Searching for Head and Shoulders Bottom Patterns under Directional Changes

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Abstract

Head and Shoulder pattern is a well-known technical trading strategy. However, what exactly constitutes a Head and Shoulder pattern under time series is sometimes ambiguous. In this thesis, we show how this pattern can be rigorously defined by using Directional Change. Directional Change is a new way to summarise price changes in the market. It records a transaction price only when the market has moved into an opposing direction by a significant degree, and where that margin of significant movement is defined by the observer. Unlike time series, Directional Change records data at irregular points. This thesis also shows how Head and Shoulder Bottom Patterns can be recognised by using Directional Change. Presenting a precise definition of Head and Shoulder pattern, therefore allows us to rigorously examine the effectiveness of a Head and Shoulder based trading strategy.

Content

1. Introduction

Technical analysis is regarded as an efficient way to study the price movements and volatility of the financial market, and its findings form a credible guide to future market behaviour. It is therefore by studying historical price changes which could then guide us to an estimate of possible future market movements. According to the study of the past price actions, many different technical chart patterns and indicators have been created to analyse the price movement of the financial market. One of the leading technical chart patterns is the Head and Shoulders Bottom Pattern (HSBP). This pattern has attracted attention from technical analysts in the financial market. It has also been much used by technical traders as an essential and important trading strategy.

Head and Shoulders Bottom Pattern (HSBP) is a well-known technical chart pattern and widely used in analysing and forecasting the behaviour of the price movements in the future. Under technical trading, when a technical trader confirms a HSBP from a technical chart, it indicates an upward reverse of the tendency in the price movement. Head and Shoulders Bottom Pattern had been widely introduced in many technical manuals [6, 20, 21]. However, the lack of an unambiguous definition of HSBP makes it difficult to recognise and therefore to evaluate the HSBP trading strategy scientifically. Hence, in this thesis, we will propose a rigorous definition of HSBP and introduce how HSBPs are recognised based on this accurate and reliable definition.

1.1 Introduction of previous works on HSBP

Head and Shoulders Bottom Pattern is a reversal chart pattern which was

initially introduced by Richard W. Schabacker [20, 21]. Schabacker introduced the concept of HSBP as being a reversal chart pattern which can help investors to forecast future price movement. Based on the work of Schabacker, Edward and Magee systematically introduced the process of the formation of an HSBP. They illustrated the relationship between the behavior of historical price movements and the formation of HSBP, and how to implement the trading strategy with HSBP [6].

Building on the work of Schabacker and Edward and Magee, analysts worked on the further research of technical patterns. Robert A. Levy (1971) summarised thirty-two possible forms of five-point chart patterns such as Channels, Double Bottom Pattern and Head and Shoulders Pattern, which included the most significant formations of the different price movements [11]. He implemented experiments that were used to test the effectiveness of these patterns for forecasting future price movement. Although the result was not satisfactory, his study methods could be used as a way to recognise the complicated chart patterns. Levy indicated five reasons for the difficulty of conducting research using chart patterns, and one of the main reasons was that with pattern recognition there is no unambiguous definition of the complicated pattern.

Osler and Chang (1999) implemented a test to evaluate the trading strategy using the Head and Shoulder Top Pattern in the Forex market, while the results were not profitable compared with other trading strategies of technical indicators [16]. In addition, Charlie and Julie (2016) illustrated that it is hard to quantify and rigorously test the chart patterns, because the theory of chart patterns was created by the experience and skill of the analysts [10]. Indeed, complex chart patterns such as Head and Shoulders Pattern is a nonlinear pattern, and there is

no fixed defining structure to quantify the shape of Head and Shoulder Pattern.

Richard W. Schabacker and Edwards and Magee have summarised the behaviour of historical price movements and proposed the concept of standard chart patterns such as HSBP. Especially, they have presented how a HSBP is formed by the historical price movements. Besides, Edwards and Magee went on to further illustrate HSBP trading strategy in practice. However, they did not present a rigorous HSBP definition to quantify this graphical chart pattern. Therefore, what is a valid HSBP mainly depends on the experience and skill of technical analysts. In addition, Osler and Chang evaluated the trading strategy of Head and Shoulders Top Pattern (HSTP), but they only presented a verbal definition of HSTP.

1.2 Research Aim and Objectives

This research aims to propose a rigorous definition of Head and Shoulders Bottom Patterns (HSBP) based on the method of Directional Change. Having a precise definition of HSBP will then allow us to evaluate the effectiveness of a HSBP based trading strategy. This thesis proposes the following steps to realise our objective of HSBP definition.

1. Summarise the graph of Head and Shoulders Bottom Pattern into seven reversal points (Chapter 3).
2. Determine these seven reversal points using the Directional Change method (Chapter 4).
3. Based on the seven reversal points, develope seven mathematical and logical HSBP conditions to limit the positions between these seven reversal points in the chart (Chapter 4).

4. Given the achievement of a rigorous definition, evaluate the effectiveness of a trading strategy using HSBP (Chapter 5).

1.3 The contributions of this research

This research mainly includes two parts:

1. The research defines HSBP through mathematical and logical conditions with the extreme points found by Directional Change.
2. The rigorous definition allows us to evaluate the HSBP trading strategies scientifically. Anyone who uses the same DC threshold, the same HSBP (six) conditions that we defined, and the same (three) trading rules, they will achieve consistent results.

1.4 The experiment of this project

The experiment aims to examine the effectiveness of HSBP recognition and a HSBP trading strategy through back-testing. In this back-testing, we selected the daily closing prices from 100 stocks in the time scale of ten years. However, this project aims to build a rigorous definition of HSBP rather than arguing for the profitability of a HSBP trading strategy. So, there are no stipulations in the selection of raw data.

According to the aim of the experiment, we developed a program called SH-1 to recognises HSBP and executes trading decisions. SH-1 recognised 67 HSBPs and opened long positions. Eventually, SH-1 closed 49 positions at the target of the return rate, and 18 positions were closed for stop loss. The results demonstrated that the program SH-1, which is based on the HSBP definition, is effective for recognising HSBPs.

2. Background

2.1 Early development of technical analysis

The American journalist Charles Dow (1851-1902) has been acknowledged as the pioneer who developed the field of the modern technical analysis. Although there were other early contributors to the concept of technical analysis, certainly Charles Dow was the founder of modern technical analysis. The core of the contribution of Charles Dow to the field of modern technical analysis is his classic theory. The fundamental Dow theory is that of general market trends, and based on this theory, the first stock index was created. The Dow Jones Industrial Average (DJIA), which is both the earliest, and still the major industrial index, was created by Charles Dow on May 26, 1896 [4, 18]. Charles Dow initially selected 12 representative stocks as the components of DJIA, which had the aim of helping investors to monitor the general trend of the stock market. In 1916, DJIA completed the first expansion of stock numbers so that the components of DJIA increased to twenty companies [4]. By 1928, DJIA had risen to the second expansion of thirty stocks, which it maintains to this day.

The main consideration of Dow Theory is the behaviour of the price movements, which is generally defined in four main parts: Bottom, Uptrend, Top and Downtrend [6, 8]. So, when the price moves up to the peak, there will be a downtrend to follow and so on. Dow's ideas on financial analysis went on to be developed by others, in 1922, William Peter Hamilton had a detailed introduction to Dow's theory in his book "The Stock Market Barometer" [8]. He

indicated that the DJIA works like a barometer which had the ability to show the current circumstance of the stock market and what the future situations of the stock market would be. Hamilton believed that DJIA was already involved in measuring all the influential factors of the stock market, and that it is pointless to compare other information with the DJIA in order to read the market accurately.

Dow theory summarised three main price trends of the market, which comprises of three general movements of stock prices — primary movement, secondary movement and daily fluctuation [6, 19, 23]. The primary movement represents the primary uptrend or downtrend in prices which normally have activity over four to six years. The secondary movement is a sharp reaction from a primary bull market or a sharp rally in a primary bear market, which usually underwent the periods from ten to sixty days. The daily fluctuation exist throughout every trading day. Based on the theory of the three types of trends, Dow believed that there was a recurrence of the financial market around every ten years, and in this period, the market will experience a peak and a valley in this long term. Dow assumed that the market exists in two main parts: the first is the bull market which indicates the price rise from the bottom, and the second is the bear market, which means that the price drops from the peak [6].

The chart Pattern was originally mentioned by Charles Dow. Initially, chart patterns were determined by the combinations of repetitive price trends (uptrends and downtrends) which delivered the regular signals to indicate the future price movements. In the 1930s, Richard W. Schabacker comprehensively introduced Technical Analysis in Charts and Patterns in his trading class and books [20, 21]. He presented a straightforward and precise definition to conclude what a

stock chart consist of, ‘A stock chart is a pictorial record of the trading history of any stock or group stocks’. Compared with fundamental analysis, Schabacker emphasised that technical chart action was another way to analyse the stock market. Also, Schabacker thought the study of chart reading aimed to discover and summarise the standard chart patterns which frequently and unanimously appear. These standard chart patterns help analysts forecast future price movement. In addition, he made great contributions to the development of technical chart patterns. Some famous patterns such as Triangle and Head and Shoulders Patterns were created by him.

One of the other important contributions in the history of technical analysis was *Technical Analysis of Stock Trends* which was published by Edwards and Magee in 1948 [6]. Edwards and Magee, based on the research of Richard W. Schabacker and their extensive experience, discussed several significant chart patterns in particular, which not only introduced the basic concepts of these patterns but also illustrated the practical application of technical patterns with the trading strategies. They discussed how the reversal patterns like Head and Shoulders Patterns were formed, and why there needs to be time to form a standard pattern. Particularly, the authors illustrated the reasons through the points of view of trading behaviour and market psychology to present the trading processes between the buyers and sellers, and finally the result of the formation of a particular pattern in a time period. And many technical manuals have continued to introduce the theory of technical chart patterns based on the works of Richard W. Schabacker and Edwards and Magee [6, 20].

2.2 Technical analysis with computer application

As a consequence of the development of personal computers in the 1970s, technical analysts started to study the market activities through mathematical methods, and consequences of these new research were called technical indicators by technical traders [10]. Technical indicators have been used to measure the market activities crossing different aspects such as Support and Resistance, Trend, Momentum, etc. Indicators such as Moving Average (MA), The parabolic stop and reverse (SAR), Relative Strength Index (RSI), etc. were the main pointers that investors widely used to analyse the market price.

The moving average is one of the most well-known and versatile indicators [1, 2, 5, 10, 14]. It is widely used in analysing price movements in the market. Because the price is constantly moving in a volatile way in the financial market, it is difficult to track the tendency of a trend. However, the moving average is a useful method which smooths out those minor volatilities on a trend, so that it will be beneficial for traders who can clearly view a major trend, rather than a minor one. The basic rule for the moving average is to calculate the average of the closing prices in the regular period. Additionally, the closing price is the price at the end of the time interval. For example, a ten minutes interval of a stock chart presents the closing prices at the end of every ten minutes interval.

The prime moving average indicator is the simple moving average(SMA), while there are several extended versions which have developed, based on SMA such as Weighted Moving Average(WMA) and Exponentially Smoothed Moving Average(EMA) [5, 10]. SMA is calculated by the sum of the closing price of a length of a period and then divide the length. For instance, to generate a 30-days

SMA under the chart of daily closing price, we need the sum of the 30 closing prices and then to divide the total by 30. Hence, Moving Average is an efficient way to eliminate the short-term fluctuations from a long time trend. For example, a 60-days moving average may filter the daily volatility. Moreover, the SMA has been developed over several successful periods by technical analysts, such as the periods of 200 days, 60 days, 30 days, 20 days and 10 days. In fact, various periods imply different purposes of tracking the price trends. Normally, analysts use 200-days SMA to trail a yearly price trend, and 30-days SMA to observe a monthly price trend.

In practice, analysts usually generate multiple moving averages with different lengths to confirm each entry and exit of every trend. For example, comparing 60-days SMA with 200-days SMA is a strategy to monitor the reversal of long periods. If the 60-days SMA cross down the 200-days SMA, an entry of yearly trend can be confirmed. On the other hand, if the 60-days SMA cross up the 200-days SMA, an exit of yearly trend can be determined (See figure 1). In addition, Charles and Julie indicated in their book that there were already tests by Brock, Lakonishok, and Lebaron (1992) published their paper which confirmed that Moving Averages have a statistical significance [10].

Figure 1. An example of 60-days SMA(Blue Line) and 200-days SMA(Red Line).

J. Welles Wilder, Jr. is one of the analysts who created several significant technical indicators in 1978 after his research of many years in the market [27]. Even today, these indicators such as the parabolic stop and reverse (SAR), the directional movement (DM) and relative strength index (RSI) have been widely used by technical traders.

The relative strength index (RSI) is the most popular indicator which was developed by J. Welles Wilder. RSI measures the velocity of the directional price movement (the ratio of price rise and price fall) in a specific time period. Welles Wilder created the equation of the Relative Strength (RS) which compare the closing prices of up and down over a previously specific period to gauge the velocity of the prices up and down. According to his original equation, relative strength (RS) is the average of the closed up of 14 days divided by the mean of the closed down of 14 days [27]. The reason for using 14 days is because it is an average half-cycle period.

RSI was developed based on RS, but it gives a range from 0 to 100, which is evident to scale the level of the index movement. There were two significant points that Welles Wilder concluded on RSI. First, it can indicate the tops and bottoms of RSI which are defined by the two levels of overbought (70) and oversold (30). So, when the index crosses above 70, there is an overbought signal in the market. However, if the index crosses below 30, the signal will warn of an oversold. Overbought and oversold mean that the price rising or decreasing is at an extremely high point or low point currently. So, when the index reaches the levels of overbought and oversold, there has to be a higher probability that the price will be a reversal (See figure 2). Second, the chart formations that RSI can form are technical patterns like triangles, flags, and head-and-shoulders. For example, RSI can form a head and shoulder pattern which can predict the price movement in the future.

Figure 2. An example of RSI.

3. Literature Review

3.1 Previous Work

Head and Shoulders Bottom Pattern (HSBP) is a recognised chart pattern used in technical analysis. It is an important reversal pattern which has the ability for forecasting the reverse of the trend from downward to upward. Technical analysts have used and applied HSBP as a reliable trading strategy to open a long position, but this can only be done when the HSBP pattern is confirmed.

The concept of Technical Pattern is developed based on charts, and in a chart, a pattern is formed by the repetitive price trends. So, this chapter will review the past study of technical analysis. It introduces the basic concept of what is a chart, and then what are general price trends. In the second part of this chapter, we will introduce the Head and Shoulders Pattern, which is the core subject of this thesis. Finally, an explanation of the method of Directional Change will be introduced, which is the main approach to be applied in the recognition of HSBP.

3.2 Chart

In technical analysis, a chart is simply a pictorial record of the financial market's trading history using data. It is a timed tool that shows graph prices and other important trading indicators over recognised time periods of a chosen section of the market [5, 20, 21].

Technical charts record the trading data in the different time frames. For example, a daily chart is plotted by the use of the daily closing prices. A long period chart such as those recorded weekly and monthly are normally used in

analysing long periods, while by contrast minutes or hours charts are used in studying intraday price.

Today there are several types of the charts which form the price series over a given time period such as line charts, bar charts, candlestick charts, Kagi charts, Renko charts, etc [5, 10]. But line charts, bar charts, and candlestick charts are the most common types of charts in technical trading.

3.2.1 Line Charts

The line chart is the simplest chart. It usually shows a graph of a series of the prices of the specific time periods [5, 10]. Normally, analysts consider the closing price as the prime data in the line chart. However, a line chart is limited because it only illustrates one price variable over the time period under consideration, which is a weak chart for the analysis of the behaviour of the price volatility in each of the time intervals.

Figure 3. An example of a line chart. (Daily)

3.2.2 Bar Charts

Under a specific time frame, the open price is the price at the start of the time interval under consideration. The closing price is the price at the end of the time interval. The high and low prices are the highest and lowest prices in each time interval.

Bar charts (OHLC) are a common type of financial chart [5, 10]. It presents open, high, low, and closing prices (OHLC) into a single bar at every time interval. Compared with line charts, bar charts present more information of the prices under consideration. It represents a set of data (OHLC) in every time interval that is advanced for analysing the price range.

Visually, a body of price bar comprises two horizontal lines and a vertical line. To be specific, the vertical line shows the price range in a time interval. The left horizontal line indicates the open price, and the right horizontal line indicates the closing price. (See figure 4)

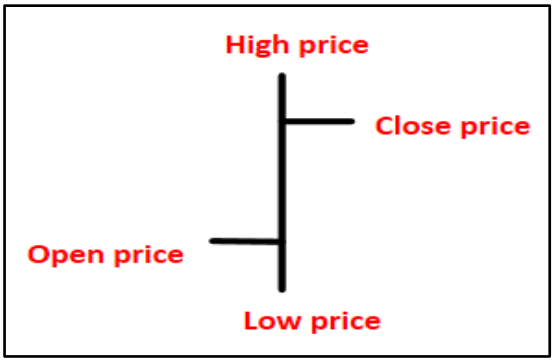

Figure 4. An example of a single bar chart.

Figure 5 is an example of a daily bar chart that indicates the OHLC at every single daily bar. The bar chart presents the price volatilities at each of the single bar, which is advantageous for analysing the price movement in the short term.

In fact, many technical indicators developed are based on the OHLC Chart, such as Parabolic stop and reverse (SAR) and Directional Movement (DM) [27].

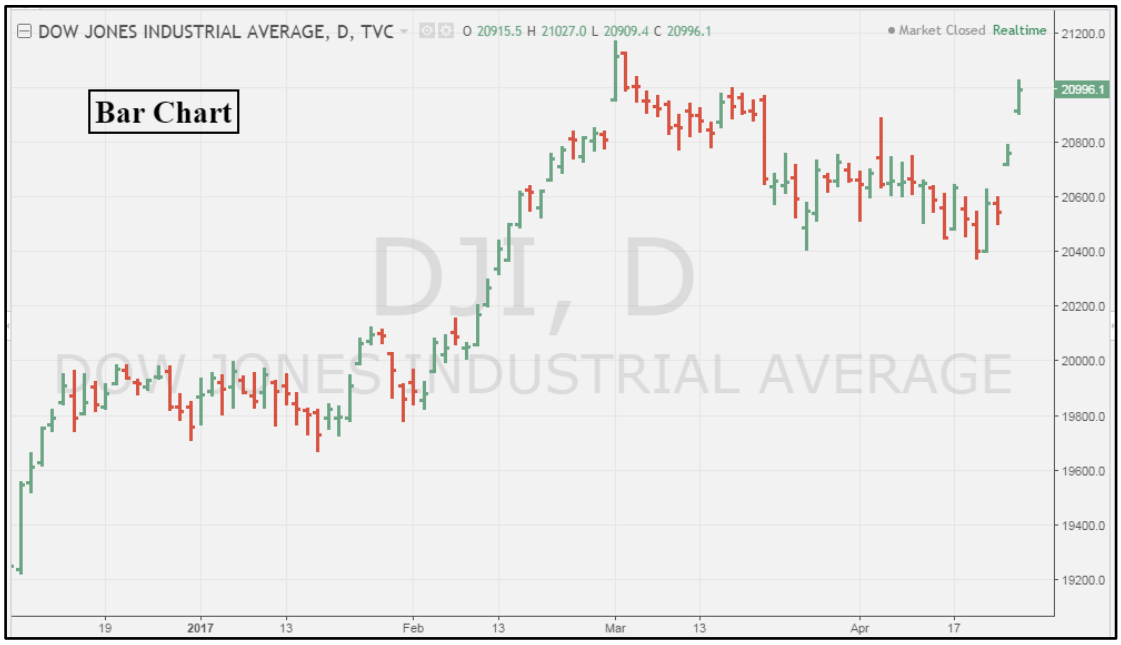

Figure 5. An example of a bar chart. (Daily)

3.2.3 Candlestick Chart

Candlestick charts or the candle chart is a Japanese chart which was developed by Munehisa Homma in the 18th century, and in 1989, Steve Nison introduced the technique of Japanese candlestick charts to the western financial world [15].

Candle charts also show a set of the four prices data (OHLC) on a single candlestick [13, 15]. The real body of a candle is defined by the range between the open and closing price, and the shape of a real body is formed by a rectangular box (See figure 6). Generally, the filled body indicates that the closing price is lower than the open price, and the empty body means that the closing price is higher than the open price (Some trading systems prefer the red and green colours to replace the filled and empty bodies).

The shadow is defined by the two thin lines, which indicate the price extremes. So, the thin line above the real body is called upper shadow, while the thin line below the real body is called lower shadow. At the top and bottom of the thin lines are the highest prices and the lowest prices. In some extreme cases, if there are no upper shadows (the close price is equal to the high price), the shapes of the candles are called shaven heads. However, if there are no bottom shadows (The close price is equal to the low price), the shapes of the candles are called shaven bottoms.

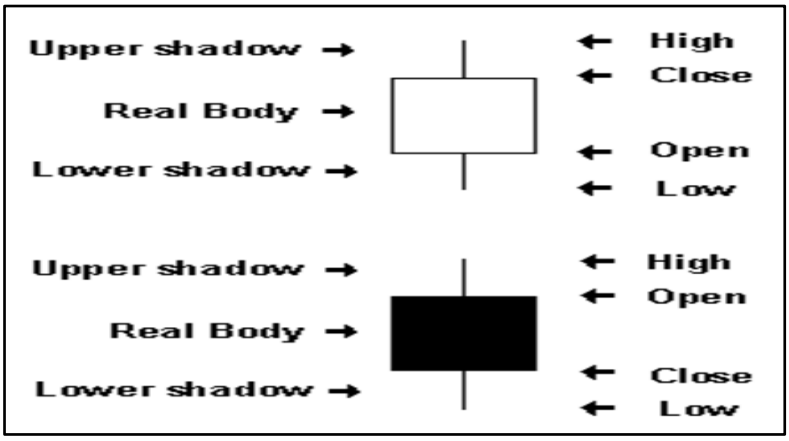

Figure 6. An example of the filled candle and empty candles. (Source: StockCharts.com)

3.3 Trends and Price Movements

According to the Dow theory, the price movement includes four main parts: Bottom, Uptrend, Top and Downtrend. These four main parts illustrate the fundamental behaviour of the price movement [6, 10, 19].

An uptrend is confirmed when the price reaches a higher peak or a higher trough. A downtrend is confirmed when the prices reach a lower peak or a lower trough [10]. In fact, it is difficult to define an uptrend or downtrend in the real-time market because the price movement is unstable.

A top or a bottom is confirmed when the direction of a trend tendency is reversed. Hence, the behaviour of the price movements follows an iterative cycle which is based on the four main steps.

In technical analysis, a consecutive up or down movement in prices confirms uptrends or downtrends. Analysts usually draw a line or a curve to express a tendency of a trend precisely.

3.4 Chart Pattern

In the early use of technical analysis, the main topics of technical analysis are around charts and chart patterns [3, 6, 9, 10, 12, 21]. A chart pattern (or formation) is a standard pattern that frequently appears in the historical chart and represents the signal of the future price movement.

In technical analysis, the price movements are based on the supply and demand in the financial market. A support level is a price level that has strong buying demands to prevent the price decline. Traditionally, chart patterns are divided into two major groups, those of continuation and reversal.

3.5 Reversal Chart Patterns

A reversal chart pattern is a pattern that illustrates a reversal of a price trend [2, 6, 14]. Reversal patterns have been developed in the past century. Many reversal patterns, such as head and shoulders, double top and double bottom have been widely applied in technical analysis.

The forming of reversal chart patterns is based on the principle of support and resistance levels [1, 6, 10, 21]. A resistance level is a price level that has strong

selling supplies that prevent the price rise. In general, trends or curves express the price movements in a period. The trends move up or down in the range of support and resistance levels. The reversal pattern is formed when the price breaks the level and moves in the opposite direction.

3.6 Head and Shoulders Pattern

The head and shoulders pattern (HSP) is one of the important reversal patterns. It indicates that a reversal signal of the price trend has taken place when the pattern is observed [1, 2, 3, 5, 6, 9, 10, 12, 14, 21, 22].

The concept of HSP has been introduced by much technical analysis over decades. It is a leading reversal pattern. HSP is a nonlinear chart pattern that contains four main parts: Left Shoulder, Head, Right Shoulder, and Neckline.

There are two types of formations on head and shoulders patterns that are distinguished by the reversal directions. A Head and Shoulders Top Pattern (HSTP) is usually observed after a solid climb in price, and the price turns down once the HSTP is confirmed. A Head and Shoulders Bottom Pattern (HSBP) is formed at the bottom of a downtrend. It indicates an upward reverse when the HSBP is determined.

3.6.1 Head and Shoulders Bottom Pattern (HSBP)

Head and Shoulders Bottom Pattern is an important reversal chart pattern. The pattern indicates an upward signal when it is confirmed. There are many descriptions that introduce HSBP in the form of descriptions by word analysis, while the definition of HSBP is weak and not precise. The definition is based on the movements of up and down trends that form HSBP. However, the further

issue of how to determine these uptrends and downtrends is not clear according to public references of technical analysis.

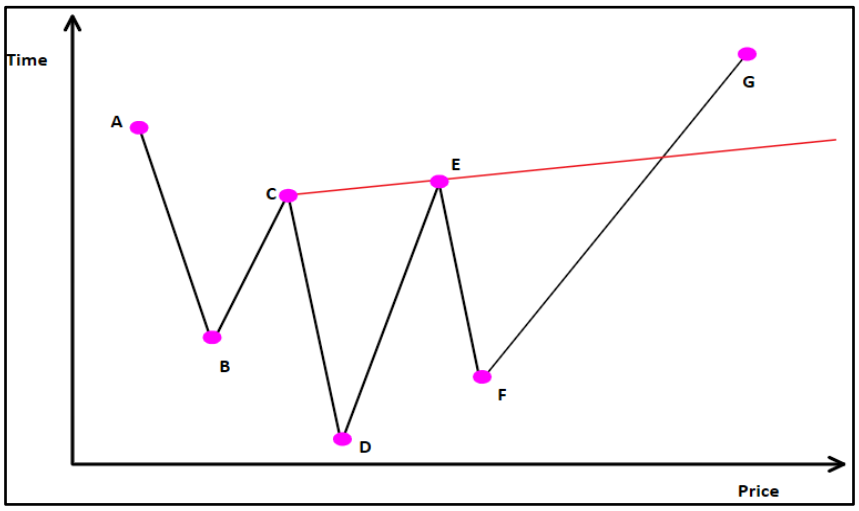

Figure 7. An example of HSBP.

3.6.1.1 Left Shoulder

The formation of left shoulder illustrates a minor reverse of the price movement after a major downturn. It is the first part of HSBP on the left of the body. Figure 7 presents an example of HSBP. At the beginning of the left shoulder, line AB indicates a downtrend and the tendency end at the first bottom point B. A rally is observed that the price reaches to the first top point C. So, the formation of left shoulder finishes at the point C. Note, the bottom point B and the top point C indicate the support point and the resistance point respectively.

3.6.1.2 Head

A head shape appears in the middle of the body following the left shoulder. The trend turns down when it meets the resistance point C. The decline of the price even exceeds first bottom point B until it meets the second support point D.

Then the downtrend recovers and climbs until it meets the second resistance point E in figure 7 (end of the Head). Note, if the direction of downtrend CD recovers but the bottom point D is higher than the point B, the process of the forming of HSBP would then be failed.

3.6.1.3 Right shoulder

The uptrend DE would terminate at the second resistance point E, trend down again. The right shoulder follows the head which starts from the point E, and the price moves downward until it meets the third support point F. Then, the direction of the trend reverses and move up to meet the neckline.

3.6.1.4 Neckline

The neckline is the important part of HSBP; it decides whether an HSBP could be confirmed. If the price rises from point F and crosses up the neckline, an HSBP can be determined. The neckline is defined by the conjunction of the first and second resistance points. In Figure 7, the line which joins point C and E has therefore defined the neckline.

3.7 Directional Change

The research that is being carried out and reported in this thesis is based on the idea of Directional Change (DC) [7, 26], and its effective use to fully describe an HSBP. Under technical charts, the price movements are graphed based on the use of time series analysis. In time series, every price point is plotted at a fixed time period. For instance, a stock chart with the hourly time frame only plots the stock price at the end of every ten minutes. However, the shapes of the reversal

chart patterns are constructed by several up and down trends, and these trends are determined by the bottom and top points (See figure 7). Under time series, there are no effective solutions to determine the bottom and top points because we cannot confirm the accurate time points by which the trends will be reversed. But according to our research, these bottom and top points of the trends can be best determined by using DC analysis rather than time series analysis.

3.7.1 Directional Change (DC) events

DC is an alternative way of summarising price changes in the financial markets. It has the ability to summarise the extreme points precisely, in contrast to time series analysis, which is tied to rely on the time frame rather than only focusing on the market prices movements, as is the case with DC. DC provides a close analysis tied to market movements. DC can confirm an extreme point when the price has changed by a significant margin (The significance being defined by analysts). So, in the financial market, when the price rallies to a given threshold from the bottom, a downtrend can be concluded. By contrast, when the price declines to a given threshold from the top, an uptrend can be confirmed. Therefore, under the DC theory, the behaviour of the price movement is illustrated by a sequence of uptrends and downtrends.

Directional Change Events comprise DC Upturn Event and DC Downturn Event. An Upturn DC Event is confirmed when the price has risen from the last trough by a certain threshold. A downturn DC Event is confirmed when the price has dropped from the last peak by a certain threshold. A DC Confirmation Point (DCCP) is placed at the end of every DC Events. DCCPs confirm the start of the new uptrend and the downtrend.

Overshoot Events conclude Upward Overshoot Event and Downward Overshoot Event. Once the DCCP confirms the new trend, the current trend enters Overshoot Event. So, a DCCP indicates the start of an upward overshoot event or a downward overshoot event. A DC Extreme Point (EP) indicates the end point at each uptrend and downtrend. In the uptrend, an EP is confirmed when the price drops from the highest point by a certain threshold. In the downtrend, an EP is determined when the price rises from the lowest point by a certain threshold. Hence, EPs indicate the conjunction point between the uptrend and downtrend.

3.7.2 A more formal definition of DC

The formal DC definition was introduced in Tsang (2010) [26]. The idea of DC definition is based on DC Events. According to Tsang et al (2016) [24], DC is a data-driven concept, where the price change dictates the recording of the price of the market, and where the researcher decides on the threshold that is significant. This captures the market's uptrends and downtrends. According to Tsang (2015) et al [25], a DC event takes two forms – a downturn DC event or an upturn DC event, and there is a downward run which is located between a downturn DC event and the next upturn DC event, while by contrast an upward run is between an upturn DC event and the next downturn DC event.

In an uptrend, Ph is a variable which continuously updates the highest price once the current price Pc exceed the previous highest price. When the current price Pc turns down and drops lower the Ph by a given threshold θ or more, a downturn is confirmed:

$$Pc \geq Ph * (1 + \theta) \quad (1)$$

Therefore, the Ph names the DC Extreme Point (EP), and the Pc is called DC Confirmation Point. The interval between the Ph and Pc is the Downturn Directional Change Event.

In a downtrend, Pl is a variable which continuously updates the lowest price once the current price Pc is lower than the previous lowest price. When the current price Pc turns up and rises higher the Pl by a given threshold θ or more, an upturn is confirmed:

$$Pc \geq Pl * (1 + \theta) \quad (2)$$

Therefore, the Ph names the DC Extreme Point (EP), and the Pc is called DC Confirmation Point. The interval between the Ph and Pc is the Downturn Directional Change Event.

3.7.3 The process of Directional Change

The procedure of DC is based on a sequence of uptrends and downtrends. An uptrend comprises Upturn Directional Change Event and Upward Overshoot Event. In contrast, a downtrend comprises Downturn Directional Change Event and Downward Overshoot Event. In an uptrend, the previous downtrend extreme point (EP) can be defined by the lowest price Pl, and the current uptrend DC confirmation point is defined by the current price Pc. In a downtrend, the previous uptrend extreme point (EP) can be defined by the highest price Ph, and the current downtrend DC confirmation point is defined by the current price Pc.

Figure 8 is an example of the DC summaries in a period of the price movement. In the chart, DC summarises three complete trends in which two downtrends and one uptrend are observed. In the event under study, three DC events were

observed by a given threshold of 0.005% (Red line arrows). In our opinion, it is obvious that DC summarises the uptrend and downtrends precisely. In contrast, a given fixed time interval hardly catches all the trends because the reversal points (Extreme points) are appearing irregularly, and can be missed.

Hence, the difference between the use of time series and DC summaries are the following: under time series, the determinations of the price changes are limited to the time intervals that they occur in, which is non-effective to observe the erratic reversal points. Unlike time series, DC summarises the reversal points based on the threshold that only occurs when the price reverses to reach a certain threshold, so a trend can be determined.

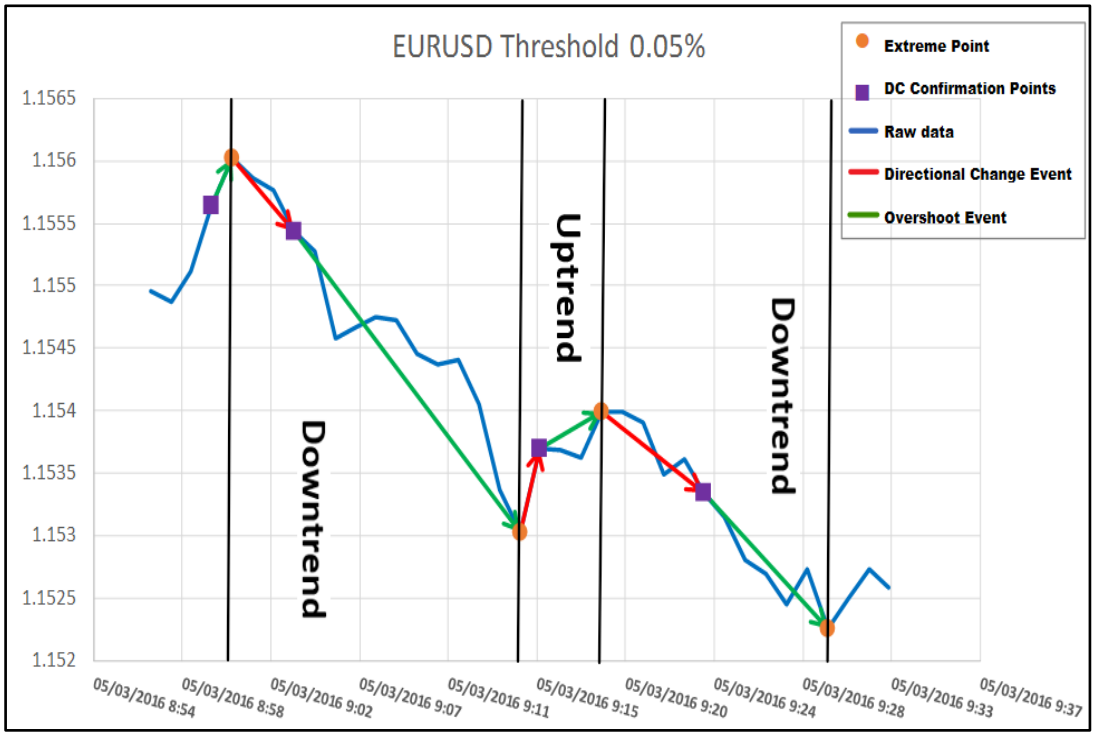

Figure 8. an example of the DC summaries.

4. Head and Shoulders Bottom Pattern (HSBP) Conditions with Directional Change

The objective of the research is two fold, it first constructs a precise definition of HSBP, and then goes on to examine the profitability of the use of HSBP as a technical trading strategy in the stock market. This section will present what is the method to establish what is HSBP, and what are the conditions for recognising the validity of HSBP. Also, the HSBP trading strategy will be introduced in the second half of the paper.

4.1 The current issues for searching for Head and Shoulders Bottom Pattern

There are two core difficulties in researching HSBP, first, the pattern can be hard to recognise, and is mostly determined by observers, and the accuracy of its recognition depends on their skills and experience [10]. So, the difficulty of the study is that there is not a recognisable clear unit rule to determine what is the formation of HSBP. Second, HSBP is generally structured by six trends (See Figure 7). Also, the trends are formed by the past price movements in the chart, and the chart plotting the price movement is based on time series so that the prices are plotted in a fixed time frame like daily chart or weekly chart (See Section 3.2). However, under time series, it is hard to determine the start and end points at each uptrend and downtrend. As mentioned in Section 3.2, under the time-axis, each price point is plotted by a fixed time frame, so a price is obtained by a corresponding time point. Based on a fixed time frame, it is difficult to

confirm an extreme point of a trend because of the unpredictability of the price movements. To be specific, under time series, the highest price and the lowest price is confirmed by a required timeframe. However, a confirmed trend is determined by itself of the price changes rather than time periods. For example, given a rate of price changes, we summarise all the price changes points, but the periods between each adjacent price changes points are not equal. Therefore, in a specific timeframe, the highest price and the lowest price cannot be confirmed as the two extreme points of a trend. That is the essential problem for clear recognition of HSBP because a pattern is generally formed by the trends. If there is no exact trend to be confirmed, it can be ambiguous to define HSBP.

4.2 The methodology for recognising Head and Shoulders Bottom Pattern(HSBP)

The approach for recognising HSBP in this research is that under the method of Directional Change, this is used to clearly confirm the reversal points of the trends that form the shape of HSBP. In order to search for a valid HSBP, this section will define the HSBP conditions to determine HSBP precisely. The idea is similar to the concept of the criteria of Head and Shoulders Top Pattern by Osler and Chang [16, 17]. But the purpose of this research is mainly focused on the mathematical and logical conditions needed to demonstrate what an HSBP is.

4.3 DC Extreme Point with HSBP

Directional Change is an alternative method to summarise the price movements; it summarises the extreme points (EPs) based on a certain chosen threshold [26].

Therefore, the uptrends and downtrends will be confirmed by connecting every two adjacent EPs.

According to the definition of HSBP in Section 3.7, an HSBP comprises seven points, A, B, C, D, E, F, and G (See Figure 7), these seven points determine six trends. In addition, under the method of DC, these seven points are confirmed when the price changes reach to a certain threshold. For example, in figure 9, suppose the EP3 is temporarily the highest point in an upward trend (Start from EP2), and then the price reverse to downward. If the price falls to reach to a given threshold θ, we confirm the EP3. Therefore, we understand that a HSBP comprises 7 EPs and these 7 EPs can be determined by the method of DC. Moreover, based on these 7 EPs, the HSBP Conditions were created to confirm the positions of these seven extreme points in a chart. (See next subsection).

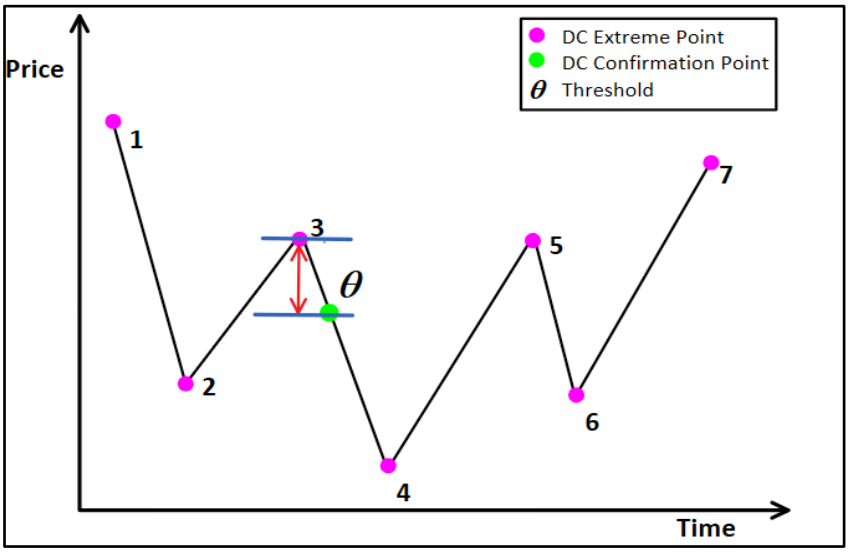

Figure 9. An example of DC summarises with the seven EPs.

4.4 Head and Shoulders Bottom Pattern Conditions

HSBP conditions are based on the definition of HSBP in Section 3.7. According to the HSBP definition, an HSBP is formed by the seven reversal points, and these points are determined by extreme points (See figure 10). But, the positional relationship between these seven EPs depends on the HSBP definition. So, to identify the positions of the seven EPs for an HSBP, this paper proposes HSBP conditions which are developed by mathematical and logical conditions between these points.

The conditions below look for a window of seven consecutive extreme points (For convenience, the extreme point from EP1 to EP7 indicates the seven EPs of HSBP). An HSBP-0 is defined as a sequence of points which satisfy the following conditions:

Condition 1: EP1>=EP2,EP3,…,EP6 (3)

Condition 2: EP3,EP5>=EP2,EP4,EP6 (4)

Condition 3: $\left|\frac{EP2-EP6}{EP6}\right| \leq \theta \times T_{AL}$ (5)

Condition 4: $\left|\frac{EP3-EP5}{EP5}\right| \leq \theta \times T_{AL}$ (6)

Condition 5: $\left|\frac{AveEP35-AveEP26}{AveEP35-EP4}\right| \leq T_{max}$ (7)

Condition 6: $\left|\frac{AveEP35-AveEP26}{AveEP35-EP4}\right| \geq T_{min}$ (8)

Condition 7: EP7>=EP2,…,EP6 (9)

Where:

- θ is threshold used by the analyst to generate DC summaries
- T_{AL}, T_{max} and T_{min} are tolerances given by the analyst
- AveEP35 in Condition 4 and Condition 5 is the mean of EP3 and EP5
- AveEP26 in Condition 4 and Condition 5 is the mean of EP2 and EP6

These conditions are explained below.

Condition 1:

The purpose of Condition 1 is to ensure that EP1 is higher than EP2 to EP6. HSBP is a reversal pattern from downward to upward. So, at the beginning of the pattern, there is a declining trend, and so the first EP should be higher than other EPs. Therefore, this condition has to correspond to the definition of Left Shoulder in Section 3.7.1.

Condition 2:

The aim of Condition 2 is to confirm the two resistance points (EP3 and EP5). According to HSBP definition, the price climbs from the two bottoms (EP2 and EP4) and return to downward when the price meets the two resistance points. So, the EP3 and EP6 are both higher than the support points (EP2, EP4, and EP6).

Condition 3:

The EP2 and EP6 are both support points (See Section 3.6). When the price falls to the levels around the EP2 and EP6 the market acquires buying support to confirm the reversal points. However, the difference between EP2 and EP6 is limited to an acceptable level. Under the shape of HSBP, if the positions between EP2 and EP6 are extremely different, the pattern is no longer able to admit to an HSBP. Hence, the aim of Condition 3 is to constrain the difference between the EP2 and EP6 to an acceptable level. That level is specified by the analyst, in the form of a multiplier (TAL) of the DC threshold (θ). Based on DC theory, the size of HSBP depends on the magnitude of the threshold. The HSBP with a higher threshold is larger than the HSBP with a lower threshold.

Condition 4:

The function of Condition 4 is similar to Condition 3, while the EP3 and EP5 are both the resistance points (See Section 3.6). The upward momentum bears selling resistances when the price reaches to the level around EP3 and EP5. But to confirm an admissible HSBP, the difference between EP3 and EP5 is constrained in a rational range. So, the purpose of Condition 4 is to limit the extreme difference between EP3 and EP5 to an acceptable level. Condition 4 is similar with Condition 3 that the TAL is specified by the analysts with a multiplier (TAL) of the DC threshold (θ).

Condition 5:

HSBP is a complex chart pattern where the positions between the head and shoulders are restricted for confirming the shape of HSBP. Although many technical chart materials introduced that the head (EP4) is below the two shoulders (EP2 and EP6), there is no unambiguous definition to determine a valid vertical difference in the chart between the two bottom shoulders and the head. Figure 11 is a failed HSBP that the EP2, EP4, and EP6 are nearly at the same price level. To prevent that, Condition 5 would use a ratio to compare the gap α (AveEP35 subtracting AveEP26) and the gap β (AveEP26 subtracting EP4). If the ratio α/β is 1, EP2, EP4, and EP6 are at the same horizontal level that the example in Figure 11 would be rejected for an HSBP. In addition, T_{max} is a parameter for the maximum limit of the ratio α/β, and the tolerance of the T_{max} is defined by the analysts.

Condition 6:

Figure 12 indicates another extreme example where there is an enormous distance in the chart between the average of EP2 and EP6 and EP4. But, there

EP2 and EP6 are too close to EP3 and EP5. It is an opposite extreme example to Figure 11 that Condition 5 specified the maximum limit of α/β. So, Condition 6 would specify the parameter, T_{min}, to limit the minimum tolerance of the ratio α/β.

Condition 7:

HSBP is a reversal pattern, it indicates an upward signal when the pattern is confirmed. Technically, an HSBP is determined when the price crosses up the neckline (See Section 3.6.1.4). However, this section only focuses on the recognition of HSBP. So, the function of Condition 7 is to confirm the position of EP7 in the chart. It is similar to Condition 1 that the EP7 should be higher than EP2 to EP6.

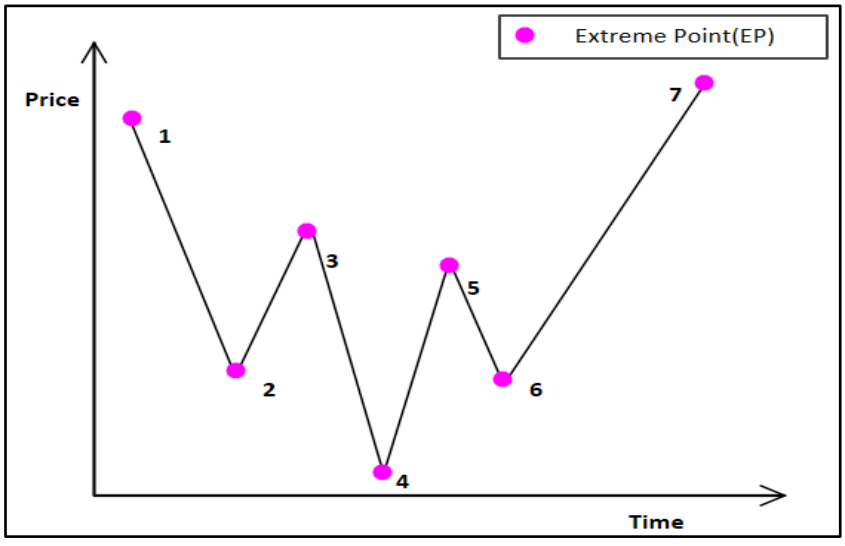

Figure 10. An example of a valid HSBP.

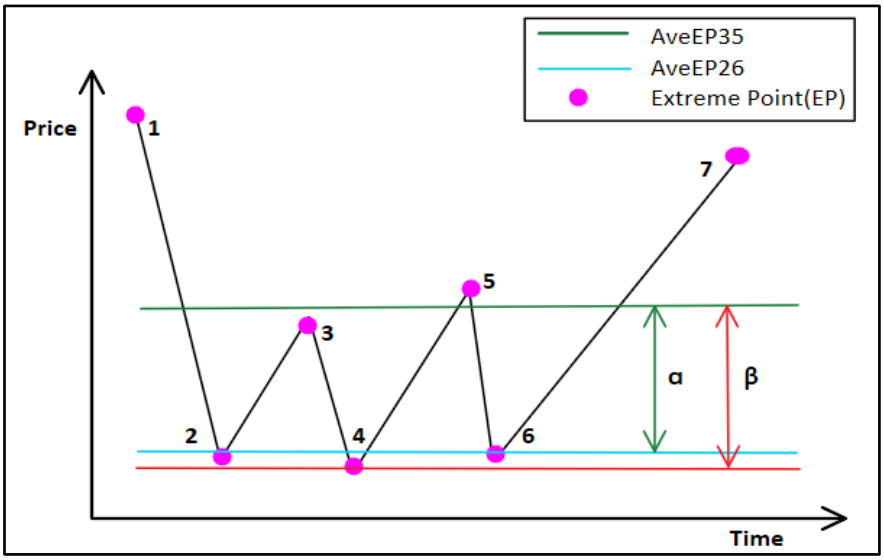

Figure 11. Example of a non-HSBP; Condition 5 is not met because the ratio between α and β is too big (α is the gap between AveEP35 and AveEP26; β is the gap between AveEP35 and EP4).

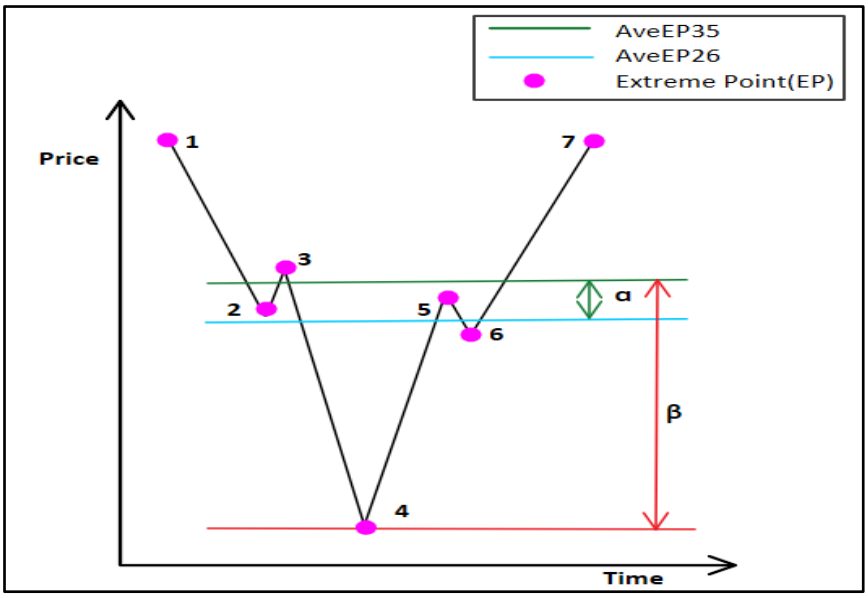

Figure 12. Example of a non-HSBP, Condition 6 is not met because the ratio between α and β is too small (α is the gap between AveEP35 and AveEP26; β is the gap between AveEP35 and EP4).

4.5 Head and Shoulders Trading Strategy

This subsection introduces the HSBP trading strategy which is called Li-1. Head and Shoulder Bottom Pattern is a reversal pattern which indicates an upward tendency when an HSBP is confirmed. According to the HSBP definition, when

the downtrend reached to EP6 (The bottom point of the right shoulder), the price would turn to an uptrend, and the EP7 would be determined if the price declined to a certain threshold comparing with the current highest price (See DC definition in Chapter 3). However, comparing HSBP trading strategy with HSBP definition (Seven HSBP conditions), there is a subtle difference in the confirmation of HSBP. Richard W. Schabacker and Edwards and Magee concluded, under HSBP trading strategy, a HSBP is confirmed when the current price upward penetrates the neckline. In fact, the event of penetrating the neckline has determined before determining the EP7 (See Figure 13). So, under Li-1, the EP7 will no longer be considered. In addition, a potential HSBP is determined when the six consecutive extreme points satisfy the first six conditions. Once this potential HSBP is confirmed, the strategy Li-1 would be involved.

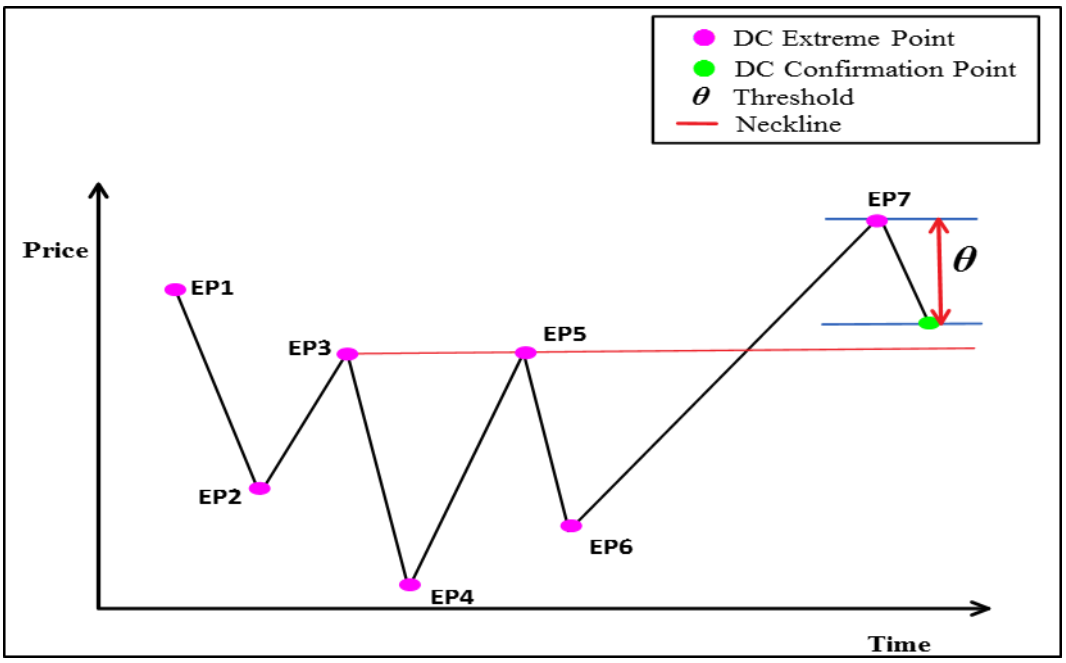

Figure 13. An example that the EP7 is confirmed by a certain threshold, while the event of penetrating the neckline has determined before determining the EP7.

The HSBP trading strategy, Li-1, comprises three trading rules, which are Open Position Rule, Selling for Profit Rule and Stop Loss Rule. Because HSBP is an upward reversal pattern, the strategy only focused on opening a long position. So, the Selling for Profit Rule and Stop Loss rule are the alternative options for closing a long position.

- **Open (Long) Position Rule (OP_Rule)**

Li-1 would open a long position when the upward trend reached a point which penetrated the neckline. Under the daily chart, we confirm a daily closing price as the final price of a given trading day. So, the daily closing price includes a specific date with the final price. Therefore, the daily chart satisfies the Cartesian coordinates system in two dimensions that the x-axis and y-axis indicate time and price respectively. Under the Cartesian coordinates system, a coordinate pair P (x, y) is defined by the value x and y that the y-coordinate of P is the value of y, and the x-coordinate of P is the value of x. In Li-1, We use X.D and X.P to denote the date and price of point X (X is the extreme point). In the previous sections, an EP denoted price, while under Li-1, an EP is defined by the co-ordinate pair (EP.D, EP.P).

OP_Rule is developed based on the work of Richard W. Schabacker and Edwards and Magee that a long position is opened following the event of penetrating the neckline. Hence, Under the Cartesian coordinates system, we determined the event, the upward trend breaking the neckline, by comparing the slope of two lines. According to the HSBP definition, a neckline is confirmed by joining EP3 (EP3.D, EP3.P) and EP5 (EP5.D, EP5.P). So, the slope of the neckline can be measured by using the point-slope equation. Another line is determined by connecting the buying point and EP3.

The following is OP_Rule for Li-1:

$$\frac{(\text{BP.P} - \text{EP3.P})}{(\text{BP.D} - \text{EP3.D})} \geq \frac{(\text{EP5.P} - \text{EP3.P})}{(\text{EP5.D} - \text{EP3.D})} \quad (10)$$

where:

- BP.P is the buying price which is sought by Li-1;
- BP.D is the number of days counted from the first day of the series in the study to the buying point, BP.
- EP5.P and EP3.P are the prices at these two points.
- EP5.D and EP3.D are the number of days from the first day of the series to EP5 and EP3, respectively.

(EP5.P – EP3.P)/(EP5.D – EP3.D) measures the angle of the slope from EP3 to EP5, which is the neckline. We call the current price BP.P (for Buying Price) if it is above the extension of the line from EP3 to EP5, as shown in Figure 14. The condition above supports a mathematical condition to recognise BP. In mathematical term, Δy is confirmed by BP.P subtracting EP3.P, meanwhile Δx can be found by BP.D subtracting EP3.D. Therefore, the slope would be obtained by Δy dividing Δx.

■ **Selling for Profit Rule (SP_Rule)**

In finance, the return is to refer a profit to investment. The purpose for SP_Rule is to determine a rate of return to close the holding position. Over a single period, the target of the return rate (Tp) is set by traders. Once a long position is executed by OP_Rule, Li-1 would track the price movement and compute the current profit. When the rate of return reaches the target profit (Tp), Li-1 will trigger the SP_Rule.

The following is the selling for profit rule for Li-1:

$$Tp \leq \frac{CP.P - BP.P}{BP.P} \quad (11)$$

where:

- BP.P is buying price;
- CP.P is the current price

Note, the different magnitude of thresholds will generate the different magnitude of uptrends and downtrends (The vertical distance between adjacent EPs). So, the different magnitude of thresholds directly generates to the different size of HSBPs of the final recognition. Therefore, Tp should reflect the scale of the threshold used in DC; e.g. Tp could be 0.5*θ or 0.75*θ, where θ is the threshold used in the DC summary.

■ **Stop Loss Rule (SL_Rule)**

SL_Rule is to design a stop loss order to close the long position when the current price is below a certain price level. We define the certain price level by an SL point (SLP) which is measured by the mean of the two support points (EP2 and EP6) in the potential HSBP. If the current price reaches or drops below the SLP, Li-1 will close the long position.

The following is the stop loss rule for Li-1:

$$SLP.P = \frac{EP2.P + EP6.P}{2} \geq CP.P \quad (12)$$

where:

- EP2.P is the price at extreme point 2;
- EP6.P is the price at extreme point 6;
- CP.P is the current price.

Overall, the HSBP trading strategy is based on the HSBP-0 conditions. Under a potential HSBP, Li-1 opens a long position when the current price upward punctures the neckline. Once the holding position reaches the profit target Tp (Tp is set by the investor), Li-1 will close the position for a profit. However, if the price falls to the stop loss level (SLP), Li-1 will close the position for stop loss. (See Figure 14)

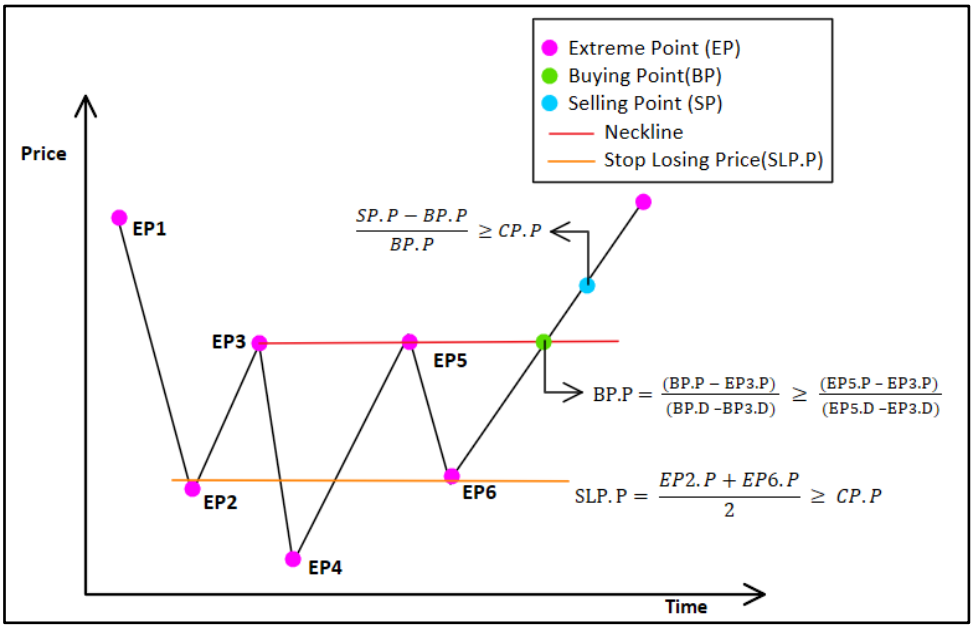

Figure 14. HSBP with trading strategy -- here CP is current price; SP_Rule and SL_Rule would be as candidate rules after opening a long position, and once current the price satisfies one of a rules SP_Rule or SL_Rule, Li-1 would close the position.

5. Experiments: Trading Under HSBP

Head and Shoulders Bottom Pattern is a complex and nonlinear chart pattern, it indicates that there is an upward direction when we are able to confirm an HSBP chart pattern. In the past, analysts drew the chart by hand, and so all chart patterns were determined by their skills and experience. These patterns were developed and concluded in the past decades to be defined by technical rules. Nowadays, computers have replaced those hand-drawn charts, and almost all technical analysis is now processed by machines.

However, because these complex patterns are ambiguous and difficult to define, there has been no easy solution to best quantify these trading patterns. This thesis is an attempt to recognise and define HSBP, and to evaluate the use of an HSBP trading strategy. The concept of this is based on the use of Directional Change (DC), which is a new and alternative method for summarising price changes in the financial markets (See Section 3.7). In the technical chart, the price is continuously moving randomly, so it is difficult to confirm price trends under time series. Because chart patterns are formed by trends, it is hard to confirm the chart patterns without determining the trends first. However, DC summarises the reversal points through a given threshold, so the endpoint of a trend is only determined when the price turns to an opposite direction and reaches a certain threshold.

Based on DC extreme points (EPs), we have developed HSBP Conditions for recognising HSBP in chart patterns so that seven EPs comprise an HSBP. The core of the HSBP trading strategy (Li-1) is to open a long position when the

price upward punctures the neckline, which is defined by joining the EP3 and EP5 [6, 20]. Li-1 also includes two rules for closing the long position. If the return of the holding position reaches to the target return rate Tp, Li-1 will close the position. A stop loss rule (SL_Rule) is triggered when the price downward drops to, or below the Stop Loss Point (SLP).

This chapter will introduce the whole working process of recognising HSBPs and then goes on to evaluate the profitability of HSBPs as a trading strategy. The main approach for executing this test has been introduced in the previous chapter, which is based on the method of Directional Change and the conditions of HSBP. According to the methodology for recognising HSBPs and the HSBP trading strategy Li-1, the structure of this experiment was constituted within three main parts. In the first part, the main aim was to summarise the raw data in the form to be used by DC. The second part concentrated on how to make a confirmation of potential HSBPs which would involve the use of HSBP conditions. The third part mainly included HSBP trading strategy Li-1, which implemented the evaluation of the profitability of HSBPs.

Based on the requirement of this experiment, we developed a program to execute a whole process of this test. The program named SH-1 (Created by the author of this thesis) is a comprehensive system. It is made up of three modules: Directional Change Computing (DCC), HSBP_Detector, and HSBP_Strategy. The function of DCC mainly includes data extraction and data transformation, which extracts the raw data set and transforms it into DC series (EPs). The purpose of the HSBP_Detector is to search for potential HSBPs which include six HSBP conditions, it scans the series of EPs in the form of a “moving window”, and determines potential HSBPs through HSBP Conditions. Li-1 is an

HSBP trading strategy, it comprises three trading rules, and the purpose is to evaluate the profitability of HSBPs in the stock market.

In the following sections, we will demonstrate the functions of the three main modules, and here will pick out some real examples from the results of this test to illustrate these three modules. In addition, an overview of the program SH-1 will be presented in order to clarify the whole working process of this experiment. Finally, the detailed results of this test will be exhibited.

5.1 DCC: From raw data to Directional Changes

Directional Change Computing (DCC) is a module of SH-1, it is the first step of the workflow under SH-1. The main function of DCC is to transform the raw data to DC data so that DCC is able to compute the EPs (Each extreme point includes the price with its date). To be specific, DCC initially requires the raw data as the input and then generates EPs based on the DC method. In this experiment, we expect to confirm as many HSBPs as possible. Hence, under the experiment, it is feasible to set a range of thresholds in order to produce the different magnitude EPs.

The main method to produce EPs is based on DC definition which define DC events under a given threshold. DC events are comprised of two parts, Downturn DC Event and Upturn DC Event. Briefly, we determine the EPs at the start of each downturn DC events and upturn DC events, while the detail of the process is explained as follows. As mentioned in Section 3.7, in a downtrend, DCC keeps tracking the lowest price Pl. If the current price, Pc, is lower than the Pl, it will be replaced by the current price Pc. When the current price reverses and

rises over the Pl by a certain threshold or more, DCC confirms an uptrend. By contrast, in an uptrend, DCC keeps tracking the highest price Ph. If the current price, Pc is higher than the Ph, it will be replaced by the current price. Then, the price falls and finally reaches or exceeds the given threshold. Then, DCC confirms a downtrend, and the highest price Ph is the EP of the last uptrend.

5.1.1 An example of trends confirmation

To visualise the working process of DCC, an example in Figure 15 presents the details of the operation of DCC. This historical chart captures the closing prices of GOOGL (Stock Symbol) in a short period from 2014/12/12 to 2015/1/8. At first, DCC requested a threshold as a parameter. Then, DCC initially determined the highest price Ph, and the lowest price Pl by comparing the closing prices of Day one Tp1 and Day two Tp2 (See Figure 16). In step one, the Ph and Pl were assigned by the values of Tp1 and Tp2. The process of DCC iterated to step two so that the current price Pc was lower than the Pl, so the Pl was replaced by the Pc (Because Pc was lower than Ph, the value of Ph remains unchanged). According to the Figure 15, Pc reversed the direction after day three, it kept rising while the Pc was still lower than the Ph in day one until day seven. In step six (day seven), the Pc reached the new high at 532.3, so the Ph was replaced by Pc. Besides, because the Pc was higher than Pl by 5%, DCC determined an uptrend from the last trend reverse at Pl.

Therefore, DCC recorded the Pl and Ph into a DC series as DCCP1.P and EP1 respectively. After determining DCCP1.P and EP1, the Ph and the Pl were both initialised with the value of Pc. After that, the process iterated to the next step, and the Ph was up from day eight to day ten. After step nine (day ten), the Pc turned the direction to downward. The Pl was assigned by the Pc in day thirteen

when the Pc was firstly under the Pl after the last initialisation in day seven. In step 15 (day sixteen), the Pc was lower than the Ph over the threshold 5%. So, DCC recorded the Ph and Pc as DCCP2.P and EP2 respectively, and then the Ph and Pl were initialized with the value of Pc. After that, the Pl is assigned by the Pc in Step 16, and the Ph was replaced by the Pc in Step 17. To illustrate a clear process, a segment of Pseudo Code will illustrate this at the end of this subsection.

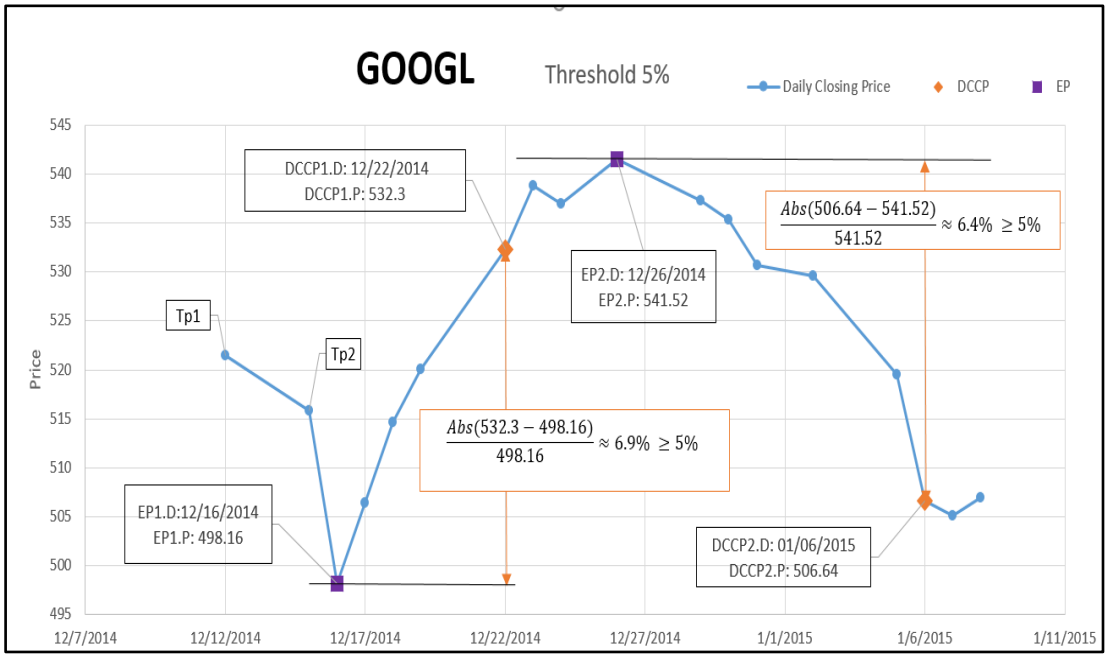

Figure 15. An example for DCC process.

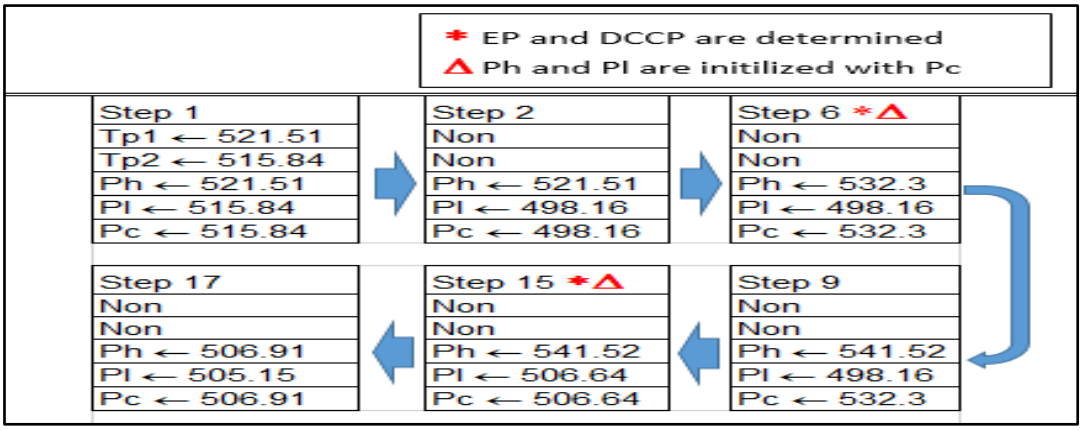

Figure 16. An example for the workflow of DCC.

■ Pseudo Code for DCC

PROGRAM DCC

Input: Rawdata(Daily closing prices), Threshold

Output: Extreme Points

Global variables {

1. rawDataArray: A raw data array
2. threshold: A given threshold
3. length: The length of rawDataArray
4. epArray: An array for storing Extreme Points
5. cp: the index of rawDataArray
6. ph: The highest price
7. pl: The lowest price

}

```
1: Function DCC(rawDataArray)
2:          cp ← 3;
3:          ph ← max(rawDataArray [1], rawDataArray [2]);
4:          pl ← min(rawDataArray [1], rawDataArray [2]);
5:          WHILE (cp <= length)
6:                    IF rawDataArray [cp] >= pl * (1 + threshold)          //Confirm an uptrend
7:                              epArray ← rawDataArray [cp];
8:                              ph ← rawDataArray [cp];
9:                              pl ← rawDataArray [cp];
10:                   ENDIF
11:                   IF rawDataArray [cp] <= ph* (1 - threshold)           //Confirm a downtrend
12:                             epArray ← rawDataArray [cp];
13:                             ph ← rawDataArray [cp];
14:                             pl ← rawDataArray [cp];
15:                   ENDIF
16:                   IF rawDataArray [cp] >= ph
17:                             ph ← rawDataArray [cp];                       //Assign the highest price
18:                   ENDIF
19:                   IF rawDataArray [cp] <= pl
20:                             pl ← rawDataArray [cp];                       // Assign the lowest price
21:                   ENDIF
22:                   cp ← cp + 1;
23:         ENDWHILE
24: END FUNCTION
```

5.2: HSBP_Detector: From DCs to Potential HSBP

HSBP_Detector is the second module under the whole process of SH-1. The main components of SH-1 are the HSBP conditions. HSBP conditions were introduced in Section 4.4 so that the purpose of HSBP conditions is to constrain a set of rational ranges between the horizontal and vertical positions of seven sequential EPs. Therefore, we can confirm an HSBP when all of the HSBP conditions are satisfied by having seven sequential EPs. However, this test aims to evaluate the profitability of HSBPs which would be involved in the HSBP trading strategy Li-1. As mentioned in Section 4.5, the confirmation of a HSBP can only be considered when the price rising upwards punctures the neckline. So, the main function of the HSBP_Detector is to determine potential HSBPs, and this module only includes the first six HSBP conditions (Condition 7 will not be involved in here). Therefore, we declare a potential HSBP when the positions of the six sequential EPs in the chart simultaneously satisfy the first six HSBP conditions.

In the workflow of SH-1, the HSBP_Detector receives the DC series (EPs) as the input from the module of DCC and simultaneously detects whether six sequential EPs satisfy six HSBP conditions. Then, the six sequential EPs would be recorded in this step. Finally, the HSBP_Detector transfers the data series of the potential HSBPs as the output to the next module.

5.2.1 A review of HSBP Conditions with an example

The main components of the HSBP_Detector are the HSBP conditions which already introduced in Section 4.4. To be clear for the illustration of this module,

this subsection will present how a potential HSBP is determined by the six HSBP conditions. Table 1 summarises the detailed data of a potential HSBP with the threshold of 18%. To visualise the data, we illustrate the data into a bar chart. Figure 17 is a bar chart of AMZN (Stock symbol), it indicates the six extreme points (EPs) and the six HSBP conditions.

According to the definition of HSBP, a HSBP is observed after a downtrend, which is executed by HSBP Condition 1 that EP1 must be higher than other five EPs. In the bar chart, the yellow horizontal line of the EP1 (88.1, 08/11/2008) indicates that EP1 is higher than other EPs. HSBP Condition 2 is to confirm the two resistance points that the EP3 and EP5 must higher than EP2, EP4 and EP6. The bar chart labels the EP3 (58.5, 11/04/2008) and EP5 (57.41, 01/06/2009) which are both higher than EP2 (48.7, 10/15/2008), EP4 (35, 11/20/2008), and EP6 (48.4, 01/27/2009). The aim of HSBP condition 3 is to constrain an acceptable tolerance between the EP2 and EP6. In order to eliminate the extreme patterns, the vertical distance between the bottom points of the two shoulders must be under constraint by a ratio T_{AL} multiplied by a certain threshold. Figure 17 indicates the vertical distance between EP2 (48.7, 10/15/2008) and EP6 (48.4, 01/27/2009) which satisfies HSBP Condition 3. The purpose of HSBP Condition 4 is to reject the extreme pattern which is similar to HSBP condition 3, it limits the vertical distance between EP3 (58.5, 11/04/2008) and EP5 (57.41, 01/06/2009) by the same ratio T_{AL} multiply by the threshold. We highlight the vertical distance between EP3 and EP5 in Figure 17, which satisfies HSBP Condition 4.

The aim of Condition 5 is to exclude the non-HSBPs that the EP2, EP4, and EP6 converge around at a horizontal line (See section 3.4), which normally is called

the triple bottom pattern (reversal). According to the definition of an HSBP, the bottom point (EP4) of the head is lower than the bottom points of the two shoulders. In order to distinguish the positions between the EP2, EP4, and EP6, Condition 5 compares the ratio α (The average of EP3 and EP5 subtracting the average of EP2 and EP6) and the ratio β (The average of EP2 and EP 6 subtracting EP4). If the value α/β is 1, the EP2, EP4, and EP6 are at the same horizontal line. So, Condition 5 constrains the positive quotient of α/β by a maximum tolerance Tmax (The maximum tolerance is set by analysts). Figure 18 presents the real historical chart of AMZN where a potential HSBP was determined by the HSBP_Detector, it illustrates a chart view of a part working process of HSBP_Detector that the Condition 5 and Condition 6 were satisfied in this chart. Basically, there are three horizontal lines for indicating AveEP35 (The average of EP3 and EP5), AveEP26 (The average of EP2 and EP6), and EP4. Therefore, the module obtained the α and β by the AveEP35 subtracting the Ave26, and the AveEP35 subtracting the Ep4 respectively. Finally, the α/β satisfied the both of Condition 5 and Condition 6 that α/β (0.42) is less than Tmax (0.65) and bigger than Tmin (0.3).

Table 1. A summary for AMZN

Stock Symbol:	AMZN	EP	Price	Date (mm/dd/yyyy)
Threshold:	18%	1	88.1	08/11/2008
T_{AL}:	0.5	2	48.7	10/15/2008
T_{max}:	0.65	3	58.5	11/04/2008
T_{min}:	0.3	4	35	11/20/2008
		5	57.4	01/06/2009
		6	48.4	01/27/2009
		BP.P	58.8	01/30/2009
		SP.P	63.6	02/03/2009

(BP.P and SP.P will be explained in the Section 4.3.1)

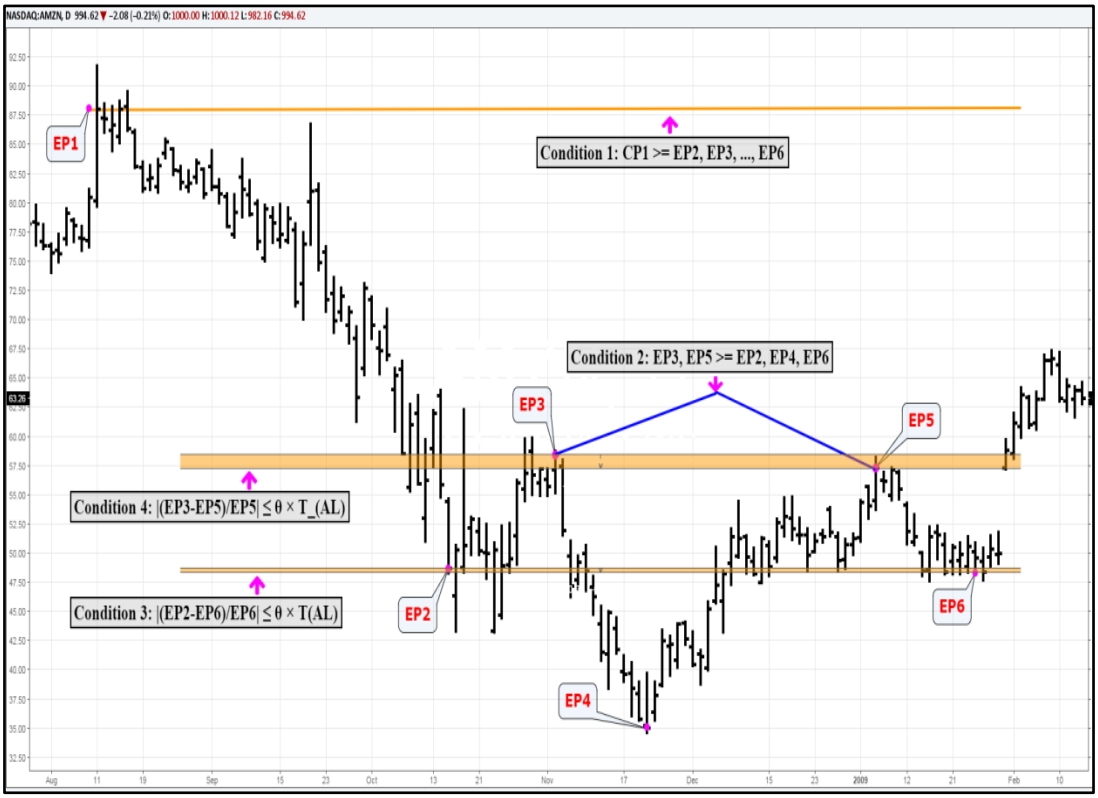

Figure 17. An example to explain Condition 1 – 4.[1]

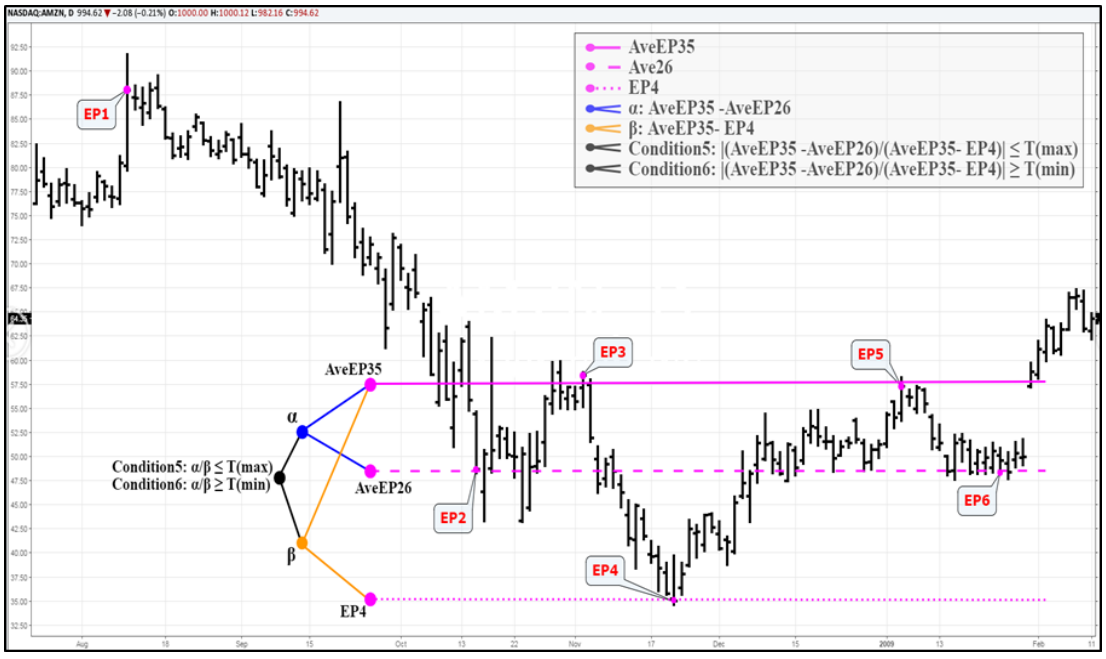

Figure 18. An example to explain Condition 5 and 6.

[1] Figure 17, 18, 22 and 23 have uploaded on Dropbox:
https://www.dropbox.com/sh/5hnoyf8tcy1i3u8/AAB31ajURpC2Eu93yeouk_FEa?dl=0

5.2.2 Scanning for potential HSBPs

The idea of HSBP conditions is to determine that the six EPs positions in the technical chart are the six EPs that form a potential HSBP when they satisfy the HSBP conditions. After the DC summary in the module of DCC, a DC series (EPs) will be transferred to the module of HSBP_Detector as the input. However, there is a limitation in the module for determining HSBP that the six HSBP conditions only determine six sequential EPs. So, the HSBP_Detector executes a moving window to scan each sequence of six EPs. The shape of a "window" is moved over the data, and the size of the "window" is defined by the amount of data that it is required to scan at every time. In addition, the moving distance depends on the requirement to determine HSBPs.

Figure 19 illustrates the mechanism of a "moving window" where the shape of the rectangle is the "window". Because HSBP conditions require six extreme points to determine a potential HSBP, we set the window size to six. In addition, we set one for the moving distance in order to scan all the possibilities of six sequential EPs. Hence, the program iterates through the DC series by using "moving window" with the window size six and the moving distance one. Also, at each of the steps, the module will collect the six EPs from the current window, and it will detect if it exhibits a potential HSBP.

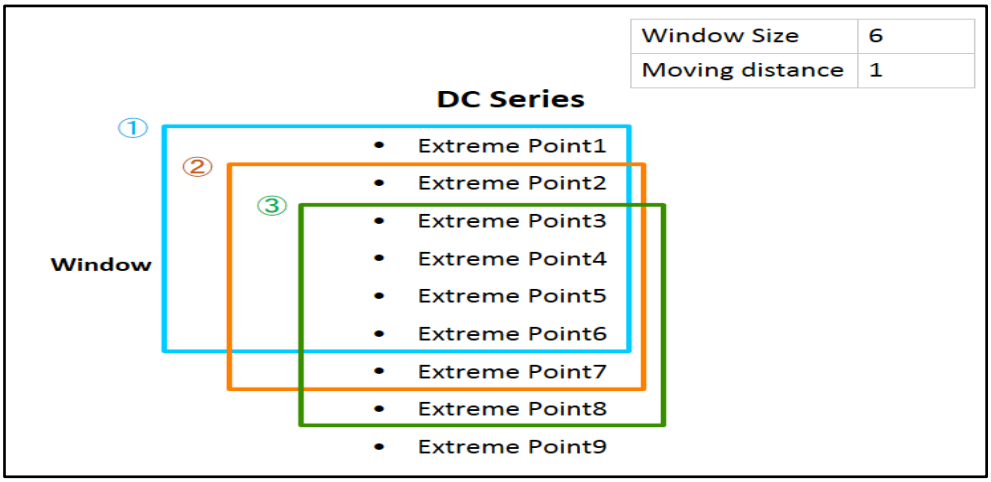

Figure 19. The Mechanism of scanning for potential HSBPs.

5.2.3 Determining Potential HSBP

Given six EPs within a window, HSBP_Detector checks whether the six sequential EPs form a potential HSBP by the six HSBP Conditions. Figure 20 illustrates the working process for determining a potential HSBP from a signal window. When the HSBP_Detector collects the sequential six EPs from window ①, the six HSBP conditions will check whether these six EPs satisfy the conditions to be considered as a potential HSBP.

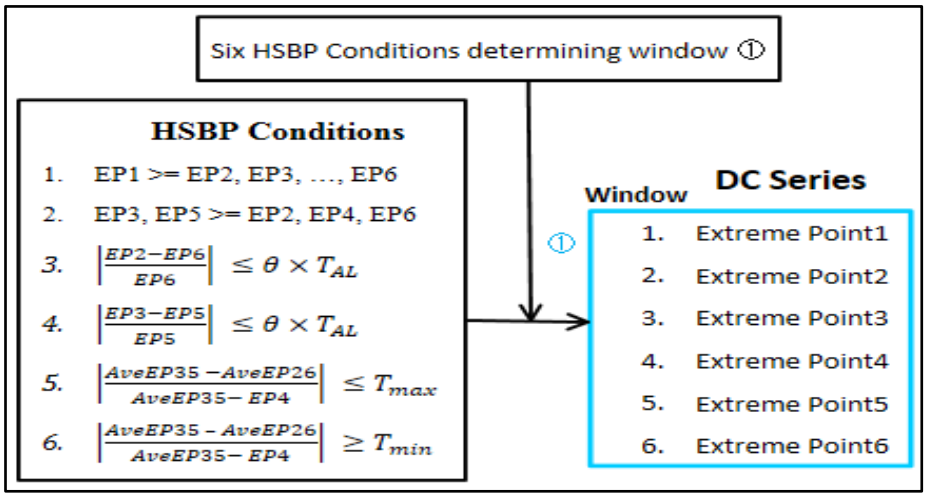

Figure 20. The mechanism of determining a potential HSBP by 6 conditions, an example.

■ Pseudo Code for HSBP_Detector

MODULE: HSBP_Detector

Input:

1. threshod // A given threshold
2. T_{AL} // Acceptable Level Tolerance
3. Tmax // the maximum limit of α/β
4. Tmin // the minimum limit of α/β
5. AEPArray[6] // A six sequential EPs list

Output: The data of Potential HSBPs

```
1: FUNCTION HSBP_Detector
        //HSBP Condition 1
2:      BOOLEAN Condition1 (AEPArray) {
3:              RETURN AEPArray[1] >= AEPArray[2] AND AEPArray[3] AND AEPArray[4]
AND
            AEPArray[5] AND AEPArray[6];}
        //HSBP Condition 2
4:      BOOLEAN Condition2 (AEPArray) {
5:              RETURN AEPArray[3] AND AEPArray[5] >= AEPArray[2] AND AEPArray[4]
AND AEPArray[6]; }
        //HSBP Condition 3
6:      BOOLEAN Condition3 (AEPArray) {
7:              RETURN Abs((AEPArray[2] - AEPArray[6]) / AEPArray[2] + AEPArray[6]) <=
Threshod * TAL; }
        //HSBP Condition 4
8:      BOOLEAN Condition4 (AEPArray) {
9:              RETURN Abs((AEPArray[3] - AEPArray[5]) / AEPArray[3] + AEPArray[5]) <=
Threshod * TAL; }
        //HSBP Condition 5
10:     BOOLEAN Condition5 (AEPArray) {
11:             Ave26 = (AEPArray[2] + AEPArray[6]) / 2;
12:             Ave35 = (AEPArray[3] + AEPArray[5]) / 2;
13:             RETURN Ave35 - Ave26) / (Ave35 - EP4) <= Tmax; }
        //HSBP Condition 6
14:     BOOLEAN Condition6 (AEPArray) {
15:             Ave26 = (AEPArray[2] + AEPArray[6]) / 2;
16:             Ave35 = (AEPArray[3] + AEPArray[5]) / 2;
17:             RETURN Ave35 - Ave26) / (Ave35 - EP4) >= Tmin; }
        //Validity check for the six HSBP conditions above and save the data of AEPArray
18:     IF (Condition1 (AEPArray) AND Condition2 (AEPArray) AND Condition3 (AEPArray) AND
19:       Condition4 (AEPArray) AND Condition5 (AEPArray) AND Condition6 (AEPArray))
20:             SaveEpData (AEPArray);
21:     ENDIF
22: END FUNCTION
```

5.3 HSBP_Strategy: Evaluating HSBP trading strategy

HSBP_Strategy is the third module in the program of SH-1. Under the whole working process, the function of HSBP_Strategy is to evaluate the trading strategy of HSBP which is called Li-1, and which was introduced in Section 4.5. Li-1 is a complete trading strategy based on Head and Shoulders Bottom Patterns. In technical chart patterns, because of the character of HSBP (One of an upward reversal patterns), this pattern indicates an upward reversal signal when the observer determines a HSBP. Because of this, only long positions would be considered under the trading strategy of HSBP.

In Section 3.6 we presented a precise definition for determining the shape of HSBP that seven extreme points confirm a HSBP. However, under the trading strategy Li-1, we expect to determine potential HSBPs instead of confirming an entire HSBP. Once a potential HSBP is confirmed, Li-1 would determine to open a long position (A buying opportunity). Also, there are two alternative rules to close the long position. The Selling for Profit Rule (SP_Rule) is executed when the price rises to the target return rate Tp. However, the price may turn to the opposite direction after opening a long position, and if the price falls to trigger the Stop Loss Rule (SL_Rule), Li-1 will close the long position.

In this experiment, Li-1 is the main component in the module of HSBP_Strategy . As a module under SH-1, HSBP_Strategy not only contains the trading strategy of HSBP but also it has all the requisite requirements to execute the trading processes. Under the workflow of SH-1, once all the potential HSBPs are confirmed from a DC series (EPs), HSBP_Detector would deliver all the data of the potential HSBPs as the input to HSBP_Strategy. When HSBP_Strategy

receives the data of the potential HSBPs (six EPs), it will track the closing price of the next date of the EP6. At this step, HSBP_Strategy would not consider EPs as the input, while it would require the raw data (Closing prices) to detect the buying opportunity when the price upward punctures the neckline. So, as a module under SH-1, HSBP_Strategy not only receives the data (potential HSBP) from HSBP_Detector, but also it requires the closing prices (Raw data) as the input to determine the opportunity for opening long positions.

When a long position is opened, HSBP_Strategy continually requires the next closing price. If the next closing price reaches to the rate of return target Tp, HSBP_Strategy will close the long position. Alternatively, HSBP_Strategy will close the long position for stop loss if the next closing price drops to the stop loss level, which is defined by the average of EP2 and EP6. In addition, there may be another situation before opening a long position, so that the next closing price may drop to under the Stop Loss Level (SLL). At this point, HSBP_Strategy would abandon the project of the detection of a buying opportunity with the current potential HSBP.

Figure 21 illustrates the working process of HSBP_Strategy in detail. The whole graph bases on the workflow from left to right. In Step one, the second module of HSBP_Detector sends the data of potential HSBPs to the third module HSBP_Strategy. Once HSBP_Strategy receives the data of potential HSBPs, it will require the closing price from the Raw Data. In Step two, HSBP_Strategy decides whether make a long position which is based on Open (Long) Position Rule (OP_Rule). If the condition that the next closing price upward punctures the neckline (Neckline is defined by connecting EP3 and EP5), HSBP_Strategy open a long position. However, if the next price falls under the stop loss level,

HSBP_Strategy will break to detect the buying opportunity of the current potential HSBP, and jumps to detect the buying opportunity of the next potential HSBP. In Step three, HSBP_Strategy will decide one of the two options to close the long position. The SP_Rule will be triggered when the price crosses over the neckline. However, HSBP_Strategy will execute SL_Rule if the next closing price reaches to the stop loss level.

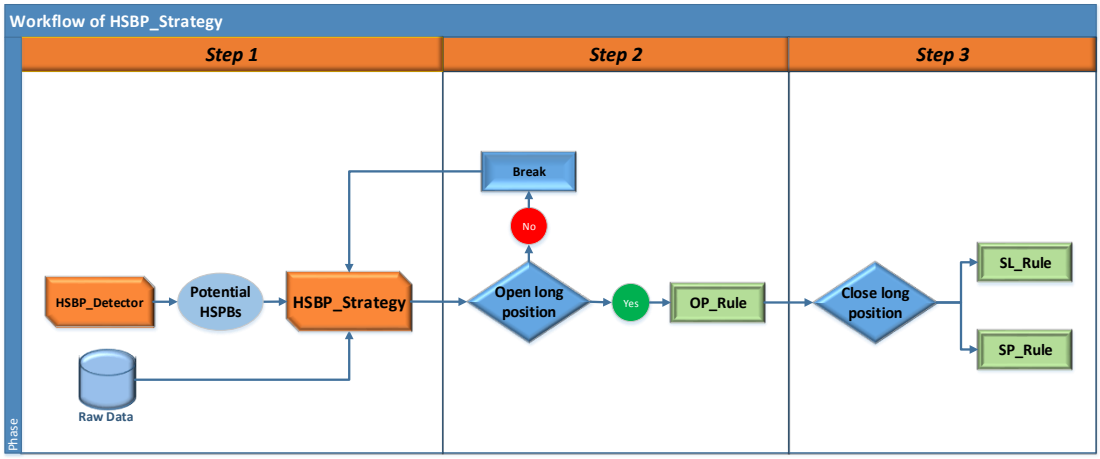

Figure 21. A workflow of HSBP_Strategy.

5.3.1 An example of HSBP trading strategy Li-1, with the module of HSBP_Strategy

This subsection will illustrate a real example of the working process of the module of HSBP_Strategy, and will introduce the trading strategy Li-1 for this example. We follow the example used in the previous section, which presented how the HSBP_Detector confirmed a potential HSBP in a period of historical prices of AMZN. Once the potential HSBP is determined, the HSBP_Detector will transmit the data of the potential HSBP (Six EPs, see Table 1) to the third module of HSBP_Strategy. HSBP_Strategy is a comprehensive trading strategy module which includes three trading rules. Under the HSBP trading strategy, a HSBP is determined when the price crosses up the neckline. So, HSBP_Strategy

will no longer have to consider the EPs. Instead, HSBP_Strategy will require the daily closing prices of the stocks (raw data) and will detect the signal of crossing the neckline. To visualise the working process of HSBP_Strategy, the following examples present HSBP_Strategy operations for the three trading rules (OP_Rule, SP_Rule, and SL_Rule).

- **HSBP_Strategy executed Open Rule Rule (OP_Rule)**

Figure 22 illustrated how HSBP_Strategy made a long position when it received the data of the potential HSBP (AMZN, threshold 18%). In Section 4.5, we introduced OP_Rule that a long position is opened when the price upward crosses the neckline. Moreover, a neckline is defined by connecting EP3 and EP5. So, HSBP_Strategy confirms the slope of the neckline m by the quotient of the vertical change and horizontal change of EP3 (EP3.P and EP3.ND) and EP5 (EP5.P and EP5.ND). Under the daily technical chart, the horizontal axis indicates the dates and the vertical axis indicates the values (Daily closing prices). Therefore, the two different types of the variables are not allowed to be set into the point-slope equation. Instead, we defined the x-coordinate as the number of days counted from the first day of the series. Such as EP3.ND, which is the number of days from the first day of the series to EP3, and EP3.P is the price of the extreme point three (EP3). As well, we indicate EP3.D as the date of EP3. In addition, HSBP_Strategy acquires another slope of the line called the Buying Line (BL) which is determined by connecting the EP3, (EP3.P, EP3.ND) and the buying point, BP (BP.P, BP.ND). Note, the buying point is the coordinate pair (EP.P, EP.ND) where HSBP_Strategy opens a long position. However, it is unable to confirm the BP before the event of crossing up the neckline has happened.

Hence, in this experiment, HSBP_Strategy supposes that the next daily closing price is a possible buying point until it confirms the actual buying point (At the point, HSBP_Strategy opens a long position). Therefore, HSBP_Strategy will compare the slope of the BL (Defined by connecting EP3 and Buying Point) with the slope of the neckline (Defined by joining EP3 and EP5). If the slope of the BL is equal or greater than the neckline, HSBP_Strategy will open the long position.

In this example, the HSBP_Detector confirmed the potential HSBP on AMZN with the threshold 18% (See Section 5.2.1). The HSBP_Detector sent the six EPs of the potential HSBP to the module of HSBP_Strategy. Then, HSBP_Strategy requested the next daily closing price of the EP6 (EP6: 48.4, 01/27/2009) from the raw data. As we mentioned before, it is unable to confirm a buying point until the price crosses up the neckline. So, HSBP_Strategy supposed that the next closing price is the buying point (BP1: 50.36, 01/28/2009). Because the unconformity exists between the price and the date of the BP, HSBP_Strategy required that the BP.ND, which is the number of days counted from the first day of the series. Therefore, HSBP_Strategy obtained the slope of BL, m which is determined by the point-slope equation:

$$m = \frac{(BP.P \; - \; EP3.P)}{(BP.ND \; - EP3.ND)}$$

Note, under OP_Rule of HSBP_Strategy, we defined BP as a variable; it starts from the next closing price after EP6 to the final BP_n point that the slope of the Buying line is greater than the neckline.

In Figure 22, the short dashed line indicates the buying line determined by BP1 (BP1: 50.36, 01/28/2009). BL is a variable under HSBP_Strategy, which is

determined by the BPx and EP3. So, it is clear that the slope of the BL1 (The short dashed line) is less than the neckline. Therefore, HSBP_Strategy required the next BP2 and checked whether the slope of the BL2 is greater or equal to the neckline. Finally, HSBP_Strategy confirmed that the slope of BL3 (The Long dashed line) is greater than that of the slope of the neckline that the price upward punctured the neckline at the BP3. HSBP_Strategy stored the data of BP3 which would be invoked in the Selling for Profit Rule (SP_Rule).

Figure 22. An example to illustrate OP_Rule and SP_Rule.

■ HSBP_Strategy executed Selling for Profit Rule (SP_Rule)

Under the workflow of the module of HSBP_Strategy, once a long position is executed, HSBP_Strategy will track the further price movement until the price satisfies one of the two close position rules (SP_Rule and SL_Rule). As mentioned in Section 4.5, the aim of SP_Rule is to define when to close long positions for a profit. So, a trader needs to set a target of the return rate Tp in the equation of SP_Rule. In this experiment, we set a unified Tp for 5% for all the

stocks to be tested, so HSBP_Strategy would track the price movement and compute the potential profit. And when the potential profit reaches the target Tp, HSBP_Strategy would close the long position. Note, in Section 4.5, we confirmed an event to sell the long position for profit when the value of the current return rate is greater or equal to the target Tp. In the inequation, The CP.P is the current price in HSBP trading strategy Li-1. However, in the module of HSBP_Strategy, we declare the next closing price is the current price.

In the example of AMZN, HSBP_Strategy finally executed a long position at the BP3 (BP3: 58.8, 1/30/2009). After that, HSBP_Strategy continuously required the next closing price (CP1: 61.15, 02/02/2009) and set the value into the inequation of the SP_Rule. The value of the rate of return at CP1 was approximately equal to 4% which is less than the target Tp. Therefore, HSBP_Strategy required the next closing price (CP2: 63.6, 02/03/2009), and the value of the rate of return at CP2 is approximately equal to 8.16% which was greater than the Tp. Hence, HSBP_Strategy closed the long position at the Selling Point (SP) with the price (SP.P) of 63.6 and the date of 02/03/2009 (See Figure 22).

Table 1 presents the results of AMZN that HSBP_Strategy opened a long position at the Buying Point (BP) with the date of 1/30/2009 and the price of 58.8, then HSBP_Strategy closed this position when the potential profit reached to the target of the rate of return Tp (SP: 63.6, 02/03/2009).

- **HSBP_Strategy executed Stop Loss Rule (SL_Rule)**

The Stop Loss Rule (SL_Rule) is a rule in Li-1, which is designed to limit losses on the long positions. Because Li-1 is designed based on the operation of HSBP,

the main strategy is to open a long position when the price crosses up the neckline. After opening a long position, if the price climbs and reaches to the Tp, Li-1 will close the long position for selling for a profit. However, the price may drop dramatically after opening the long position. According to the definition of HSBP, EP2 and EP6 are both support points that the price reverses to when it drops to these two points. So, we define a certain stop loss level by a Stop Loss Point(SLP) which is measured by the average of EP2 and EP6 in a potential HSBP. Hence, when the price falls to the certain stop loss level, the module of HSBP_Strategy will close the long position automatically.

Figure 23 is an example of when HSBP_Strategy closed the long position for stop loss. At the first, HSBP_Strategy received the data of the six EP from the HSBP_Detector and required the next closing price (BP1) from the raw data. On the date of 07/26/2006, HSBP_Strategy opened a long position at the BP that the slope of BL8 (The long dashed line) is greater than the slope of the neckline. Once the long position was opened, HSBP_Strategy recurrently required the next closing price (CP1.P) and checked whether the CP1.P satisfied one of two close position rules (SP_Rule and SL_Rule). On the date of 07/26/2006, the price CP1.P reached to the top at 10.45, while the potential profit did not reach the target rate of return Tp. Afterward, HSBP_Strategy continually required the next closing price, and at the CP10 (10.13, 08/09/2006) the price broke down through the neckline. Although the price rebounded and crossed up the neckline again at CP19 (10.25, 08/22/2006), the price dropped under the neckline on the next day. Finally, the price downward punctured the stop loss level, which is determined by the mean of EP2 and EP6. Therefore, HSBP_Strategy executed stop loss at the stop loss point (SLP) on the date of 09/11/2006 with the price 8.17.

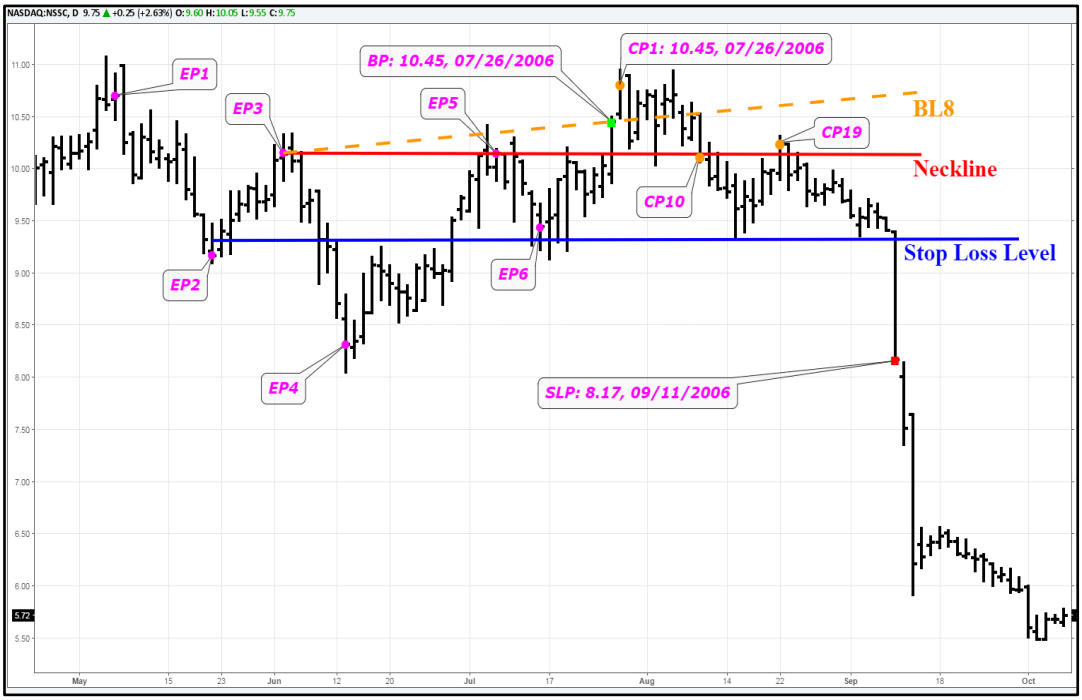

Figure 23. An example that HSBP_Strategy closed the long position for stop loss.

Table 2 presents the results of NSSC [2] that HSBP_Strategy opened a long position on the date of 07/26/2006 with the price of 10.45 and closed this position for stop loss when the price broke down the stop loss level at the SLP (SLP: 8.17, 09/11/2006).

Table 2. A summary for NSSC

Stock Symbol:	NSSC	EP	Price	Date (mm/dd/yyyy)
Threshold:	7%	1	10.707	05/05/2006
T_{AL}:	0.5	2	9.167	05/22/2006
Tmax:	0.65	3	10.147	06/02/2006
Tmin:	0.3	4	8.32	06/13/2006
		5	10.15	07/07/2006
		6	9.45	07/14/2006
		BP.P	10.45	07/26/2006
		SLP.P	8.17	09/11/2006

[2] NSSC is the symbol of NAPCO Security Technologies, Inc.

5.4 An overview of SH-1 workflow

Overall, this experiment was projected to test two main functions. First, the recognition of Head and Shoulder Bottom Pattern is the essential purpose of this project to achieve. To accomplish this aim, we used the method so called "DC+HSBP Conditions". Directional Change (DC) has been introduced in Section 3.8, and it is a different method to summarise price changes in the financial market. And HSBP conditions are created based on the definition of HSBP, so that the purpose is to structure an efficient framework to determine HSBPs. One of the goals is to recognise the extreme points on the body of the pattern. The second aim of this test is to evaluate the profitability of the use of HSBP as a trading strategy. The approach of the evaluation based on the HSBP trading strategy developed for this paper which is called Li-1 contains three trading rules.

According to the requirements of this experiment, SH-1 was created. It mainly comprised three modules which were DC Computing (DCC), HSBP_Detector and HSBP_Strategy. In order to run the program SH-1, an analyst needs to set four parameters. First, a range of thresholds are required, which would be used in the module of DCC for computing EPs. Second, the analysts need to set the parameters of the T_{AL} , Tmax , and Tmin (See Section 4.4) which would be involved in the module of HSBP_Detector. Third, a target of the rate of return will be required in the module of HSBP_Strategy. In addition, an input file is required to provide raw data.

The working process of SH-1 starts from the DCC module which requires the raw data (The daily closing prices of the stocks) and computes EPs based on the

preset thresholds. DCC would deliver the EPs as the inputs to HSBP_Detector. The module of HSBP_Detector comprises two components. The method of Moving Window is used to scan every six sequential EPs of a DC series (EPs). Meanwhile, the six HSBP Conditions would detect each set of six EPs for confirming potential HSBPs. All the data of potential HSBPs would be passed to HSBP_Strategy. HSBP_Strategy has been introduced in Section 4.3. It requires the data of potential HSBPs and raw data (Daily closing prices with the dates) in order to execute all the trading actions (See Figure 24). All the results of trading actions would be recorded as the outputs of SH-1, which would be used for analysing the trading strategy of HSBP.

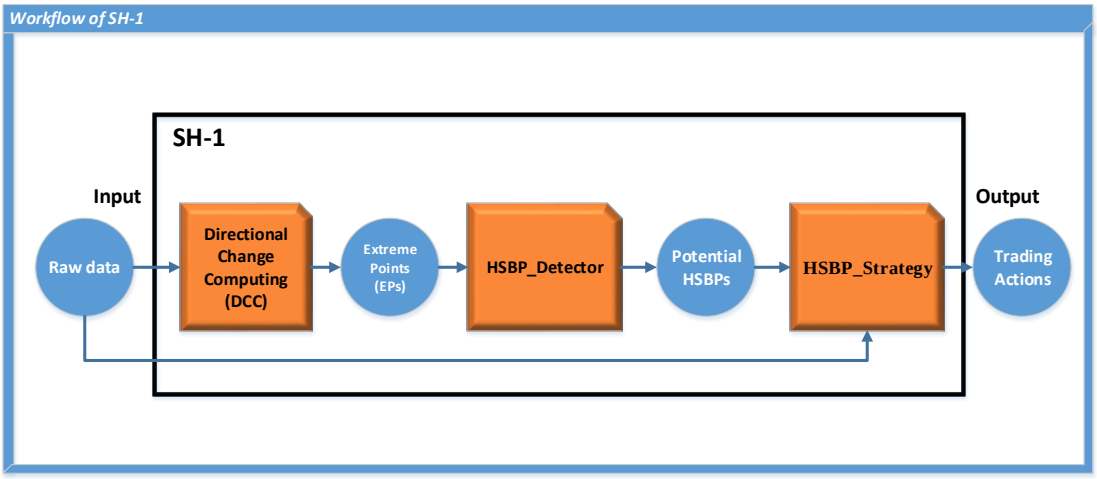

Figure 24. SH-1 flow diagram.

5.5 Result

In this back-testing, SH-1 firstly randomly selected 100 stocks from NASDAQ as original data[3] (All the original data was inputted to SH-1 in the form of excel files). Besides, this back-testing used a set of thresholds from 5% to 30% for

[3] The periods of the selected 100 stocks from 01/2004 to 11/2015.

measuring various EPs of magnitude. Therefore, SH-1 first computed all original data by the threshold of 5% and then increased the threshold each time by 1% until it reached 30% (See Table 3).

Table 3. All data and parameters used in this experiment

Original data	Historical daily closing prices from 100 stocks in NASDAQ
Thresholds	5% - 30% (increase 1% each time)
T_{AL}	0.5
T_{max}	0.65
T_{min}	0.3
T_p	5%

According to the workflow of SH-1, the program produces the trading actions as the final results of this back-testing. In fact, the final outputs of SH-1 not only include the trading actions but also affords all the relevant data to the final trading actions (All the results are shown in the table 4 of Appendix). In Table 4, the first left column indicates the threshold where Li-1 found a potential pattern at that threshold. On the left second column is the name of the stock. The columns, from third to fifth show 6 EPs with their relative prices and dates. In addition, the last two rows record the results of trading decisions. Among these, BP.P is Buying Price; BP.D is Buying Point Date; SP.P is the Selling Price; SP.D is Selling Point Date; SL.P means Stop Loss Price; SL.D means Stop Loss Date.

HSBP_Strategy opened 67 long positions from these 100 stocks. Eventually, 49 positions were closed for a selling profit, and 18 positions were executed for stop loss (See Appendix). Table 5 summarised the necessary data of this experiment. There are two technical issues with the trading strategy which have been modified in this summary. Firstly, this back-testing pre-set 5% for the

target rate return of all the trading actions. However, because we used the closing prices as the raw data, the final profits of the 49 long positions were different. For example, a position with a big jump in a trading day may lead to a higher rate of return if HSBP_Strategy closes the position at the date, which may greatly exceed the target rate of return. Likewise, a long position may be closed for stop loss, while HSBP_Strategy may close a position under the stop loss level sharply. Therefore, we uniformly adjusted the trading results of the rate of returns and the stop losses. For this test, all the 49 profitable trades were taken at the same target return rate Tp 5%, while the other 18 trades were automatically closed by HSBP_Strategy at the stop loss level. In addition, we simulated a 1 million dollars account to run through the data of the 67 records. In the end, the financial capital was $2,050,085, and the average holding days for each trade was 32.12 days (See Table 5).

Table 5. Summarizes for trading results of HSBP_Strategy

Median return	5%
Average return	1.29%
Standard deviation (risk)	0.064176
Maximum drawdown	-16.62%
Number of taking profit trades	49
Number of stop loss trades	18
Ave Holding days	32.12
Initial Capital	USD 1,000,000
Final Capital	USD 2,050,085
Time Scale	01/2004 to 11/2015

6. Discussion

6.1 The advantage of DC in the definition of HSBP

Head and Shoulder Bottom Pattern is a nonlinear chart pattern. There was no accurate definition for this pattern. In fact, the concept of HSBP was developed by the experiences and skills of the analysts. Even in some of the well-known books in the field of technical analysis, the definition of HSBP mainly tended to illustrate the shape of the pattern or to introduce the usage of HSBP trading strategy in the stock markets. However, it is ambiguous to confirm the formation of HSBP specifically. For instance, there was no clear definition to specifies the positions of the three bottom points in a HSBP. Therefore, it is difficult to quantify HSBP in order to implement the recognition of the pattern through computers. However, Directional Change is a positive method to define the framework of HSBP. It is simple to summarise the bottom points by confirming the extreme points of the downtrends. Moreover, a HSBP comprises seven extreme points, and these EPs can be determined by DC with a given threshold. In addition, HSBP conditions are created to identify positions of the seven EPs on the chart which are the essential element in this experiment. In this experiment, we confirm a potential HSBP by using the six HSBP conditions which are the six rigorous mathematical conditions as introduced in Section 4.4. The HSBP trading strategy Li-1 is a valuable trading strategy for HSBP, and the main strategy of Li-1 is to open long positions, which was the idea brought forward by the pioneers of technical analysis [6, 20].

6.2 Different thresholds produce different number of potential HSBPs.

According to the results of the experiment, there were 67 trading actions executed in this back-testing in the periods from 01/2004 to 11/2015. Among of these, 49 trading actions made profits, and 18 positions were closed at the stop loss levels. To be specific, 48 trading actions were executed within the thresholds from 5% to 10%. 11 trading decisions were made between 11% and 15%, and three positions were performed with the threshold over 15%. Moreover, all the 18 positions were executed at the stop loss levels with the threshold from 5% to 15%.

To summarise the trading records above, the most of the trading actions were executed with the thresholds between 5% and 10%, and that means the majority of potential HSBPs were determined under that thresholds range. It is beneficial to establish a rational range of the thresholds for further experiments. Also, we assume that the different markets exhibit different volatilities, which would need adjustments in the chosen threshold, relative to the specific stock market.

According to the Figure 25, it is obvious that 64 out of total trading actions were executed in the range between 5% - 20% and only three long positions opened over the threshold of 20%. Among of these, all the stop-loss actions were executed in the range of the thresholds between 5% and 15%. Besides, the results indicated that all long positions were finally closed at the target 5% with the thresholds over 15%. Overall, there are two points to summarise and discuss for the correlation between thresholds and the HSBP trading strategy. First, most of the HSBPs were confirmed in the range of thresholds between 5% to 20%.

Second, based on the 5% target of the rate of return, there is high probability that the HSBP trading strategy can make profits when the thresholds are over 15%.

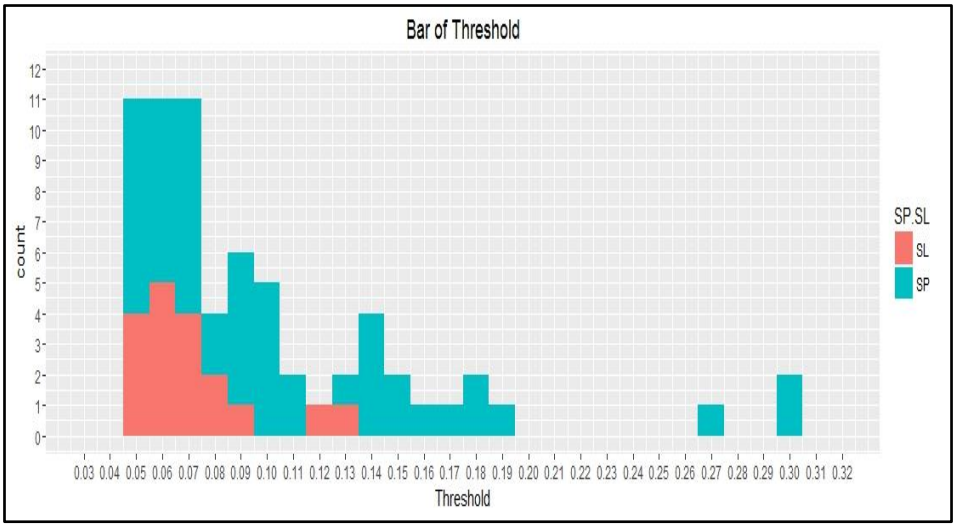

Figure 25. A summary of the trading actions results.

6.3 Uncommon HSBPs

Under the six HSBP Conditions, there were some uncommon HSBPs which deviated from the classic acknowledgment of HSBP. But, these patterns were confirmed by SH-1. Although most of the technical analysis manuals introduced that the formation of Head and Shoulders Pattern has the property of symmetry, there is no evidence to prove this is the case. According to the results, 23 uncommon HSBPs indicated asymmetrical features. Based on the shapes of this uncommon HSBP, we separated them into two classifications approximately.

1. The first group is the asymmetries of the two shoulders in the HSBPs that the periods (days) of the formation of one shoulder is longer than another shoulder.
2. The second group is the asymmetries of the left and the right trend of the EP4 that the periods of one trend is longer than another trend.

Figure 26 is an example of the uncommon HSBP which was recognised in the periods from 02/04/2012 to 29/06/2012 in NHC[4] (It both includes the features of 1 and 2). First, the periods of the formations in left shoulders is longer than the periods of the formations in right shoulders for 10 trading days. Second, the periods of the left downtrend of EP4 is longer than the periods of the right uptrend of EP4 for 24 trading days.

Figure 26. An extreme HSBP, the periods from EP3 to EP4 is much longer than the periods from EP4 to EP5 and the left shoulder and right shoulder are asymmetric.

If we follow the classic definition of Head and Shoulders Pattern, it is clear that these uncommon HSBPs cannot be confirmed as HSBPs. However, the results represented that 17 out of 23 uncommon HSBPs were finally closed the positions by SH-1 at the target of the rate of return. The result alerted us to consider whether these uncommon HSBPs could be confirmed as HSBPs. In

[4] NHC is the symbol of National Healthcare Corp.

fact, there were two reasons to support the idea to confirm HSBPs for these uncommon HSBPs. First, these patterns were determined under the HSBP conditions and the trading strategy Li-1. Second, the positive results presented that these patterns may not be denied to indicate the reverses of the tendencies, and fundamentally HSBP is a reversal pattern. Therefore, it is conclusive to admit that these patterns are HSBPs under our HSBP definition.

Schabacker, Edwards and Magee [6, 20] both presented that the formation of Head and Shoulders Pattern based on the support and resistance conditions. Moreover, the price movements are simply volatile in the gap between the support and resistance level. For example, the price may irregularly move up and down when it meets the support and resistance level. Hence, it is possible that, under the framework of HSBP Conditions, there are some HSBPs that were confirmed with the uncommon shape of the asymmetries.

Overall, this study focused on building the foundations of the conditions for common HSBP. In this experiment, we established the basic structure of common HSBPs which were constructed by the method of Directional Change and HSBP Conditions. Based on the fundamental framework, the further improvements for HSBP conditions would be beneficial to improve the ability of accuracy for recognising HSBPs.

6.4 Comparison to previous work

This section presents a comparison with the previous work from Osler and Chang [16, 17]. They used the technical indicator called zigzag to summarise the reversal points [22]. Zigzag is a popular indicator to determine uptrends and

downtrends in technical analysis. In fact, both Zigzag and DC can summarise the EPs when a threshold is given, while Directional Change can summarise more information for the price changes. A peak is defined by a decline of a constant percentage threshold after a local maximum price. A trough is defined by an ascent of a constant percentage threshold after a local minimum price.

According to the past work from Osler and Chang, they tested head and shoulder top pattern (HSTP) in the Forex market. Their main method to determine HSTPs based on the five HSTP criteria which they limit the shape of HSTP. Basically, there are five reversal points on the body of HSTP which is obtained by the technical zigzag indicator. Moreover, they developed these criteria based on the eight technical manuals, and there was no specific mathematical equation or algorithm. Besides, they compared the trading strategy of HSTP with the other technical indicators, and the results indicated that HSTP is not a significant trading strategy for making profits compared with other technical indicators.

For the experiment of HSBP, we focus more on constructing a framework to recognise HSBPs. To determine a precise HSBP, we built seven EPs framework of HSBP and, based on DC EPs, created clear mathematical conditions to confirm HSBPs. So, the definition of HSBP is unambiguous given a threshold and parameters in the conditions. The aim to develop trading strategy Li-1 is to evaluate the profitability of the confirmed HSBPs in the stock market, and the results demonstrated the usefulness of HSBP defined under HSBP conditions.

7. Conclusion

7.1 The significance of this thesis

Head and Shoulders Pattern has been widely used for detecting the upward reversal signal of the market trends, and technical traders generally apply Head and Shoulders Pattern as a trading strategy to search for trading opportunity. For example, a buying opportunity will be obtained when the price upward penetrates the neckline for HSBP. The descriptions of HSBP have been published from many technical books since, Richard W. Schabacker introduced the theory of Head and Shoulders Pattern in the 1930s. However, the pattern was normally described in words in the literature, and there was no clear definition to what constituted a Head and Shoulders Pattern. The reasons for the ambiguous definition is mainly because the complexity of the nonlinear pattern, and the theory of Head and Shoulders Pattern were established by the experiences and skills of the technical analysts. So, this thesis aims to define Head and Shoulders Pattern under Directional Change (DC) framework. It is precise to determine the extreme points (reversal points) of the trends by using the DC method. Given a threshold, DC summarises all the extreme points from a raw data series, which is significant for solving the confirmation of general price trends in the financial markets. Also, a HSBP is essentially formed by the six trends. So, it is unambiguous to confirm these six trends by using the DC method. Based on DC extreme points, we defined HSBP Conditions in terms of mathematical and logical relationships, which is the core to determine the positions between the

seven sequential EPs in the chart. Therefore, once we give the required parameters to the program, it will detect HSBP precisely.

The HSBP trading strategy Li-1 is built based on the HSBP thus defined. The experiment had examined the performance of Li-1. In the back-testing, the program randomly selected 100 stocks from NASDAQ. The results of this test indicated that Li-1 can be a profitable trading strategy, and all the executions of the trading decisions based on the 67 potential HSBPs were determined by the HSBP conditions.

Overall, there are two contributions made by this thesis to the field. First, it constructed a rigorous definition of HSBP based on Directional Change. Second, given the approach of HSBP-0, it allows us to evaluate the effectiveness of HSBP scientifically. In addition, we defined a trading strategy, Li-1, and examined the performance of Li-1. The results suggest that Li-1 can be a profitable trading strategy (We are not arguing for the profitability of HSBP trading strategy, and this conclusion is only based on the results of the back-testing).

7.2 Future works

HSBP-0 is the first step for the recognition of Head and Shoulders Bottom Pattern. This subject merely considers the essential factors for determining the framework of HSBP, while it has more improvements in the aspect of refining determination of HSBPs. However, for the trading strategy of HSBP, this project only presented the basic trading rules for the examination of recognising HSBP. Richard W. Schabacker and Edwards and Magee both indicated that the factor of the

volume is decisive in consideration of HSBP trading strategy[6][20]. However, Bulkowski argued that the factor of high volume does not directly guarantee the performance of HSBP trading strategy [3]. Hence, the further works will focus on the HSBP trading strategy, especially in consideration of the factors which may influence the performance of HSBP trading strategy.

Additionally, the approach of HSBP-0 for recognising HSBP is fundamental through using DC to identify EPs, and the HSBP conditions are the core to specify the positions between the seven EPs. This approach also can be applied to recognise other technical patterns. These will be considered through future works.

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APPENDIX

Table 4

Threshold	Name of Share	EP	Price	Date	Threshold	Name of Share	EP	Price	Date
0.05	ELTK	1	3.19	11/27/2013	0.14	BRKR	1	15.56	4/20/2010
		2	2.3	12/6/2013			2	11.97	6/8/2010
		3	2.44	12/9/2013			3	13.76	6/18/2010
		4	2.2	12/17/2013			4	10.88	7/19/2010
		5	2.4	12/19/2013			5	13.76	8/4/2010
		6	2.27	12/20/2013			6	11.89	8/31/2010
	BP.P	BP.D	SP.P	SP.D		BP.P	BP.D	SP.P	SP.D
	2.428	12/23/2013	2.66	1/7/2014		13.78	9/13/2010	14.58	10/5/2010

Threshold	Name of Share	EP	Price	Date	Threshold	Name of Share	EP	Price	Date
0.06	ELTK	1	3.19	11/27/2013	0.08	AMZN	1	96.3	1/2/2008
		2	2.3	12/6/2013			2	68.5	2/6/2008
		3	2.44	12/9/2013			3	77.7	2/13/2008
		4	2.2	12/17/2013			4	62.4	3/3/2008
		5	2.5	12/24/2013			5	75.9	3/24/2008
		6	2.29	12/30/2013			6	69.8	3/28/2008
	BP.P	BP.D	SLP.P	SLP.D		BP.P	BP.D	SP.P	SP.D
	2.66	1/7/2014	2.29	1/24/2014		76.7	4/1/2008	81	4/23/2008

Threshold	Name of Share	EP	Price	Date	Threshold	Name of Share	EP	Price	Date
0.27	ELTK	1	5.35	3/28/2005	0.13	AMZN	1	96.3	1/2/2008
		2	2.15	5/2/2005			2	68.5	2/6/2008
		3	3.12	5/17/2005			3	77.7	2/13/2008
		4	1.69	6/7/2005			4	62.4	3/3/2008
		5	2.82	7/14/2005			5	82	4/28/2008
		6	2.21	7/19/2005			6	72.4	5/9/2008
	BP.P	BP.D	SP.P	SP.D		BP.P	BP.D	SLP.P	SLP.D
	3.06	7/26/2005	3.28	8/8/2005		84.5	6/5/2008	68.5	7/11/2008

Threshold	Name of Share	EP	Price	Date	Threshold	Name of Share	EP	Price	Date
0.1	PLKI	1	17.03	7/5/2011	0.18	AMZN	1	88.1	8/11/2008
		2	13.51	8/8/2011			2	48.7	10/15/2008
		3	14.94	8/9/2011			3	58.5	11/4/2008
		4	11.62	10/3/2011			4	35	11/20/2008
		5	15.69	11/18/2011			5	57.4	1/6/2009
		6	13.93	11/25/2011			6	48.4	1/27/2009
	BP.P	BP.D	SP.P	SP.D		BP.P	BP.D	SP.P	SP.D
	15.95	11/28/2011	16.85	1/31/2012		58.8	1/30/2009	63.6	2/3/2009

Threshold	Name of Share	EP	Price	Date	Threshold	Name of Share	EP	Price	Date
0.07	NSSC	1	10.707	5/5/2006	0.06	FCBC	1	32.83	3/1/2005
		2	9.167	5/22/2006			2	27.5	3/24/2005
		3	10.147	6/2/2006			3	29.32	4/7/2005
		4	8.32	6/13/2006			4	26.31	4/15/2005
		5	10.15	7/7/2006			5	29.01	5/9/2005
		6	9.45	7/14/2006			6	27.32	5/13/2005
	BP.P	BP.D	SLP.P	SLP.D		BP.P	BP.D	SP.P	SP.D
	10.45	7/26/2006	8.17	9/11/2006		29.33	5/26/2005	31.18	6/15/2005

Threshold	Name of Share	EP	Price	Date	Threshold	Name of Share	EP	Price	Date
0.07	NSSC	1	3.13	3/30/2012	0.09	FCBC	1	40.05	3/21/2007
		2	2.89	4/11/2012			2	29.16	6/12/2007
		3	3.11	5/11/2012			3	31.91	6/19/2007
		4	2.67	5/18/2012			4	25.52	7/24/2007
		5	3.06	6/7/2012			5	32.17	8/8/2007
		6	2.82	6/22/2012			6	29.1	8/14/2007
	BP.P	BP.D	SP.P	SP.D		BP.P	BP.D	SP.P	SP.D
	2.98	7/19/2012	3.15	8/24/2012		33.12	8/16/2007	35.21	8/22/2007

Threshold	Name of Share	EP	Price	Date	Threshold	Name of Share	EP	Price	Date
0.14	NSSC	1	3	6/24/2011	0.07	EEI	1	14.65	4/17/2009
		2	2.4	8/11/2011			2	13.43	5/1/2009
		3	2.78	9/13/2011			3	14.43	5/6/2009
		4	1.97	11/17/2011			4	11.85	5/13/2009
		5	2.9	1/31/2012			5	14.22	5/29/2009
		6	2.44	2/15/2012			6	13.24	6/3/2009
	BP.P	BP.D	SP.P	SP.D		BP.P	BP.D	SLP.P	SLP.D
	2.95	3/15/2012	3.13	3/26/2012		14.22	6/4/2009	13.01	6/22/2009

Threshold	Name of Share	EP	Price	Date	Threshold	Name of Share	EP	Price	Date
0.07	EEI	1	11.088	1/28/2015	0.07	CIA	1	7.049	4/16/2004
		2	9.75	2/5/2015			2	6.49	4/20/2004
		3	10.47	2/19/2015			3	7.014	4/22/2004
		4	8.58	3/18/2015			4	5.267	5/13/2004
		5	10.71	6/26/2015			5	6.813	6/16/2004
		6	9.91	7/13/2015			6	6.332	6/22/2004
	BP.P	BP.D	SP.P	SP.D		BP.P	BP.D	SP.P	SP.D
	11.18	7/24/2015	11.75	9/2/2015		6.935	6/25/2004	7.284	6/29/2004

Threshold	Name of Share	EP	Price	Date	Threshold	Name of Share	EP	Price	Date
0.12	EEI	1	12.35	2/10/2014	0.13	CHEF	1	18.5	8/3/2011
		2	9.328	4/17/2014			2	12.98	9/6/2011
		3	11.14	5/27/2014			3	15.37	9/16/2011
		4	8.35	11/25/2014			4	11.7	10/3/2011
		5	10.75	1/14/2015			5	14.82	10/28/2011
		6	9.19	1/26/2015			6	13.09	11/29/2011
	BP.P	BP.D	SLP.P	SLP.D		BP.P	BP.D	SP.P	SP.D
	11.088	1/28/2015	9.18	3/16/2015		14.47	12/2/2011	15.84	12/6/2011

Threshold	Name of Share	EP	Price	Date	Threshold	Name of Share	EP	Price	Date
0.3	DMND	1	40.56	12/9/2011	0.07	CETV	1	26.36	10/13/2010
		2	26.92	12/20/2011			2	18.75	11/29/2010
		3	38.04	1/27/2012			3	21.2	1/3/2011
		4	12.98	11/21/2012			4	17.96	2/22/2011
		5	34.93	3/31/2014			5	20.68	3/3/2011
		6	24.58	1/30/2015			6	19.31	3/16/2011
	BP.P	BP.D	SP.P	SP.D		BP.P	BP.D	SP.P	SP.D
	33.33	6/25/2015	35.65	10/26/2015		20.7	3/21/2011	21.79	4/7/2011

Threshold	Name of Share	EP	Price	Date	Threshold	Name of Share	EP	Price	Date
0.15	DGI	1	31.61	9/11/2014	0.09	CE	1	47.01	8/31/2011
		2	26.79	10/13/2014			2	35.6	9/22/2011
		3	31.02	10/29/2014			3	39.41	9/27/2011
		4	24.07	12/11/2014			4	31.49	10/4/2011
		5	31.34	12/26/2014			5	40.85	10/14/2011
		6	26.89	1/30/2015			6	37.27	10/19/2011
	BP.P	BP.D	SP.P	SP.D		BP.P	BP.D	SP.P	SP.D
	33.25	2/27/2015	35.18	3/3/2015		42.17	10/24/2011	44.76	10/27/2011

Threshold	Name of Share	EP	Price	Date	Threshold	Name of Share	EP	Price	Date
0.08	DDD	1	5.306	5/12/2010	0.06	HCP	1	28.85	10/26/2004
		2	4.232	5/24/2010			2	26.18	11/19/2004
		3	4.756	5/27/2010			3	28.31	12/22/2004
		4	3.919	6/8/2010			4	23.45	4/6/2005
		5	4.636	6/18/2010			5	28.43	6/1/2005
		6	4.282	6/24/2010			6	26.6	6/27/2005
	BP.P	BP.D	SLP.P	SLP.D		BP.P	BP.D	SLP.P	SLP.D
	4.639	6/28/2010	4.185	6/30/2010		28.58	8/2/2005	25.39	8/8/2005

Threshold	Name of Share	EP	Price	Date	Threshold	Name of Share	EP	Price	Date
0.09	CLC	1	34.19	12/8/2008	0.06	HCP	1	40.6	4/28/2011
		2	30.03	12/24/2008			2	35.03	6/10/2011
		3	33.68	1/5/2009			3	38.2	7/8/2011
		4	27.49	1/14/2009			4	28.77	8/8/2011
		5	32.43	1/15/2009			5	37.28	8/31/2011
		6	29.73	1/26/2009			6	34.94	9/9/2011
	BP.P	BP.D	SLP.P	SLP.D		BP.P	BP.D	SLP.P	SLP.D
	31.84	1/28/2009	29.79	2/19/2009		37.42	9/16/2011	34.86	9/28/2011

Threshold	Name of Share	EP	Price	Date	Threshold	Name of Share	EP	Price	Date
0.11	CLC	1	33.68	1/5/2009	0.09	HCP	1	40.6	4/28/2011
		2	27.49	1/14/2009			2	35.03	6/10/2011
		3	32.82	2/6/2009			3	38.2	7/8/2011
		4	23.41	3/20/2009			4	28.77	8/8/2011
		5	32.51	5/8/2009			5	37.55	9/20/2011
		6	27.89	6/22/2009			6	33.83	10/3/2011
	BP.P	BP.D	SP.P	SP.D		BP.P	BP.D	SP.P	SP.D
	32.48	7/23/2009	35.25	1/14/2010		37.97	21/10/2011 0	40.19	10/28/2011

Threshold	Name of Share	EP	Price	Date	Threshold	Name of Share	EP	Price	Date
0.1	HCP	1	43.95	9/18/2013	0.07	FNGN	1	22.84	4/30/2012
		2	39.05	10/4/2013			2	19.85	5/17/2012
		3	43.05	10/25/2013			3	21.58	6/6/2012
		4	35.66	12/12/2013			4	18.16	8/1/2012
		5	43.73	9/5/2014			5	22.03	8/7/2012
		6	39.47	9/24/2014			6	20.53	8/23/2012
	BP.P	BP.D	SP.P	SP.D		BP.P	BP.D	SP.P	SP.D
	43.97	10/31/2014	47.14	1/7/2015		22.4	9/13/2012	23.72	9/21/2012

Threshold	Name of Share	EP	Price	Date	Threshold	Name of Share	EP	Price	Date
0.06	HBHC	1	33.31	10/24/2011	0.05	FMC	1	12.5	12/1/2004
		2	29.08	11/1/2011			2	11.67	12/9/2004
		3	31.59	11/8/2011			3	12.255	12/28/2004
		4	27.58	11/25/2011			4	10.855	1/24/2005
		5	31.43	12/9/2011			5	12.07	2/2/2005
		6	29.5	12/14/2011			6	11.463	2/10/2005
	BP.P	BP.D	SP.P	SP.D		BP.P	BP.D	SP.P	SP.D
	31.43	12/16/2011	33.8	1/9/2012		12.063	2/15/2005	12.893	3/1/2005

Threshold	Name of Share	EP	Price	Date	Threshold	Name of Share	EP	Price	Date
0.06	HBHC	1	35.63	11/12/2014	0.06	FMC	1	15.65	7/22/2005
		2	29.11	12/15/2014			2	12.68	10/12/2005
		3	31.09	12/29/2014			3	13.655	11/1/2005
		4	25.19	1/21/2015			4	12.3	11/18/2005
		5	31.07	3/12/2015			5	13.852	12/2/2005
		6	28.7	3/19/2015			6	12.963	12/19/2005
	BP.P	BP.D	SLP.P	SLP.D		BP.P	BP.D	SP.P	SP.D
	31.07	4/15/2015	28.3	4/27/2015		14.403	2/1/2006	15.305	2/15/2006

Threshold	Name of Share	EP	Price	Date	Threshold	Name of Share	EP	Price	Date
0.05	GLDC	1	4.75	8/22/2005	0.07	FMC	1	46.43	7/21/2011
		2	4.4	8/23/2005			2	35.145	8/8/2011
		3	4.713	8/30/2005			3	37.78	8/15/2011
		4	4.2	9/6/2005			4	33.375	8/22/2011
		5	4.678	9/9/2005			5	37.965	8/31/2011
		6	4.43	9/12/2005			6	35.21	9/12/2011
	BP.P	BP.D	SLP.P	SLP.D		BP.P	BP.D	SLP.P	SLP.D
	4.67	9/13/2005	4.4	9/19/2005		38.22	9/15/2011	34.36	9/22/2011

Threshold	Name of Share	EP	Price	Date	Threshold	Name of Share	EP	Price	Date
0.07	GILD	1	24.185	4/6/2009	0.08	INT	1	40.91	3/30/2011
		2	21.865	4/21/2009			2	36.44	4/19/2011
		3	23.8	4/28/2009			3	39.58	4/29/2011
		4	20.72	5/27/2009			4	33.11	6/13/2011
		5	23.94	6/25/2009			5	39.02	7/21/2011
		6	22.22	7/10/2009			6	35.54	8/2/2011
	BP.P	BP.D	SLP.P	SLP.D		BP.P	BP.D	SLP.P	SLP.D
	24.275	7/21/2009	21.915	10/23/2009		39.49	8/3/2011	35.6	8/5/2011

Threshold	Name of Share	EP	Price	Date	Threshold	Name of Share	EP	Price	Date
0.05	GABC	1	24.89	9/24/2012	0.1	INT	1	19.23	12/30/2008
		2	21.75	10/19/2012			2	15.41	1/12/2009
		3	22.86	11/1/2012			3	17.57	1/28/2009
		4	19.98	11/15/2012			4	13.075	3/9/2009
		5	22.73	12/20/2012			5	17.045	3/26/2009
		6	21.24	12/28/2012			6	15.43	4/1/2009
	BP.P	BP.D	SLP.P	SLP.D		BP.P	BP.D	SP.P	SP.D
	23.02	1/2/2013	21.29	4/9/2013		17.005	4/9/2009	18.005	4/16/2009

Threshold	Name of Share	EP	Price	Date	Threshold	Name of Share	EP	Price	Date
0.09	GABC	1	13.6	9/12/2008	0.14	IILG	1	17.63	2/14/2011
		2	11.66	9/30/2008			2	12.55	6/13/2011
		3	12.9	10/1/2008			3	14.42	7/7/2011
		4	10.4	3/18/2009			4	10.4	8/8/2011
		5	12.98	4/17/2009			5	14.75	11/7/2011
		6	11.85	4/24/2009			6	12.35	11/25/2011
	BP.P	BP.D	SP.P	SP.D		BP.P	BP.D	SP.P	SP.D
	13.9	5/20/2009	14.99	6/24/2009		15.51	3/9/2012	16.42	3/14/2012

Threshold	Name of Share	EP	Price	Date	Threshold	Name of Share	EP	Price	Date
0.06	HOT	1	62.82	6/1/2006	0.09	MBLX	1	159.48	8/9/2007
		2	55.55	6/14/2006			2	130.8	8/15/2007
		3	61.51	7/3/2006			3	142.62	8/17/2007
		4	50.19	8/11/2006			4	123.9	9/13/2007
		5	60.52	9/20/2006			5	148.38	9/27/2007
		6	56.79	9/28/2006			6	134.52	10/11/2007
	BP.P	BP.D	SP.P	SP.D		BP.P	BP.D	SP.P	SP.D
	60.64	10/5/2006	65.61	11/21/2006		162.78	10/12/2007	173.34	10/31/2007

Threshold	Name of Share	EP	Price	Date	Threshold	Name of Share	EP	Price	Date
0.16	LBY	1	16.81	7/7/2011	0.17	LIOX	1	7.3	3/5/2014
		2	11.36	8/22/2011			2	5.11	5/8/2014
		3	13.31	8/29/2011			3	6.16	7/3/2014
		4	10.08	10/5/2011			4	4.13	10/10/2014
		5	13.27	10/27/2011			5	5.85	12/29/2014
		6	11.25	11/25/2011			6	4.98	1/30/2015
	BP.P	BP.D	SP.P	SP.D		BP.P	BP.D	SP.P	SP.D
	14.03	1/19/2012	14.89	1/25/2012		5.81	2/17/2015	6.2	6/8/2015

Threshold	Name of Share	EP	Price	Date	Threshold	Name of Share	EP	Price	Date
0.1	LBIX	1	15.7	3/12/2007	0.05	OII	1	16.89	1/6/2009
		2	13.25	3/21/2007			2	14.29	1/14/2009
		3	14.95	3/23/2007			3	15.025	1/15/2009
		4	11.788	4/11/2007			4	14.055	1/20/2009
		5	14.8	4/16/2007			5	15.36	1/21/2009
		6	13.45	4/23/2007			6	14.62	1/22/2009
	BP.P	BP.D	SP.P	SP.D		BP.P	BP.D	SP.P	SP.D
	15.65	5/7/2007	16.7	5/25/2007		15.88	1/23/2009	17.525	1/28/2009

Threshold	Name of Share	EP	Price	Date	Threshold	Name of Share	EP	Price	Date
0.18	KOP	1	45.73	4/29/2011	0.05	OBCI	1	4.49	10/17/2014
		2	28.39	8/22/2011			2	3.47	10/29/2014
		3	33.55	8/30/2011			3	3.73	10/31/2014
		4	24.13	9/23/2011			4	3.3	11/10/2014
		5	36.23	11/4/2011			5	3.68	11/14/2014
		6	28.45	11/25/2011			6	3.46	11/17/2014
	BP.P	BP.D	SP.P	SP.D		BP.P	BP.D	SLP.P	SLP.D
	39.79	2/1/2012	41.83	1/22/2013		3.64	11/28/2014	3.45	12/2/2014

Threshold	Name of Share	EP	Price	Date	Threshold	Name of Share	EP	Price	Date
0.05	KBAL	1	12.7	7/30/2015	0.3	OBCI	1	1.95	2/9/2004
		2	10.3	8/25/2015			2	1.21	7/23/2004
		3	10.93	8/31/2015			3	1.59	8/4/2004
		4	9.31	9/29/2015			4	0.93	12/1/2004
		5	10.7	10/12/2015			5	1.79	1/10/2005
		6	10.16	10/21/2015			6	1.23	1/11/2005
	BP.P	BP.D	SP.P	SP.D		BP.P	BP.D	SP.P	SP.D
	10.79	10/23/2015	11.64	11/3/2015		1.97	1/28/2005	2.37	1/31/2005

Threshold	Name of Share	EP	Price	Date	Threshold	Name of Share	EP	Price	Date
0.05	MGLN	1	38.46	10/18/2004	0.06	NHC	1	47.02	4/2/2012
		2	33.7	11/11/2004			2	43.13	4/10/2012
		3	35.66	11/29/2004			3	46.25	4/27/2012
		4	31.39	12/10/2004			4	40.96	6/13/2012
		5	35.565	12/21/2004			5	45.32	6/19/2012
		6	33.41	1/5/2005			6	42.5	6/21/2012
	BP.P	BP.D	SLP.P	SLP.D		BP.P	BP.D	SP.P	SP.D
	36.21	1/14/2005	33.39	2/15/2005		45.23	6/29/2012	48.56	7/13/2012

Threshold	Name of Share	EP	Price	Date	Threshold	Name of Share	EP	Price	Date
0.05	MGLN	1	47.79	6/13/2007	0.06	NCT	1	16.886	2/7/2007
		2	39.57	8/9/2007			2	13.642	3/5/2007
		3	42.22	8/16/2007			3	14.676	3/9/2007
		4	38.29	9/17/2007			4	12.885	3/14/2007
		5	42.62	10/12/2007			5	14.747	3/26/2007
		6	40.55	11/1/2007			6	13.854	4/2/2007
	BP.P	BP.D	SP.P	SP.D		BP.P	BP.D	SLP.P	SLP.D
	45.48	11/2/2007	47.95	12/20/2007		15.075	4/18/2007	13.622	6/25/2007

Threshold	Name of Share	EP	Price	Date
0.05	PII	1	78.62	5/24/2012
		2	71.97	6/1/2012
		3	75.59	6/6/2012
		4	68.63	6/13/2012
		5	75.03	7/19/2012
		6	70.98	7/24/2012
	BP.P	BP.D	SP.P	SP.D
	75.21	7/26/2012	80.76	9/10/2012

Threshold	Name of Share	EP	Price	Date
0.07	SBR	1	56.01	7/9/2012
		2	44	11/15/2012
		3	47.93	11/29/2012
		4	39.37	12/28/2012
		5	48.28	2/8/2013
		6	45	2/21/2013
	BP.P	BP.D	SP.P	SP.D
	49.2	4/5/2013	51.71	5/10/2013

Threshold	Name of Share	EP	Price	Date
0.07	PII	1	22.435	2/1/2008
		2	20.025	2/19/2008
		3	21.635	2/26/2008
		4	18.415	3/10/2008
		5	21.845	4/8/2008
		6	20.345	4/11/2008
	BP.P	BP.D	SP.P	SP.D
	22.215	4/16/2008	23.595	5/1/2008

Threshold	Name of Share	EP	Price	Date
0.15	SBR	1	44.76	11/26/2008
		2	37.6	12/22/2008
		3	44.475	1/6/2009
		4	28.83	3/9/2009
		5	42.92	5/14/2009
		6	37.27	5/21/2009
	BP.P	BP.D	SP.P	SP.D
	42.76	6/1/2009	44.92	6/11/2009

Threshold	Name of Share	EP	Price	Date
0.1	PPP	1	2.92	5/29/2012
		2	2.59	6/13/2012
		3	2.88	6/20/2012
		4	2.37	6/28/2012
		5	2.82	7/3/2012
		6	2.54	7/12/2012
	BP.P	BP.D	SP.P	SP.D
	2.79	7/18/2012	2.93	7/19/2012

Threshold	Name of Share	EP	Price	Date
0.19	RMBS	1	46.8	4/18/2006
		2	14.79	7/27/2006
		3	17.63	7/31/2006
		4	10.26	8/11/2006
		5	19.23	10/13/2006
		6	15.99	11/9/2006
	BP.P	BP.D	SP.P	SP.D
	21.72	11/16/2006	23.1	11/24/2006

Threshold	Name of Share	EP	Price	Date
0.11	PPP	1	4.835	1/20/2015
		2	3.18	2/20/2015
		3	3.55	2/27/2015
		4	2.9	3/10/2015
		5	3.72	3/23/2015
		6	3.35	3/30/2015
	BP.P	BP.D	SP.P	SP.D
	3.85	4/6/2015	4.05	5/12/2015

Threshold	Name of Share	EP	Price	Date
0.05	YUM	1	78.3	11/22/2013
		2	71.6	12/12/2013
		3	76.56	1/7/2014
		4	66.16	2/3/2014
		5	77.4	3/10/2014
		6	73.2	3/27/2014
	BP.P	BP.D	SP.P	SP.D
	78.65	6/3/2014	83.23	7/9/2014

Threshold	Name of Share	EP	Price	Date
0.14	RIC	1	9.85	4/28/2011
		2	7.15	5/5/2011
		3	8.55	5/27/2011
		4	6.46	6/16/2011
		5	8.65	8/3/2011
		6	7.53	8/8/2011
	BP.P	BP.D	SP.P	SP.D
	8.75	8/10/2011	9.61	8/15/2011

Threshold	Name of Share	EP	Price	Date
0.08	YUM	1	32.87	1/5/2009
		2	27.57	2/2/2009
		3	30.29	2/9/2009
		4	23.47	3/9/2009
		5	29.86	3/26/2009
		6	27.48	3/31/2009
	BP.P	BP.D	SP.P	SP.D
	30.03	4/2/2009	31.82	4/16/2009

Threshold	Name of Share	EP	Price	Date
0.06	UNM	1	23.82	6/15/2010
		2	21.26	7/2/2010
		3	23.24	8/2/2010
		4	19.45	8/26/2010
		5	22.92	11/4/2010
		6	21.48	11/23/2010
	BP.P	BP.D	SP.P	SP.D
	23.26	12/8/2010	24.58	12/22/2010