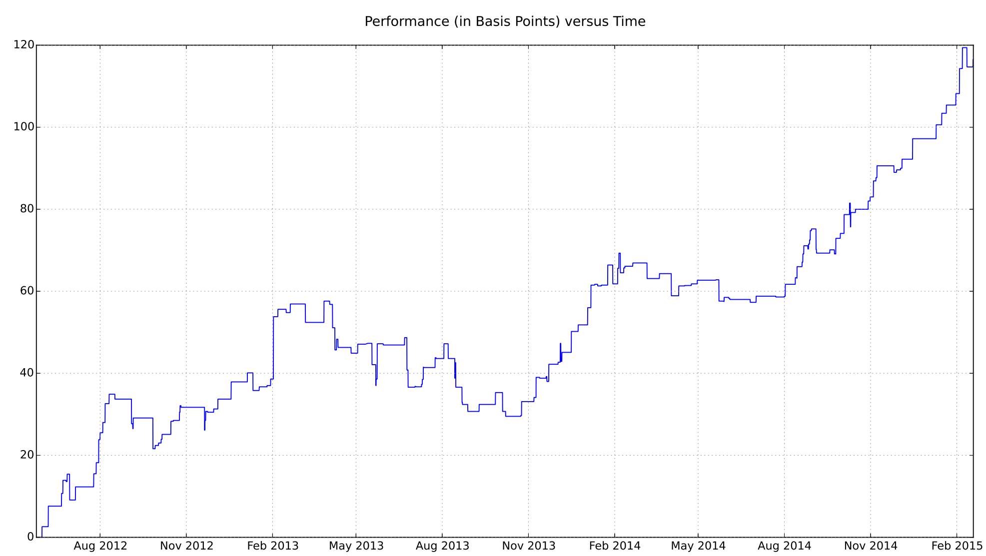

Figure 3. Lowest Maximal Drawdown Performance.

[9]Maximal Drawdown is defined as the largest consecutive loss over time.

2.3. **Walk-Forward Optimisation Technique.** To test the model for robustness, experimentation using a walk forward optimisation technique was done.

In this technique, optimisation is performed over a time window of 2 years, followed by applying resultant parameters over an out-sample period of 1 month, then re-optimising over the past 2 years and so on. The metrics used for optimisation targets were best realised basis points, best sortino ratio and least maximal drawdown.

Note that the effective out-sample period for all tests are from 26/05/2014 to 24/01/2015.

2.3.1. *Using Best Realised Basis Points.* The results of the walk forward optimisation with a focus on maximising the realised basis point outcome are as follows.

The statistics are shown on Table 5 below.

Table 5. Statistics for Walk-Forward: Basis Points Optimisation.

Total Realised BP	109.8
Win/Loss Mean	$2.16/-2.73$
Win/Loss Variance	2.67/7.35
Win/Loss Median	$1.8/-1.3$
Largest Win/Loss	$8.2/-8.6$
Trades Won/Lost/Break-Even	105 (70.95%) / 43 (29.05%) / 0 (0.00%)
Average Duration of Trade	13.75 hours
Maximal Drawdown (Duration)	-15.2 (91.5 hours)
Maximal Draw-up (Duration)	72.9 (1006.0 hours)
Maximum Consecutive Wins/Losses	19/3

Figure 4 below shows a plot of the walk-forward performance with time.

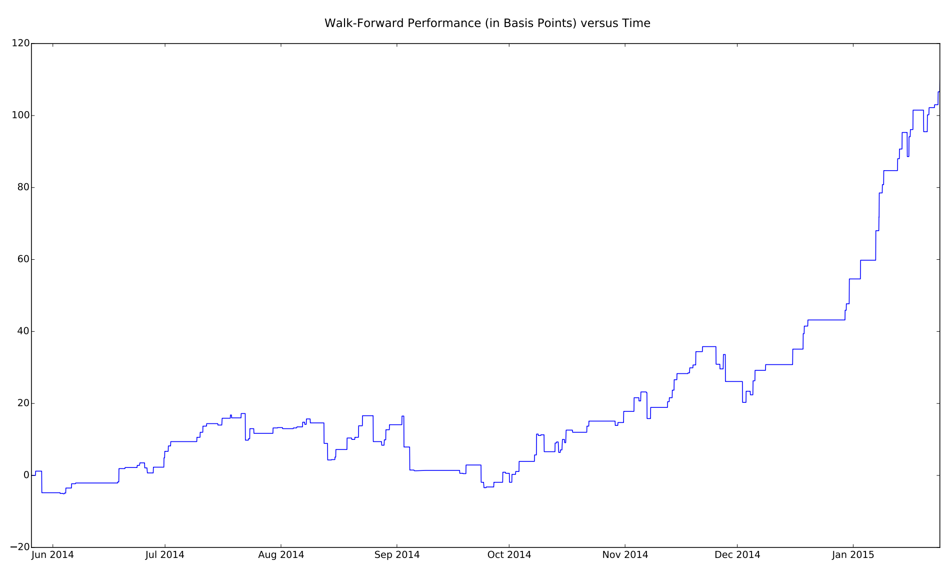

Figure 4. Walk Forward Performance with Basis Point Optimisation.

2.3.2. *Using Best Sortino Ratio.* The results of the walk forward optimisation with a focus on maximising the strategies Sortino Ratio are as follows.

The statistics are shown on Table 6 below.

TABLE 6. Statistics for Walk-Forward: Sortino Ratio Optimisation.

Total Realised BP	76.9
Win/Loss Mean	$2.19/-2.78$
Win/Loss Variance	2.71/6.81
Win/Loss Median	$1.95/-1.4$
Largest Win/Loss	$8.2/-7.5$
Trades Won/Lost/Break-Even	82 (68.91%) / 37 (31.09%) / 0 (0.00%)
Average Duration of Trade	12.91 hours
Maximal Drawdown (Duration)	-16.5 (325.83 hours)
Maximal Draw-up (Duration)	61.4 (1134.17 hours)
Maximum Consecutive Wins/Losses	16/5

Figure 5 below shows a plot of the walk-forward performance with time.

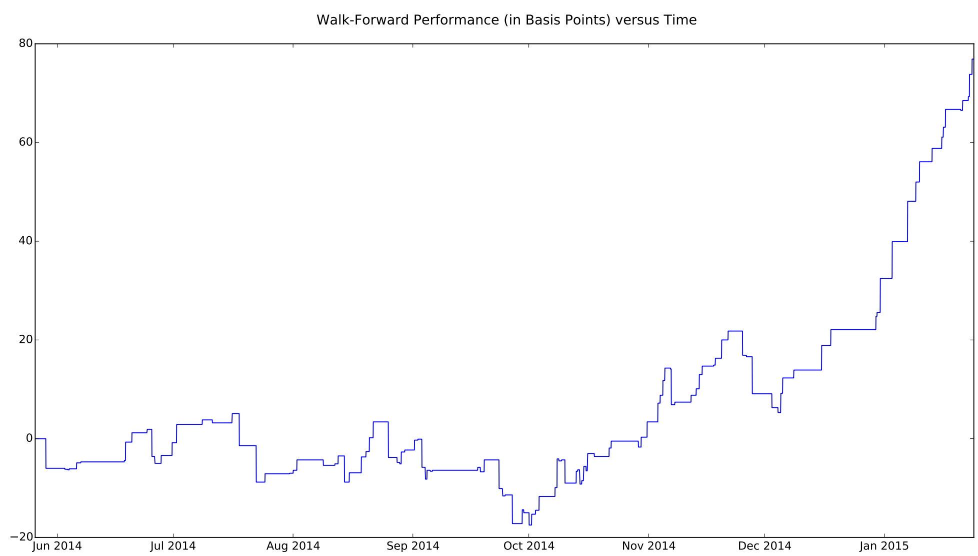

FIGURE 5. Walk Forward Performance with Sortino Ratio Optimisation.

2.3.3. *Using Least Maximal Drawdown.* Another effort taken to increase the stability of profit was to experiment with minimising the maximal drawdown in the optimisation process. The results for this case were interesting.

The statistics are shown on Table 7 below.

Table 7. Statistics for Walk-Forward: Maximal Drawdown Optimisation.

Total Realised BP	47.8
Win/Loss Mean	$2.02/-1.39$
Win/Loss Variance	1.58/3.42
Win/Loss Median	$2.0/-0.750$
Largest Win/Loss	$5.0/-5.8$
Trades Won/Lost/Break-Even	32 (72.73%) / 12 (27.27%) / 0 (0.00%)
Average Duration of Trade	8.71 hours
Maximal Drawdown (Duration)	-5.9 (469.33 hours)
Maximal Draw-up (Duration)	16.4 (1114.17 hours)
Maximum Consecutive Wins/Losses	7/3

Figure 6 below shows a plot of the walk-forward performance with time.

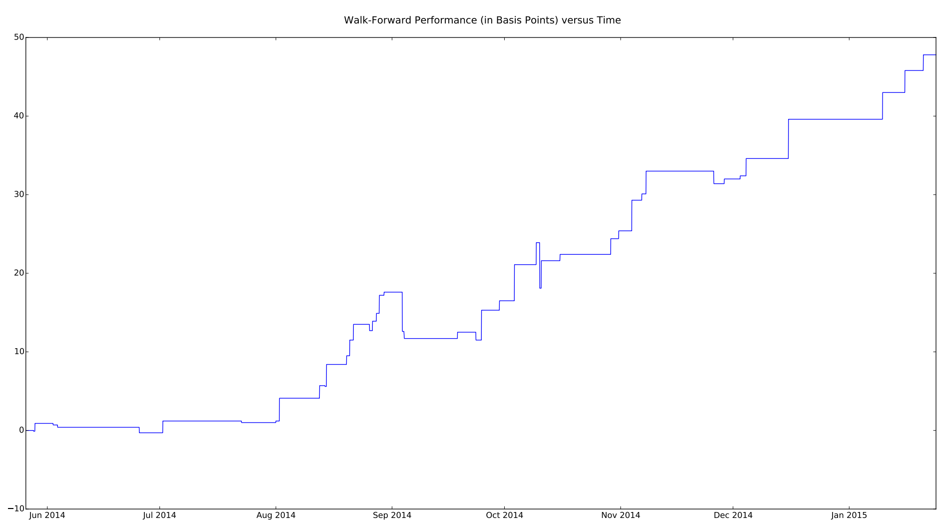

Figure 6. Walk Forward Performance with Maximal Drawdown Optimisation.

3. Analysis of Strategy

3.1. **Slippage Involved.** A study was made on the effects of slippage on the general performance of the strategy. Figure 7 below displays the effect of varying slippage on the general performance of the strategy[10]. For this case, we are able to break even when the slippage is (approximately) less than 0.9 basis points per side.

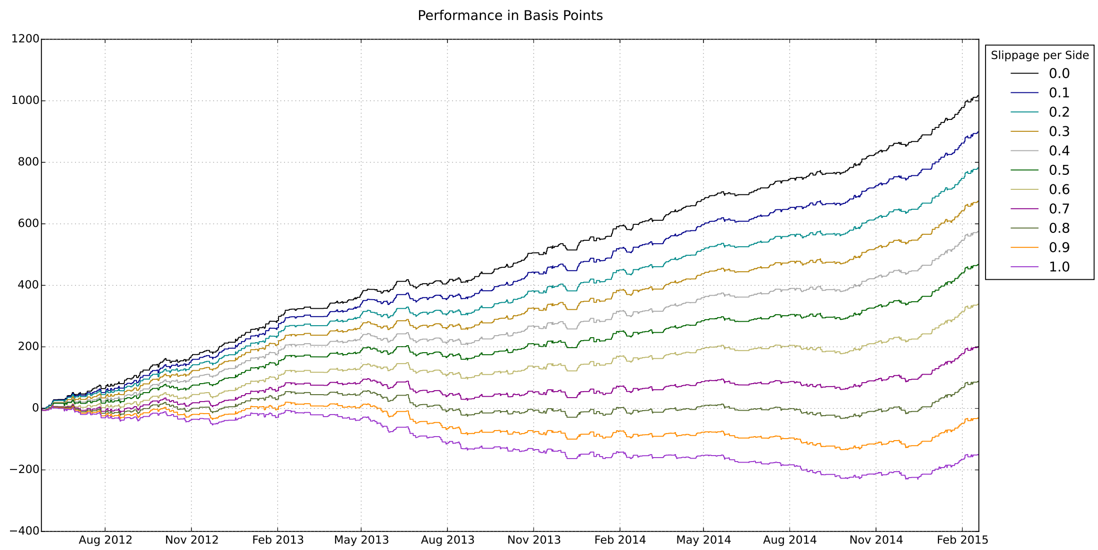

Figure 7. Study on Slippage.

The main reason for assuming a slippage of 0.5 basis points per side is due to the complex nature of execution (legging the outrights) in this strategy. Our point is that the trader's experience in execution has a significant impact on the outcome of this strategy.

3.2. **Other Drawbacks.** A list of drawbacks

(1) Data size is small. Our results would be much more conclusive if we were supplied with larger (and more reliable?) data sets. This is particularly true for the walk-forward optimisation test. An ideal size would be at least 5 years. Furthermore, due to the mean reverting nature of this strategy; a 'stress test' during a period such as the 2008 sub-prime mortage crisis would be favourable for us to study potential pitfalls.
(2) Another issue is the problem of liquidity - which we have assumed to be complete throughtout this study. In actual fact, this is far from the truth. During certain sessions, we would expect to have less liquidity. This would inherently effect potentially favourable executions of this strategy.

3.3. **Potential Ideas.** Further research should be done on this strategy. Potential untested ideas include

(1) Carry out conditional optimisation. In particular, maximise realised basis points while keeping maximal drawdown below 15 basis points and Sortino Ratio above 3.
(2) Consider using other metrics for analysing performance as well as optimising. For example, we could introduce a maximal draw-up : maximal drawdown ratio.
(3) Consider modifying the in-sample : out-sample ratio when implementing the walk forward optimisation.

[10]The signal parameters used in the slippage test, represented by Figure 7, were fixed at:

$$L_{entry} = 31,\ L_{exit} = 53,\ S_{entry} = 60,\ S_{exit} = 41,\ X_{stop} = 5.0$$

4. Further Needs

A discussion of final issues related to furthering the research as well as properly executing the strategy is provided.

4.1. What We Need.

The list below is a compilation of what is required to further the research as well as execution of the strategy.

(1) The nature of this strategy requires us to have a 24/7 team of execution traders, or an automated executing system. An ideal trader profile would have at least 1 year's worth of experience trading in the SFE and a good grasp of the market microstructure.

(2) Historical, hourly bar data for the Curve Tens Tens. In particular data from CQG would be ideal due to the rollover-continuation settings available. Data should be 5 years or more.

(3) Alternative software or better hardware could be considered for more efficient backtesting/optimisation, although this is not much of an issue.