Analysis of Trading with Harmonic Patterns in US Stock, Forex, and Crypto Market

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1 Abstract

Harmonic patterns are geometric price patterns derived from Fibonacci ratios used to predict future price movements. In this paper, the profitability of trading some common bullish harmonic patterns, including the Gartley, butterfly, bat, and crab, in the US stock, Forex, and Crypto market is evaluated. SPDR S&P 500 ETF Trust, the EUR/USD pair, and the BTC/USD pair are selected to represent each market. Two pattern matching algorithms are developed. One of which exhaustively generates 'perfect' harmonic patterns for comparison. Another makes avail of the Zig Zag indicator to filter out the local extreme points for computing the retracement levels and comparing with the levels defined in the patterns. The result of the study indicates that the occurrence of these patterns is not high in general, which results in low profitability. However, it is observed that the bullish bat pattern and the bullish crab pattern have a high accuracy in predicting price reversals in an upward trending market.

2 Introduction

Harmonic patterns are geometric price patterns which have precise Fibonacci retracement and expansion levels defining the position of each turning point. The origin of harmonic patterns can be traced to the book *Profits in the Stock Market*, written by Harold McKinley Gartley, in 1935 [1]. The Fibonacci levels of the patterns were later defined by Larry Pesavento, Scott Carney, and other financial analysts. Nowadays, various commercial products of harmonic pattern indicators and scanners have been developed. Among all these patterns, the Gartley, butterfly, bat, and crab are the most popular and well-known ones to technical traders.

The underlying technical analysis tool used in finding harmonic patterns is the Fibonacci retracement. It measures the retracement levels of price by taking two extreme points on a chart and dividing the vertical distance by important Fibonacci levels. In Figure 1, a local maximum of around $1.175 and a local minimum of approximately $1.156 were taken as two reference points. The price retraced to about 38.2% from the local minimum, then went down again. If the price went to about $1.1655 after the local minimum instead, it would become a 61.8% retracement.

Figure 1: An illustration of the Fibonacci retracement tool

Harmonic patterns are commonly used by traders to predict future price movements. Typically, a harmonic pattern contains 5 points – points X, A, B, C, and D (or points 0, 1, 2, 3, and 4 equivalently) - forming an ‘M-shaped’ or a ‘W-shaped’ structure, with several exceptions including the ABCD pattern and the three drives pattern. Traders often place orders when buying or selling signals are confirmed in the potential reversal zone, which is the area at point D. Trading with harmonic patterns is claimed to be profitable due to the premise that Fibonacci retracements are used frequently, which makes the reactions defined by the patterns more likely and more repeatedly to occur [2]. Some believe that harmonic patterns remove the subjectivity of trading chart patterns by explicitly specifying the retracement ratios.

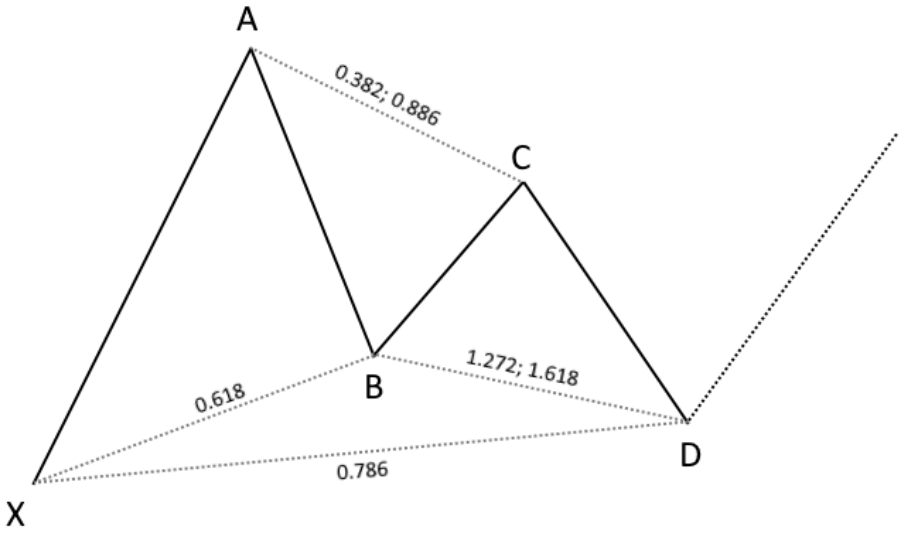

Figure 2: The Garley pattern defined in Investopedia

The major Fibonacci ratios used in the patterns include 0.382, 0.50, 0.618, 0.786, 0.886, 1.13, 1.618, … These ratios are derived from the Fibonacci sequence: 0, 1, 1, 2, 3, 5, 8, 13, 21, 34, … Although the ratios in harmonic patterns are deemed to be precise and accurate by the community, different versions of retracement levels of the same pattern have been developed and can be found in various information sources, which might cause confusion to individuals. Using the Gartley pattern as an example, while the leg CD is defined as 1.272 to 1.618 extension of leg AB in Investopedia [3], the same leg is also defined as 1.272 to 1.618 of leg BC on the website harmonics.app [4], and the 1.13 to 1.618 projection of leg BC on the website HarmonicTrader.com [5].

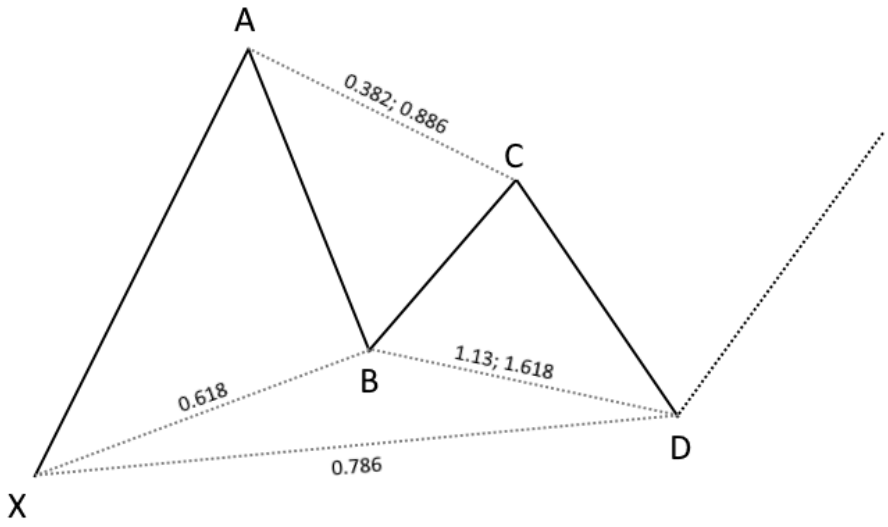

Figure 3: The bullish Gartley pattern defined in HarmonicTrader.com

In this study, a primary focus would be given to the bullish Gartley pattern, and other popular ones would be discussed afterwards. The study aims to investigate the occurrence of the common bullish harmonic patterns in the US stock, Forex, and Crypto markets and the profitability of trading with these patterns in a single instrument. Two algorithms of scanning harmonic patterns will be examined, in terms of their accuracy, followed by analyzing the profitability.

In Section 3, the data, tools, and evaluation metrics for the profitability of trading harmonic patterns are described. Next, Section 4 explains the details of each harmonic pattern and the process flow of a backtesting program. In Section 5, the accuracy of the first pattern matching algorithm and the drawback are discussed. In Section 6, the second pattern matching algorithm is introduced and is used to evaluate the profitability of the bullish Gartley pattern in different markets. Thereafter, Section 7 analyzes other popular bullish harmonic patterns, including the butterfly, the bat, and the crab, and Section 8 concludes the work.

3 Data, Tools and Evaluation

3.1 Data

Mainly three instruments are used throughout the study:

1. SPDR S&P 500 ETF Trust (SPY)
2. The EUR/USD pair
3. The BTC/USD pair

The SPDR S&P 500 ETF Trust tracks the Standard & Poor's 500 Index, which is comprised of 500 large companies listed on the stock exchanges in the United States and represents the stock market's performance. The second instrument, the currency pair EUR/USD, indicates how many US Dollars are needed to purchase 1 Euro while the BTC/USD pair shows the price of 1 Bitcoin in US Dollars. The three instruments are the most-traded ones in the US stock, Forex, and Crypto market, respectively, and are chosen to be the representative of these three markets.

The data used in the study are obtained from the historical data feed of the Dukascopy Group. Since the earliest data of SPY and the BTC/USD pair that can be extracted from the platform is in 2017, the hourly data of the three instruments from 01/09/2017 to 01/09/2021 are used. The close price in each data frame is extracted for data processing.

3.2 Tools

Algorithm implementation and backtest are conducted in Python 3.9 using numpy, pandas, and matplotlib. In addition, two other third-party libraries, TA-Lib and ZigZag, are also used to introduce some technical analysis indicators and identify relative extreme points of a time series in Section 6 [6].

TA-Lib introduces the average true range, a market volatility indicator, which is for defining the price target and stop-loss in the program. The average true range is defined as follows [7]:

$$TR = Max[(H - L), Abs(H - C_P), Abs(L - C_P)]$$

$$ATR = \frac{1}{n}\sum_{i=1}^{n} TR_i$$

TR$_i$ is the true range at a particular time, which is the maximum of 'high minus low', 'the absolute value of high minus previous close', and 'the absolute value of low minus previous close'. ***ATR*** is the moving average of true range ***TR***, usually using 14 for ***n***.

The library ZigZag introduces a simplified version of the Zig Zag indicator. A typical Zig Zag indicator is customizable in 3 parameters– the ***deviation***, ***depth***, and ***backstep***:

1. The ***deviation*** is the minimal price change required for the indicator to define a new extreme and to plot a swing high (a local maximum) or a swing low (a local minimum) on the chart. It is equivalent to a threshold of identifying a new extreme point.
2. The ***depth*** sets the minimal time interval where the indicator will define a new extreme if the threshold is passed. It is usually expressed in the unit of candlesticks.
3. The ***backstep*** specifies the minimum number of bars that have an opposite direction to the current bar between 2 extrema to be plotted. For example, if the value of ***backstep*** equals 3, after a new swing high, there should be at least three red candlesticks to have a new swing low been formed.

In the library ZigZag, only the parameter ***deviation*** is considered, and it is expressed in terms of the percentage change of price. For example, if an instrument has a price of $1000 per unit at a swing low, and the ***deviation*** is set to be 5%, a local maximum point is identified only if the price increases over $50 to at least $1050. If it is a swing high, a local minimum point is identified only after the price drops under $950.

3.3 Evaluation Metrics

The number of trades, the success rate of predicting price movement (abbreviated to success rate), compound annual growth rate, and maximum drawdown are the four key indicators to evaluate the profitability of trading harmonic patterns.

3.3.1 Number of trades

Once a similar pattern is identified, the program enters a trade. Therefore, the number of trades is a measure of how frequent a similar pattern occurs in the market.

3.3.2 Success Rate

The success rate, ***r***, is expressed as the ratio of profiting trades, n_p, to the total number of trades, n_t. It indicates how accurate a specific pattern is to predict future price trends.

$$r = \frac{n_p}{n_t}$$

3.3.3 Compound Annual Growth Rate

The compound annual growth rate, ***CAGR***, measures the rate of return of the investment. A higher ***CAGR*** usually implies a better investment strategy. The ***CAGR*** of the buy-and-hold strategy is a benchmark to evaluate our trading strategy. The ***CAGR*** is defined as follows:

$$CAGR = \left(\frac{Ending\ value}{Beginning\ value}\right)^{\frac{1}{n}} - 100\%$$

n is the number of years.

3.3.4 Maximum Drawdown

The maximum drawdown, ***MDD***, is the maximum observed loss from a peak to a trough of a portfolio before a new peak is attained. It allows an investor to examine the risk of the strategy and decide whether he or she can tolerate the risk.

$$MDD = \frac{Trough\ Value - \ Peak\ Value}{Peak\ Value}$$

4 Methodology

4.1 Popular Harmonic Patterns

In this study, the algorithm is firstly developed for scanning the bullish Gartley pattern. Different sets of retracement levels in other popular harmonic patterns, including the butterfly, bat, and crab, will be substituted into the corresponding parameters in the later part. The profitability of each pattern will be examined individually.

4.1.1 The Gartley Pattern

Different variants of Gartley patterns with different ratios have been developed. This study adopts 3 different sets of Fibonacci retracement levels for the Gartley pattern, which are **(0.618, 0.382, 1.13)**, **(0.618, 0.382, 1.272)**, and **(0.618, 0.886, 1.618)** respectively. Using the first ordered set **(0.618, 0.382, 1.13)** as an example, leg AB is defined as the 0.618 retracement of leg XA, leg BC is defined as the 0.382 retracement of leg AB, and leg CD is defined as the 1.13 projection of leg BC.

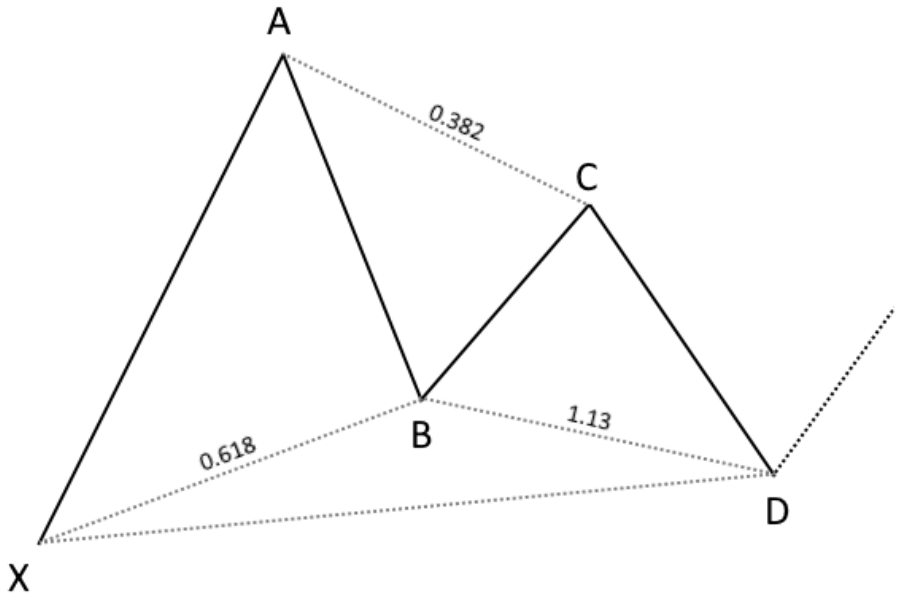

Figure 4a: The first Gartley pattern

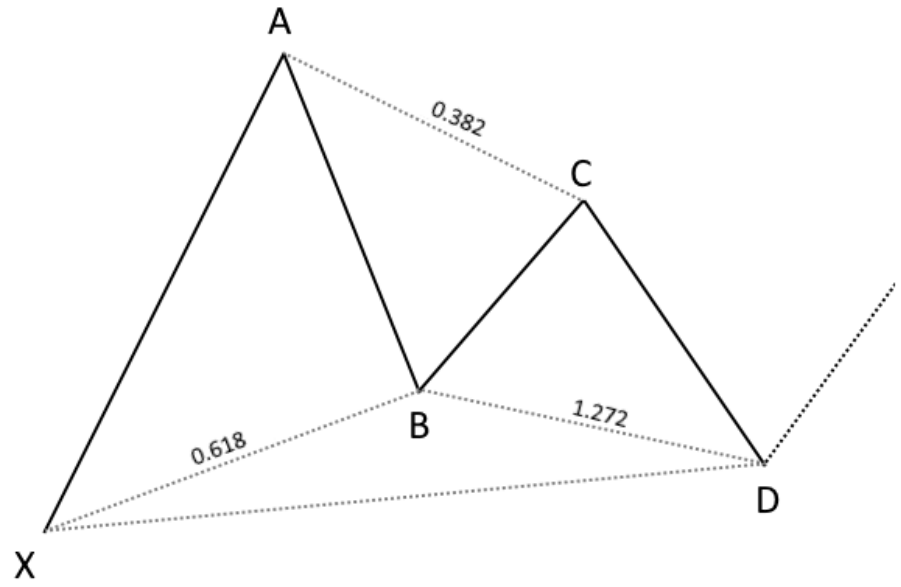

Figure 4b: The second Gartley pattern

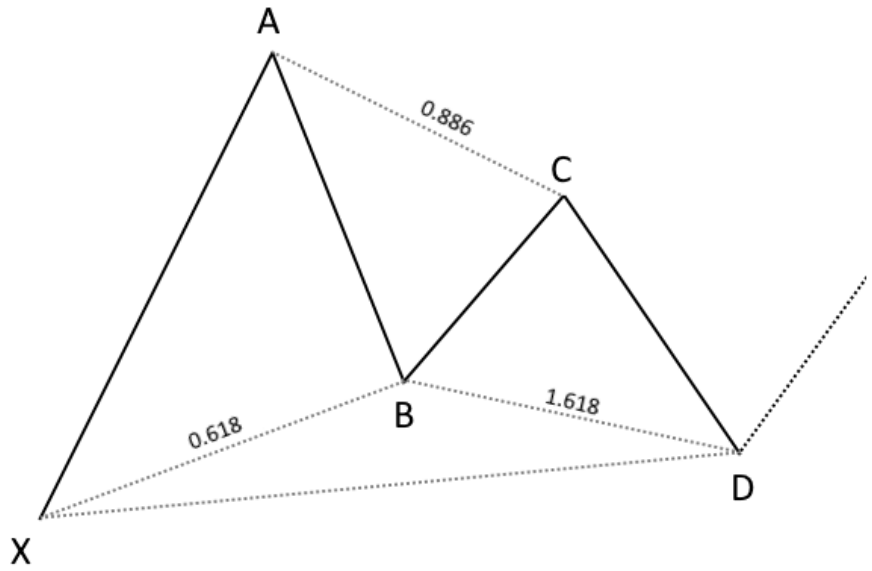

Figure 4c: The third Gartley pattern

Other harmonic traders also consider ‘leg CD being 0.786 retracement of leg XA’ and ‘AB=BC’ (which means the leg BC has a similar number of candlesticks as the leg AB) as confluence, which signals a higher probability of success when trading with the Gartley pattern. However, this study may not cover all of these because the trade opportunity is limited.

4.1.2 The Butterfly Pattern

Retracement levels of **(0.786, 0.382, 1.618)**, **(0.786, 0.886, 2.618)** are used.

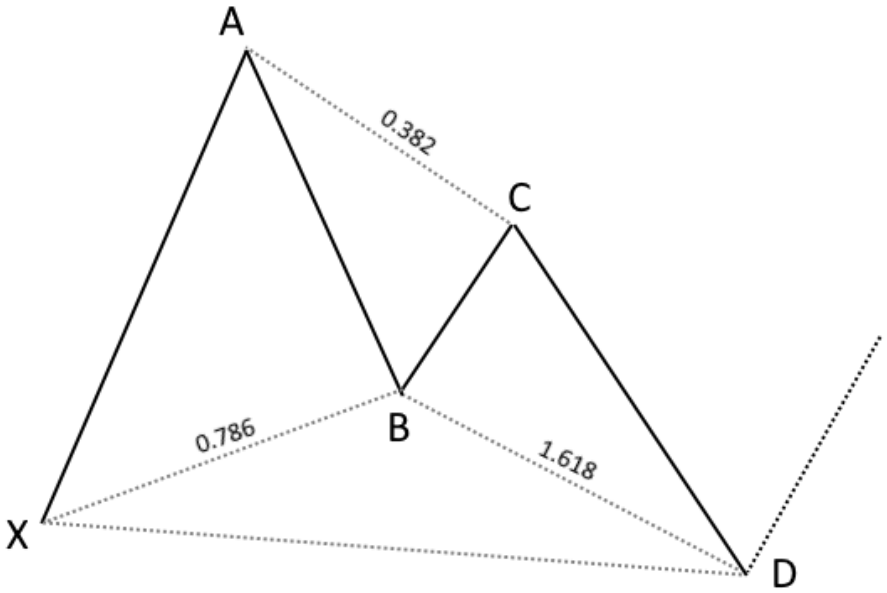

Figure 5a: The first butterfly pattern

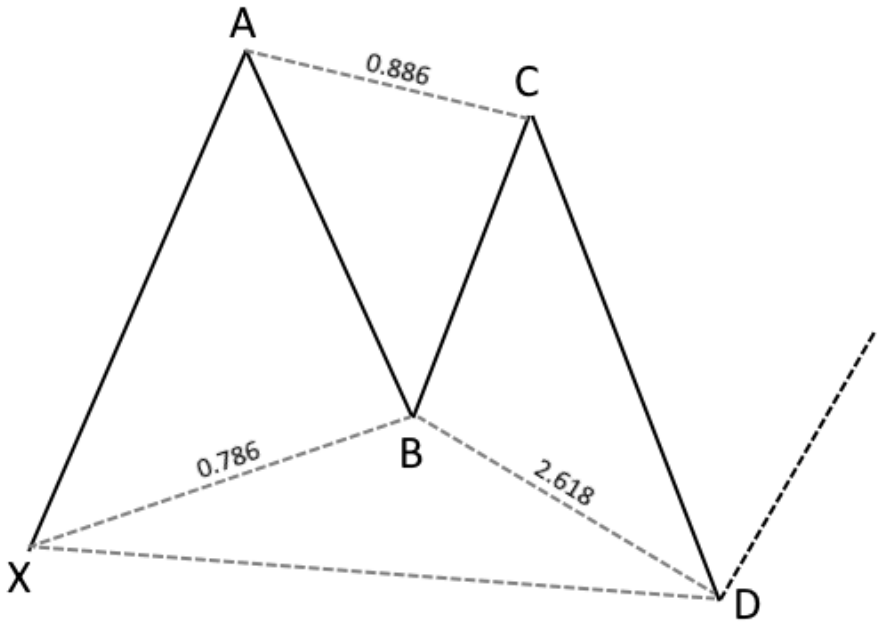

Figure 5b: The second butterfly pattern

4.1.3 The Bat Pattern

Retracement levels of **(0.382, 0.382, 1.618)**, **(0.382, 0.886, 2.618)**, **(0.5, 0.382, 1.618)**, **(0.5, 0.886, 2.618)** are used.

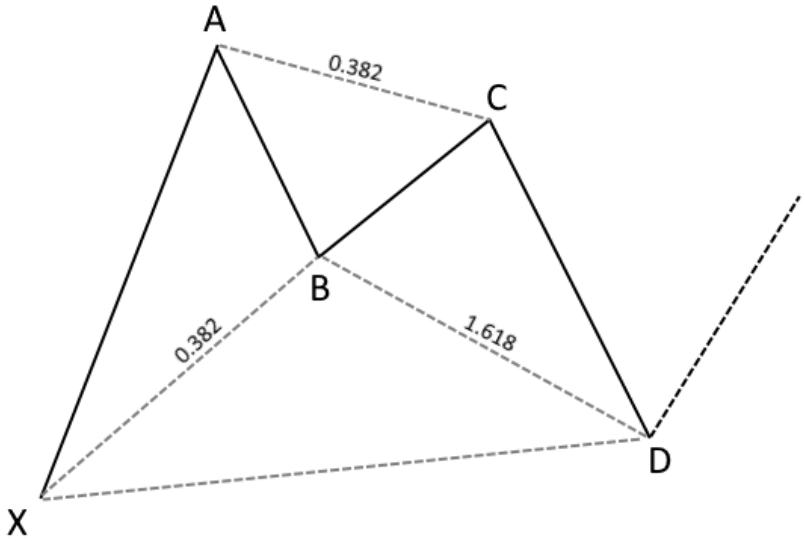

Figure 6a: The first bat pattern

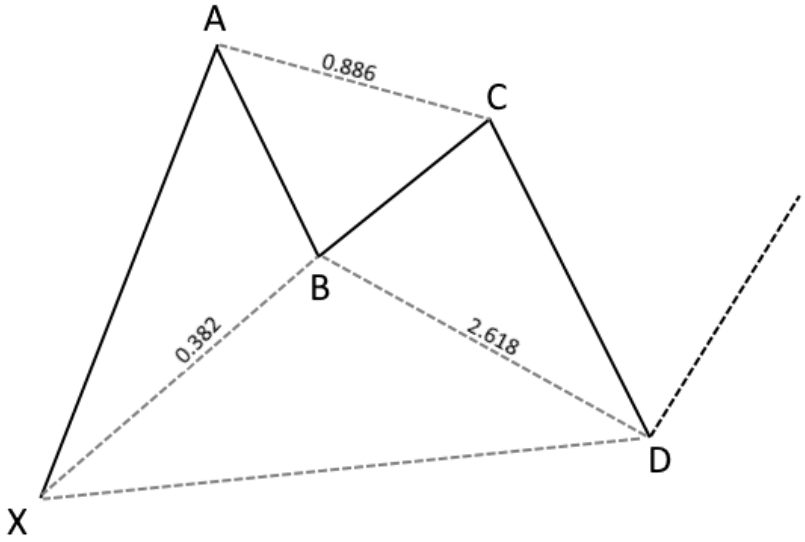

Figure 6b: The second bat pattern

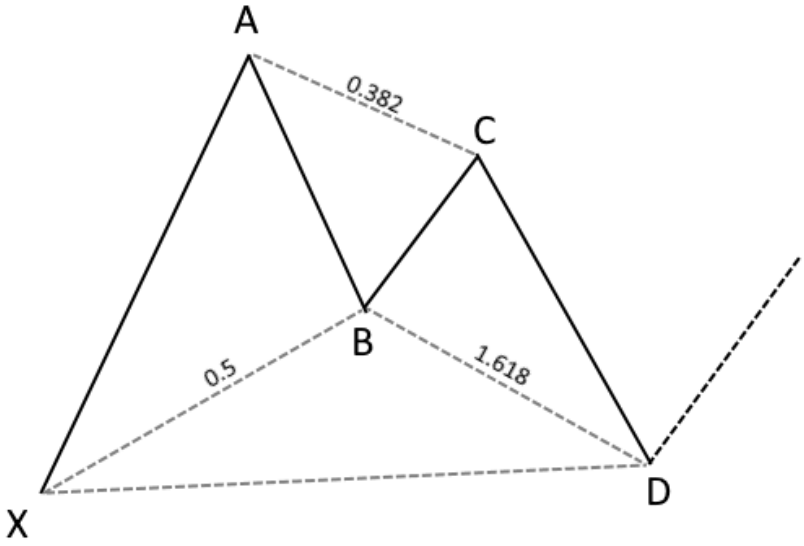

Figure 6c: The third bat pattern

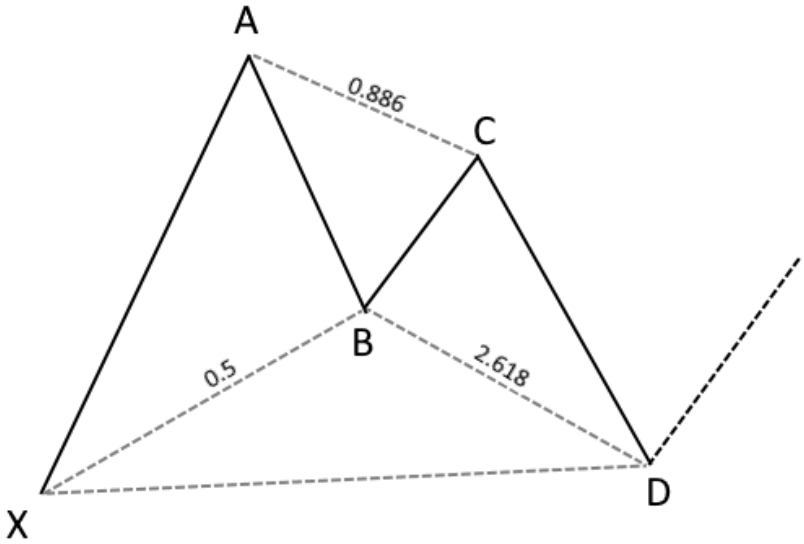

Figure 6d: The fourth bat pattern

4.1.4 The Crab Pattern

Retracement levels of **(0.382, 0.382, 2.618)**, **(0.618, 0.886, 3.618)** are used.

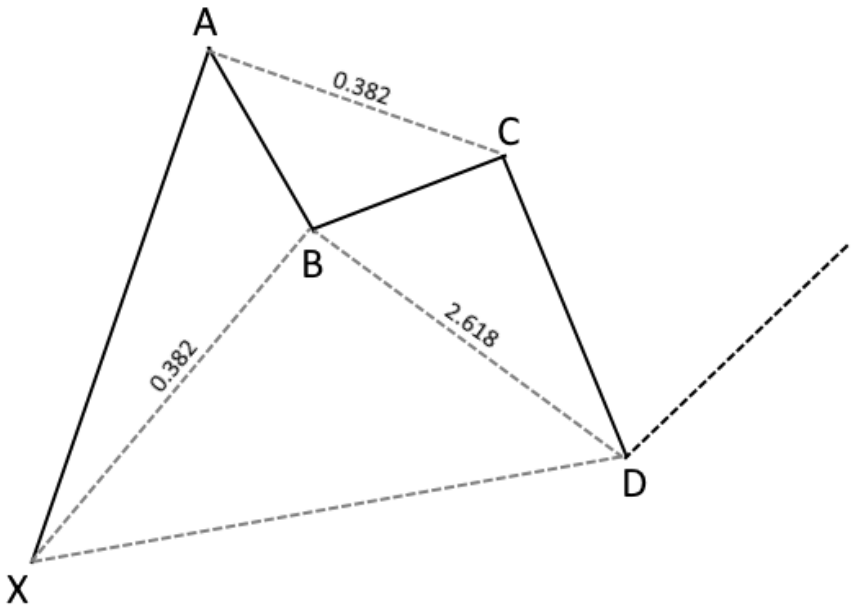

Figure 7a: The first crab pattern

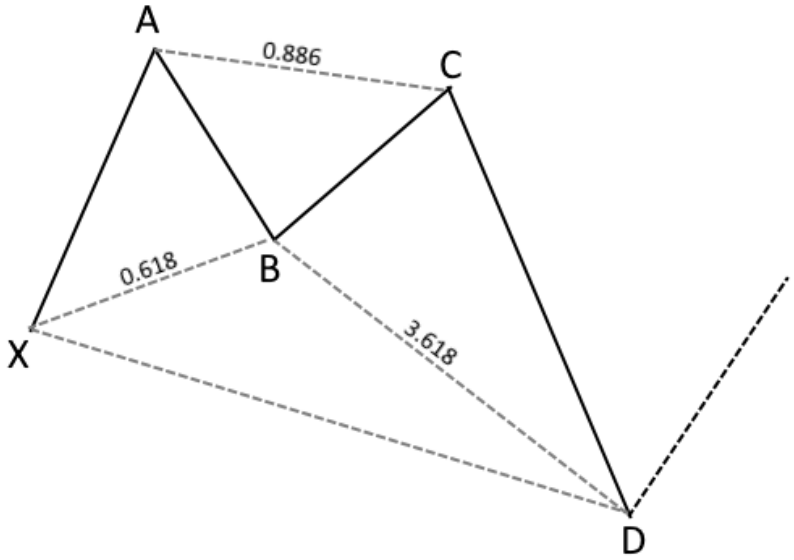

Figure 7b: The second crab pattern

4.2 Pattern Matching Algorithm and Entry

Two pattern matching algorithms are developed to scan for price movements with a similar shape and retracement levels as the bullish Gartley pattern. For each unit time of trading, the program extracts the latest array of historical data and scans for potential Gartley patterns.

The first algorithm uses brute force to measure the difference between the price movement and predefined shapes with different lengths. The second one applies the Zig Zag indicator to search for 'M-shaped' price movements that have a similar shape as points XABC of the Gartley and calculate the corresponding retracement levels. If the error between the price movements and the predefined conditions is tolerable, the program will enter a long position.

4.3 Price Target, Stop-loss, and Exit

When the program successfully finds a bullish Gartley pattern and enters a trade, it sets a price target and a stop-loss to exit the trade. The price target is defined as the 0.618 retracement of leg AD (measured from point A to the current price level), which would not be too aggressive or too conservative. The stop-loss is set at 1 ATR below point X, which provides enough hedging for random price fluctuations. A constant ***max_trade_time*** = 1000 is defined so that the program will exit a trade if the number of candlesticks passed exceeds the ***max_trade_time*** and neither the price target nor the stop-loss is hit. It is also assumed that there is no commission fee.

For each trade, the result is plotted on a graph. In the graph, the price movement is in blue, overlaid with the harmonic pattern in red. The entry price is represented by a horizontal black line, while a horizontal green line and a horizontal red line represent the price target and stop-loss, respectively.

5 Algorithm I

5.1 Brute Force Pattern Matching

In this algorithm, the program would exhaustively generate 'perfect' bullish Gartley patterns with different lengths and compare the generated pattern with historical prices within the range. Once the error between the pattern and historical data is below the threshold, the program would enter a trade and exit when the target or the stop-loss is hit.

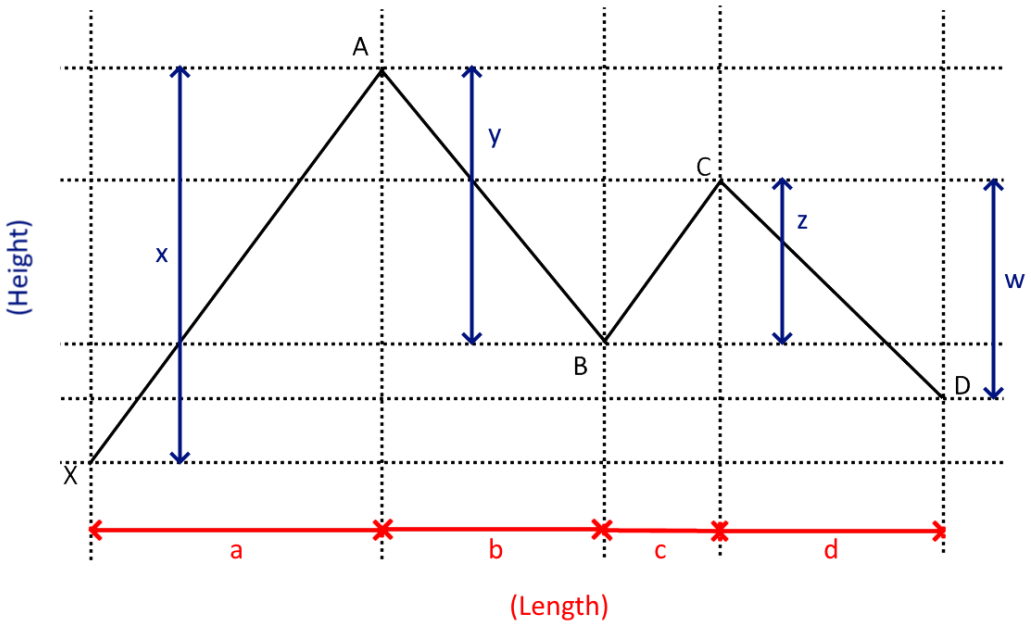

Figure 8: An illustration of the template of the 'perfect' Gartley pattern

For every hourly candle, the following pseudocode of generating scales of the patterns is executed:

```
Gartley = [[0.618, 0.382, 1.13], [0.618, 0.382, 1.272], \
    [0.618, 0.886, 1.618]]

for retracement_levels in Gartley:
    for a = min_XA_length to max_XA_length:
        for b = min_AB_length to max_AB_length:
            for c = min_BC_length to max_BC_length:
                for d = min_CD_length to max_CD_length:
                    x = 1
                    y = x * retracement_levels[0]
                    z = y * retracement_levels[1]
                    w = z * retracement_levels[2]
                    scale = generate_scale(a, b, c, d, x, y, z, w)
```

Processing the array ***scale***, a new variable ***pattern*** later becomes an array, with length ***(a+b+c+d)***, of prices at every data point in the pattern. For the minimum length of each leg, ***min_XA_length***, ***min_AB_length***, ***min_BC_length***, ***min_CD_length*** are defined to be 3. For the maximum length, ***max_XA_length*** is set to be 60, and the remaining ones (***max_AB_length***, ***max_BC_length***, ***max_CD_length***) are set to be 30. Except that the price levels at point X and point A are taken from the historical data, all other data points in the array ***pattern*** are computed from the array ***scale*** and the difference of prices of these 2 points.

In the pattern matching part, the error between the generated pattern and the historical prices (within the range of the generated pattern) is computed. The following error function, which is a variant derived from the mean absolute error, MAE, is computed:

$$error\ \varepsilon = \frac{\sum_{i=0}^{a+b+c+d} \frac{abs(H_i - P_i)}{Height_{XA}}}{a+b+c+d+1}$$

, where $\boldsymbol{H_i}$ is the historical price at point $\boldsymbol{i}$, $\boldsymbol{P_i}$ is the price at point $\boldsymbol{i}$ in the generated pattern, $\boldsymbol{Height_{XA}}$ is the difference of price level between point X and point A, and ***a, b, c, d*** are the lengths of legs as described in Figure 4.

If the error $\boldsymbol{\varepsilon}$ is less than or equal to the threshold $\boldsymbol{T}$, the program would consider the recent price movement as a bullish Gartley pattern and enter a trade.

In this algorithm, whenever there are consecutive historical data with the same price, which may potentially form a horizontal line in the price chart, only one of them is persevered, and others are discarded, with a purpose to minimize their effect on the error calculation.

5.2 Results

The accuracy of the algorithm is tested with the data of SPDR S&P 500 ETF Trust (SPY).

Parameter	Evaluation Metrics			
T	Number of trades	Success rate (%)	CAGR (%)	MDD (%)
Buy-and-hold strategy	-	-	16.29	-34.90
0.05	0	-	0.00	0.00
0.1	64	70.31	-1.57	-13.55

Table 1: Results of SPDR S&P 500 ETF Trust (SPY) using hourly data from Sept. 1, 2017, to Sept. 1, 2021

From the test results, the program enters 64 trades when the error threshold $\boldsymbol{T}$ is 0.1, with a high success rate of 70.31%. However, the balance suffers from a net loss, losing 1.57% per year on average. Moreover, when a smaller threshold $\boldsymbol{T}$ = 0.05 is used, the program does not enter any trade for the 4 years. This may suggest that there is no accurate, similar pattern found, and it may imply that the success trades obtained from the results when $\boldsymbol{T}$ is 0.1 is not fully contributed by the bullish Gartley patterns.

To evaluate the performance of the algorithm more deeply, the graphs of individual trades are examined. There are mainly two problems discovered from the graphs.

Firstly, the algorithm may misinterpret some price movements as the Gartley pattern.

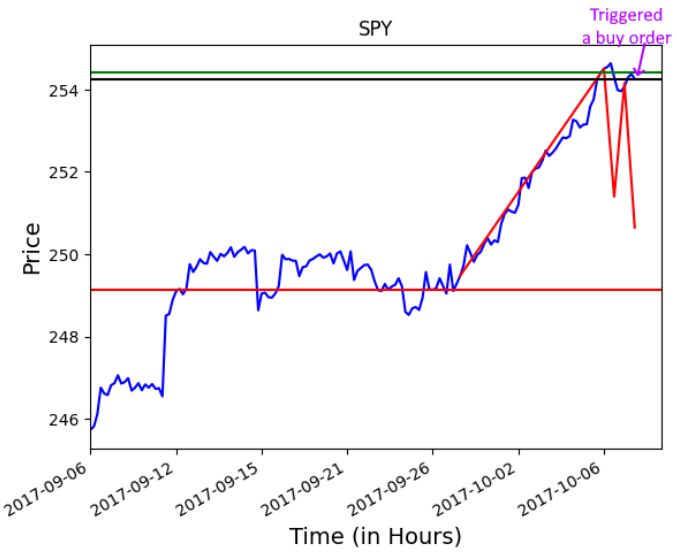

Figure 9a: The generated pattern misaligned with the price movement

In the figure, it is evident that the generated Gartley pattern does not align with the price movement, but the algorithm counts this as a Gartley pattern because the overall MAE is below ***T***. This shows that the algorithm may not be accurate enough. Moreover, this creates an unbalanced risk-to-reward ratio. As the stop-loss is defined as 1 ATR below point X, and the price target is between point A and the current price, the algorithm leads to a low-reward but high-risk trade, which makes it unprofitable in the long run.

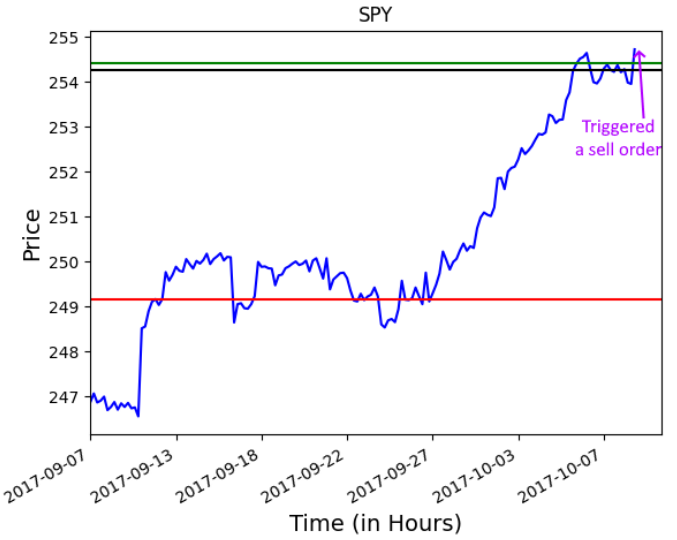

Figure 9b: Result of the trade: Winning a profit (after selling at a price above the price target)

Although the price rises above the price target ultimately, it is inconclusive to claim that the algorithm accurately scans the Gartley pattern and, thus, predicts the price movement correctly.

Another problem is that the algorithm may fail to detect the real trough or the real peak.

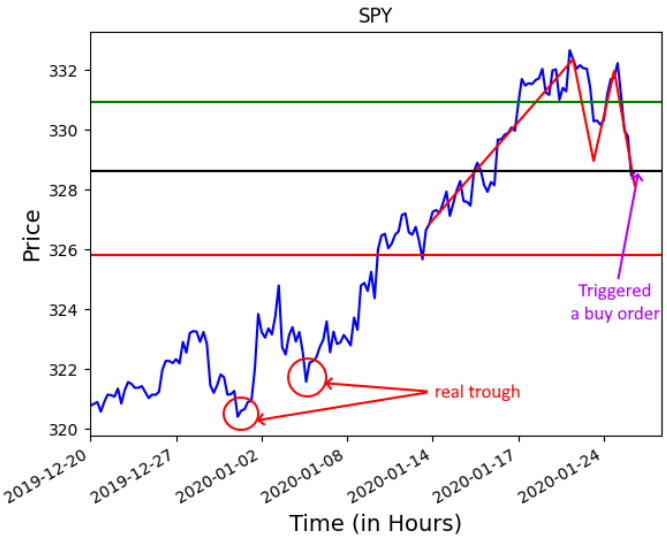

Figure 10a: Failing to detect the real trough for point X but triggering a buy order

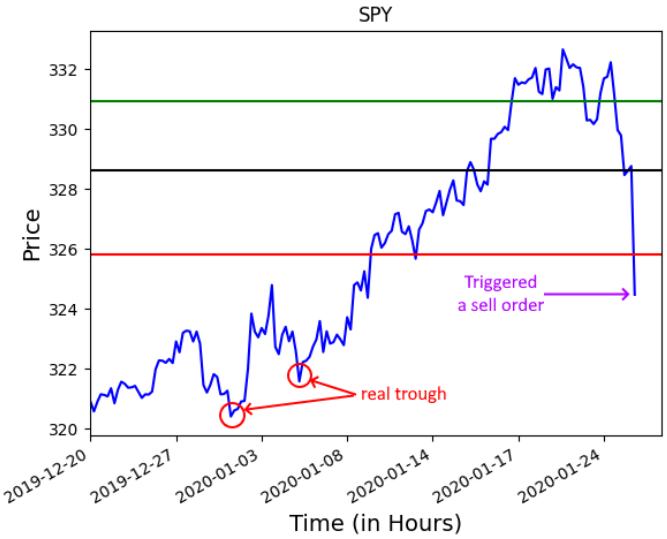

Figure 10b: Result of the trade: Suffering from a loss (after triggering the stop-loss)

The starting point of the impulse wave XA should be located at one of the areas indicated by the two red circles, but the algorithm determines point X as a point in the rising trend between the trough and point A. As a result, the measured retracement level may be incorrect. The retracement of leg AB, in reality, is much lower than 0.618 of leg XA. Therefore, it may be a possible reason for losing in the trade.

Since the algorithm is inaccurate in scanning Gartley patterns, the results in the other two markets will not be examined. Another algorithm is developed instead.

5.3 Summary

The brute force pattern matching algorithm occasionally detects a correct Gartley pattern and predicts the price movement in the right direction. However, a few problems are observed with regard to the algorithm, which may be inaccurate in scanning the pattern.

In light of this, in the next algorithm, the Zig Zag indicator is applied to identify all relative extrema, or so-called pivots, in the time series, before pattern matching to avoid the same issue from arising.

6 Algorithm II and Analysis of the Bullish Gartley Pattern

6.1 Identifying Relative Extrema by the Zig Zag Indicator

Introducing the Zig Zag indicator, the effect of noise in price movement can be reduced, as the indicator only plots trends on the graph when a predefined threshold for the price movement in a reversal, ***deviation***, is exceeded.

The algorithm first extracts an array of the latest historical data, ***price***, with the size equal to the ***max_count_time***, which is a variable storing the length of time series to be evaluated. The ***min_count_time*** is always 5 as it is the minimum requirement for five local extreme points. Then, the Zig Zag indicator is applied to the array ***price***, and the index of relative maxima and relative minima would be stored in another array, ***pivots_index***. The last point in the time series ***price*** is always treated as an extreme point in this algorithm. Thus its index would be stored as the last element of ***pivots_index***. If the count of ***pivots_index*** is greater than or equal to 5, the latest five indexes are kept, and others are discarded. The algorithm would treat the five points in the time series as points X, A, B, C, and D accordingly. If the five points are in a potentially bullish setup, where the price of point A is greater than that of point X, the algorithm will start comparing the corresponding retracement levels.

Once points X, B, D are identified as relative minima, and points A, C are identified as relative maxima, the respective retracement levels would be calculated by the following pseudocode snippet:

```
## price of each point is extracted from the array price
## by price[pivots_index[i]]
XA = absolute difference between price of points X and A
AB = absolute difference between price of points A and B
BC = absolute difference between price of points B and C
CD = absolute difference between price of points C and D

## retracement level of the array price
AB_retracement_level = AB/XA
BC_retracement_level = BC/AB
CD_retracement_level = CD/BC
```

As the retracement levels are computed, the program would calculate the difference between the retracement levels in ***price*** (***AB_retracement_level, BC_retracement_level, and CD_retracement_level***) and those defined in the Gartley pattern (***retracement_levels[0], retracement_levels[1], retracement_levels[2]***), then compute it as a percentage error over price change of leg XA (***AB_error, BC_error, CD_error***), and finally compare the percentage error with a predefined threshold value, ***T***:

```
T = value of threshold defined by user
Gartley = [[0.618, 0.382, 1.272], [0.618, 0.886, 1.618]]
is_Gartley = False

## comparing the retracement level
for retracement_levels in Gartley:
    AB_error = abs(retracement_levels[0] - AB_retracement_level)
    BC_error = abs(retracement_levels[1] - BC_retracement_level)*AB/XA
    CD_error = abs(retracement_levels[2] - CD_retracement_level)*BC/XA
    if (AB_error <= T and BC_error <= T and CD_error <= T):
        is_Gartley = True

## enter a trade if a Gartley pattern is recognized
if (is_Gartley):
    start_trading()
```

The program will enter a trade if all retracement level requirements of a Gartley pattern are satisfied.

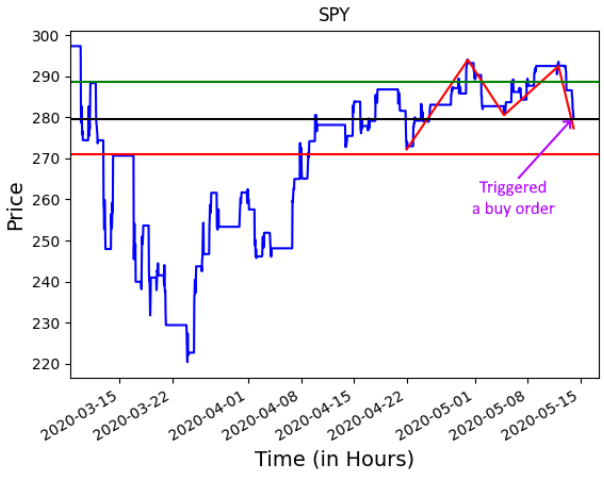

Figure 11a: Identifying local extrema by the Zig Zag indicator and comparing the retracement levels

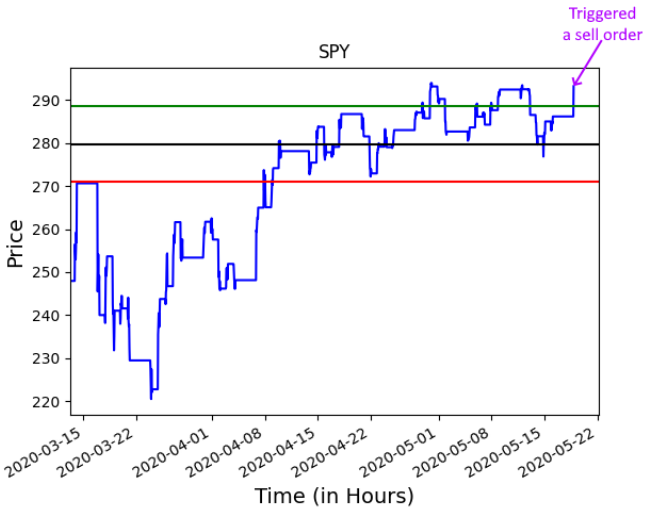

Figure 11b: Result of the trade: Winning a profit

In general, the accuracy of scanning the Gartley pattern is high, as the Zig Zag indicator determines the locations of peaks and troughs wisely and ignores those smaller than the ***deviation***. The retracement levels in the historical data are compared with the levels defined in the pattern. When the retracement levels match, the algorithm counts it as a Gartley pattern.

6.2 Results

The performance of the bullish Gartley pattern in the Forex market is first examined, followed by the US stock market and the Crypto market.

Parameters			Evaluation Metrics			
max_count_time	T	deviation (%)	Number of trades	Success rate (%)	CAGR (%)	MDD (%)
Buy-and-hold strategy			-	-	-0.06	-15.10
800	0.05	0.15	7	71.43	0.33	-0.58
		0.30	6	16.67	-0.13	-1.46
		0.45	1	0.00	-0.08	-0.67
		0.60	3	0.00	-0.39	-1.54
	0.1	0.15	19	63.16	0.27	-1.31
		0.30	11	27.27	-0.12	-2.25
		0.45	8	62.50	0.86	-0.69
		0.60	7	57.14	0.46	-1.15
1600	0.05	0.15	7	71.43	0.33	-0.58
		0.30	6	16.67	-0.13	-1.46
		0.45	1	0.00	-0.08	-0.67
		0.60	3	0.00	-0.39	-1.54
	0.1	0.15	18	61.11	0.19	-1.31
		0.30	11	27.27	-0.12	-2.25
		0.45	8	62.50	0.86	-1.00
		0.60	6	50.00	0.20	-1.15

Table 2a: Results of EUR/USD Currency Pair using hourly data from Sept. 1, 2017, to Sept. 1, 2021

The results suggest that there is a tradeoff between the preciseness of retracement levels in pattern matching and the number of trades entered. It can be observed that when threshold ***T*** decreases, with the ***max_count_time*** and the ***deviation*** remaining constant, the number of trades has reduced for most ***deviation***. With a lower threshold ***T***, thus a lower error tolerance, it is less likely to find price movement similar to a Gartley pattern.

Another observation is that the occurrence of the bullish Garley pattern is infrequent. Taking (800, 0.1, 0.15%) as (***max_count_time, T, deviation***), there is merely 19 similar patterns in four years and only 12 of which correctly predict a reversal after point D. On average, 3 bullish Gartley patterns are observed per year, which might be deemed as rare.

Moreover, most combinations of parameters that discover around 10 or above similar patterns have a success rate around 50% to 60%. This possibly indicates that the prediction of price movement may be inaccurate, as it is near 50%. However, owing to the small sample size of the discovery of similar patterns, it is inconclusive that the success rate is low.

Nevertheless, it is evident that the profitability of solely trading a kind of harmonic pattern in a single instrument is low. If one only establishes a long position for the bullish Gartley pattern in the EUR/USD currency pair, one will at most have a CAGR of 0.86% from the above results. Although the CAGR is higher than that for the buy-and-hold strategy (-0.006%), a typical Forex trader usually has a positive and better annual return compared with the best CAGR in the table.

Parameters			Evaluation Metrics			
max_count_time	T	deviation (%)	Number of trades	Success rate (%)	CAGR (%)	MDD (%)
Buy-and-hold strategy			-	-	-0.06	-15.10
800	0.15	0.15	46	58.70	0.28	-4.02
		0.30	30	16.67	-1.60	-8.17
		0.45	12	58.33	0.86	-1.38
		0.60	11	54.54	0.59	-1.58

Table 2b: Results of EUR/USD Currency Pair using hourly data from Sept. 1, 2017, to Sept. 1, 2021 (Cont.)

To further evaluate the occurrence and the accuracy of the Gartley pattern in the Forex market, a larger threshold ***T*** = 0.15 is used. Firstly, there is approximately a twofold increase in the frequency of the bullish Gartley with smaller up-and-downs (***deviation***). For example, when the ***deviation*** is 0.15%, the number of trades rises from 19 (for ***T*** being 0.1) to 46.

It can also be observed that the success rate is consistent with the previous results, mostly around 50% to 60%. However, with a higher threshold ***T***, the error tolerated in pattern matching is larger. Thus, the quality of the matched pattern is lower in terms of abiding by the retracement level. As the success rate is similar, it may possibly imply that the Gartley pattern is not the most dominant factor in affecting future price movements.

Parameters			Evaluation Metrics			
max_count_time	T	deviation (%)	Number of trades	Success rate (%)	CAGR (%)	MDD (%)
Buy-and-hold strategy			-	-	16.29	-34.90
800	0.05	0.25	0	-	0.00	0.00
		0.50	0	-	0.00	0.00
		0.75	3	33.33	0.30	-2.11
		1.00	3	33.33	0.30	-2.11
	0.1	0.25	5	80.00	0.81	-1.32
		0.50	2	100.00	0.71	-0.40
		0.75	9	11.11	-1.04	-5.63
		1.00	5	20.00	-0.20	-3.92

Table 3a: Results of SPDR S&P 500 ETF Trust (SPY) using hourly data from Sept. 1, 2017, to Sept. 1, 2021

The above results also imply a low occurrence of bullish Gartley pattern in SPY, as none of the combinations of parameters yields more than 10 trades in 4 years. It seems that increasing ***deviation*** would decrease the success rate, as there is a significantly low success rate of 11.11% when the threshold ***T*** is 0.1, and the ***deviation*** is 0.75%. We might verify the claim by backtesting with a higher ***deviation*** and a higher ***max_count_time***, which allow the Zig Zag indicator to capture enough extrema of larger price movements.

Parameters			Evaluation Metrics			
max_count_time	T	deviation (%)	Number of trades	Success rate (%)	CAGR (%)	MDD (%)
Buy-and-hold strategy			-	-	16.29	-34.90
1600	0.1	1.00	4	25.00	0.11	-2.71
		2.00	1	100.00	1.14	-5.70
		3.00	1	100.00	1.37	-2.64
		4.00	0	-	0.00	0.00
		5.00	0	-	0.00	0.00
3200		1.00	4	25.00	0.11	-2.71
		2.00	2	100.00	2.62	-5.70
		3.00	1	100.00	1.46	-3.19
		4.00	0	-	0.00	0.00
		5.00	0	-	0.00	0.00

Table 3b: Results of SPDR S&P 500 ETF Trust (SPY) using hourly data from Sept. 1, 2017, to Sept. 1, 2021 (Cont.)

The data above seemed to contradict the above claim, but the sample size (number of trades) is quite small. The ***max_count_time*** is increased to 1600 and 3200 because a larger price movement generally requires more time to develop, but the difference is not huge. To enable more samples to be obtained, the next backtest is conducted using a higher threshold ***T***.

Parameters			Evaluation Metrics			
max_count_time	T	deviation (%)	Number of trades	Success rate (%)	CAGR (%)	MDD (%)
Buy-and-hold strategy			-	-	16.29	-34.90
1600	0.15	0.25	22	59.09	0.55	-5.36
		0.50	13	46.15	0.36	-2.58
		0.75	18	27.77	-1.14	-7.06
		1.00	8	37.50	-0.03	-4.85
		2.00	4	100.00	4.37	-5.71
		3.00	2	100.00	2.52	-2.64
		4.00	1	100.00	1.13	-0.85
		5.00	0	-	0.00	0.00

Table 3c: Results of SPDR S&P 500 ETF Trust (SPY) using hourly data from Sept. 1, 2017, to Sept. 1, 2021 (Cont.)

The claim seems to be valid for ***deviation*** lower than or equal to 1.00%. The success rate decreases gradually from about 60% to 30%, which has a similar distribution with that when threshold ***T*** is 0.05 and 0.1. The number of trades also has a significant increase for small ***deviation***.

For a larger deviation, the success rate reaches 100%. This is due to the small sample size and the soaring price trend after the dip in March 2020 due to the outbreak of COVID-19 in the US. It implies that large price movements are determined by market news more than harmonic patterns. For instance, it is found that when ***T*** is 0.15, and the ***deviation*** is 2%, all the trades are executed after the plunge in March 2020.

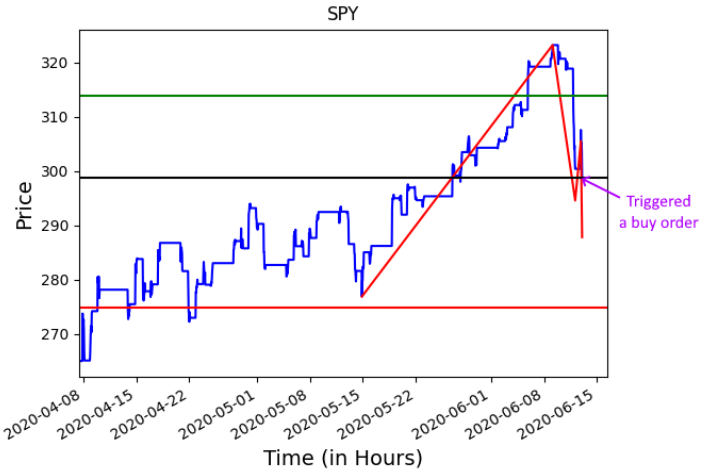

Figure 12a: Example of an entry after the plunge in March 2020

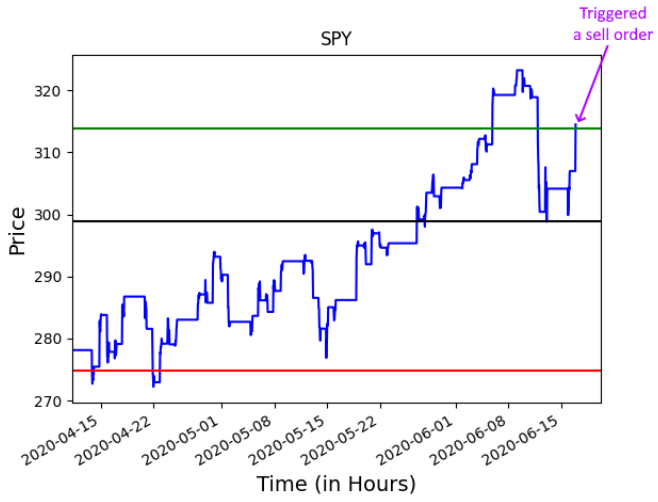

Figure 12b: Result of the trade: Winning a profit

While the highest CAGR obtained from the data is 4.37%, a buy-and-hold strategy has a CAGR of 16.29% from Sept. 1, 2017, to Sept. 1, 2021. This suggests that trading with the bullish Gartley pattern only in SPY is not as profitable as strong holding it. Nevertheless, the risk of only trading with the bullish pattern in SPY is much lower than that of strong holding, as evidenced by the MDD.

Parameters			Evaluation Metrics			
max_count_time	T	deviation (%)	Number of trades	Success rate (%)	CAGR (%)	MDD (%)
Buy-and-hold strategy			-	-	77.71	-83.87
800	0.05	0.25	6	66.67	-0.02	-4.54
		0.50	5	40.00	-1.42	-8.33
		0.75	4	25.00	-1.58	-8.95
		1.00	3	0.00	-3.01	-12.86
	0.1	0.25	43	74.42	8.15	-15.29
		0.50	47	63.83	1.30	-18.2
		0.75	36	50.00	-8.78	-33.89
		1.00	26	42.31	-6.37	-27.37

Table 4: Results of BTC/USD using hourly data from Sept. 1, 2017, to Sept. 1, 2021

In the table, the success rate lies between 40% and 75% in general. The sample size, which is the number of trades, is much greater when the threshold ***T*** is 0.1 compared to 0.05. The 8.15% CAGR on row 6 is also exceptionally high compared with the performance in trading EUR/USD currency pair and SPY. However, given the fact that Bitcoin has been strongly bullish with a CAGR of 77.71% for strong holding, the seemingly high success rate and CAGR may be considered biased, in fact. Furthermore, the CAGRs in other settings are even negative, which may signal that solely trading with the pattern in BTC/USD is not an effective strategy in terms of profitability. Yet, it is important to note that the risk incurred in the buy-and-hold strategy is extremely high, with an MDD of -83.87%.

Another finding related to the success rate is that it is higher with a smaller ***deviation***. For ***T*** being 0.1, the success rate diminishes gradually from 74.42% to 42.31%. It may suggest that Gartley patterns with a smaller price movement can predict the price more accurately. A possible reason is that smaller fluctuations are driven by the usual reactions between buyers and sellers. And for larger up-and-downs in the Crypto market, they are more related to important market events and news. Thus they are less relevant to Fibonacci retracement.

iShares Core S&P Small-Cap ETF (IJR), another ETF in the US stock market with a higher standard deviation than SPY, is examined below to evaluate the performance of the Gartley pattern in a more volatile US stock.

Parameters			Evaluation Metrics			
max_count_time	T	deviation (%)	Number of trades	Success rate (%)	CAGR (%)	MDD (%)
Buy-and-hold strategy			-	-	12.94	-46.82
1600	0.1	0.25	10	70.00	1.15	-2.06
		0.50	9	44.44	0.48	-3.87
		0.75	6	50.00	1.18	-1.43
		1.00	5	40.00	0.62	-2.55
		1.25	1	100.00	0.54	0.00
		1.50	3	100.00	2.30	-3.38
	0.15	0.25	28	64.29	2.53	-3.44
		0.50	24	41.67	-0.82	-8.50
		0.75	17	35.29	-2.20	-11.14
		1.00	13	23.08	-2.92	-11.91
		1.25	8	37.50	-1.06	-8.76
		1.50	12	33.33	-1.46	-12.31

Table 5: Results of iShares Core S&P Small-Cap ETF (IJR) using hourly data from Sept. 1, 2017, to Sept. 1, 2021

In general, the profitability and accuracy of the Gartley pattern are higher when the retracement levels are abided more closely. In the table, a larger threshold ***T*** = 0.15 exhibits a lower success rate and a generally lower return. When ***T*** is 0.15, most records have a negative return and a higher risk, as reflected by the CAGR and MDD. The claim would be more convincing if more samples of patterns could be collected.

6.3 Summary

In most situations, the frequency of the Gartley is low when the retracement levels of the pattern are strictly followed. From the results above, the number of trades is not greater than 10 in 4 years when the threshold ***T*** is 0.05. Although patterns with a higher similarity can be obtained, it leads to small sample size for testing the success rate and fewer trading opportunities for traders. In contrast, when a larger error is allowed (***T*** = 0.15), the algorithm can discover more entry points, but the trader is usually exposed to a higher risk.

In both the US stock market and Crypto market, when the ***deviation*** is below 1%, a pattern of diminishing success rates is observed as the ***deviation*** increases. A likely cause is that the Gartley pattern is more accurate for small up-and-downs. Small price movements are more likely to follow the Gartley pattern compared with larger movements. Larger movements are usually propelled by market news and the economic environment, so the Gartley pattern may often fail. In the backtest of SPY, when the ***deviation*** further increases and is higher than a specific value (1%), the success rate increases. For example, when ***T*** is 0.15 and ***deviation*** is 2%, 3%, or 4%, the success rate reaches

100%. It is discovered that all the trades are executed after the plunge in March 2020 (due to the outbreak of COVID-19 in the US) and take advantage of the skyrocketing bullish trend after the dip. Since the price is likely to move upwards, the success rate for patterns with large up-and-downs is high.

A problem observed in this strategy is that it fails to fully capture the profit from a strongly bullish trend. To maximize the gains in such a trend, the best strategy is to enter at the minimum point and exit at the maximum point. However, the nature of the strategy is to trade when a potential price reversal is recognized. The trade opportunity is low, and the program enters a trade at some points within the trend and exits early once the price targets are hit. Thus, it is much less profitable than the buy-and-hold strategy in a trending market.

Regarding risk management, the risk-to-reward ratio is sometimes inconsistent in the backtest. Although the rules for the entry, target, and stop-loss are fixed, the value of the ratio is not. On some occasions, the stop-loss, which is 1 ATR below the entry, causes the risk-to-reward ratio to higher than 1:1. As a result, it may further reduce the return.

In summary, trading the bullish Gartley pattern in a single instrument is ineffective in the three markets, owing to the rare occurrence and instability in predicting price movement.

7 Analysis of the Bullish Butterfly, Bat, and Crab in Different Markets

In the following section, the performance of other popular bullish harmonic patterns, including the butterfly, the bat, and the crab, is examined using the algorithm in Section 6. For each pattern, the performance in the US stock market is first examined, followed by the Forex market and the Crypto market.

7.1 Results

7.1.1 The Butterfly Pattern

Parameters			Evaluation Metrics			
max_count_time	T	deviation (%)	Number of trades	Success rate (%)	CAGR (%)	MDD (%)
Buy-and-hold strategy			-	-	16.29	-34.90
1600	0.05	0.25	1	100.00	0.28	-0.08
		0.50	0	-	0.00	0.00
		0.75	0	-	0.00	0.00
		1.00	0	-	0.00	0.00
		2.00	0	-	0.00	0.00
		3.00	0	-	0.00	0.00
		4.00	0	-	0.00	0.00
		5.00	0	-	0.00	0.00
	0.1	0.25	5	60.00	0.41	-1.02
		0.50	2	100.00	0.93	-1.07
		0.75	4	75.00	0.92	-1.54
		1.00	1	0.00	-0.39	-2.98
		2.00	0	-	0.00	0.00
		3.00	1	100.00	1.52	-2.46
		4.00	0	-	0.00	0.00
		5.00	0	-	0.00	0.00
	0.15	0.25	10	50.00	-0.26	-3.46
		0.50	5	60.00	0.67	-2.59
		0.75	6	50.00	-0.18	-5.71
		1.00	1	0.00	-0.39	-2.98
		2.00	1	100.00	1.12	-5.71
		3.00	1	100.00	1.39	-2.54
		4.00	0	-	0.00	0.00
		5.00	0	-	0.00	0.00

Table 6: Results of SPDR S&P 500 ETF Trust (SPY) using hourly data from Sept. 1, 2017, to Sept. 1, 2021

Parameters			Evaluation Metrics			
max_count_time	T	deviation (%)	Number of trades	Success rate (%)	CAGR (%)	MDD (%)
Buy-and-hold strategy			-	-	-0.06	-15.10
1600	0.05	0.25	2	50.00	0.08	-0.31
		0.50	0	-	0.00	0.00
		0.75	1	100.00	0.44	-1.23
		1.00	0	-	0.00	0.00
	0.1	0.25	7	57.14	0.53	-0.53
		0.50	1	0.00	0.08	-1.33
		0.75	1	100.00	0.41	-1.42
		1.00	1	100.00	0.45	-1.09
	0.15	0.25	18	44.44	0.44	-3.45
		0.50	2	50.00	0.21	-1.33
		0.75	3	100.00	0.71	-2.00
		1.00	1	100.00	0.40	-1.09

Table 7: Results of EUR/USD Currency Pair using hourly data from Sept. 1, 2017, to Sept. 1, 2021

Parameters			Evaluation Metrics			
max_count_time	T	deviation (%)	Number of trades	Success rate (%)	CAGR (%)	MDD (%)
Buy-and-hold strategy			-	-	77.71	-83.87
1600	0.05	0.25	7	57.14	0.39	-1.87
		0.50	5	60.00	0.84	-1.51
		0.75	4	50.00	0.46	-1.51
		1.00	1	0.00	-0.30	-1.18
	0.1	0.25	25	52.00	0.63	-5.69
		0.50	21	61.90	-0.69	-14.58
		0.75	18	38.89	-3.07	-17.78
		1.00	13	53.85	5.25	-7.54
	0.15	0.25	64	53.13	-0.62	-17.25
		0.50	50	54.00	-3.37	-27.37
		0.75	45	48.89	-4.35	-31.80
		1.00	42	44.19	4.76	-20.50

Table 8: Results of BTC/USD Currency Pair using hourly data from Sept. 1, 2017, to Sept. 1, 2021

In general, the number of trades is higher when the ***deviation*** is lower, and the MDD, and thus the risk, is higher when the error threshold ***T*** is higher. This is the same in other patterns, such as the Gartley, the Bat, and the Crab.

For SPY, most CAGRs are around 0 % to 1%, and the number of trades does not exceed 10. This may indicate that the occurrence of the butterfly pattern in the US stock market is not high.

For EUR/USD, in most settings, the number of trades is limited and not more than 3. There are two exceptions with 7 and 18 trades, respectively, but the success rates of them are not high, around 50%.

The CAGRs are all positive and higher than that in the buy-and-hold strategy.

For BTC/USD, the number of trades is significantly higher than those in the previous two markets. For example, when ***T*** is 0.15, each setting has the number of trades greater than 40, where the largest number of trades is 64 when the ***deviation*** is 0.25%. However, the success rates are around 50%, and some settings even have a negative CAGR, suffering from a net loss. It is also obvious that the risk in BTC/USD is higher than the other two instruments on average. The risk is highest when ***T*** is 0.15, where MDDs of -17.25%, -27.37%, -31.80%, and -20.50% can be observed.

In summary, the bullish butterfly pattern is not frequent in the US stock market and the Forex market. The annual return from this pattern is not high generally, and the accuracy in predicting price reversal is also not high enough.

7.1.2 The Bat Pattern

Parameters			Evaluation Metrics			
max_count_time	T	deviation (%)	Number of trades	Success rate (%)	CAGR (%)	MDD (%)
Buy-and-hold strategy			-	-	16.29	-34.90
1600	0.05	0.25	2	100.00	0.44	-1.32
		0.50	1	100.00	0.33	-0.04
		0.75	0	-	0.00	0.00
		1.00	0	-	0.00	0.00
		2.00	0	-	0.00	0.00
		3.00	0	-	0.00	0.00
		4.00	0	-	0.00	0.00
		5.00	0	-	0.00	0.00
	0.1	0.25	13	69.23	1.31	-4.87
		0.50	6	66.67	0.37	-3.10
		0.75	4	0.00	-1.85	-7.70
		1.00	2	0.00	-1.48	-7.16
		2.00	2	50.00	0.75	-2.10
		3.00	0	-	0.00	0.00
		4.00	0	-	0.00	0.00
		5.00	0	-	0.00	0.00
	0.15	0.25	31	67.74	1.58	-5.56
		0.50	13	76.92	1.71	-3.59
		0.75	9	22.22	-2.85	-12.60
		1.00	9	55.56	-0.81	-8.42
		2.00	3	66.67	1.56	-2.10
		3.00	1	100.00	1.37	-2.64
		4.00	0	-	0.00	0.00
		5.00	0	-	0.00	0.00

Table 9: Results of SPDR S&P 500 ETF Trust (SPY) using hourly data from Sept. 1, 2017, to Sept. 1, 2021

Parameters			Evaluation Metrics			
max_count_time	T	deviation (%)	Number of trades	Success rate (%)	CAGR (%)	MDD (%)
Buy-and-hold strategy			-	-	-0.06	-15.10
1600	0.05	0.25	3	0.00	-0.34	-1.48
		0.50	4	0.00	-0.19	-1.53
		0.75	0	-	0.00	0.00
		1.00	0	-	0.00	0.00
	0.1	0.25	21	38.10	-0.52	-4.28
		0.50	9	22.22	-0.30	-3.61
		0.75	1	100.00	0.33	-1.50
		1.00	0	-	0.00	0.00
	0.15	0.25	34	61.76	-0.92	-6.90
		0.50	9	22.22	-0.35	-3.74
		0.75	4	75.00	0.01	-5.13
		1.00	2	50.00	-0.61	-5.06

Table 10: Results of EUR/USD Currency Pair using hourly data from Sept. 1, 2017, to Sept. 1, 2021

Parameters			Evaluation Metrics			
max_count_time	T	deviation (%)	Number of trades	Success rate (%)	CAGR (%)	MDD (%)
Buy-and-hold strategy			-	-	77.71	-83.87
1600	0.05	0.25	27	81.48	1.94	-12.16
		0.50	17	47.06	-0.88	-12.11
		0.75	10	50.00	-0.85	-11.99
		1.00	10	20.00	-2.66	-10.21
	0.1	0.25	103	75.73	12.25	-9.74
		0.50	68	58.82	-1.41	-15.83
		0.75	47	57.45	2.07	-18.50
		1.00	45	60.00	6.94	-13.22
	0.15	0.25	215	66.98	1.69	-35.23
		0.50	144	59.03	-9.80	-43.78
		0.75	103	54.37	-4.61	-38.71
		1.00	85	52.94	-4.11	-39.98

Table 11: Results of BTC/USD Currency Pair using hourly data from Sept. 1, 2017, to Sept. 1, 2021

Different from other bullish harmonic patterns, a relatively higher occurrence for the bat is observed, as evidenced in the number of trades, in all three markets.

For SPY, the success rate is greater than 65%, and the CAGR is around 1% to 2% when ***T*** is 0.1 or 0.15, and the ***deviation*** is 0.25% or 0.5%. The bullish bat pattern can predict the price reversal with satisfactory accuracy and provide a certain amount of net return in this setting.

For EUR/USD, the CAGRs are around -1% to 0%. This is possibly due to the overall downtrend of EUR/USD. Thus, trading the bullish bat in a downtrend market may be unprofitable in the long run.

For BTC/USD, the number of trades is extremely high when ***T*** is 0.15, and the ***deviation*** is 0.25%, where the program enters 215 trades in total. The success rate around 60% to 65% is also acceptable, which offers a good prediction towards the price reversal. The CAGR depends on the value of the parameters. For instance, the CAGR can be as high as 12.25% when ***T*** is 0.1, and the ***deviation*** is 0.25%. It can also be as low as -9.80% when T is 0.15, and the ***deviation*** is 0.5%. The risk is also the highest among the three instruments on average, where the MDDs around -40% can be seen when ***T*** is 0.15.

In summary, the bullish bat pattern has a high success rate in both the US stock market and the Crypto market when the ***deviation*** is small. The occurrence of the pattern is extremely high in BTC/USD and gives a good prediction towards the future price movement.

7.1.3 The Crab Pattern

Parameters			Evaluation Metrics			
max_count_time	T	deviation (%)	Number of trades	Success rate (%)	CAGR (%)	MDD (%)
Buy-and-hold strategy			-	-	16.29	-34.90
1600	0.05	0.25	0	-	0.00	0.00
		0.50	0	-	0.00	0.00
		0.75	0	-	0.00	0.00
		1.00	0	-	0.00	0.00
		2.00	0	-	0.00	0.00
		3.00	0	-	0.00	0.00
		4.00	0	-	0.00	0.00
		5.00	0	-	0.00	0.00
	0.1	0.25	4	50.00	0.51	-3.37
		0.50	2	50.00	0.09	-1.66
		0.75	0	-	0.00	0.00
		1.00	0	-	0.00	0.00
		2.00	0	-	0.00	0.00
		3.00	0	-	0.00	0.00
		4.00	0	-	0.00	0.00
		5.00	0	-	0.00	0.00
	0.15	0.25	10	60.00	0.54	-3.37
		0.50	4	75.00	1.16	-1.66
		0.75	1	0.00	-0.67	-4.09
		1.00	1	0.00	-0.67	-4.09
		2.00	0	-	0.00	0.00
		3.00	0	-	0.00	0.00
		4.00	0	-	0.00	0.00
		5.00	0	-	0.00	0.00

Table 12: Results of SPDR S&P 500 ETF Trust (SPY) using hourly data from Sept. 1, 2017, to Sept. 1, 2021

Parameters			Evaluation Metrics			
max_count_time	T	deviation (%)	Number of trades	Success rate (%)	CAGR (%)	MDD (%)
Buy-and-hold strategy			-	-	-0.06	-15.10
1600	0.05	0.25	2	0.00	-0.40	-1.73
		0.50	0	-	0.00	0.00
		0.75	0	-	0.00	0.00
		1.00	0	-	0.00	0.00
	0.1	0.25	6	33.33	-0.41	-2.26
		0.50	0	-	0.00	0.00
		0.75	0	-	0.00	0.00
		1.00	0	-	0.00	0.00
	0.15	0.25	13	38.46	-0.42	-3.60
		0.50	0	-	0.00	0.00
		0.75	1	100.00	0.57	-0.43
		1.00	0	-	0.00	0.00

Table 13: Results of EUR/USD Currency Pair using hourly data from Sept. 1, 2017, to Sept. 1, 2021

Parameters			Evaluation Metrics			
max_count_time	T	deviation (%)	Number of trades	Success rate (%)	CAGR (%)	MDD (%)
Buy-and-hold strategy			-	-	77.71	-83.87
1600	0.05	0.25	5	60.00	-0.17	-2.08
		0.50	4	75.00	1.33	-4.51
		0.75	3	66.67	1.63	-3.44
		1.00	1	100.00	1.60	-0.59
	0.1	0.25	48	66.67	2.86	-13.64
		0.50	25	64.00	0.00	-13.20
		0.75	15	60.00	2.19	-11.91
		1.00	12	75.00	4.21	-14.84
	0.15	0.25	103	64.08	1.33	-17.94
		0.50	62	69.35	3.11	-13.13
		0.75	35	71.43	8.77	-22.00
		1.00	30	70.00	6.44	-24.69

Table 14: Results of BTC/USD Currency Pair using hourly data from Sept. 1, 2017, to Sept. 1, 2021

For both SPY and EUR/USD, the number of trades in different settings is less than 10 on average.

For BTC/USD, the number of trades is sufficient for a larger $\boldsymbol{T}$. It is also observed that the CAGRs are all positive, except for the first row. This suggests that the bullish crab pattern can be a good price reversal indicator in a strongly bullish market. For one, the last two rows have CAGRs of 8.77% and 6.44%, respectively. Same as the previous patterns, BTC/USD has the highest MDD and risk on average among the three instruments.

7.2 Summary

For both SPY and EUR/USD, the most traded instruments in the US stock and the Forex market, respectively, it is observed that all the examined bullish harmonic patterns, including the Gartley, the butterfly, the bat, and the crab, are relatively infrequent. This leads to a low number of trades. Thus trading with these patterns alone may not be highly profitable.

Nevertheless, in the Crypto market, the occurrence of all patterns is higher. A plausible reason is that the price volatility in BTC/USD is higher compared with the other two instruments, which is more likely to result in the formation of harmonic patterns.

Another observation is the bullish bat pattern has the highest occurrence among all the harmonic patterns in all markets. The success rate of it is also high, usually higher than 60%, for the US stock market and the Crypto market when the deviation of the Zig Zag indicator is low (0.25% or 0.50%). This suggests the bullish bat pattern can be a good indicator in an upward trending market.

Finally, for the crab pattern, it is discovered that nearly all CAGRs, in different parameter settings of the error threshold ***T*** and the ***deviation***, are positive. This may signal that the bullish crab pattern can also be a good indicator for price reversal in a strongly bullish market.

8 Conclusion

In conclusion, traders should not use harmonic patterns as their trading strategy. The backtests results indicate that the passive, buy-and-hold strategy yields a higher CAGR in both the US stock and the Crypto market. For the Forex market, despite possibly outperforming the buy-and-hold strategy, using harmonic patterns alone still has a small annual return and underperforms the strategies used by typical Forex traders. It signals that trading the bullish harmonic patterns is not profitable.

The major drawback of trading the harmonic patterns is the low occurrence of these patterns, which provides few trading opportunities. Another perceived problem regarding harmonic patterns is that it could still be subjective for traders to find swing highs and swing lows for drawing these patterns, even though the patterns offer an objective measure for the retracement levels by using the Fibonacci retracement tool.

Nevertheless, it is discovered that, in an upward trending market, the bullish harmonic patterns, especially the bat, and the crab, can potentially indicate a potential price reversal. It is suggested that traders may identify trading opportunities by the confluence of harmonic patterns and other technical analysis tools, such as the moving average, relative strength index, and Bollinger Bands, in their strategies.

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