TRADING & QUANTITATVE RESEARCH REPORT

Algorithmic trading – Price Spikes

An investigation of non-randomness
on the foreign currency exchange markets

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INTRODUCTION

Introduction

The aim of this report is to explore whether sudden changes in currency exchange rates on the FX market could be exploited by using automated, quantitative trading methods, or algorithms. Throughout the report, these sudden price changes will be referred to as price spikes. Collaborating with Century Analytics, our team defined the rules based on which price spikes were identified and developed multiple strategies that could potentially leverage the price spikes. The strategies were then tested on a range of currencies using historical data. Note, that our tests do not include brokerage fees or slippage, calculate with the bid-ask average price, and only investigate whether the developed algorithms (strategies) yield positive results. Our main assumption: if an algorithmic strategy is successful on multiple currencies on the investigated time period, then a non-randomness exists on the market that can be further exploited.

Generally, price spikes could be thought of as quick rallies that in the price activity of an instrument. The phenomenon itself is widely used in technical analysis as an indicator future price developments.[1] In the last few decades, computerized data analysis and trading have become the predominant force in driving trading volumes.[2] A quick overview of how these systems work could be seen on Exhibit 1: in quantitative trading systems, the data is collected automatically about historical prices, market news or investor sentiment. A model is then created that concludes the main parameters of the algorithm to be run: what are the patterns, definitions that mark the start or end of the trading positions and what are the parameters that help decide how to trade. The model is then put through an iterative process by introducing new data and optimizing the model variables.

Our Data Collection

The data we used in our investigation was received from Century Analytics. The initial datasets were the millisecond frequency, historic ask and bid prices of AUDUSD, EURCHF, EURUSD, GBUSD and USDCHF currency pairs on the Oct 2018 and Feb 2019 time period. No additional data was analyzed.

Our Model Creation

Century Analytics provided us with the definitions and strategies we tested. The first point of investigation was to transform the millisecond data into one-minute candlestick charts to enable visual pattern recognition. Once, the definition of a spike was set, four different strategies were defined to utilize the phenomenon. These strategies were then evaluated on all currency pairs, providing a basis for comparative analysis. Our models were developed entirely with Python, where we used the Pandas, NumPy and Plotly libraries.

1 Based on conversations with Century Analytics

2 https://www.cnbc.com/2017/06/13/death-of-the-human-investor-just-10-percent-of-trading-is-regular-stock-picking-jpmorgan-estimates.html

Price Spike

To define a spike event, our unit of analysis was the % change between the closing price of minute 15 versus the opening price of minute 1 as below:

$$\left|\frac{p_i^{close}}{p_{i-14}^{open}}\right| = \Delta_i \text{ , where i = all minute bars}$$

p marks the bid price or the average of ask and bid prices if available. A spike event occurs, when the 15-minute change is over the 2 months (2M) rolling average plus two times the 2M rolling standard deviation (backwards looking):

$$\Delta_i \geq \bar{\Delta}_i + 2\sqrt{\frac{\sum_{j=i-2M}^{i}(\Delta_j - \bar{\Delta})}{2M-1}},$$

where 2M = rolling two months of trading prior the "i" minute,

and $\bar{\Delta}_i = \frac{1}{2M} \times \sum_{j=i-2M}^{i} \Delta_j$

As the definition indicates, a spike begins, when the 15-minute change is outside of the 2-months rolling boundaries and lasts until this minutely change reverts back to be within the boundaries.. A visualization could be seen below on Exhibit 2. Additional conditions included setting a 15-min "reversal" time window following the end of each spike, where no additional spikes were defined. We also excluded those spikes that were missing any datapoints in-between the start-, and endpoints.

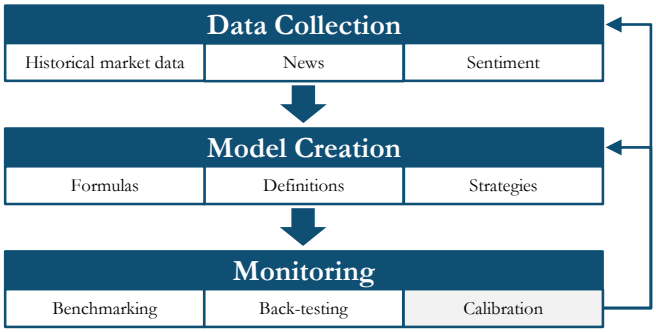


Exhibit 1: Schematic view of algorithmic trading systems. Own composition adapted from: https://www.aranca.com/knowledge-library/articles/investment-research/the-ai-revolution-in-banking

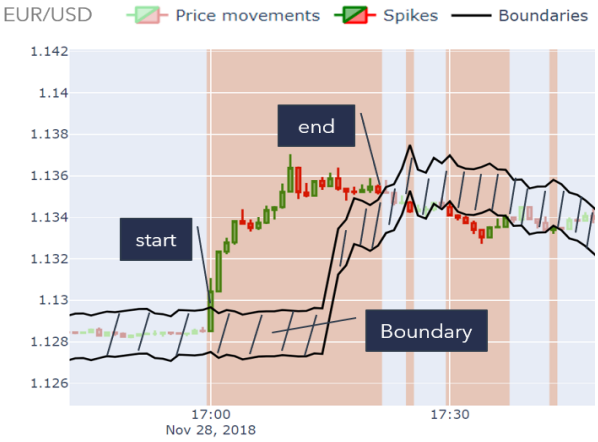


Exhibit 2: Visual representation of a price spike according to our definition. Own composition

METHODOLOGY & STRATEGIES

Process steps

A smiplified BPMN process chart below illustrates the efforts. Note, that we used visual aids to define and consult the strategies, therefore visualization was an important step in the process. The method for this research was based on Python libraries such as Pandas and NumPy. These libraries aided in resampling various datasets, calculating the %-change and setting our spike definitions into numbers and code. Plotly and Seaborn(?) together with an external software, Visual Paradigm were utilised for all visaualisations during this project.

Our research that consisted mainly of identifying price spikes and testing strategies was initialised with resampling the EURUSD millisecond-level currency pair between 2018.01.01 and 2019.02.29. Resampling the data set to one-minute bars was important in order to set the foundations for our definitions that are being discussed throughout the paper. The resampling was then followed by a calculation of the 15 minute %-change which was then compared to two additional estimated parameters such as the two months rolling average and two standard deviations. The following step was to check the condition and check the number of identified spikes consisted in the dataset. After the attained numbers of spikes were visualised, we proceeded to defining four algorithmic strategies which will be discussed on more detailed level further in this paper. The strategy definitions were based on suggestions from Century Analytics. After the completion of all algorithm, back testing of each strategy was conducted. The attain results were then visualised and analysed in order to check for evidence of non-random behavior on the FX market.

If any non-randomness was to be identified then the working strategy would have been proceeded with for further tests in orther clean and exploit the finindgs for further research. Otherwise if non abnormality was found, an iterative approach was taken in order to adjust the definition of spikes and conduct new tests.

Strategy setup

Four different strategies were defined in order to check if above definition leads to any significant results in non-randomness on the FX market. The strategies consist of long or short trades, that start at the first minute bar ex-post a spike. Each strategy defines a target (T) and stop-loss (SL), and within the minute the price moves out of the T-SL boundary, the position is closed out. Consequently, for long positions T>SL is true. If the alteration (p(k)) of the price exceeds T (p(k)>T) the trading will close with a profit, whereas if passes the SL (p(k)<SL) the trading position will close with a loss. The minimum distance between the price change and the boundaries to close off the trade was set to one pip.

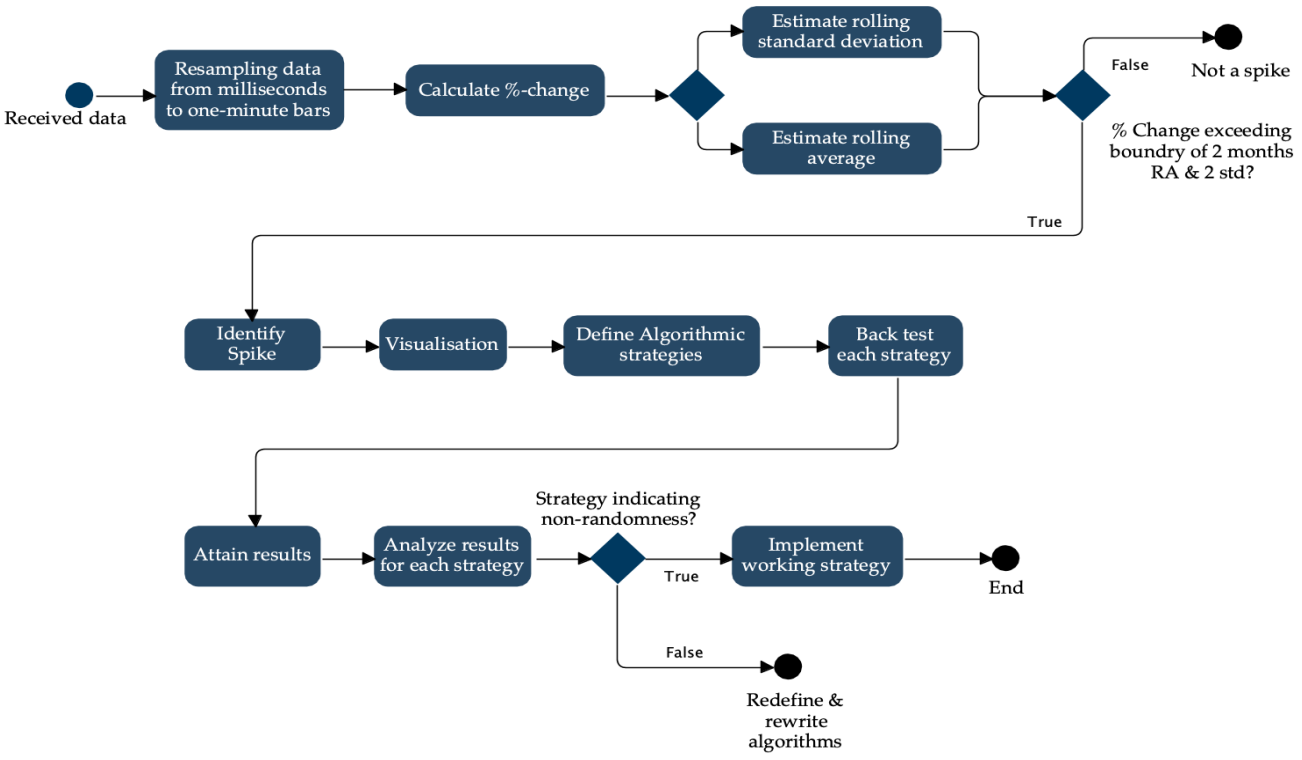


Exhibit 3: BPMN flow chart describing the process flow in this research.

STRATEGIES & RESULTS

Strategy setup cont.

The difference among the four strategies is how the T and SL is set relative to the opening price of the first minute following a spike. In the defined strategies distance between T, the opening price and SL is either dynamic (dependent on the range of a spike) or static (set in a fixed number of pips). Our work uses four different dynamic approaches: symmetric one range, symmetric half range, asymmetric and symmetric fixed strategy. One range is defined as the difference between highest [lowest] point of a one-minute bar of a downwards spike and the opening price of the first minute following the spike for short positions. For long positions, the range is the difference between the minimum of an upwards spike and the open price of the minute bar following the spike.

Additional conditions: all positions were discarded, where both the SL and T were included in the one-minute bar. Furthermore, we suspended those positions where the trade did not end 5 minutes before the start of the weekend.

All four strategies can be easily described as following:

- **Strategy I**: A symmetric approach where the range between the opening price of the trade and the T and SL equals to the magnitude of a spike which is the difference between minimum [maximum] of a spike and the open price of the minute bar after the spike, plus 1 pip.
- **Strategy II**: a symmetric approach where the range between the opening price of the trade and the T and SL equals to half of the price spike magnitude plus 1 pip.
- **Strategy III**: An asymmetric approach where the range between the opening price of the trade and the T is twice the range between the opening price of the trade and the SL.
- **Strategy IV**: A symmetric approach where the range between the opening price of a trade and the T and SL equals to a fixed range of 15 pips.

The described trading strategies were provided/inspired by Century Analytics with a purpose to follow the identified spike patterns in order to find evidence of potential non-randomness.

Underneath follows an example of a trade based on Strategy 2 which resulted in a profit. The chart displays the EURUSD currency pair on the 14th of November 2018, between 18:45 and 20:05. The illustrated example shows an execution of a long position where FX was entered at the minute bar after the identified price spike. Following the price movement towards reaching the level of the Target, at that point the position was ended, and a profit would have been attained.

Results on EUR/USD 2018.10 – 2019.02

The total number of trades for the investigated EUR/USD currency pair on the Oct 2018 – Feb 2019 time window were 5809, of which 2774 long and 3035 short.

	Strategy I	Strategy II	Strategy III	Strategy IV
Win rate	45%	40%	30%	44%
Position length	143.94	30.58	262.24	213.17
Time to reach T	141.45	33.56	340.84	209.27
Time to reach SL	138.98	27.80	218.23	203.19
Standard deviation	2.45	2.45	2.45	2.45

Exhibit 4: results on average for all currency pairs per strategy.

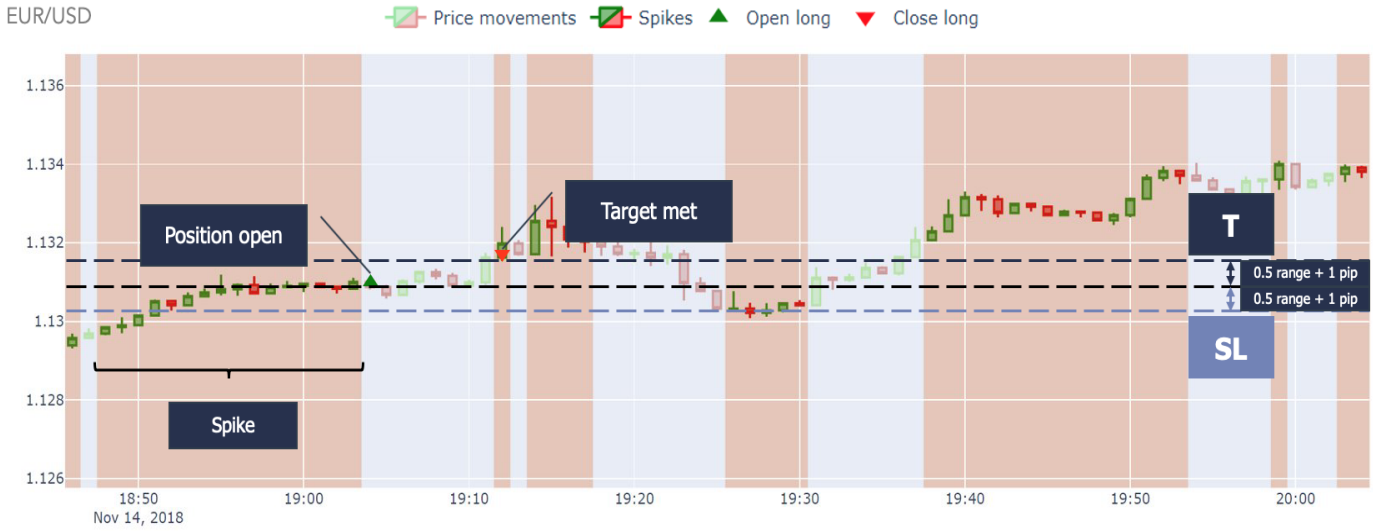


Exhibit 5: An example of a profitable trade by applying Strategy 2 on historical data of the EURUSD currency pair dated 14th of November 2018.

DISCUSSION & CONCLUSION

Discussion

The attained test results from the total number of 691 trades for the investigated EUR/USD currency pair on the Oct 2018 – Feb 2019 time window. All trades based on the spike definition and on the four strategies in this paper, have showed a rather low, if none, return in average. In addition to that the results of the defined strategy did not show any evidence of non-randomness on the FX markets that were included in the research data.

Something that can be interesting to investigate and worth mentioning is that the duration of price spikes is consequent with on average two peaks each working day. One of the peaks occurs in the beginning of a working day around 08:00 while the second one occurs at the end of a working day around 15:00 on average.

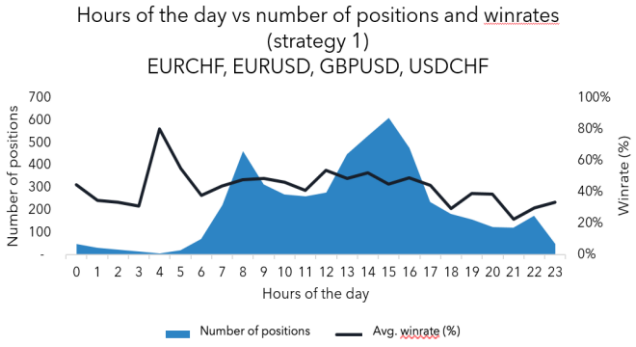


Exhibit 6: Hours of normal working day versus number of positions and win rate from Strategy I approach.

Further worth mentioning is that the test results did not show any evidence of correlation between the range of a spike and win rates throughout all the trades. No matter the magnitude of each triggering spike, almost all the executed trades within the test lead to negative but close to 0% returns. That can be observed in Exhibit X bellow.

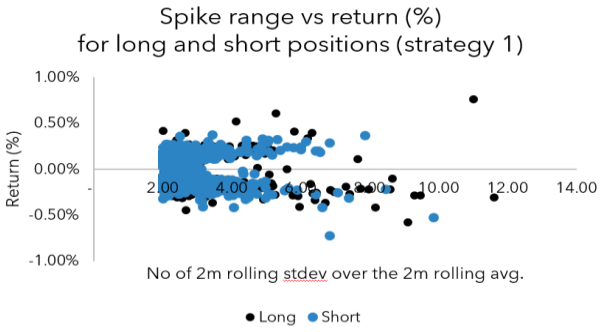


Exhibit 7: A scatter plot that shows spike range vs return on both long and short trades based on strategy I.

Having the results consulted, our work ought to entail further analysis and tweaking of spike and strategy definition, hence we can conclude that win rates and average returns do not indicate the persistence of anticipated bias. Visualizing the results with the help of matrix scatterplots, the data suggests association between the range of the spike relative to the 2M rolling average and the absolute value of the return of positions.

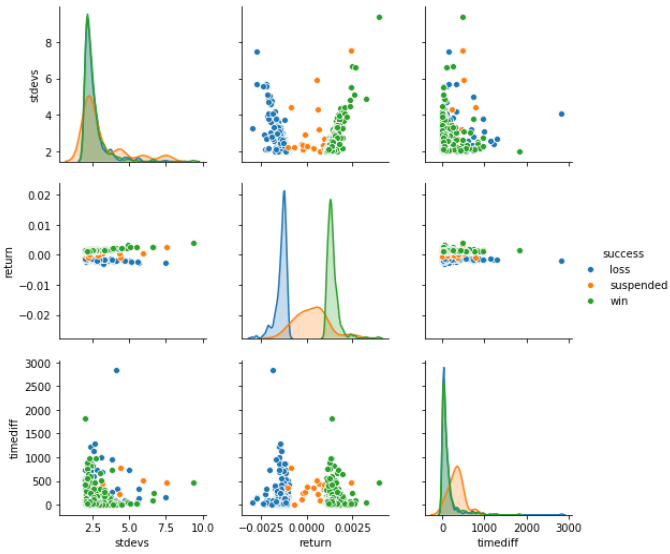


Exhibit 8: Scatterplots and Histograms showing the relations between returns, standard deviations and time difference.

Worth mentioning is that the current research is a product of a comparison of two somewhat different spike definitions where of the first was is defined as the first minute bar above the threshold and its fourteen predecessors.

Exhibit 9: Comparison of the latest and the previous definition of a spike

Future steps

A few sugestions for potential future steps from our point of view are to analyse more longitudinal datasets by testing new and different strategies such as for eg. Inverse strategy for short spikes or a short strategy which closes at the fourth minute. That in order to confirm and strengthen findings and to check if the potential results are a clear evidence of non-randomness which can be indicated and described with TA patterns. Further suggestions can be lookin into different types data by performing web scrapping which later can be utilised in an algorithm in search of non-randomness.

APPENDIX

Exhibit 10: Summary of strategies and currency pairs. Old versus new definition.

New Definition

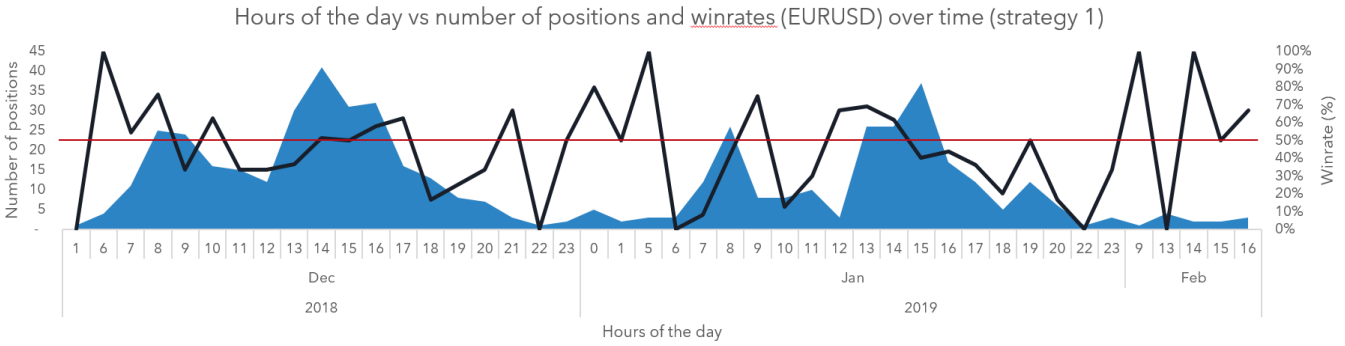
Position type	Sum of Winrate(%)	Average of Position_length (min)	Average of Return (%)	Average of stdevs
1	**45%**	**143.94**	**-0.016%**	**2.48**
AUDUSD	46%	182.34	-0.016%	2.45
EURCHF	43%	158.88	-0.017%	2.53
EURUSD	46%	121.84	-0.013%	2.45
GBPUSD	45%	120.79	-0.019%	2.47
USDCHF	45%	158.44	-0.013%	2.49
2	**40%**	**30.58**	**-0.016%**	**2.48**
AUDUSD	41%	44.48	-0.019%	2.45
EURCHF	40%	30.49	-0.013%	2.53
EURUSD	41%	26.69	-0.013%	2.45
GBPUSD	37%	24.35	-0.025%	2.47
USDCHF	43%	34.28	-0.010%	2.49
3	**30%**	**262.24**	**-0.018%**	**2.48**
AUDUSD	32%	323.69	-0.005%	2.45
EURCHF	28%	282.71	-0.022%	2.53
EURUSD	31%	223.51	-0.012%	2.45
GBPUSD	28%	230.30	-0.028%	2.47
USDCHF	30%	286.08	-0.014%	2.49
4	**44%**	**213.17**	**-0.017%**	**2.48**
AUDUSD	46%	283.46	-0.018%	2.45
EURCHF	42%	358.53	-0.022%	2.53
EURUSD	46%	137.01	-0.011%	2.45
GBPUSD	42%	52.13	-0.019%	2.47
USDCHF	45%	308.60	-0.015%	2.50
Grand Total	**40%**	**162.58**	**-0.017%**	**2.48**

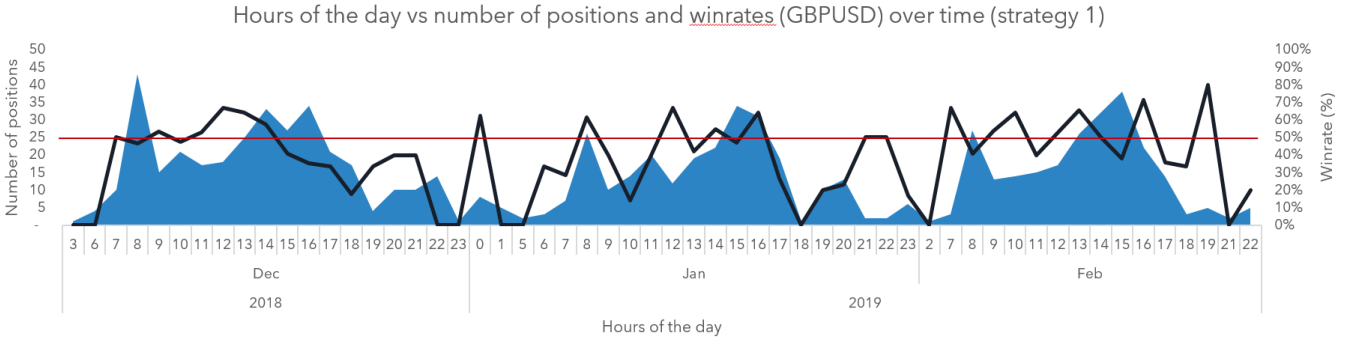
Old Definition

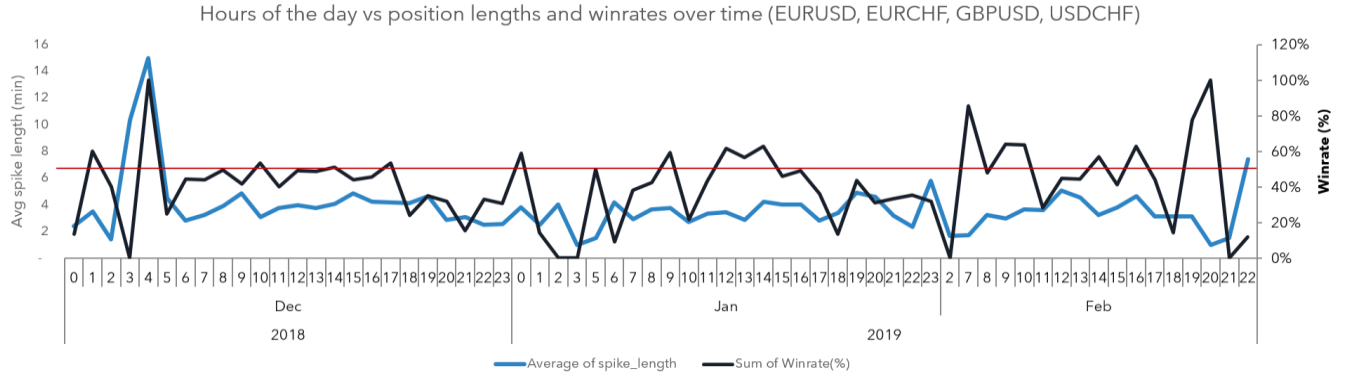
Row Labels	Sum of Winrate (%)	Average of Position_length (min)	Average of Return (%)	Average of stdevs
1	**49%**	**170.04**	**-0.004%**	**2.58**
AUDUSD	50%	205.91	0.000%	2.60
EURCHF	47%	191.26	-0.009%	2.56
EURUSD	49%	141.47	-0.003%	2.56
GBPUSD	49%	148.76	-0.009%	2.62
USDCHF	50%	180.35	0.000%	2.57
2	**45%**	**35.99**	**-0.009%**	**2.58**
AUDUSD	44%	48.18	-0.012%	2.60
EURCHF	46%	37.36	-0.005%	2.56
EURUSD	48%	31.34	-0.002%	2.56
GBPUSD	42%	29.26	-0.018%	2.62
USDCHF	47%	39.23	-0.006%	2.57
3	**31%**	**316.83**	**-0.008%**	**2.58**
AUDUSD	35%	391.67	0.012%	2.60
EURCHF	28%	338.15	-0.020%	2.56
EURUSD	34%	262.10	0.000%	2.56
GBPUSD	29%	284.51	-0.023%	2.62
USDCHF	33%	341.63	-0.003%	2.57
4	**47%**	**225.16**	**-0.008%**	**2.58**
AUDUSD	51%	280.79	0.003%	2.60
EURCHF	45%	399.73	-0.014%	2.56
EURUSD	49%	141.71	-0.001%	2.56
GBPUSD	45%	53.57	-0.013%	2.62
USDCHF	47%	308.72	-0.009%	2.57
Grand Total	**43%**	**187.10**	**-0.007%**	**2.58**

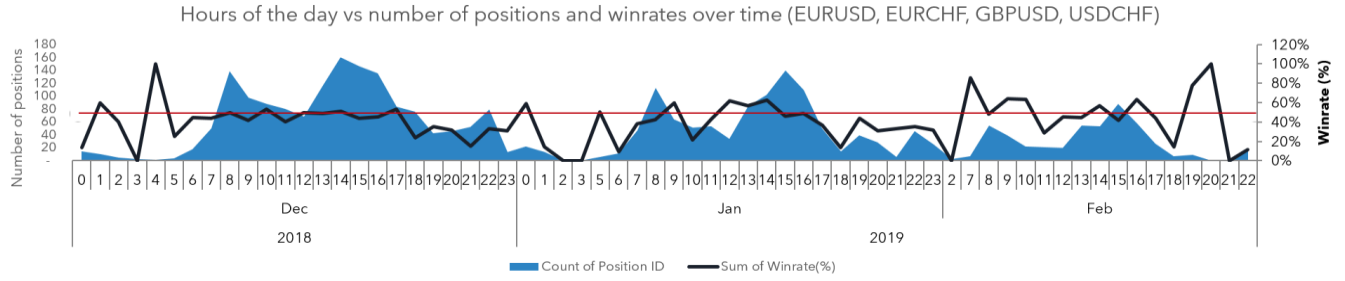
APPENDIX cont.

Exhibit 11: Hours of the day vs positions and winrates for different currency pairs.









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