Fisic Financial Research Report

Random Walk, Moving average cross over and PSAR study on forex price action

Abstract:

A Mathlab study which looks at the profitability of four different methods to mark a trend and identify turnaround points is outlined.

The four methods used are *Random Walk, Moving Averages Crossover, Parabolic Stop and Reverse, PSARAdd*, Data for six different forex pairs -EURUSD, GBPUSD, AUSUSD, EURJPY, GBPJPY, USDJPY-is examined and overall performance is reported for different period/ranges (5 min, 15 min, and 30 min over one week, 60 min and 240 min over two weeks, and 1 day over 1 and 10 years). The PSARAdd uses 4-hour periods over 1 year.Parametric studies for optimisation are also included.

The PSAR add method gives the most promising results.

Background

The success of any market forecasting algorithm (algo) depends on identifying trends (up, down, or sideways), and then **buying long in an up market**, **selling short in a down market**, and **holding pat during a sideways or random market**. The three market states can be seen below for the euro US dollar (EURUSD) high, shown at one-day periods over a range of one year (June 2012 – June 2013) (For source data, see Appendix C).

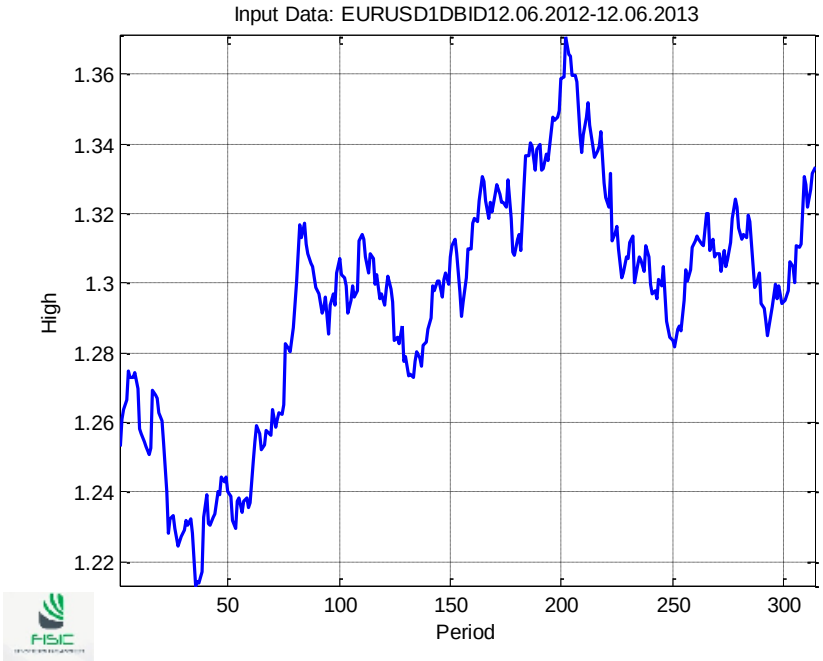

Figure 1 EURUSD High June 2012 – June 2013

Clearly, a long up trend existed from Day 40 to Day 200 (early July to mid November) followed by a 50-day down trend to Day 250, which if successfully identified (entrance and

exit) will make a profit for the algo. A couple of sideways periods can also be seen, between Days 80 and 150 and Days 240 and 300.

Note that not all trades will be profitably closed and a particular algo may lose more trades than it wins, but will be successful if it is profitable over the long run. It's not about always being right, but about being profitable, and such "trend-following systems" make money in an up (buy long) or down market (sell short) and lose money in a sideways market or when a trend reverses. As Faith (2007, pg 22) noted, some systems "have 65 or 70 percent losing trades," and thus one should be mindful of "outcome bias," that is, judging an algo based on a single trade rather than overall performance.

Note that algorithmic trading gives an edge to computer-aided systems, where trades can be made in microseconds, taking advantage of the smallest of market discrepancies. Almost three-quarters of all trading today is algorithmic, where "the average holding time period for stocks on Wall Street has shrunk to a mere 22 seconds" (Ohayon, 2011). Note, however, that a successful system must also include the operation costs for each trade or "spread."

A number of trend-following systems are available to identify profitable entry and exit points, correctly marking the beginning of a trend or "breakout" as well as any trend-ending turnaround points. All look to optimize the entry and exits points for maximum overall profit.

Perhaps the simplest trend-following system shows the high, low, open, and close of a trade (or period) as in a "candle chart," where green candles show an increasing price and red candles show a decreasing price over the period length, where the height of the candle is the close – open and the protruding wicks are the high and the low. As illustrated below in Figure 2, candle charts help visualize trends over time from the high, low, open, and close price, and their relationships to each other. Figure 3 shows an actual time series candle chart for EURUSD over a three-week period in June 2013.

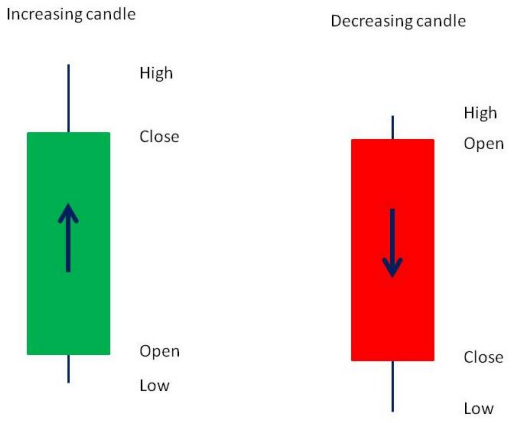

Figure 2 Price candles (green increasing period price, red decreasing period price)

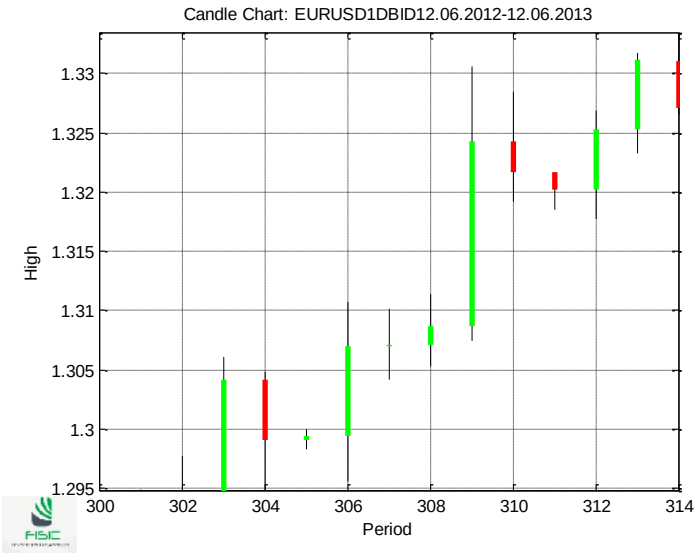

Figure 3 Candle chart time series EURUSD June 2013

Candle charts are not sufficiently sophisticated to pinpoint precise turnaround points in a successful trading strategy, however, and thus more mathematically rigorous models are required to quantify a changing time series (whether a high-frequency 5-minute period or a longer daily period). Here, we look at four systems to mark a trend more precisely and identify turnaround points (**Random Walk, Moving Averages Crossover, Parabolic Stop and Reverse, PSARAdd**), using data for six different forex pairs (EURUSD, GBPUSD, AUSUSD, EURJPY, GBPJPY, USDJPY). Overall performance is reported for different period/ranges (5 min, 15 min, and 30 min over one week, 60 min and 240 min over two weeks, and 1 day over 1 and 10 years). The PSARAdd uses 4-hour periods over 1 year. The systems can also be used in tandem and positions can be added to as in a basket system.

1. Random Walk or Reversion to Mean

The Random Walk has an interesting place in market lore. It is the basis of the "efficient market hypothesis," an idea posited by University of Chicago economist Eugene Fama to describe the workings of a perfect working market, where prices accurately and instantaneously measure the underlying value of all stocks. Traders compete and buy and sell according to their self interest and thus the market reflects the true price of all stocks at any given time. In this fairy-tale world, prices fluctuate up and down and no one can determine the direction, as in a random walk.

Such a market is a fairy tale for a number of reasons. Firstly, and perhaps most importantly, macroeconomic decisions will affect the supposed free and natural interplay of the market, such as the Federal Reserve announcing new interest rates, the European Central Bank announcing a change in monetary strategy, even a tsunami or election result that frightens or excites the market. Furthermore, no information is instantaneous, and lots of temporary arbitrage opportunities exist for those in the know or more technologically able. Such a market also suggests that there is a constant zero position about which stocks fluctuate, impossible with a changing volume. Of course, each trade can be thought of as a zero-sum, but the overall system is ever growing or shrinking.

But the random walk is an interesting and simple method to analyze a series of either-or events, whether flipping a coin, landing red or black in roulette, or increasing or decreasing prices of a share, and is worth a look (White, 2012, 2013). If I flip a coin and it comes up

heads, is it more or less likely to come up heads the next time? If I flip a coin and it comes up heads twice, is it more or less likely to come up heads the next time? For a series of fair coin tosses, the odds are even and one would expect a 50-50 split over the long run. Such a system is mean regressed, that is, it tends towards an even split, and shouldn't stray too far from its midpoint, *i.e.*, the middle of a normal or Gaussian distribution.

This is opposite to using the opening price as a trend indicator as suggested by Lukeman (2000, pg. 57), where one "trade[s] only on the side of the opening price signal," noting that "the opening price signal is a simple and effective gauge for determining the daily trend of a stock. … If you adhere to this principle and respect what it is telling you, it will prevent you from fighting a trend and bottom or top fishing." With readily available data at hand (see Appendix C), we can quantify this simple algo.

The results of the simple Random Walk Mean Reversion algo, which marks a trend based on the direction of the previous close, is shown below. Here, the algo is not very profitable (about 50% right and 50% wrong), and especially so when the spread is included.

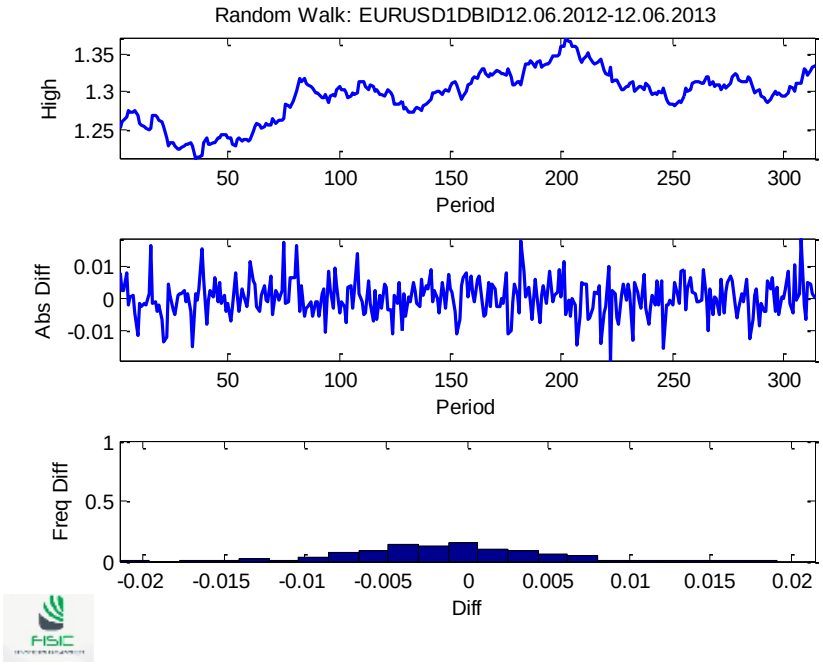

Figure 4 Random Walk Mean Reversion EURUSD June 2012 – June 2013

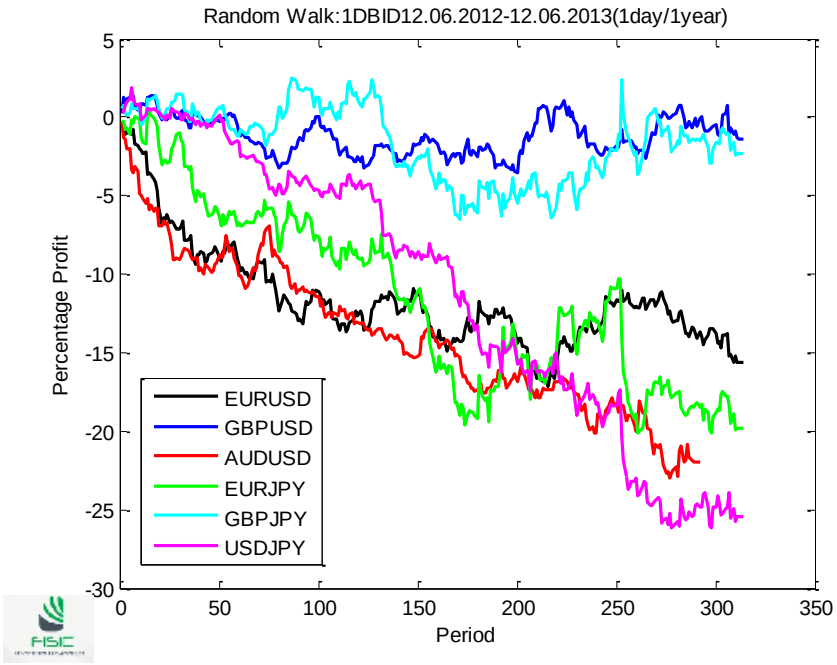

Figure 5 Cumulative Random Walk Mean Reversion EURUSD June 2012 – June 2013

2. The Moving Averages Crossover (MASC) Algo

A Moving Average (MA) is a data smoothing technique, where the price is averaged over a number of periods, as can be seen below in Figure 6 for the daily EURUSD pair over one year (June 2012 – June 2013), which shows a 20-day (fast) and an 80-day (slow) moving average superimposed over the daily high.

When two moving averages cross, a trend is predicted and a trade is made, indicated by the direction of the slower moving average. As shown below for the EURUSD data, at Day 71 the faster, shorter-period, 20-day MA crosses the slower, longer-period 80-day MA moving up, indicating a buy long trade. At Day 120, the next crossover, the trade is closed (at a profit) and another trade is initiated (another buy long trade since the slower 80-day MA is again moving up) and is closed at the next crossover, Day 154 (at a profit). Four more trades are initiated and closed at the next four crossovers as show in Table 1.

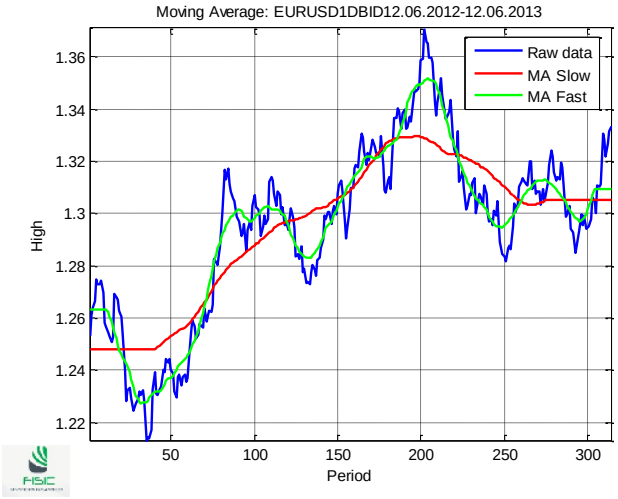

Figure 6: 80-day, 20-day MA simple crossover: 1 year daily close, EURUSD (June 2012 – June 2013)

Trade #	Crossover	Trend	Buy/Sell	Profit
1	71	up	buy	Y
2	120	up	buy	Y
3	154	up	buy	Y
4	172	up	buy	Y
5	186	up	buy	N
6	222	down	sell	N
--	260	down	--	--

Table 1: 80-day, 20-day MA simple crossover: 1 year daily close, EURUSD (June 2012 – June 2013)

Cumulative results for the Moving Averages Simple Crossover algo are shown below for 6 currency pairs (Table 2 and Figure 7). Each figure shows the raw data (with the two moving averages), the buy/sell indicators, and the overall profit (with (red) and without (blue) the spread). A comparative percentage profit for all currency pairs (1 year daily close) is shown in Figure 8. Complete results for all periods are shown in Appendix A. From the results, one can see that the MASC algo is profitable, although very few trades are made.

Currency	Spread	No of trades	Win %	Profit	Profit %
EURUSD	0.0002	6	67	+ 0.053	+ 4.00
GBPUSD	0.0003	4	75	+ 0.974	+ 6.21
AUDUSD	0.0002	7	43	+ 0.002	+ 0.16
EURJPY	0.0003	6	100	+31.8	+26.9
GBPJPY	0.0004	6	83	+27.4	+19.3
USDJPY	0.0002	6	50	+ 3.06	+ 2.04

Table 2: 80-day, 20-day MA simple crossover: 1 year daily close, EURUSD, GBPUSD, AUDUSD, EURJPY, GBPJPY, USDJPY (June 2012 – June 2013)

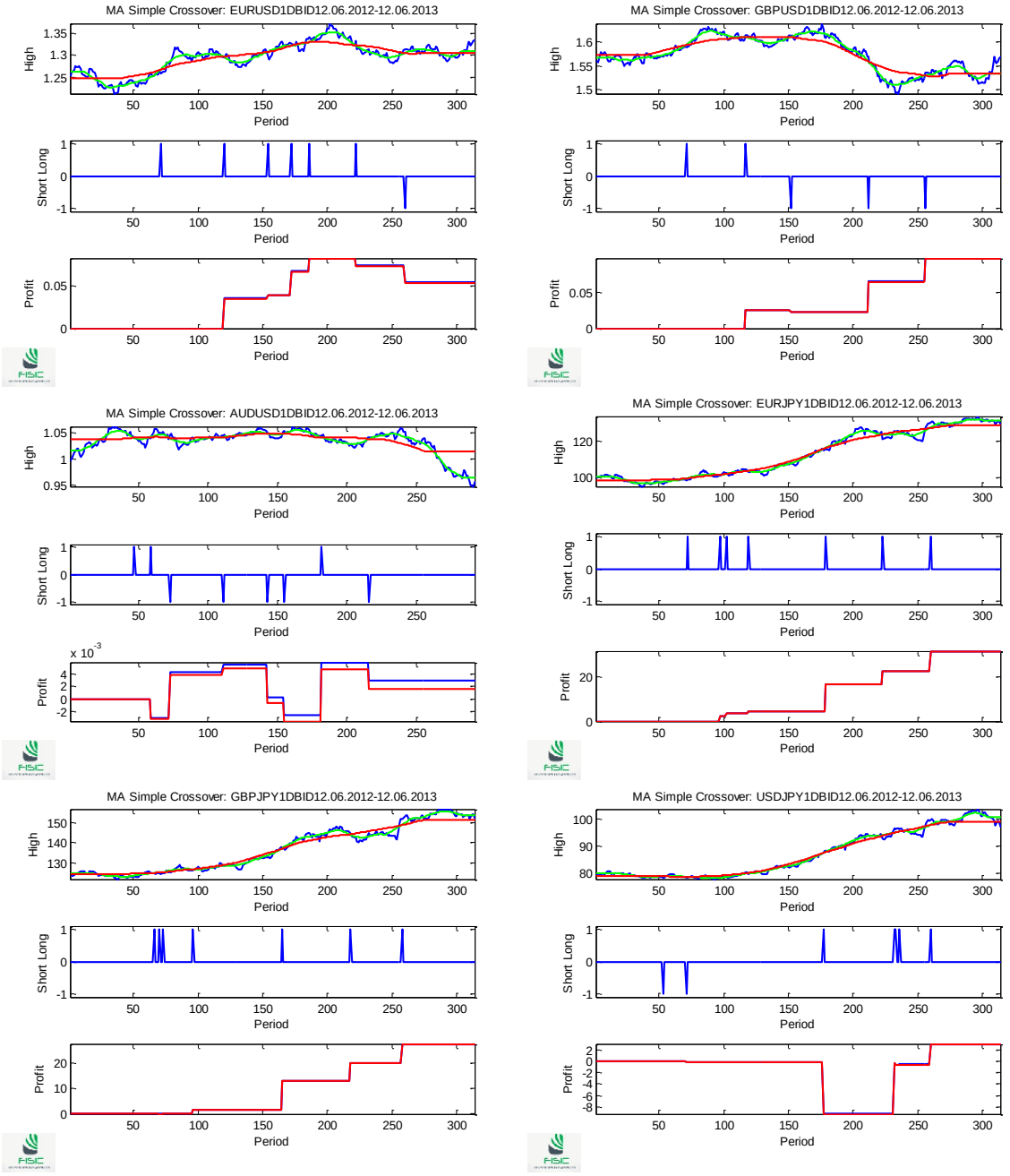

Figure 7: 80-day, 20-day MA simple crossover: 1 year daily close, EURUSD, GBPUSD, AUDUSD, EURJPY,GBPJPY, USDJPY (June 2012 – June 2013)

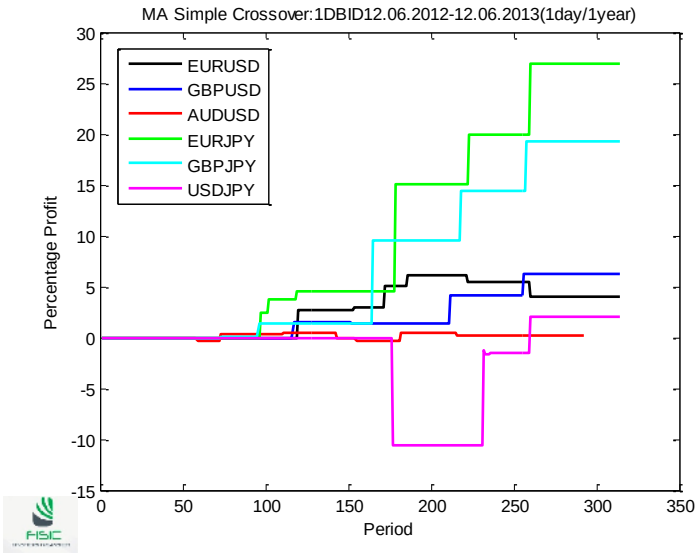

Figure 8 MA Simple Crossover Percentage Profit 1 year daily close, EURUSD, GBPUSD, AUDUSD, EURJPY, GBPJPY, USDJPY (June 2012 – June 2013)

A parametric study of different moving averages was conducted to optimize the best ratio for a given period, for example, the fast moving average (MA Fast) varied from 15 to 24 days and the slow moving average (MA Slow) from 26 to 157 days (1-day/1-year) as shown below for the EURUSD pair.

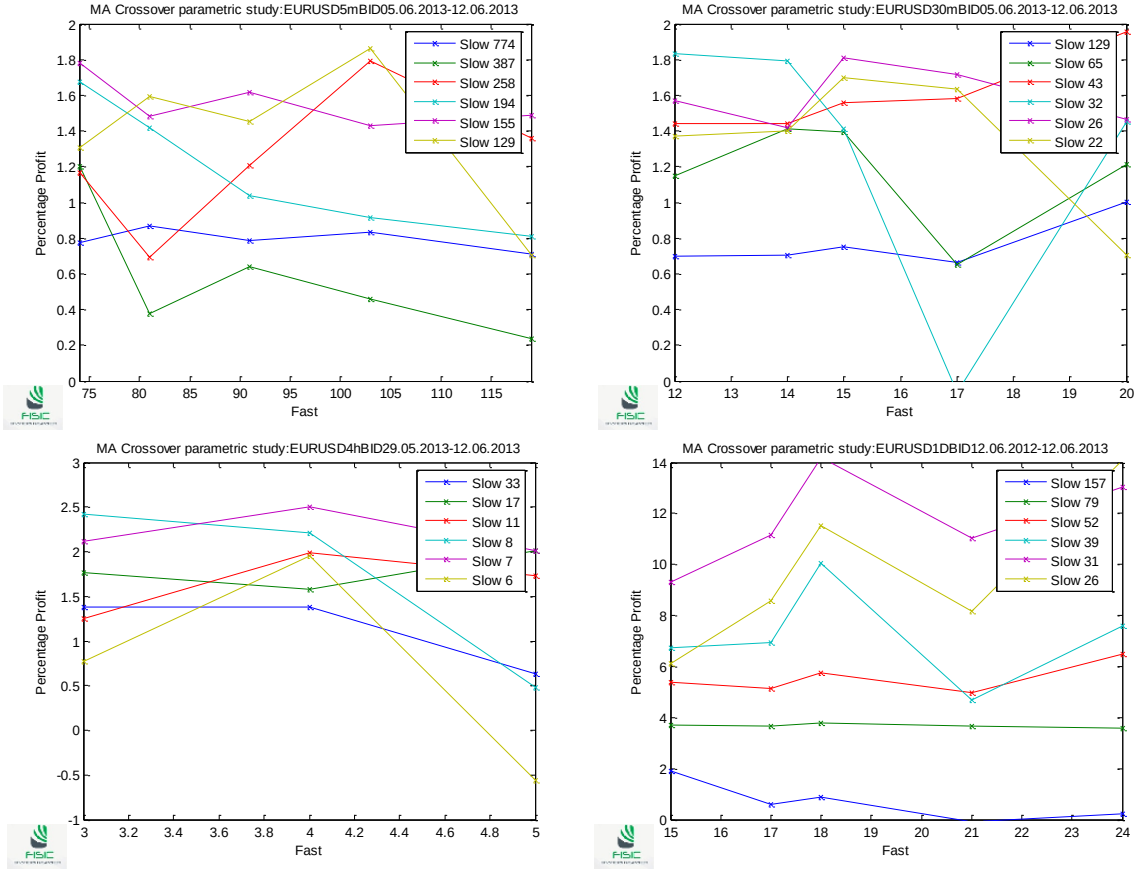

Figure 9 MA Crossover optimization EURUSD: 5- and 30-minute period over 1 week (top), 4 hours over two weeks (bottom left), and 1 day over 1 year (bottom right)

Note that comparing moving averages for different periods must be period-independent and thus a constant number of smoothing points is used, for example, for the 1-day yearly data, the 80-day MA corresponds to a smoothing factor of 4 (314 days/4 = 78.5) and the 20-day MA corresponds to a smoothing factor of 16 (314/16 = 19.6) for a data set of 314 days. The smoothing factors are then varied from 2 to 12 (MA Slow) and from 13 to 21 (MA Fast), giving corresponding period-independent averages.

The results are presented for a series of MA Slows as seen above in Figure 9 for a comparison of four periods: 5 minutes (top left), 30 minutes (top right), 4 hours (bottom left), and 1 day (bottom right) for EURUSD. Some interesting observations can be made. Firstly, a faster MA Slow produces a higher profit percentage for each period (except 4 hr). Generally, there is a peak in the MA Fast, which suggests that the MA Slow / MA Fast pair can be optimized for a given period, as is seen especially in the 4-hour period graph (bottom left), where an MA Slow of 7 and an MA Fast of 4 is optimum, and the 1-day period graph (bottom right), where an MA Slow of 31 and an MA Fast of 18 is optimum (in this case, corresponding to a 31-day and an 18-day moving average). Note that both ratios here (MA Slow / MA Fast) are about 2/1. Generally, the same applies to all currencies pairs (see Appendix B), although more analysis is required to quantify the effect of a trending currency on optimum MAs.

Exponential moving averages can also be used to give greater weight to more recent data. As Lukeman (2000, pg 52) noted "Exponential [moving average] is the most widely used today, because it allocates greater weight to the last trading day, responds to changes faster, and factors in older data rather than dropping it."

3. The Parabolic Stop And Reverse (PSAR) Algo

The Parabolic Stop And Reverse (PSAR) algo moves with higher acceleration than the Moving Averages Crossover algo to identify trending markets and is calculated as in Eq. 1.

$$SAR(n) = SAR(n\text{-}1) + ACCFAC\ (\ EP(n\text{-}1) - SAR(n\text{-}1)\ ) \qquad \text{[Eq. 1]}$$

where,

SAR(n) is the value of the indicator,
ACCFAC is the acceleration factor (0.2),
EP(n-1) is the highest (or lowest) price for the previous period (EP=HIGH for long positions and EP=LOW for short positions).

The height of the PSAR movement depends on the scale of the price movement. The faster the price change, the faster the indicator approaches the price. The indicator is below price in a bull market (green Up Trend) and above price in a bear market (red Down Trend). If the price crosses the PSAR line, the indicator flips (up → down or down → up), signalling the end of a trend and positions are closed. The maximum or minimum price for the previous period serves as the starting point for the next as can be seen below in Figure 10.

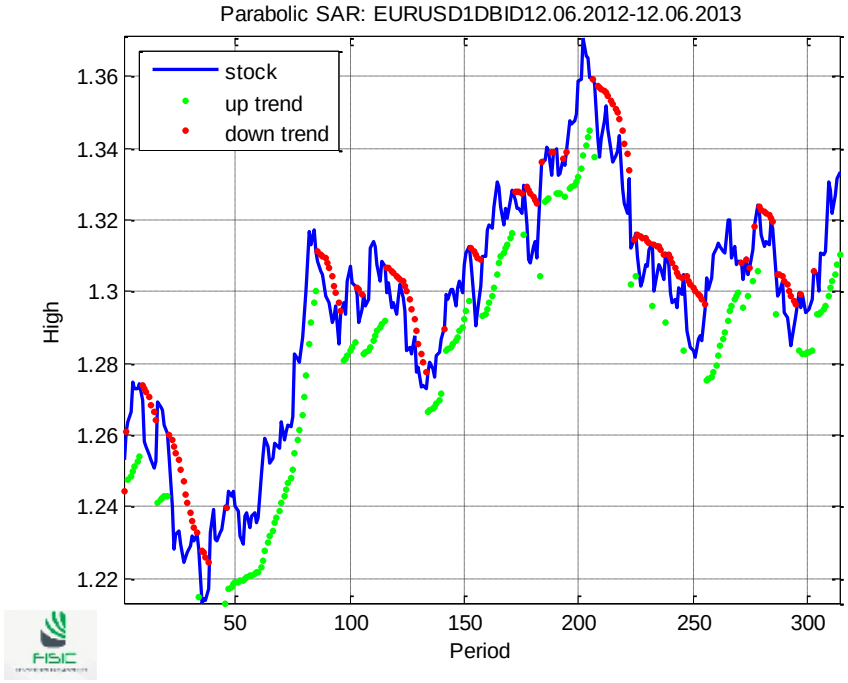

Figure 10 PSAR Indicator for EURUSD (1 year 1 day data June 6, 2012-2013)

The PSAR algo is analyzed for each currency pair below. Table 3 gives the period, range, no of periods, no of trades in each period, winning percentage of trades and profit (absolute and percentage) with spreads for each trade for six periods. Figure 11 shows the period price, period differences, and cumulative equity performance (with and without spread). The comparative percentage profit is shown in Figure 12. Complete results for all periods are shown in Appendix A.

EURUSD (.0002 spread)

Period	Range	No periods	No of trades	Win %	Profit	Profit %
5 min	1 week	1548	324	39	-0.059	-4.50
15 min	1 week	516	100	37	-0.001	-0.75
30 min	1 week	258	65	37	-0.016	-1.18
60 min	2 weeks	250	41	37	-0.001	-0.09
4 hr	2 weeks	66	13	69	+0.035	+2.69
1 day	1 year	314	61	48	+0.046	+3.47
1 day	10 years	3126	748	47	+1.67	+121.5

GBPUSD (.0003 spread)

Period	Range	No periods	No of trades	Win %	Profit	Profit %
5 min	1 week	1549	331	48	-0.061	-3.94
15 min	1 week	517	121	39	-0.031	-1.95
30 min	1 week	259	53	34	-0.016	-1.00
60 min	2 weeks	252	33	55	+0.026	+1.67
4 hr	2 weeks	66	12	75	+0.068	+4.35
1 day	1 year	314	77	47	+0.059	+3.92
1 day	10 years	3135	682	49	+2.30	+135.8

GBPJPY (.0004 spread)

Period	Range	No periods	No of trades	Win %	Profit	Profit %
5 min	1 week	1549	317	44	+13.4	+8.87
15 min	1 week	517	107	45	+8.90	+5.92
30 min	1 week	259	50	38	+5.01	+3.31
60 min	2 weeks	252	57	46	+7.06	+4.64
4 hr	2 weeks	66	14	50	-0.50	-0.33
1 day	1 year	314	79	52	+21.0	+14.9
1 day	10 years	3115	605	47	+335.3	+197.6

EURJPY (.0003 spread)

Period	Range	No periods	No of trades	Win %	Profit	Profit %
5 min	1 week	1548	312	44	+9.28	+7.17
15 min	1 week	516	111	53	+10.9	+8.49
30 min	1 week	258	38	47	+6.80	+5.26
60 min	2 weeks	250	52	62	+7.01	+5.37
4 hr	2 weeks	66	12	17	-4.34	-3.32
1 day	1 year	314	60	53	+26.6	+22.7
1 day	10 years	3112	663	50	+228.3	+177.7

AUDUSD (.0002 spread)

Period	Range	No periods	No of trades	Win %	Profit	Profit %
5 min	1 week	1548	288	46	+0.03	+3.22
15 min	1 week	516	89	46	+0.02	+2.44
30 min	1 week	258	40	53	+0.03	+3.29
60 min	2 weeks	250	44	41	-0.01	-1.49
4 hr	2 weeks	66	10	50	-0.003	-0.31
1 day	1 year	292	80	55	+0.04	+3.74
1 day	10 years	2945	626	45	+1.40	+161.9

USDJPY (.0002 spread)

Period	Range	No periods	No of trades	Win %	Profit	Profit %
5 min	1 week	1717	332	45	+10.3	+10.6
15 min	1 week	573	102	43	+8.02	+8.29
30 min	1 week	287	40	35	+2.51	+2.61
60 min	2 weeks	265	47	38	+2.91	+3.03
4 hr	2 weeks	69	16	38	+1.26	+1.29
1 day	1 year	314	80	49	+6.09	+6.98
1 day	10 years	3130	645	49	+123.3	+120.0

Table 3 PSAR for 5 currency pairs over 6 periods: EURUSD, GBPUSD, GBPJPY, EURJPY, AUDUSD, USDJPY over 5, 15, 30, 60, and 240 minutes and 1 day periods

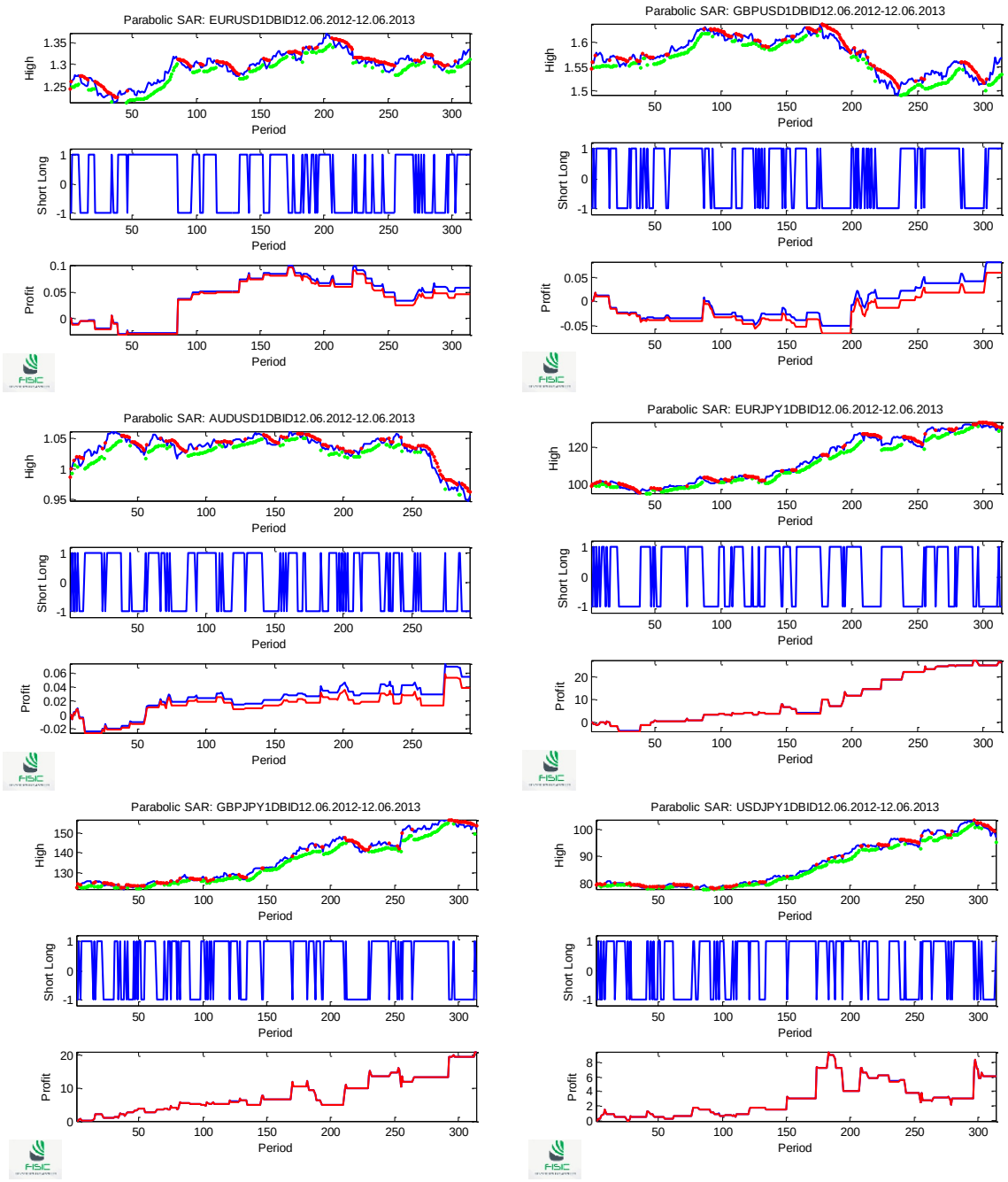

Figure 11: PSAR 1 year daily close: EURUSD, GBPUSD, AUDUSD, EURJPY, GBPJPY, USDJPY (June 2012 – June 2013)

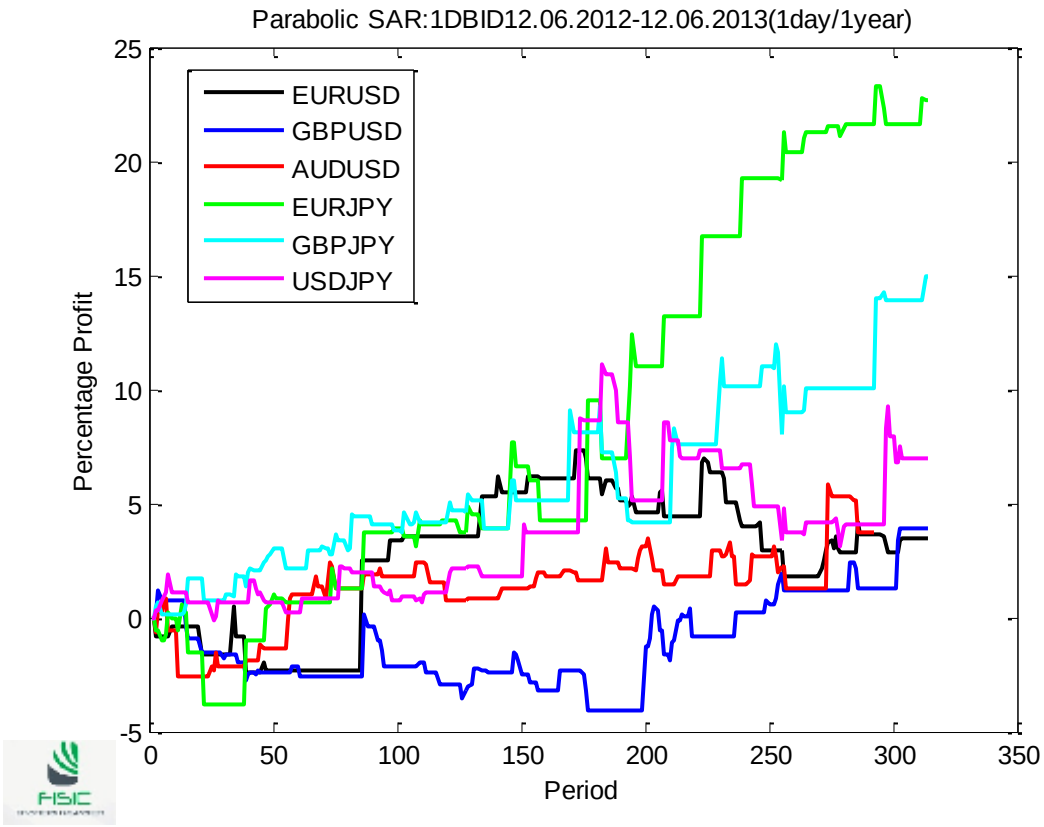

Figure 12 PSAR Percentage Profit 1 year daily close, EURUSD, GBPUSD, AUDUSD, EURJPY, GBPJPY, USDJPY (June 2012 – June 2013)

Generally, the PSAR algo outperforms the MASC algo for the periods surveyed, except for the EURUSD and GBPUSD for the shorter periods in the week of June 5-June 12, 2013(See Appendix A). It should be noted that the MASC algo depends on the number of crossovers to open and close positions and thus is executed very much less as can be seen in a parametric study to optimize the two moving averages (See Appendix B). Note also that the PSAR algo is often wrong more than right (Win % < 50%) but is nonetheless profitable (See Table 3), whereas the MASC algo generally has a much greater Win % over a significantly less number of trades (See Table 2).

Of course, it is easy to curve-fit the left side of a time series using historical data. It is another to predict the right side in real time. The emphasis here is on optimization and not curve fitting. Care must also be taken by employing stops to avoid excessive losses.

Williams (2010) noted that "trend trading can be difficult to exploit for profit with some trading approaches. Breakout methods, for example, can lead to explosive gains but also suffer a series of false starts where an entry is signaled but then rejected by the market. This causes a series of stop losses to be hit that can be a demoralizing experience, not only because the trader loses money but because it drains self-confidence."

When asked to name the simple truths Bill Eckhardt had found in a 35-year trading career, he advised, "Use only robust estimators and very large samples, not dozens, but thousands" (Collins, 2011).

4. The Parabolic Stop And Reverse with Moving Average Add (PSARAdd) Algo

The Parabolic Stop And Reverse with moving average add (PSARAdd) uses the PSAR to identify entrance and exit points but makes a further trade depending on whether the moving average is above or below the entrance point (adding to the position). The trade is then closed at the next PSAR exit point (*i.e.*, at the next stop and reverse point when the trend indicator flips, either up→ down or down → up). A 20-period moving average is used but can be parametrized to optimize.

Figure 13 below (left) shows the PSARAdd over 1 year at 4-hour periods for the EURUSD currency pair and in close up (right). There are four conditions, two of which result in a winning trade (LTMA+ and STMA-).

- long trend (red → green) with moving average above the turning point (LTMA+)
- long trend (red → green) with moving average below the turning point (LTMA-)
- short trend (green → red) with moving average above the turning point (STMA+)
- short trend (green → red) with moving average below the turning point (STMA-)

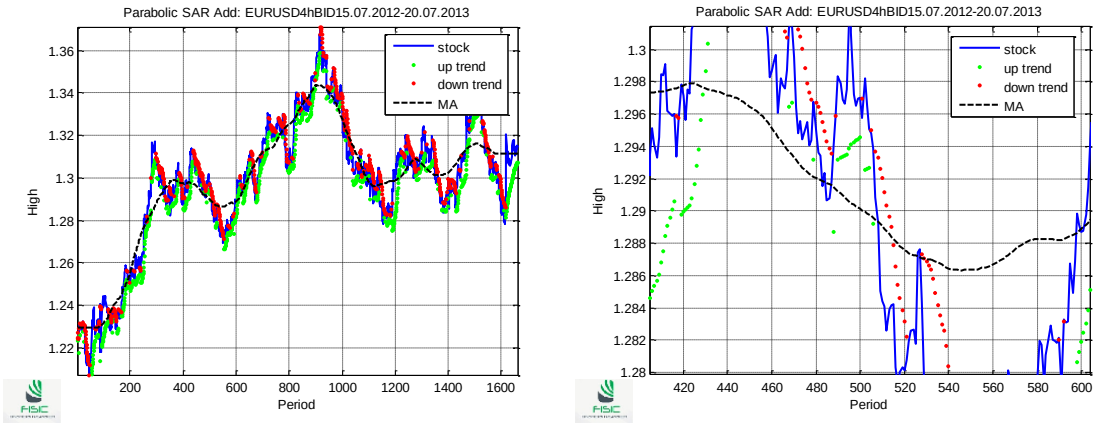

Figure 13 PSAR ADD, EURUSD 1 year 4-hr (June 2012 – June 2013)

Figure 14 shows the period price (with SAR indicators and MA), trade indicators, and cumulative equity performance (with and without spread) for the six currency pairs reported above over 1 year at 4-hour periods. The 20-period moving average is used, *i.e.*, a 5-day moving average in this case. The comparative percentage profit is shown in Table 4 and Figure 15.

Currency	No of PSAR trades	No of PSARAdd trades	Win %	Profit	Profit %
EURUSD	289	152	53	0.27	20.1
GBPUSD	319	165	58	0.31	19.9
AUDUSD	386	194	48	0.20	19.6
EURJPY	324	163	54	52.1	44.8
GBPJPY	321	163	56	50.3	34.9
USDJPY	313	165	56	30.6	34.1

Table 4 PSARAdd for 6 currency pairs over one year at 4-hr periods: EURUSD, GBPUSD, GBPJPY, EURJPY, AUDUSD, USDJPY

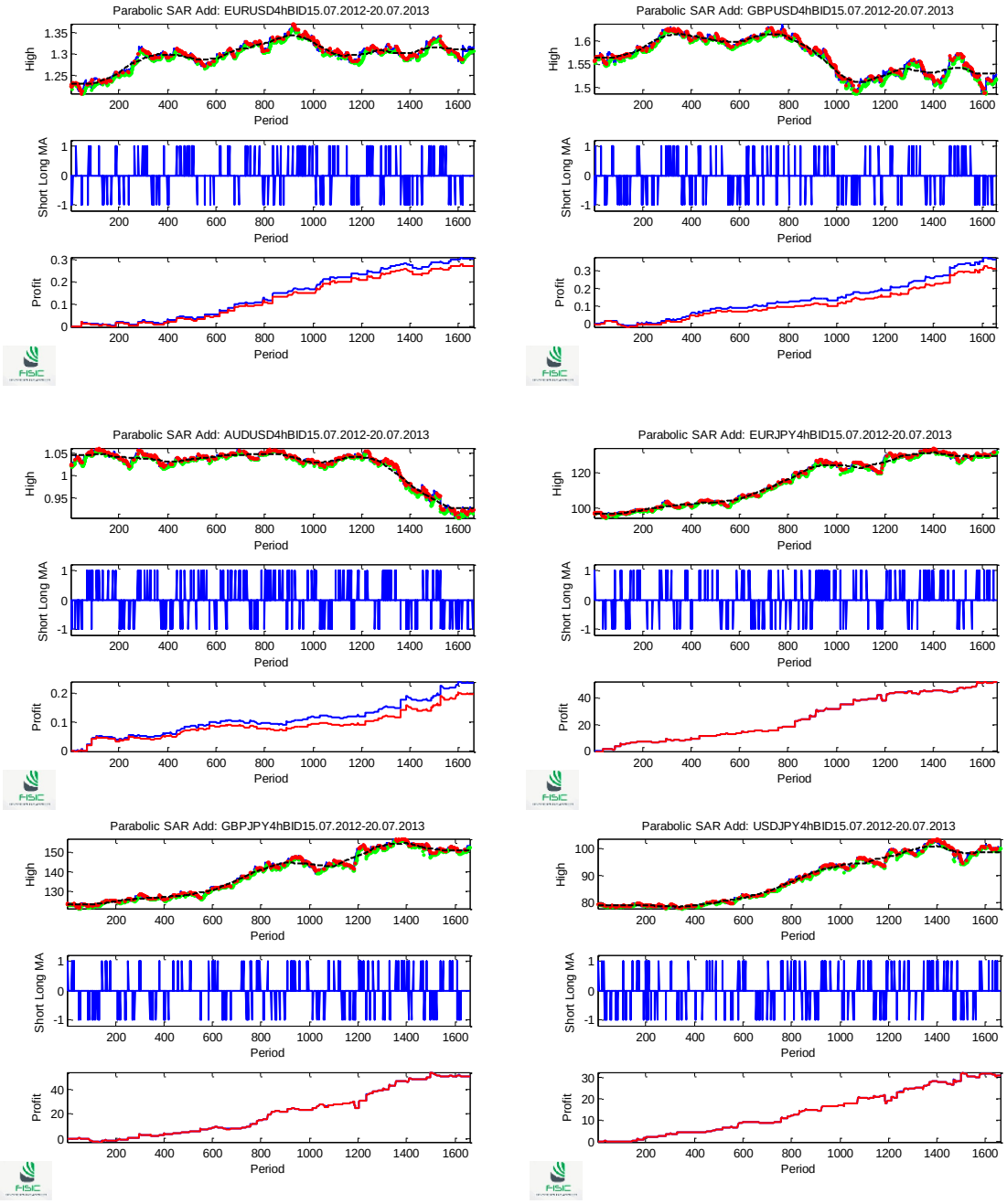

Figure 13: PSARADD 1 year 4-hr: EURUSD, GBPUSD, AUDUSD, EURJPY, GBPJPY, USDJPY (June 2012 – June 2013)

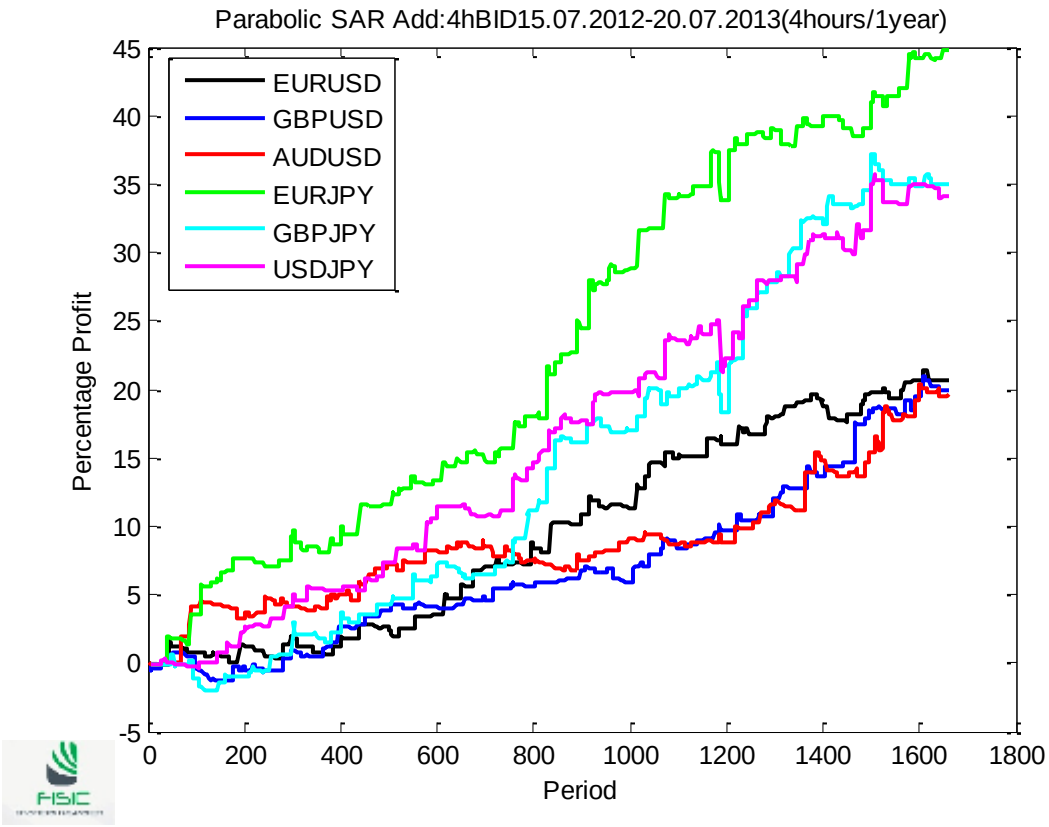

Figure 14 PSARAdd Percentage Profit 1 year 4-hr, EURUSD, GBPUSD, AUDUSD, EURJPY. GBPJPY, USDJPY (June 2012 – June 2013)

Note that the performance is additional to that reported for the PSAR alone and shows a profitable strategy for all currency pairs over the range and period reported. Current currency trends should be considered and multiple add-ins are possible but would require more sophisticated iterative accounting. One could also vary the amount of the add based on the difference between the entrance point and the moving average at the entrance point.

Appendix A: MA Crossover and PSAR Cumulative Algo Percentage Profits for seven time periods and six currency pairs

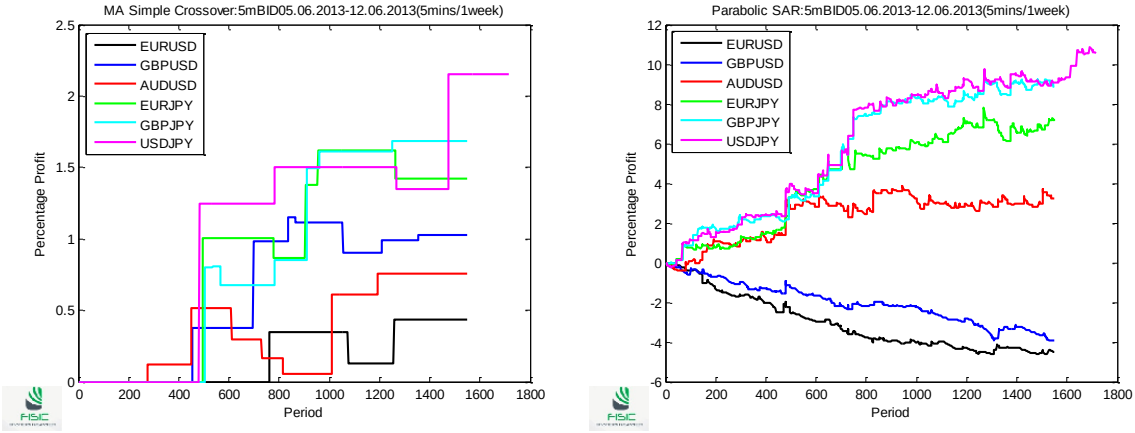

Figure A.1 MA Crossover and PSAR Algo 5 minute period over 1 week (June 6-12, 2013): EURUSD, GBPUSD, AUDUSD, EURJPY, GBPJPY, USDJPY

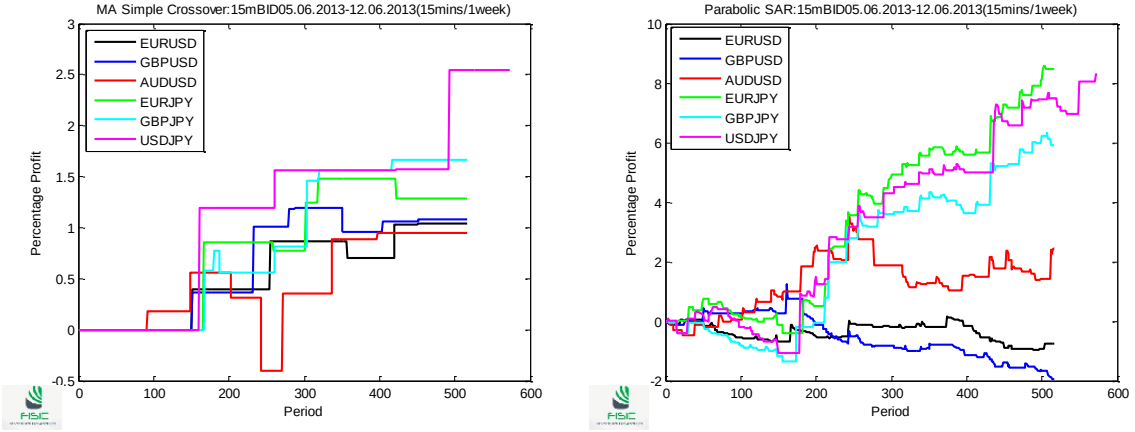

Figure A.2 MA Crossover and PSAR Algo 15 minute period over 1 week (June 6-12, 2013): EURUSD, GBPUSD, AUDUSD, EURJPY, GBPJPY, USDJPY

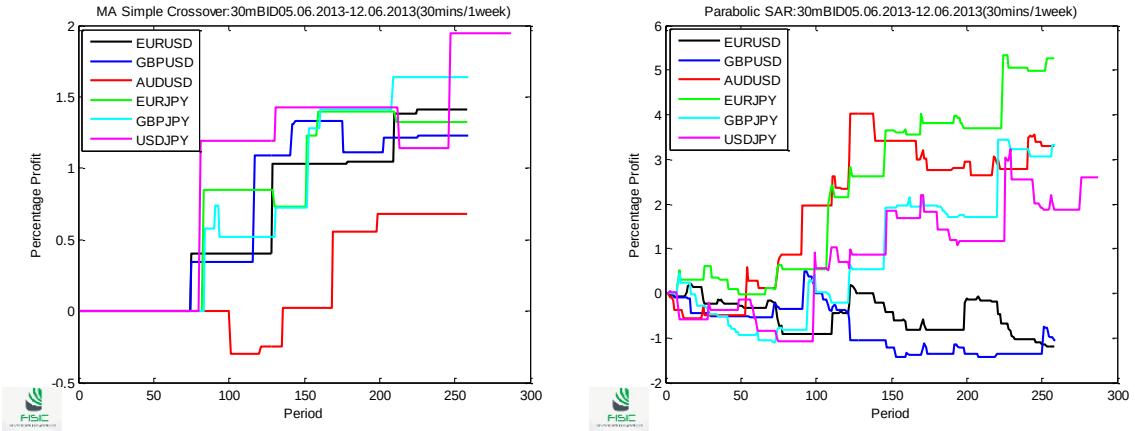

Figure A.3 MA Crossover and PSAR Algo 30 minute period over 1 week (June 6-12, 2013): EURUSD, GBPUSD, AUDUSD, EURJPY, GBPJPY, USDJPY

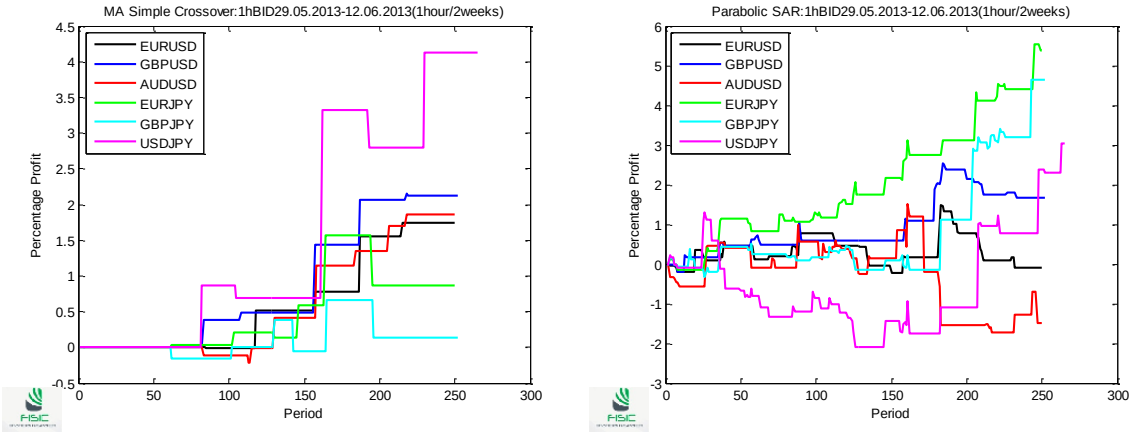

Figure A.4 MA Crossover and PSAR Algo 120 minute period over 2 weeks (May 29 - June 12, 2013): EURUSD, GBPUSD, AUDUSD, EURJPY, GBPJPY, USDJPY

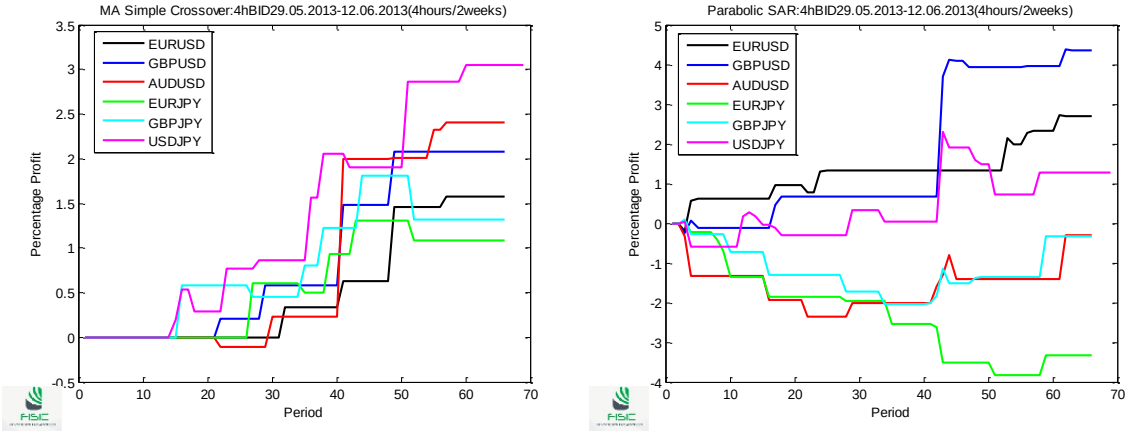

Figure A.5 MA Crossover and PSAR Algo 240 minute period over 2 weeks (May 29 - June 12, 2013): EURUSD, GBPUSD, AUDUSD, EURJPY, GBPJPY, USDJPY

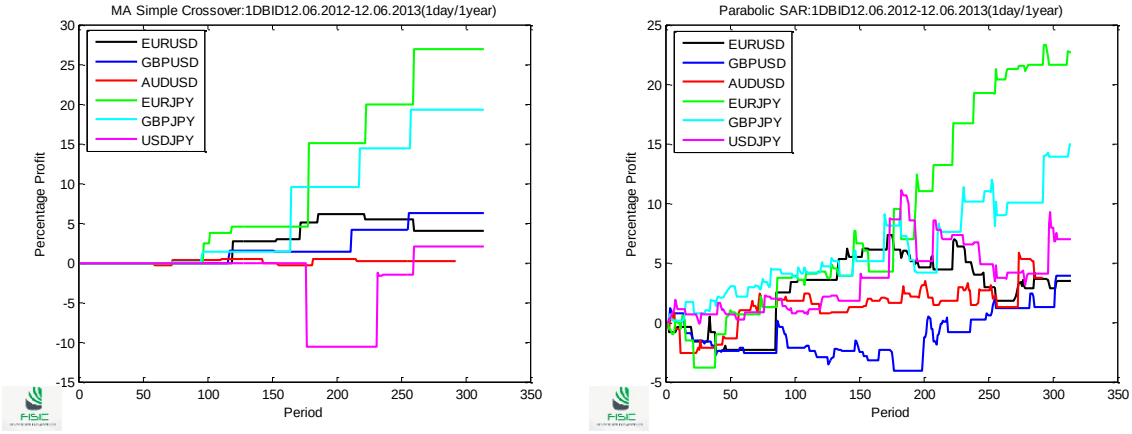

Figure A.6 MA Crossover and PSAR Algo 1 day period over 1 year (June 2012 - June 2013): EURUSD, GBPUSD, AUDUSD, EURJPY, GBPJPY, USDJPY

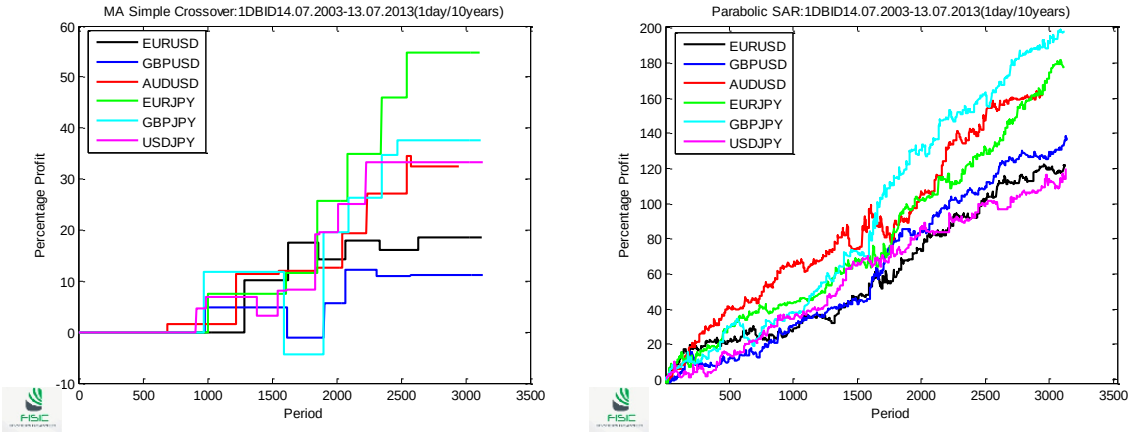

Figure A.7 MA Crossover and PSAR Algo 1 day period over 10 years (July 2003 - July 2013): EURUSD, GBPUSD, AUDUSD, EURJPY, GBPJPY, USDJPY

Appendix B MA Crossover parametric study of MA Slow and MA Fast for four time periods and six currency pairs (Number of smoothing points: MA Slow 2-12, MA Fast 13-21)

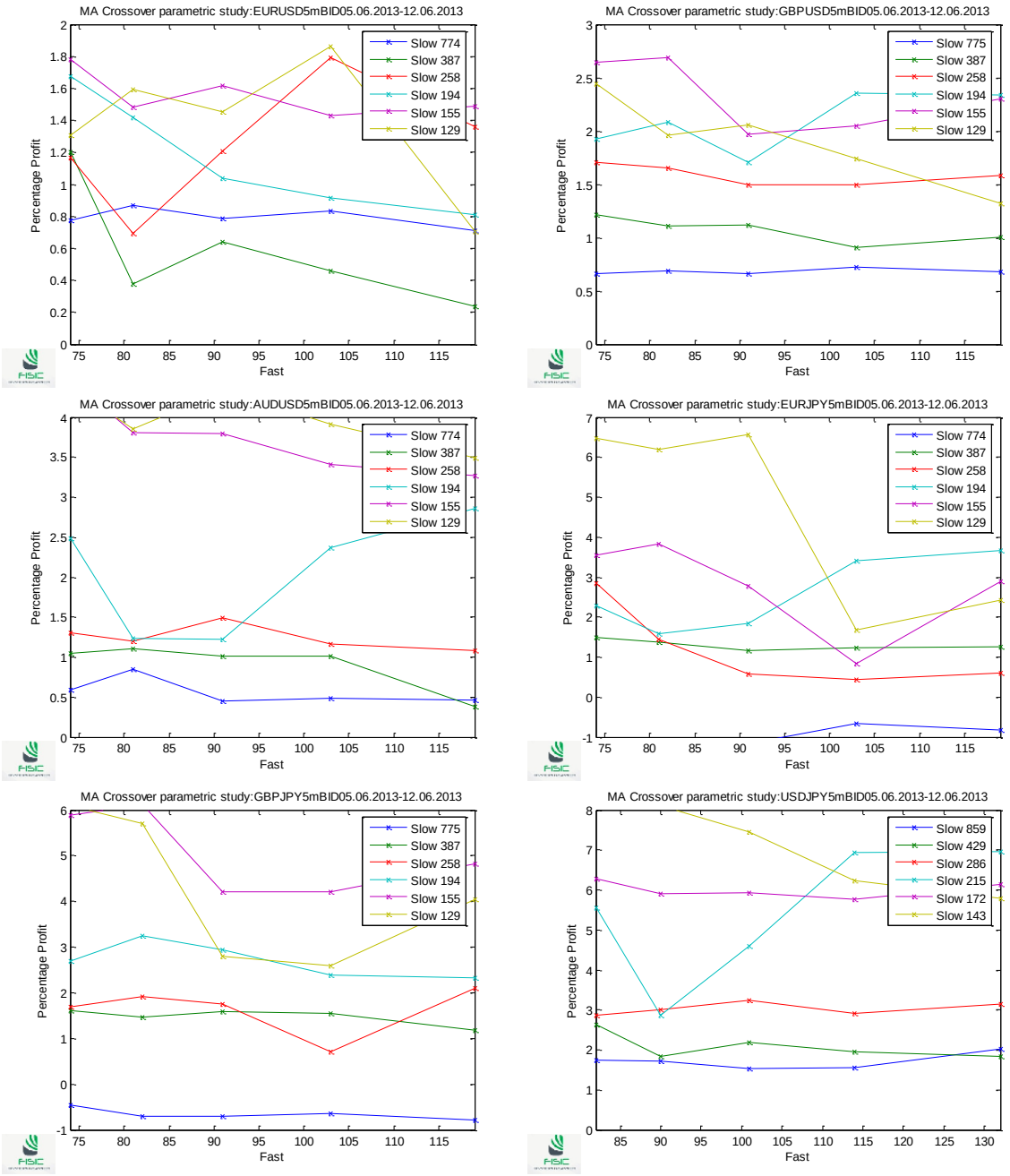

Figure B.1 MA Crossover optimization 5 minute period over 1 week (June 6-12, 2013): EURUSD, GBPUSD, AUDUSD, EURJPY, GBPJPY, USDJPY

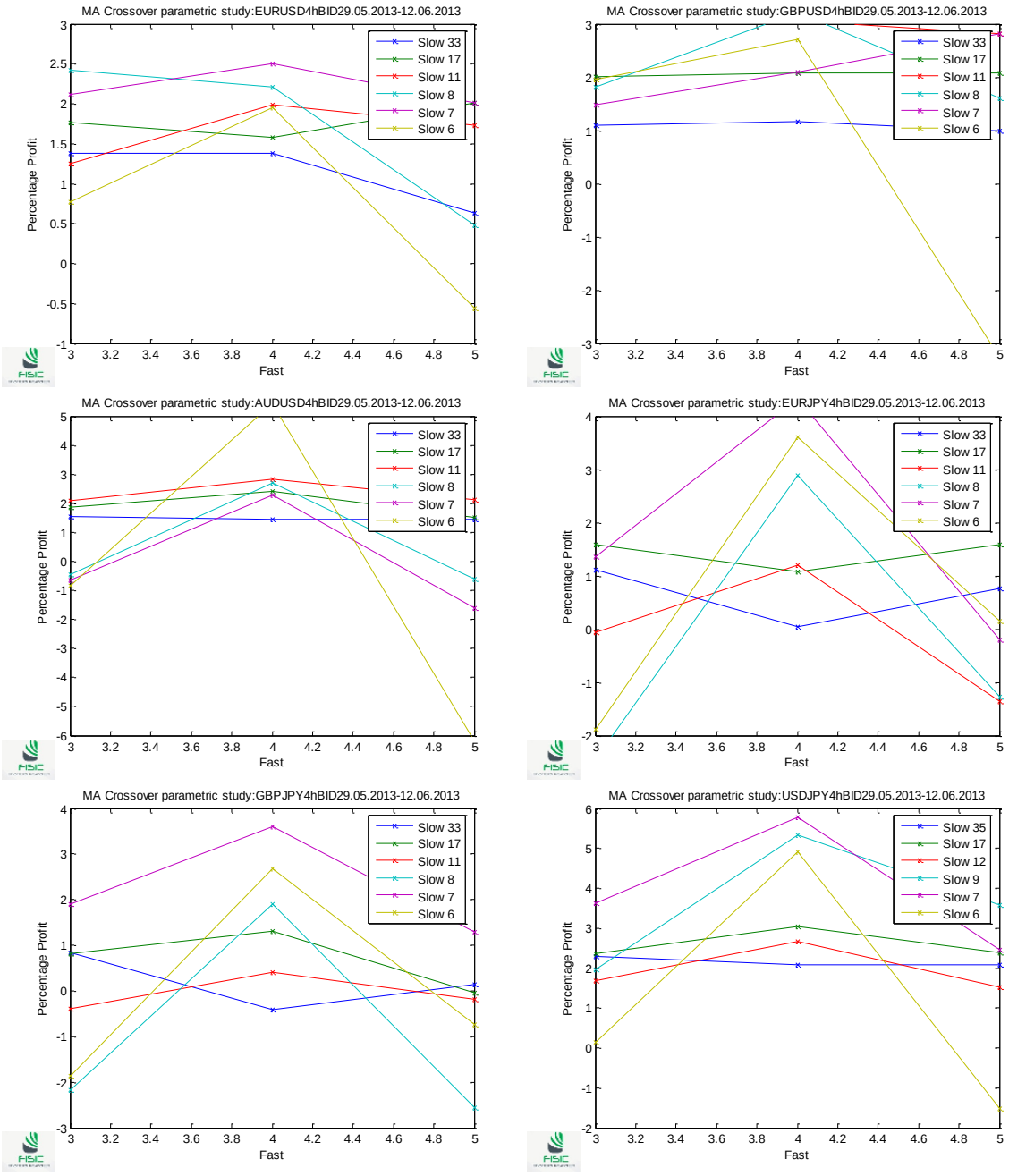

Figure B.2 MA Crossover optimization 4 hour period over 2 weeks (May 29 - June 12, 2013): EURUSD, GBPUSD, AUDUSD, EURJPY, GBPJPY, USDJPY

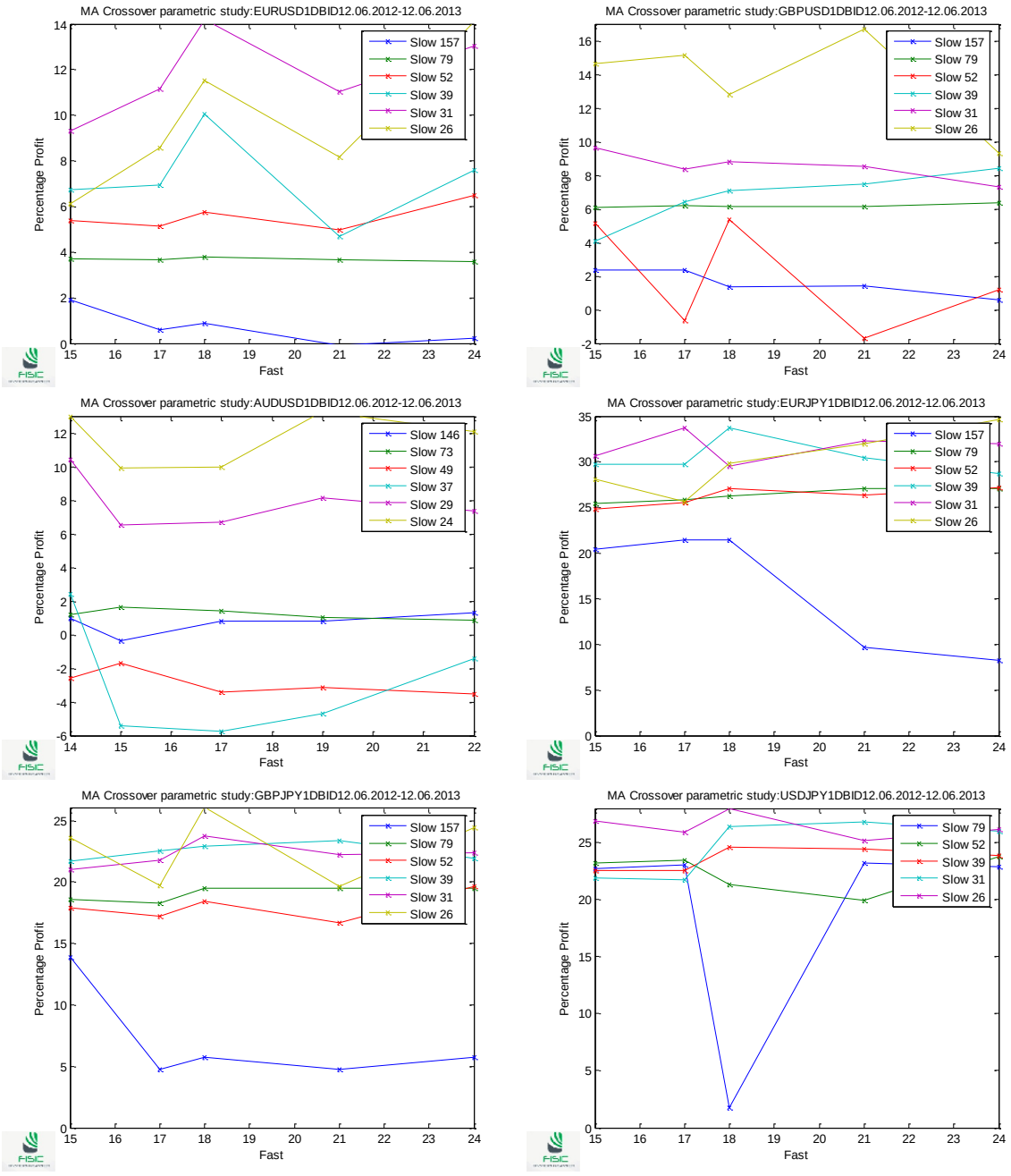

Figure B.3 MA Crossover optimization 1 day period over 1 year (June 2012 - June 2013): EURUSD, GBPUSD, AUDUSD, EURJPY, GBPJPY, USDJPY

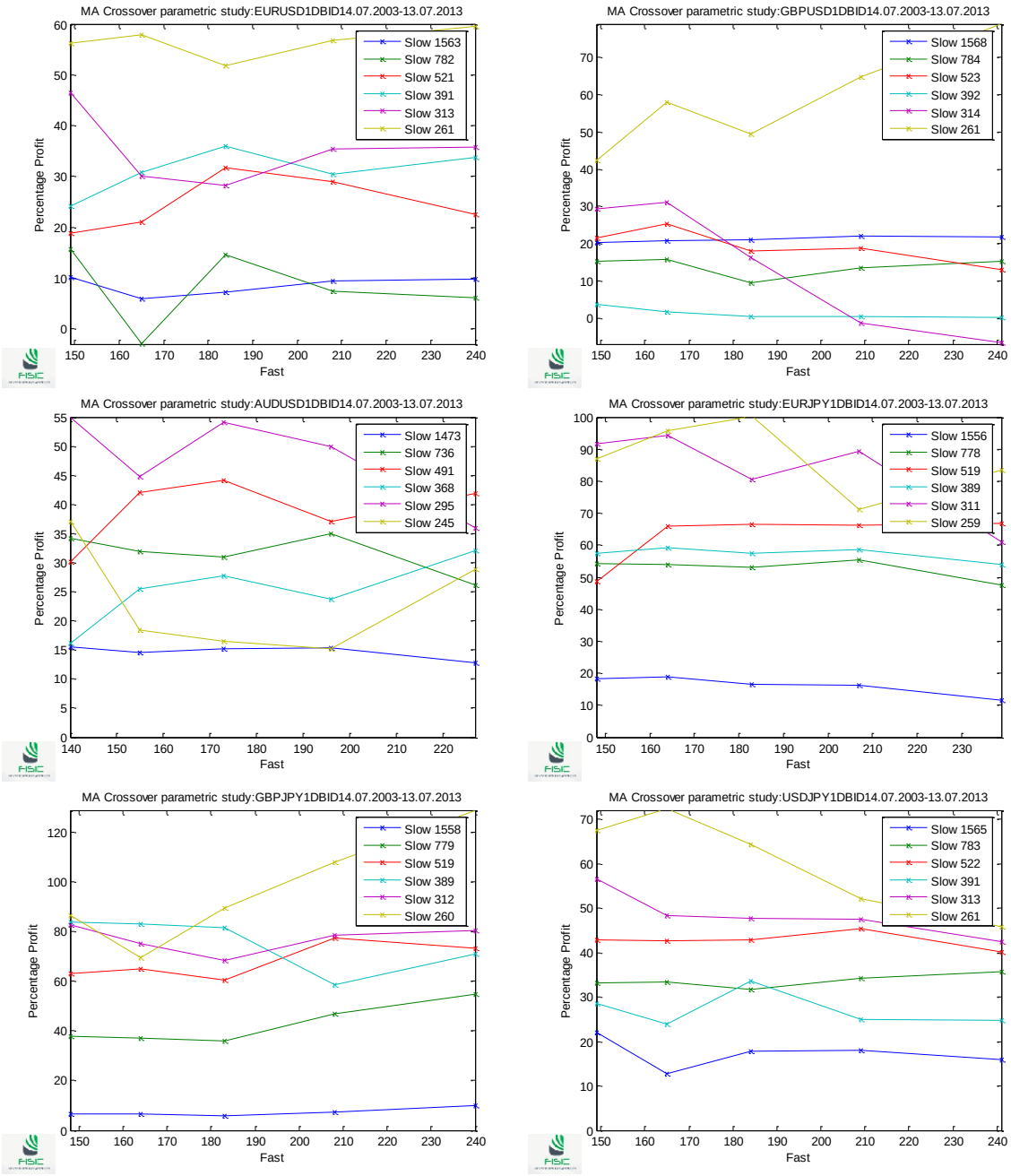

Figure B.4 MA Crossover optimization 1 day period over 10 years (July 2003 - July 2013): EURUSD, GBPUSD, AUDUSD, EURJPY, GBPJPY, USDJPY

Data Reference

Currencies	Time periods	Range
EURUSD	5 minutes/1 week	June 5-June 12, 2013
GBPUSD	15 minutes/1 week	June 5-June 12, 2013
AUDUSD	30 minutes/1 week	June 5-June 12, 2013
EURJPY	1 hour/2 weeks	May 29-June 12, 2013
GBPJPY	4 hours/2 weeks	May 29-June 12, 2013
USDJPY	1day/1 year	June 12, 2012-June 12, 2013
	1day/10 years	July 14, 2003-July13 13, 2013

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