TRADING & QUANTITATVE RESEARCH REPORT

HARMONIC MARKETS

FURTHER ANALYSIS ON HARMONIC TRADING PATTERNS AND THEIR EFFECTS ON THE FOREX MARKET

IN COLLABORATION WITH:

CENTURY ANALYTICS

ANALYST: PONTUS GREEN

SUPERVISOR: JOHAN HAMMARSTEDT & JAN MUELLER

2020-05-20

INTRODUCTION & THEORY

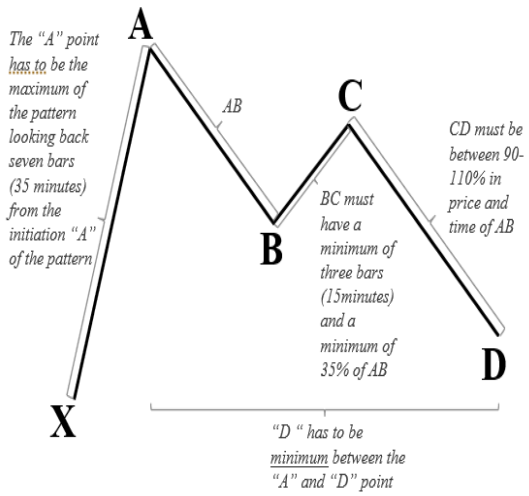


Exhibit 1: Illustration of the criteria of a bullish ABCD pattern

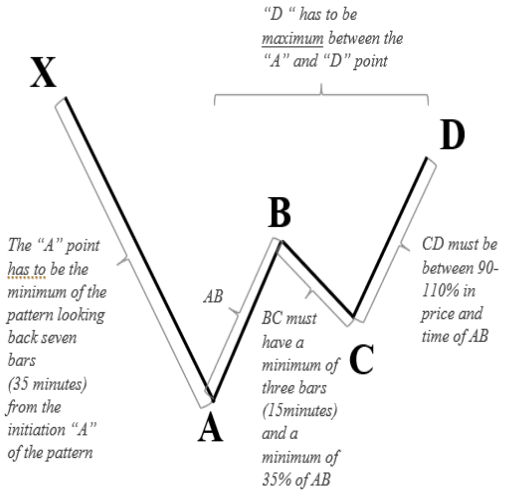


Exhibit 2: Illustration of the criteria of a bearish ABCD pattern

Introduction

Harmonic markets is one of many trading strategies that takes place on the Forex Trading Market. Building on top of the research report[1], part of their definition and theory will be restated in this paper. The purpose of this research is to further analyse whether re-occurring harmonic patterns in the foreign exchange market have trends. As mentioned in their report[2], the idea is to investigate whether the patterns could offer the trader any indication of future short-term movements of currency pairs. It is also of big importance to mention that the assumption about inefficient markets must be made for our theory to work.

To expand on last years report, the focus lies on adding the finishing touch on their conclusion. In their report it is mentioned that: "As the data is limited, one should be hesitant about drawing any definitive conclusions as far as market sentiment and the predictive ability of ABCD patterns are concerned." Therefore, more data are going to be gathered and analyzed to conclude the ABCD patterns predictive ability. It will also consist of validating the code and make sure that the patterns it detects on the market are correct. Any errors found will be accounted for and fixed.

Theory

The same definition will be used in this research as before-mentioned paper. In their paper they looked at a one of the patterns included in Harmonic markets, it is commonly referred to as an Impulse. There are two types of Impulse patterns, the Bullish ABCD pattern and the Bearish ABCD pattern. These patterns will be quoted as follows from *Harmonic Markets*, 2019 :

In order for a fluctuation to be considered a bullish ABCD pattern, the following criteria have to be satisfied:

- Point A(point of initiation) must be a local extremum, that is, it must be the highest value of throughout the entire harmonic pattern as well as the highest point looking back seven points from the initiation of the pattern.
- The length (time) of BC must be a minimum of three bars (15 minutes)
- BC must be a minimum of 35% of AB in price
- The length (in time and price) of CD must be 90-110% of the length of AB

See "Exhibit 1: Illustration of the criteria of a bullish ABCD pattern".

Its counterpart, the bearish ABCD patterns is defined similarly and is displayed in Exhibit 2:

- Point A (point of initiation) must be a local extremum, that is, it must be the lowest value throughout the entire harmonic pattern as well as the lowest point looking back seven points from the initiation of the pattern
- The length (time) of BC must be a minimum of three bars (15 minutes)
- BC must be a minimum of 35% of AB in price
- The length (in time and price) of CD must be 90-110% of the length of AB"

See "Exhibit 2: Illustration of the criteria of a bearish ABCD pattern".

Upon detecting a point D with the preceding A,B and C Points that satisfy the mentioned criteria's, the investor can expect a price reversal and bet on an increase/decrease for respective bullish/bearish patterns. *See Exhibit 3 and 4.* Building further on this is to investigate if there are patterns that are non-random and could give the trader advantage.

1 Yasser Mahfoud, Victoria Helin, Emil Håkansson, 2019, Harmonic Markets.
2 Ibid

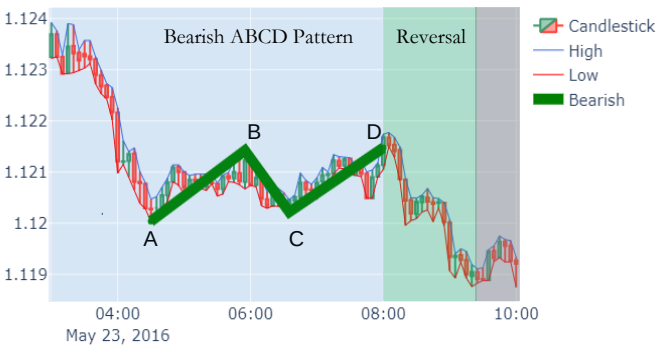


Exhibit 3: Bearish ABCD pattern, including price reversal on May 23rd , 2016.

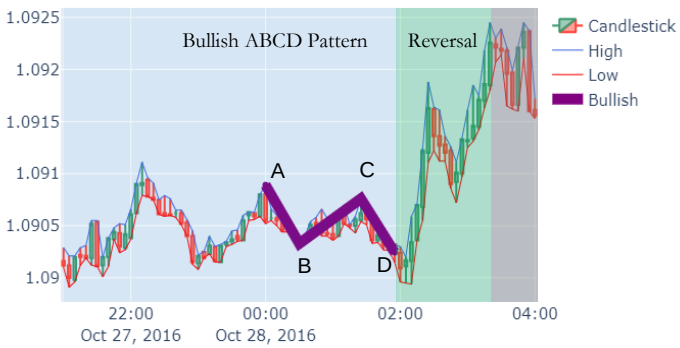


Exhibit 4: Bullish ABCD pattern, including price reversal on October 28th, 2016.

DATA & METHOD

Data

The data used in the report will consist of OHLC-values of currency pairs exchange. Due to the low availability of long time series containing OHLC-values, bid-prices had to be used. One of the datasets used in this paper consists of OHLC-values for bid-prices of the EUR/USD exchange rate between 2003-01-01 and 2018-12-31; all in 1-minute resolution, it was then resampled to a 5-minute resolution. The other data set used was AUD/USD exchange rate between 2003-01-01 and 2018-01-01; all in 15-minute resolution.

The EUR/USD data consisted of some missing minutes. To solve this issue the pandas[3] aggregate function was used. In a 5-minute interval, the function picks the first minute's open and last minute's close respectively, and for high/low it picks max and min in this interval, see *example in exhibit 5*. The trouble with this resampling is that there could be deviations in price that are not accounted for in the data. Further problems in the data involved a trend of missing minutes. Especially during dates close or under holidays. Except for these problems, the overall movement of the market is still captured and can be used to test the theory, but the reader should interpret it when reading the results later.

Date	Open	High	Low	Close
2005-02-23 01:40:00	NaN	NaN	NaN	NaN
2005-02-23 01:41:00	1.2345	1.2345	1.2344	1.2345
2005-02-23 01:42:00	1.2344	1.2346	1.2344	1.2344
2005-02-23 01:43:00	1.2343	1.2344	1.2343	1.2345
2005-02-23 01:44:00	NaN	NaN	NaN	NaN

Resampling

Date	Open	High	Low	Close
2005-02-23 01:45:00	1.2345	1.2346	1.2343	1.2345

Exhibit 5: Example on how the data was resampled when there was minutes missing. (This example shows how OHLC-data with 1-minute period was resampled).

Trading strategies

"The two trading strategies are centered around acting if the algorithm detects that a price reversal is imminent." from *Harmonic Markets*, 2019[2]. The strategies will only briefly be covered in this paper. As the algorithm detects a pattern, it will take a position on the D point. A long position is taken on bullish patterns and shorts for bearish. In Strategy 1 the positions are closed upon increasing or decreasing 38.2% of AD (in pips). In strategy 2 positions are closed upon increasing or decreasing by 20 pips of D. For further reference see appendix. See Appendix 1 for chart example.

Reflections and improvements

The algorithm that is used to trade and detect patterns is covered in *Harmonic Markets*, 2019[2]. Validating that the patterns are correct and makes sense from a real-time perspective is crucial. If not, the results would not give any valuable information to the trader. The validation was done by chart observations and making sure that it corresponded to the trading data, then changes were made accordingly.

The first major change was that the D value had to be more realistic. Determining exactly what value its should be is impossible. The Program detects patterns on a 5-minute resolution, ideally the D point should be set directly when the 90-110% in price of AB criteria is met, which is hard to determine because of the resolution. E.g. In the Bullish pattern it projects onto the low of all the bars following the C point, this implies that the code would set the D point at a low when the criteria is met, specifically the cases when this low does not exceed 110% of AB in price. Which leads to the D value being set at the extreme of the bar, consequently this does not reflect how it would run in a real-time environment.

3 Pandas is a library in the programming language Python used to handle data.
4 Yasser Mahfoud, Victoria Helin, Emil Håkansson, 2019, Harmonic Markets.
5 Ibid.

Exhibit 6: "Realistic D" is where the D value should be.

To make it somewhat more realistic, the code will project the value to be as close to 90% of AB in price as possible without breaking any other criteria. This change is justified by the logical observation, that there is a downward trend in the underlying currency pair between the C and D point for the bullish patterns and vice versa for the bearish. *Example in exhibit 6.*

In strategy 1, there was trouble that led to positions being closed at an imaginary value. Since our patterns at times could be minimal, and the ratio strategy set its range on the stop/limit based on AD*0.382, (AD in price). A consequence of this was that the stop/limit range does not reach the following bar's high or low. The trades where this happened were invalidated since the number of data points was sufficient without including these.

Another issue was variables missing in the code that could have affected the previous research. The D point was evaluated at the wrong value when taking positions in some of the patterns.

Definition change

While back-testing the theory on the data, questionable patterns arose. The algorithm detected faulty patterns when candlesticks had repeating high/low values. The solution was simply to add another criteria. See Exhibit 6. This led to a loss of half the resulting data, but as mentioned earlier having correct patterns is the most important factor in this research.

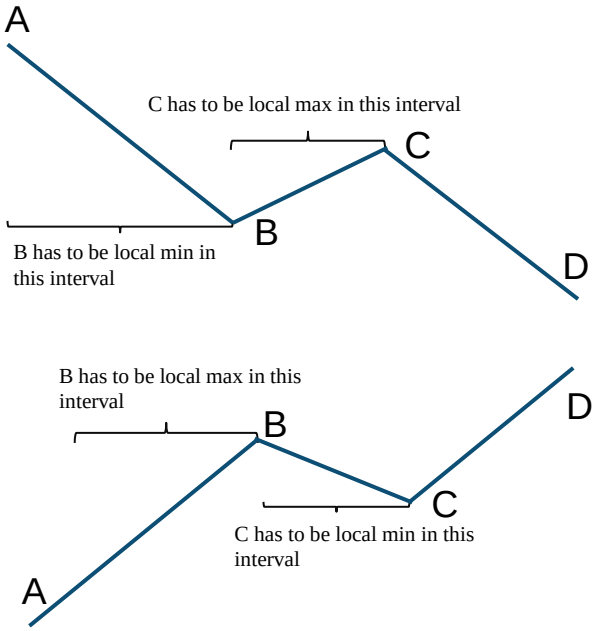


Exhibit 7: Additional criteria's added on both the bearish and bullish ABCD patterns.

RESULTS

AUD/USD **Strategy 1**

Period 2003-2018	Bullish	Bearish	Total
NUMBER OF TRADES	934	950	1884
WIN RATE	57.92%	53.37%	55.65%
AVG POSITION LENGTH	00:55	1:02	0:59
AVG RETURN	0.0270%	0.0068%	0.0338%
TOTAL RETURN	25.23%	6.41%	31.64%

AUD/USD **Strategy 2**

Period 2003-2018	Bullish	Bearish	Total
NUMBER OF TRADES	947	955	1902
WIN RATE	52.48%	51.31%	51.90%
AVG POSITION LENGTH	4:08	4:08	4:08
AVG RETURN	0.0154%	0.0066%	0.0220%
TOTAL RETURN	14.58%	6.26%	20.84%

Exhibit 8: Results of strategy 1 and 2 from AUD/USD, period 2003-2018. ***(15-minute resolution)***

Strategy 1 EUR/USD

Period 2003-2018	Bullish	Bearish	Total
NUMBER OF TRADES	2694	2674	5368
WIN RATE	53.04%	50.19%	51.62%
AVG POSITION LENGTH	00:24	00:22	00:23
AVG RETURN	0.0026%	0.0016%	0.0042%
TOTAL RETURN	7.08%	4.19%	11.27%

Strategy 2 EUR/USD

Period 2003-2018	Bullish	Bearish	Total
NUMBER OF TRADES	2728	2688	5416
WIN RATE	52.24%	49.52%	50.88%
AVG POSITION LENGTH	3:35	3:35	3:35
AVG RETURN	0.0073%	-0.0018%	0.0028%
TOTAL RETURN	19.88%	-0.05%	19.83%

Exhibit 9: Results of strategy 1 and 2 from EUR/USD, period 2003-2018. ***(5-minute resolution.)***

Results

To capture the results and to draw comparisons between the AUD/USD and EUR/USD data, tables in exhibit 8 and 9 are presented. It is of great importance to take into consideration that the resolution of the data is different.

The total amount of ABCD patterns found during this period for both of the underlying data sets were 7318. AUD/USD in **15-minute resolution** had a total of 1902 patterns, while EUR/USD in **5-minute resolution** had 5416. It is important to note that the results are without any trading fees; this research aims to explore the price movements rather than the potential gain. Because of this, positions that were held over weekends were removed from the results, and other faulty trades were also invalidated. As seen in the tables above, some of the trades were invalidated on strategy 1.

The win rate is above 50% in both tests, and the highest was the AUD/USD Strategy 1, with 55.65%. The worst performing test was Strategy 2 on the EUR/USD with 50.88%. The bullish patterns also had a higher percentage in all the tests.

The average position length is roughly the same for bullish and bearish patterns. Even though the resolution is different between the data sets, the average length is approximately the same for both tests.

Analysis of what time the patterns were most likely to occur during the day was done. As illustrated in exhibit 9, the data suggests that ABCD patterns are more likely to occur during early hours and, less likely to occur towards closing hours of offices. See Appendix 1 for AUD/USD.

T-tests was performed on the data and no significance was found.

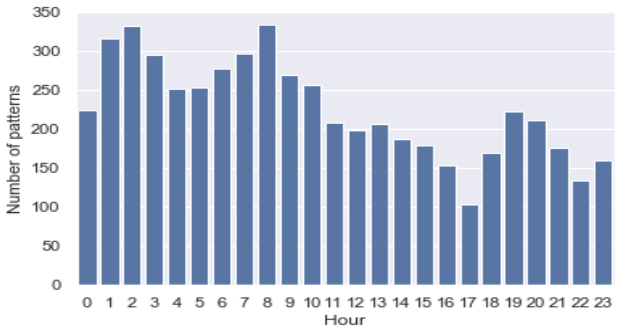


Exhibit 10: Illustration of daily occurrence of both bullish and bearish ABCD patterns. (EUR/USD)

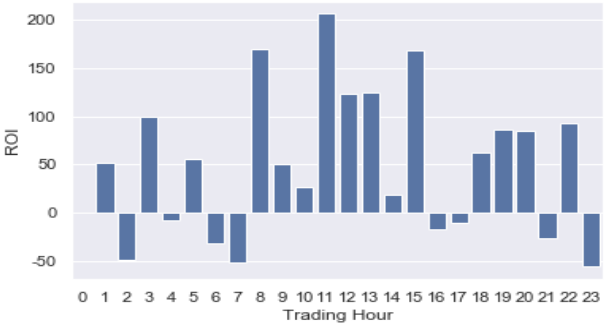


Exhibit 11: Illustration of average return on bullish ABCD patterns, using both strategy 1 and 2, per trading hour. (EUR/USD). Y-axis is multiplied by a factor of 100,000 for readability.

DISCUSSION

Discussion & more results

To analyze if there is any indication of patterns that are non-random. The following parameters were of interest:

- Is the D point higher or lower than the opening of the day
- Length of the pattern (AD bars)
- BC in % of AD (pips)
- BC Pips

The D point being over or under the opening of the day, could indicate that the patterns are detecting a bullish or bearish market on that day, this will be referred to as trading on trending markets. As illustrated in exhibits 11 and 12, the result in pips for the period are visualized. The green line represents the idea of trading on a trending market for both exhibits. See Appendix 1 for the AUD/USD charts.

Furthermore, as seen in exhibit 14, if the program only would take positions on these trending markets, there is a minimal increase by 1-2% in the win rate. It is vital to account for that a substantial amount of trades goes away when making this comparison. Since the increase is not significant, it concludes that trading on trending markets does not yield any potential gain of interest.

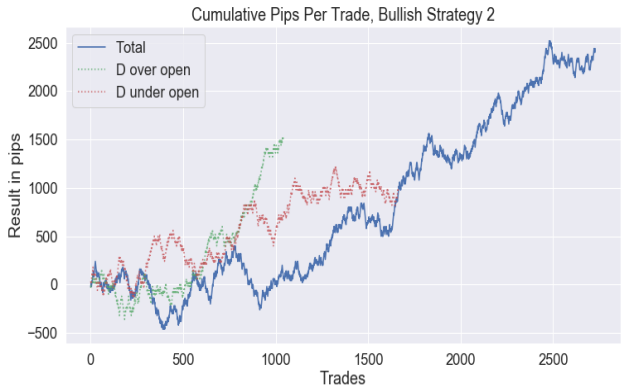


Exhibit 12: Illustration of result per trade, dashed lines are portions of the total amount of trades. (EUR/USD).

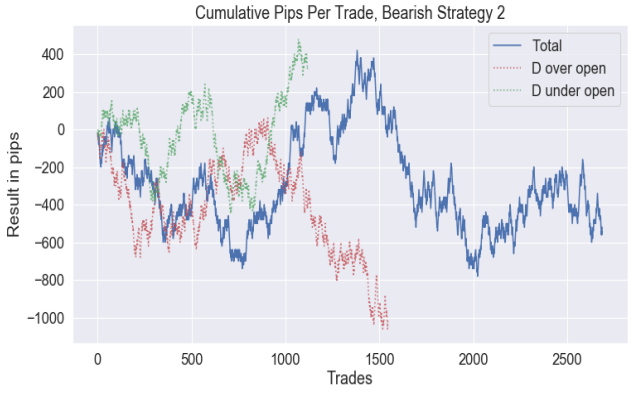


Exhibit 13: Illustration of result per trade , dashed lines are portions of the total amount of trades. (EUR/USD).

Trading results in total	Strategy 1	Strategy 2
Bullish win rate	53.04%	52.24%
Bearish win rate	50.19%	49.52%

Trading results on trending market	Strategy 1	Strategy 2
Bullish win rate	54.00%	53.64%
Bearish win rate	52.71%	50.76%

Exhibit 14: Illustration of win rate change when only taking positions on trending markets (right table).

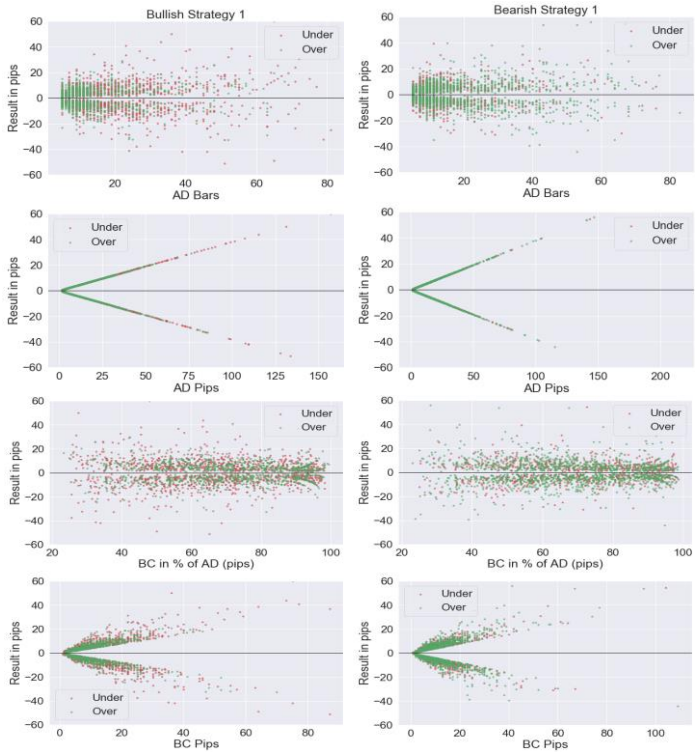


Exhibit 15: Illustration of scatterplots depending on the parameters. (EUR/USD)

Analyzing the other key parameters was done by scatterplots. If any clusters indicate that there were more favorable/unfavorable trades, this fact could conclude the predictive abilities of the ABCD patterns. Moreover, the parameter that if the D point was over/under the opening of the day was also partitioned in these illustrations. The clusters did not indicate any predictive abilities that could be of interest, see exhibit 15. Note that these are only the results from strategy 1, further analysis was also done on strategy 2, and the same conclusions held there.

Of interest is the fact that the average length of position for both data sets is the same for bullish and bearish patterns. After a pattern is detected, independent of which strategy is used. The market movement has reached the stop limit or loss within this time, this could indicate some predictability; further data must be gathered to draw any concise conclusions.

Conclusion

Even though the algorithm profits using these strategies, there still is no clear indication of its earnings. As seen in exhibit 12, there is a rapid gain between 1600-1800 trades if these quick successions in trades are random needs further investigation. Looking at the other data set, AUD/USD between periods 2003-2018, the same conclusion holds. However, the probability of having consecutive unsuccessful trades seems just as likely by analyzing the plots.

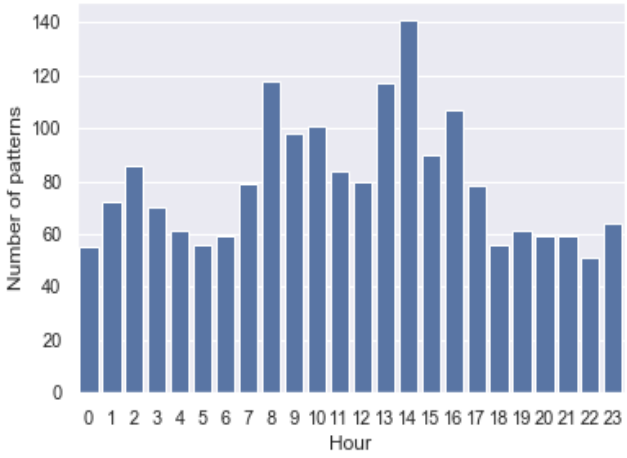
A lot of time was spent on debugging and other small fixes. Therefore the data has not had the proper time to be thoroughly analyzed. To acknowledge is that there are harmonic patterns to be found on the market, though it does not seem like a price reversal is imminent in such a way that it matches our theory.

Further improvement is to reduce the algorithm's processing time to be able to get hold of trading results quickly. An additional comparison between currency pairs is needed. More parameters could be added to see if there are any indications of trades that are favorable. The fact that there is no substantial difference in average position length of the bullish and bearish ABCD pattern, could reveal some interesting insights about the harmonic markets.

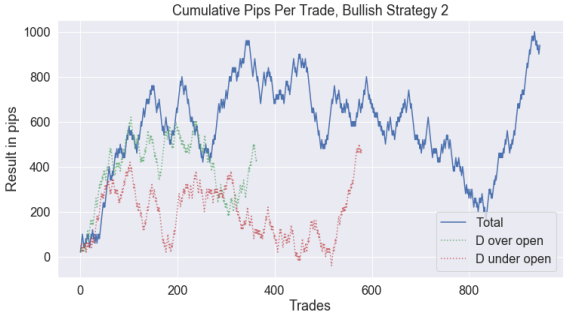
APPENDIX 1

Exhibit 4: Illustration of the two trading strategies.

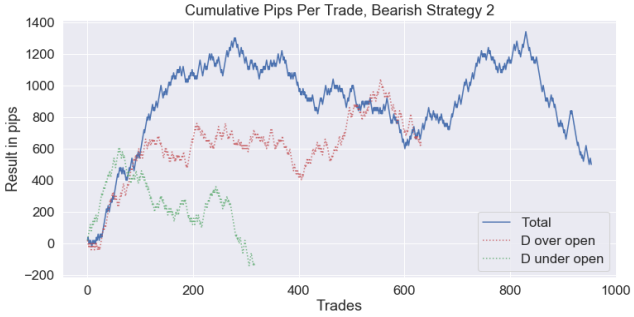
Picture 1. An example of the two trading strategies, , Harmonic Markets, 2019, Yasser Mahfoud, Victoria Helin and Emil Håkansson.



Picture 2. Representation of AUD/USD, patterns detected hourly.



Picture 3. Illustration of result per trade , dashed lines are portions of the total amount of trades. (AUD/USD).



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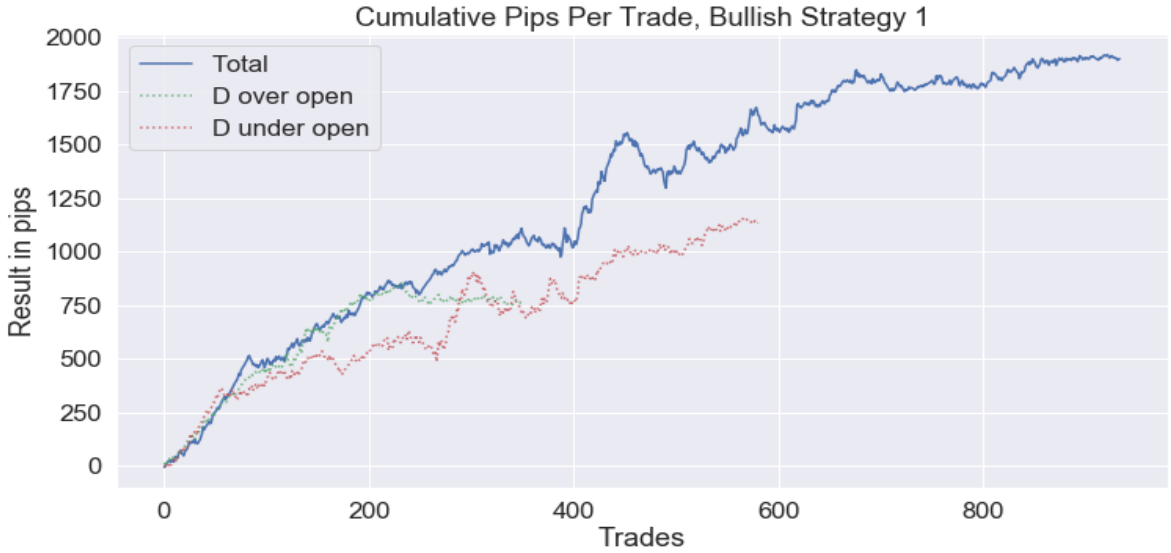

Picture 5. Illustration of result per trade for the best performing strategy, dashed lines are portions of the total amount of trades. (AUD/USD).

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Other