Dynamical Models of Stock Prices Based on Technical Trading Rules Part III: Application to Hong Kong Stocks

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Key words: Fuzzy systems; stock markets; technical analysis; chaos; nonlinear dynamical systems

Abstract

In Part III of this paper, we apply the price dynamical model with big buyers and big sellers developed in Part I of this paper to the daily closing data of the top 20 stocks in Hang Seng Index in Hong Kong Stock Exchange. The basic idea is to estimate the strength parameters of the big buyers and the big sellers in the model and make buy/sell decisions based on these parameter estimates. We develop two trading strategies: (i) Follow-the-Big-Buyer which buys when big buyer begins to appear and there is no sign of big sellers, holds the stock as long as the big buyer is still there, and sells all holdings of this stock once the big buyer disappears; and (ii) Ride-the-Mood which buys as soon as the big buyer strength begins to surpass the big seller strength and sells all holdings of the stock once the big seller strength is larger than the big buyer strength. Based on the testing over 198 two-year intervals uniformly distributed across the six-year period from 03-July-2007 to 28-June-2013 which includes a variety of scenarios, the net profits would increase 47% or 64% on average if an investor switched from the benchmark Buy-and-Hold strategy to the Follow-the-Big-Buyer or Ride-the-Mood strategies during this period, respectively.
1. Introduction

Stock market is a battlefield among traders with different beliefs (e.g. Graham and Dodd, 1940; Keynes, 1935; Livermore, 1940; Lynch, 1994; Soros, 2003), and it is the winner’s belief that determines the destiny of the stock price\(^1\). So our basic trading philosophy is to follow the winners. But who are the winners? In this paper we concentrate on one type of traders who we believe are very likely to be the winners: the big buyers and the big sellers\(^2\). To follow the big buyers/sellers, we must first find some way to detect them based on the noisy price data. This seems to be a mission impossible, given the fact that the main task of these large investors is to hide their intentions as secret as possible by implementing a variety of sophisticated strategies to confuse or mislead other traders (e.g. Kirilenko and Lo, 2013; Jiang, 2013). But, above all these ever-changing strategies, one thing is almost certain: the big buyer (seller) must buy (sell) a large amount of the stock within a reasonable period of time with prices not too much higher (lower) than the market price at the time when the buying (selling) decision was made (Bouchaud, Farmer and Lillo, 2008). It seems inevitable that Heuristic 7 and Heuristic 6 in Part I of this paper are the best choices for the big buyers and the big sellers, respectively.

To further justify Heuristics 7 and 6, we quote below what Walter Deemer\(^3\) said in an interview by Andrew Lo (page 26 of Lo and Hasanhodzic, 2009):

> When I went to work for Putnam Investments in 1970, in my very early days, I told one of the big fund managers that IBM had just broken out. “Fine, but I can’t buy it,” he said. “It’s already broken out and moving, the price is rallying. I can’t really buy it in size. So what I need you to do is tell me before it breaks out.” So I went back to my office and spent quite a bit of time working on that, but I soon found out that when you’re dealing with major institutions, managing large sums of money, you need to tell them that the only time they can really buy in quantity is during the decline, and the only time they can really sell in quantity is in a rally.

The last two lines of the quote above are Heuristics 7 and 6. So now we move on to use Heuristics 7/6 as the model for the big buyers/sellers. Specifically, as we developed in

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\(^1\) If there were no winners, the prices would be purely random.

\(^2\) Of course there are other types of winners such as “the crowd” who have the so-called “swarm intelligence” (Kennedy and Eberhart, 2001) and follow Keynes’ Beauty Contest Theory (Keynes, 1935).

\(^3\) Walter Deemer is the featured technical analyst in Dean LeBaron’s book *Dean LeBaron’s Treasury of Investment Wisdom*, joining such luminaries as John Bogle, Peter Lynch, and George Soros as the chosen gurus in their fields (quote from page 25 of Lo and Hasanhodzic, 2009).
Part I of this paper and rewrite it here, the price dynamical model for the big buyers and the big sellers is the following:

$$\ln(p_{t+1}) = \ln(p_t) + a_6(t) \cdot ed_6\left(x_t^{(1,n)}\right) + a_7(t) \cdot ed_7\left(x_t^{(1,n)}\right) + \varepsilon(t)$$  \hspace{1cm} (1)$$

where \(ed_6\) (\(ed_7\)) is the excess demand of the big seller (buyer), \(a_6\) (\(a_7\)) is the strength parameter of the big seller (buyer), and \(\varepsilon(t)\) is the price impact of other traders except the big seller and the big buyer.

The first step of our trading strategies is to estimate the strength parameters \(a_6(t)\) and \(a_7(t)\) based on the price data up to the current time \(t\). Then, the trading strategies are developed based on the following three simple arguments:

- Positive \(a_6(t)\) implies the existence of big sellers;
- Positive \(a_7(t)\) implies the existence of big buyers;
- \(a_7(t) > a_6(t)\) indicates the price is in a rising mode, and \(a_7(t) < a_6(t)\) means the price is in a declining mode.

From the first two arguments above we develop a trading strategy called “Follow-the-Big-Buyer”, and based on the third argument above we develop a trading strategy called “Ride-the-Mode”; the basic ideas of these two strategies are as follows:

- **Follow-the-Big-Buyer**: Buy the stock once \(a_7(t)\) becomes positive and \(a_6(t)\) is negative (which means there are big buyers coming and there are no big sellers); hold the stock as long as \(a_7(t)\) is still positive (which means do not sell the stock as long as the big buyers are still buying, no matter what happens to the price or whether there are big sellers; stand firm with your big buyers); sell the stock once \(a_7(t)\) becomes negative (quit if your big buyers stop buying); the buy-sell round trip is completed and watch out for the next cycle.

- **Ride-the-Mode**: Buy the stock once \(a_7(t) - a_6(t)\) becomes positive (which means the big buyers are gaining an upper hand over the big sellers); hold the stock as long as \(a_7(t) - a_6(t)\) is still positive; sell the stock once \(a_7(t) - a_6(t)\) becomes negative (which means the big sellers become strong than the big buyers); the buy-sell round trip is completed and watch out for the next cycle.

In Section 2, we will show the details of the recursive lease-squares algorithm with exponential forgetting for estimating the parameters \(a_7\) and \(a_6\) based on price data, and simulate the algorithm to get a feeling of the accuracy of the estimated parameters. In Sections 3 and 4, we will develop the Follow-the-Big-Buyer and Ride-the-Mode strategies, respectively, and test them over the top 20 blue-chip stocks listed in the
Hong Kong Stock Exchange for the six year period from July 4, 1997 to June 28, 2013 using daily closing data only. Section 4 concludes the paper.

2. The Estimation Algorithm

Consider the price dynamical model (1) with the excess demand function \( ed_6 \) and \( ed_7 \) given as (from Part I of this paper):

\[
ed_6(x_t^{(1,n)}) = \frac{-0.1 \mu_{PS}(x_t^{(1,n)}) - 0.2 \mu_{PM}(x_t^{(1,n)}) - 0.4 \mu_{PL}(x_t^{(1,n)})}{\mu_{PS}(x_t^{(1,n)}) + \mu_{PM}(x_t^{(1,n)}) + \mu_{PL}(x_t^{(1,n)}) + \mu_{AZ}(x_t^{(1,n)})} \quad (2)
\]

\[
ed_7(x_t^{(1,n)}) = \frac{0.1 \mu_{NS}(x_t^{(1,n)}) + 0.2 \mu_{NM}(x_t^{(1,n)}) + 0.4 \mu_{NL}(x_t^{(1,n)})}{\mu_{NS}(x_t^{(1,n)}) + \mu_{NM}(x_t^{(1,n)}) + \mu_{NL}(x_t^{(1,n)}) + \mu_{AZ}(x_t^{(1,n)})} \quad (3)
\]

where the membership functions \( \mu \)'s are given in Fig. 1 of Part I of this paper, and

\[
x_t^{(1,n)} = \ln\left( \frac{\sum_{i=0}^{n-1} p_{t-i}}{p_t} \right) \quad (4)
\]

Substituting the membership functions into (2) and (3), we obtain:

\[
ed_6(x_t^{(1,n)}) = \begin{cases} 
0 & x_t^{(1,n)} \leq 0 \\
-0.1x_t^{(1,n)} - \frac{w}{w} & 0 \leq x_t^{(1,n)} \leq 2w \\
-0.2x_t^{(1,n)} + 0.2 & 2w \leq x_t^{(1,n)} \leq 3w \\
-0.4 & 3w \leq x_t^{(1,n)}
\end{cases} \quad (5)
\]

\[
ed_7(x_t^{(1,n)}) = \begin{cases} 
0.4 & x_t^{(1,n)} \leq -3w \\
-0.2x_t^{(1,n)} - \frac{w}{w} & -3w \leq x_t^{(1,n)} \leq -2w \\
-0.1x_t^{(1,n)} - \frac{w}{w} & -2w \leq x_t^{(1,n)} \leq 0 \\
0 & 0 \leq x_t^{(1,n)}
\end{cases} \quad (6)
\]

which are plotted in Fig. 1. Notice from (5) and (6) or Fig. 1 that at any value of \( x_t^{(1,n)} \), either \( ed_6(x_t^{(1,n)}) \) or \( ed_7(x_t^{(1,n)}) \) is zero. More specifically, when the price is in a rising
mode \((x_t^{(1,n)} > 0)\), the big buyer excess demand \(ed_7(x_t^{(1,n)})\) is zero; when the price is in a declining mode \((x_t^{(1,n)} < 0)\), the big seller excess demand \(ed_6(x_t^{(1,n)})\) is zero.

![Excess demand function](image)

**Fig. 1:** Excess demand functions \(ed_6(x_t^{(1,n)})\) (big seller) and \(ed_7(x_t^{(1,n)})\) (big buyer).

Now suppose we are given the price data \(\{p_0, p_1, \ldots, p_t, p_{t+1}\}\), our goal is to estimate the strength parameters \(a_6(t)\) and \(a_7(t)\) in model (1) based on this information set. Let \(r_{t+1} = \ln(p_{t+1}/p_t)\) be the return and define

\[
a_t = (a_6(t), a_7(t))^T
\]

(7)

\[
ed_t = \left(ed_6(x_t^{(1,n)}), ed_7(x_t^{(1,n)})\right)^T
\]

(8)

then the price dynamic equation (1) becomes

\[
r_{t+1} = ed_t^T a_t + \varepsilon(t)
\]

(9)

We can reasonably assume that the strength parameters \(a_t = (a_6(t), a_7(t))^T\) of the big buyer/seller are slowly time-varying, because a large buy/sell order has to be cut into small pieces and implemented incrementally over a long period of time due to the small liquidity available in the order book. A good method to estimate slowly time-varying
parameters is the standard Recursive Least Squares Algorithm with Exponential Forgetting which minimizes the weighted summation of error:

\[ E_{t+1}(a) = \sum_{i=1}^{t} \lambda^{t-i} (r_{t+1} - ed_{t}^T a)^2 \]  

(10)

to obtain the estimate of \( a_t \), denoted as \( \hat{a}_t \), through the following recursive computations (see e.g. page 53 of Åström and Wittenmark, 1995; or Wang, 1994):

\[ \hat{a}_t = \hat{a}_{t-1} + K_t (r_{t+1} - x_t^T \hat{a}_{t-1}) \]  

(11)

\[ K_t = \frac{P_{t-1} x_t}{x_t^T P_{t-1} x_t + \lambda} \]  

(12)

\[ P_t = (I - K_t x_t^T)P_{t-1}/\lambda \]  

(13)

where the initial \( \hat{a}_0 = 0, P_0 = \gamma I \) for some large \( \gamma \), and \( \lambda \in (0,1) \) is a forgetting factor to put more weight on recent data as in (10).

Before applying the algorithm to real stock data to identify big buyers and big sellers in the next two sections, we perform simulations to get some feeling about the performance of the parameter estimation algorithm. Let the price \( p_t \) be generated by model (1) with \( n=3, w=0.01 \), initial prices \( p_{-2} = p_{-1} = p_0 = 10, a_7(t) \) and \( -a_6(t) \) given as the blue lines in the top sub-figures of Figs. 2 to 4, and \( \varepsilon(t) \) being an i.i.d. zero-mean Gaussian random process with standard deviation \( \sigma \). Fig. 2 shows a simulation run of model (1) and the parameter estimation algorithm (11)-(13) with \( \sigma = 0.02, \lambda = 0.95 \) and \( \gamma = 10 \), where the bottom sub-figure is the price series \( p_t \) and the upper sub-figure plots the true parameters \( a_7(t) \) and \( -a_6(t) \) (blue lines) and their estimates \( \hat{a}_7(t) \) and \( -\hat{a}_6(t) \) (red lines). We see from Fig. 2 that the parameter estimates \( \hat{a}_7(t) \) and \( -\hat{a}_6(t) \) can in general catch up with the changes of the true parameters \( a_7(t) \) and \( -a_6(t) \), but the estimates \( \hat{a}_7(t) \) and \( -\hat{a}_6(t) \) are noisy.

To judge whether the estimates \( \hat{a}_7(t) \) and \( -\hat{a}_6(t) \) in Fig. 2 are good or not, we need to determine the signal-to-noise ratio of the prices \( p_t \) used in Fig. 2. Since in model (1) the signal term is \( a_6(t) ed_6(x_t^{(1, n)}) + a_7(t) ed_7(x_t^{(1, n)}) \) and the noise term is \( \varepsilon(t) \), we define the signal-to-noise ratio as follows:

\[ S/N = \left( \frac{1}{N} \sum_{t=1}^{N} \left( a_6(t) ed_6(x_t^{(1, n)}) + a_7(t) ed_7(x_t^{(1, n)}) \right)^2 \right)^{1/2} / \left( \frac{1}{N} \sum_{t=1}^{N} (\varepsilon(t))^2 \right)^{1/2} \]  

(14)
For the price $p_t$ in Fig. 2, the signal-to-noise ratio is $1.0518$, which means the price impact of the big seller plus the big buyer is roughly equal to the summation of the price impacts of the rest of the traders.

To see the performance of the estimation algorithm for more signal-to-noise cases, we show in Figs. 3 and 4 the simulation results with signal-to-noise ratio equal to $2.0675$ and $0.50156$, respectively. That is, for the price $p_t$ in Fig. 3 (Fig. 4), the price impact of the big seller plus the big buyer is about twice (half) as strong as the summation of the price impacts of the rest of the traders. From Figs. 2 to 4 we conclude that:

- The stronger the strength of the big buyer/seller with respect to the rest of the traders, the better the estimates of the strength parameters of the big buyer/seller;
- In the cases where the big buyer/seller is as strong as or stronger than the rest of the traders, we have good chance to identify the existence of the big buyer/seller in a timely fashion and to estimate their strengths correctly;
- Even in the case where the strength of the big buyer/seller is only about half of the other traders, we can still manage to detect the existence of the big buyer/seller (with longer delay).

Since big buyer/seller by definition should be stronger than other traders (otherwise they are not big), the conclusions above give us good confidence to apply the estimation algorithm to real stock data to detect the real hidden big buyers/sellers and follow them up; this is what we are going to do, next.

Fig. 2: Simulation of the parameter estimation algorithm for the case of signal-to-noise = $1.0518$. Top: true $a_7(t)$ and $-a_6(t)$ (blue lines) and their estimates (red lines). Bottom: the price $p_t$. 
Fig. 3: Simulation of the parameter estimation algorithm for the case of signal-to-noise = 2.0675.
Top: true $a_7(t)$ and $-a_6(t)$ (blue lines) and their estimates (red lines). Bottom: the price $p_t$

Fig. 4: Simulation of the parameter estimation algorithm for the case of signal-to-noise = 0.50156.
Top: true $a_7(t)$ and $-a_6(t)$ (blue lines) and their estimates (red lines). Bottom: the price $p_t$
3. Strategy 1: Follow-the-Big-Buyer (FollowBB)

The basic idea of the Follow-the-Big-Buyer (FollowBB) strategy was discussed in the Introduction, and the detailed algorithm is now given in Fig. 5, where

\[
\bar{a}_6(t, 3) = \frac{1}{3} \sum_{i=0}^{2} \hat{a}_6(t - i), \quad \bar{a}_7(t, 3) = \frac{1}{3} \sum_{i=0}^{2} \hat{a}_7(t - i)
\]  \hspace{1cm} (15)

are the 3-day moving averages of the estimated parameters \( \hat{a}_6(t) \) and \( \hat{a}_7(t) \) which are obtained from the parameter estimation algorithm (11) to (13). We use moving averages of the parameter estimates because we see from the simulation results in Figs. 2-4 that the parameter estimates were noisy and moving averages can smooth out the noise. The positive side of using moving averages is that false alarm rate can be reduced due to the reduction of noise, whereas its negative side is the increase of delays in detecting the arrival and depart of the big buyer/seller so that to miss the best buy/sell times. Notice from Fig. 5 that for a single stock using this strategy there are only has two states: full-cash or full-stock, no mixed cash/stock status.

Fig. 5: The buy-sell cycle of Strategy 1: Follow-the-big-buyer (FollowBB).
We now apply the Follow-the-Big-Buyer (FollowBB) strategy to the daily closing prices of the top 20 stocks in the Hang Seng Index (HSI) listed in the Hong Kong Stock Exchange. Table 1 shows the stock numbers, the company names, their industries, and the weights in HSI as of 2013-06-17 of these 20 stocks. We will use the daily closing price data of these 20 stocks during the six year period from July 03, 2007 to June 28, 2013 to test the trading strategies. Since the market conditions changed wildly during this period (the top sub-figure of Fig. 6 shows the HSI daily closings during this period which includes: 1) the strong rise in late 2007; 2) the big decline due to the 2008 financial crisis; 3) the recovery after the panic; and 4) the “ordinary” years from 2010 to 2013), it gives us a good chance to test the trading strategies in different market conditions.

We choose two years as the length for performance evaluation, and test the trading strategies for a large number of two year periods uniformly distributed over these six years; the bottom sub-figure of Fig. 6 illustrates the scheme: each test interval has 492 trading days (roughly two years), the first test interval starts from 03-07-2007, the second test interval starts 5 trading days later, the third starts another 5 trading days later, ..., and the 198th test interval ends around 28-06-2013 so that the whole six years are covered. For each test interval, we ran the FollowBB strategy in Fig. 5 for each of the 20 stocks in Table 1 using their daily closing prices as the \( p_t \) in our parameter estimation algorithm (11) to (13) with \( \lambda = 0.95, \gamma = 10, n=3 \) and \( w=0.01 \).

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\(^\text{4}\) All stock price data used in this paper were downloaded from \url{http://finance.yahoo.com} and were adjusted for dividends and splits.
Table 1: The stocks used to test the investment strategies: the top 20 stocks in Hang Seng Index (HSI) with the highest weights.

| Stock No. | Company names                              | Industry                     | Weights (%) in HSI as of 2013-06-17 |
|-----------|--------------------------------------------|------------------------------|-----------------------------------|
| 1         | HK0005 HSBC Holdings plc                   | Money Center Banks           | 15                                |
| 2         | HK0939 China Construction Bank Corporation | Money Center Banks           | 7.46                              |
| 3         | HK0941 China Mobile                        | Wireless Communications      | 6.97                              |
| 4         | HK1398 Industrial and Commercial Bank of China | Money Center Banks         | 5.58                              |
| 5         | HK3988 Bank of China Ltd                   | Money Center Banks           | 4.04                              |
| 6         | HK0883 China National Offshore Oil Corporation | Independent Oil & Gas     | 3.56                              |
| 7         | HK0857 PetroChina Co Ltd                   | Major Integrated Oil & Gas  | 2.92                              |
| 8         | HK0013 Hutchison Whampoa Ltd               | Wireless Communications      | 2.46                              |
| 9         | HK0386 China Petroleum & Chemical Corporation | Major Integrated Oil & Gas | 2.3                               |
| 10        | HK2628 China Life Insurance Company Ltd    | Life Insurance              | 2.24                              |
| 11        | HK0001 Cheung Kong (Holdings) Ltd          | Real Estate Development     | 2.22                              |
| 12        | HK0016 Sun Hung Kai Properties Ltd         | Real Estate Development     | 2.21                              |
| 13        | HK0388 Hong Kong Exchanges and Clearing Ltd | Mortgage Investment       | 1.98                              |
| 14        | HK0002 CLP Holdings Ltd                    | Electric Utilities          | 1.76                              |
| 15        | HK2318 Ping An Insurance                   | Insurance                   | 1.76                              |
| 16        | HK0003 The Hong Kong and China Gas Company | Gas Utilities              | 1.64                              |
| 17        | HK0004 The Wharf (Holdings) Ltd            | Property Management         | 1.49                              |
| 18        | HK0006 Power Assets Holdings Ltd           | Diversified Utilities       | 1.44                              |
| 19        | HK2388 BOC Hong Kong (Holdings)            | Money Center Banks          | 1.39                              |
| 20        | HK0011 Hang Seng Bank Ltd                  | Money Center Banks          | 1.34                              |
Fig. 6: The Hang Seng Index from 03-07-2007 (22151 point) to 28-06-2013 (20803 point) (top) and the test intervals for the investment strategies (bottom): 492 trading days (roughly two years) per test interval, and 198 such test intervals in sequence with five trading days apart.
Let CashIn$_X(i, j)$ be the initial money given to the $i$'th stock in Table 1 ($i = 1$ is HK0005, $i = 2$ is HK0939, ..., $i = 20$ is HK0011) at the start of the $j$'th test interval in Fig. 6 using strategy $X$ and CashOut$_X(i, j)$ be the cash value at the end of the test interval (If the FollowBB strategy is in the “stock” status of Fig. 5 at the last day of a test interval, then sell all holdings of the stock at the price of the last day to get the cash), then the annual return of trading strategy $X$ on stock $i$ over test interval $j$ is

$$
ar_X(i, j) = \frac{\text{CashOut}_X(i, j) - \text{CashIn}_X(i, j)}{2 \text{CashIn}_X(i, j)}$$

(16)

where $i = 1, 2, ..., 20; j = 1, 2, ..., 198$; and $X$ takes one of the three trading strategies: FollowBB of Fig. 5, RideMood whose details will be given next section in Fig. 12, and Buy&Hold which is the Buy-and-Hold strategy as follows:

- **Buy-and-Hold (Buy&Hold)**: Buy the stock in the first day of the investment interval with all the cash allocated to this stock, hold the stocks until the last day of the investment interval and at that time sell all the holdings of this stock.

The Buy-and-Hold strategy is the standard benchmark for comparing different investment schemes because it is often claimed in the academic literature that no strategy can outperform the Buy-and-Hold strategy consistently (see e.g. Malkiel, 2012). In all of our test scenarios in this paper, we show the returns of the Buy-and-Hold strategy as the benchmark for comparison.

Figs. 7.1 to 7.5 plot $ar_X(i, j)$ as function of $j$ for each of the 20 stocks ($i = 1$ to 20) using the three strategies $X =$ FollowBB (green), $X =$ RideMood (red) and $X =$ Buy&Hold (blue). From Figs. 7.1 to 7.5 we see that for a fixed strategy $X$ and a fixed stock $i$ the annual returns $ar_X(i, j)$ (a curve in Figs. 7.1 to 7.5) change wildly over the 198 test intervals. To get a summary of the overall performance of a trading strategy for a stock, define the average annual return of strategy $X$ for stock $i$ as:

$$aar_X(i) = \frac{1}{198} \sum_{j=1}^{198} ar_X(i, j)$$

(17)

and its standard deviation:

$$sdv_X(i) = \left( \frac{1}{198} \sum_{j=1}^{198} (ar_X(i, j) - aar_X(i))^2 \right)^{\frac{1}{2}}$$

(18)
Table 2 gives the $a_{arX(i)}$’s and the $sdv_X(i)$’s of the three trading strategies for the 20 stocks in Table 1. Also shown in Table 2 are the average numbers of buy-sell cycles per year over the 198 test intervals using the three trading strategies, which will be used to compute the costs of the trading strategies. Since a test interval is two years, the average number of buy-sell cycles per year of the Buy&Hold strategy is 0.5 for all the stocks.

Fig. 7.1: Annual returns of the three strategies FollowBB (green), RideMood (red) and Buy&Hold (blue) over the 198 test intervals in Fig. 6 for stocks HK0005, HK0939, HK0941 and HK1398.
Fig. 7.2: Annual returns of the three strategies FollowBB (green), RideMood (red) and Buy&Hold (blue) over the 198 test intervals in Fig. 6 for stocks HK3988, HK0883, HK0857 and HK0013.

Fig. 7.3: Annual returns of the three strategies FollowBB (green), RideMood (red) and Buy&Hold (blue) over the 198 test intervals in Fig. 6 for stocks HK0386, HK2628, HK0001 and HK0016.
Fig. 7.4: Annual returns of the three strategies FollowBB (green), RideMood (red) and Buy&Hold (blue) over the 198 test intervals in Fig. 6 for stocks HK0388, HK0002, HK2318 and HK0003.

Fig. 7.5: Annual returns of the three strategies FollowBB (green), RideMood (red) and Buy&Hold (blue) over the 198 test intervals in Fig. 6 for stocks HK0004, HK0006, HK2388 and HK0011.
Table 2: Average annual returns, the standard deviations and the average number of buy-sell cycles per year of the 20 stocks over the 198 test intervals in Fig. 6 using FollowBB, RideMood and Buy&Hold strategies.

|   |       | Average Annual Return (±standard deviation), average number of buy-sell cycles per year |       | Average Annual Return (±standard deviation), average number of buy-sell cycles per year |
|---|-------|------------------------------------------------------------------------------------------------|-------|------------------------------------------------------------------------------------------------|
| 1 | HK 0005 | FollowBB RideMood Buy&Hold | 2.67% (±11.8%), 2.4 | HK 0001 | FollowBB RideMood Buy&Hold | 10.7% (±17.4%), 2.6 |
|   |        | 11.74% (±11.73%), 3.7 | -5.4% (±14.5%), 0.5 |       |        | 6.4% (±14.2%), 4.4 | 6.6% (±17%), 0.5 |
| 2 | HK 0939 | FollowBB RideMood Buy&Hold | 9.49% (±10.9%), 2.3 | HK 0016 | FollowBB RideMood Buy&Hold | 20% (±14.9%), 1.9 |
|   |        | 10.76% (±11.2%), 3.8 | 6.39% (±16.6%), 0.5 |       |        | 20.2% (±18.8%), 3.8 | 7.4% (±22%), 0.5 |
| 3 | HK 0941 | FollowBB RideMood Buy&Hold | 0.66% (±4.5%), 2.8 | HK 0388 | FollowBB RideMood Buy&Hold | 27.2% (±36%), 2.8 |
|   |        | -5.52% (±5.83%), 5.4 | 1.39% (±11.2%), 0.5 |       |        | 24.6% (±39.5%), 3.5 | 12% (±32.8%), 0.5 |
| 4 | HK 1398 | FollowBB RideMood Buy&Hold | 8.3% (±12.8%), 3.1 | HK 0002 | FollowBB RideMood Buy&Hold | 6.31% (±5.35%), 1.4 |
|   |        | 8.34% (±17.1%), 3.6 | 6.13% (±16.1%), 0.5 |       |        | 3.92% (±5.9%), 4.9 | 9.49% (±8.2%), 0.5 |
| 5 | HK 3988 | FollowBB RideMood Buy&Hold | 22.2% (±25.8%), 2.4 | HK 2318 | FollowBB RideMood Buy&Hold | 20.4% (±24.5%), 3.1 |
|   |        | 30.7% (±30.5%), 3.3 | 8.38% (±21.8%), 0.5 |       |        | 10.9% (±17.1%), 4.1 | 6.7% (±25.7%), 0.5 |
| 6 | HK 0883 | FollowBB RideMood Buy&Hold | 9.72% (±17.3%), 3.2 | HK 0003 | FollowBB RideMood Buy&Hold | 11.7% (±11.9%), 1.9 |
|   |        | 15.3% (±19.9%), 4.3 | 21.6% (±32.9%), 0.5 |       |        | 17% (±11.1%), 3.7 | 25.8% (±13.6%), 0.5 |
| 7 | HK 0857 | FollowBB RideMood Buy&Hold | 5.66% (±16.2%), 3.3 | HK 0004 | FollowBB RideMood Buy&Hold | 5.6% (±13.8%), 3.8 |
|   |        | 2.54% (±10.2%), 5.5 | 7.95% (±17.8%), 0.5 |       |        | 21% (±23.4%), 5.8 | 25% (±37.4%), 0.5 |
| 8 | HK 0013 | FollowBB RideMood Buy&Hold | 23.7% (±18.6%), 1.9 | HK 0006 | FollowBB RideMood Buy&Hold | 6.61% (±7.35%), 2.1 |
|   |        | 15.7% (±15.3%), 4 | 13.3% (±26.8%), 0.5 |       |        | 7.79% (±9.59%), 4.6 | 15.1% (±8.44%), 0.5 |
| 9 | HK 0386 | FollowBB RideMood Buy&Hold | 11.1% (±8.36%), 2.2 | HK 2388 | FollowBB RideMood Buy&Hold | 38.1% (±24.7%), 1.8 |
|   |        | 5.31% (±11.3%), 4.1 | 11.3% (±17.6%), 0.5 |       |        | 37.4% (±29.5%), 3.4 | 23.6% (±37.5%), 0.5 |
| 10| HK 2628 | FollowBB RideMood Buy&Hold | 1.98% (±13.9%), 2.4 | HK 0011 | FollowBB RideMood Buy&Hold | 4.48% (±7.45%), 2.7 |
|   |        | -3.16% (±13.1%), 4.6 | -3.83% (±15.5%), 0.5 |       |        | 12.2% (±7.64%), 3.3 | 3.89% (±11.9%), 0.5 |
From Table 2 we see that in terms of the average annual returns, the FollowBB strategy outperforms the benchmark Buy&Hold strategy for 12 stocks and underperforms the Buy&Hold strategy for the other 8 stocks. It is interesting to observe the top five winners and the top five losers, in terms of the difference between the average annual returns of FollowBB and Buy&Hold, and their industries listed as follows:

**Top Five Winners:**
1. HK0388 (Mortgage Investment), \( aar_{FollowBB} - aar_{Buy&Hold} = 15.2\% \).
2. HK2388 (Money Center Banks), \( aar_{FollowBB} - aar_{Buy&Hold} = 14.5\% \).
3. HK3988 (Money Center Banks), \( aar_{FollowBB} - aar_{Buy&Hold} = 13.82\% \).
4. HK2318 (Insurance), \( aar_{FollowBB} - aar_{Buy&Hold} = 13.7\% \).
5. HK0016 (Real Estate Development), \( aar_{FollowBB} - aar_{Buy&Hold} = 12.6\% \).

**Top Five Losers:**
1. HK0004 (Property Management), \( aar_{FollowBB} - aar_{Buy&Hold} = -19.4\% \).
2. HK0003 (Gas Utilities), \( aar_{FollowBB} - aar_{Buy&Hold} = -14.1\% \).
3. HK0883 (Independent Oil & Gas), \( aar_{FollowBB} - aar_{Buy&Hold} = -11.88\% \).
4. HK0006 (Diversified Utilities), \( aar_{FollowBB} - aar_{Buy&Hold} = -8.49\% \).
5. HK0002 (Electric Utilities), \( aar_{FollowBB} - aar_{Buy&Hold} = -3.18\% \).

We have two observations from the lists above:

**Observation 1:** Three of the top five losers are local utility companies in Hong Kong. Since the profit increments of the local utility companies in Hong Kong are strongly regulated by the government, there are usually no “surprises” in performance so that the big investors are in general not interested in these stocks. Since our FollowBB strategy depends on the existence of the big buyers, its poor performance on these utility stocks is understandable.

**Observation 2:** All the top five winners are finance and real estate related companies. Since the main driving forces of Hong Kong economy stem from finance and real estate related activities, it is no surprise that big buyers are interested in these stocks. Since our FollowBB strategy is designed to capture the big buyers and take advantage of their actions, its higher return over the Buy-and-Hold strategy is well justified.

To see the overall performance of the trading strategies, we propose a very simple portfolio scheme: Distribute the initial money to the 20 stocks according to their weights in HSI, and then run the trading strategy (FollowBB, RideMood or Buy&Hold) independently for each stock until the closure of the portfolio. Fig. 8 illustrates this
scheme for an investment interval, where \( w(i) \) is the weight of the \( i \)'th stock in Table 1 in HIS (\( w(1) = 15\% \), \( w(2) = 7.46\% \), ..., \( w(20) = 1.34\% \)). We see from Fig. 8 that once the initial money is distributed to the 20 stocks, no money will be redistributed among the stocks; that is, the investment for each stock is done independently. Hence, if a stock is doing good, we keep the profit within this stock for the subsequent buy/sell cycles; if a stock is doing badly, it will has less cash for its future investment.

Fig. 9 shows the annual returns of the portfolio using the three trading strategies FollowBB, RideMood and Buy&Hold over the 198 test intervals in Fig. 6. Specifically, with \( ar_X(i,j) \) defined in (16), the three curves in Fig. 9 are

\[
port_X(j) = \frac{1}{\sum_{i=1}^{20} w(i)} \sum_{i=1}^{20} w(i) ar_X(i,j)
\]  

(19)

for \( X = FollowBB \) (green), \( X = RideMood \) (red) and \( X = Buy&Hold \) (blue), respectively, where \( w(i) \) is the weight of the \( i \)'th stock in Table 1 in HIS.

Fig. 8: Portfolio scheme for a test interval in Fig. 6, where Strategy1 FollowBB is Fig. 5, Strategy2 RideMood is Fig. 12, and Strategy3 Buy&Hold is the standard Buy-and-Hold strategy.
Fig. 9: Annual returns of the portfolio, $port_X(j)$, using the three trading strategies $X =$FollowBB (green), $X =$RideMood (red) or $X =$Buy&Hold (blue) over the 198 test intervals in Fig. 6.

To obtain a summary of the overall performance of a trading strategy for the portfolio, we take the average of each curve in Fig. 9 to get the average annual return on portfolio of strategy $X$ defined as:

$$aar_X(port) = \frac{1}{198} \sum_{j=1}^{198} port_X(j)$$  \hspace{1cm} (20)

and its standard deviation:

$$sdv_X(port) = \left( \frac{1}{198} \sum_{j=1}^{198} (port_X(j) - aar_X(port))^2 \right)^{\frac{1}{2}}$$  \hspace{1cm} (21)

Table 3 gives: (i) the $aar_X(port)$’s and $sdv_X(port)$’s of the three trading strategies; (ii) the average buy-sell cycle numbers per year of the three strategies on the portfolio which are computed as the weighted average of the buy-sell cycle numbers shown in
Table 2 for the 20 stocks with weights \( w(i) \); (iii) the average total cost per year to maintain the portfolio using the three trading strategies which equals the average buy-sell cycle numbers per year times the cost per buy-sell cycle which equals 0.4\%; and (iv) the net profits per year. Also shown in Table 3 are the average profit increments if an investor switched from the benchmark Buy-and-Hold strategy to our Follow-the-Big-Buyer or Ride-the-Mood strategies during this period. Specifically, we see from Table 3 that if an investor switched from Buy&Hold to FollowBB, the annual net return would increase from 5.7\% to 8.4\% --- an increase of 47\%. Furthermore, this net return increase is achieved with less uncertainty --- the standard deviation is reduced from 15\% for Buy&Hold to 9.9\% for FollowBB: a decrease of 34\%.

Table 3: Portfolio performance of the three strategies over the 198 test intervals in Fig. 6.

| Strategy     | Average annual return on portfolio (±standard deviation), | Average number of buy-sell cycles per year | Cost per year (assume per buy-sell cycle cost is 0.4\%) | Net return per year (second column minus fourth column) |
|--------------|-----------------------------------------------------------|-------------------------------------------|------------------------------------------------------|---------------------------------------------------|
| FollowBB     | 9.4\% (±9.9\%)                                           | 2.5                                       | 1\%                                                  | 8.4\%                                             |
| RideMood     | 11\% (±10.4\%)                                           | 4.1                                       | 1.64\%                                               | 9.36\%                                            |
| Buy&Hold     | 5.9\% (±15\%)                                            | 0.5                                       | 0.2\%                                                 | 5.7\%                                             |

(FollowBB net return – Buy&Hold net return)/ Buy&Hold net return

47\% (profit increase if switch from Buy&Hold to FollowBB)

(RideMood net return – Buy&Hold net return)/ Buy&Hold net return

64\% (profit increase if switch from Buy&Hold to RideMood)

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5 The cost of a buy-sell cycle is computed as follows: Brokerage fee 0.18\% of transaction amount for selling only (on promotion); Stamp duty 0.1\% of transaction amount for both buying and selling; Transaction levy 0.003\% of transaction amount for both buying and selling; and Trading fee 0.005\% of transaction amount for both buying and selling. Other fees are ignorable comparing with the fees above. So the average cost per buy-sell cycle is: 

\[
(0.18\% + 0.1\% \times 2 + 0.003\% \times 2 + 0.005\% \times 2) = 0.396\%.
\]
To get a more concrete feeling of how the FollowBB strategy achieved the good performance, we show, in Figs. 10.1 to 10.20 and Tables 4.1 to 4.4, the buy/sell details of the 20 stocks using the FollowBB strategy over the last test interval in Fig. 6: 04-07-2011 to 28-06-2013, where the top sub-figures in Figs. 10.1 to 10.20 plot the daily closing prices of the 20 stocks\(^4\) (each figure for one stock) over the test interval and the buy (vertical green lines) sell (vertical red lines) points, the bottom sub-figures in Figs. 10.1 to 10.20 plot the 3-day moving averages \(-\bar{a}_6(t, 3)\) and \(\bar{a}_7(t, 3)\) of the estimated parameters \(-\bar{a}_6(t)\) and \(\bar{a}_7(t)\) using the parameter estimation algorithm (11) to (13) with \(\lambda = 0.95, \gamma = 10, n=3\) and \(w=0.01\), and Tables 4.1 to 4.4 give the details of the buy/sell dates, prices and returns for all the buy/sell cycles. More specifically, in the bottom sub-figures of Figs. 10.1 to 10.20 the green lines are the \(\bar{a}_7(t, 3)\) in positive \((\bar{a}_7(t, 3) > 0\) implies the existence of big buyer), red lines are the \(-\bar{a}_6(t, 3)\) in negative \((-\bar{a}_6(t, 3) < 0\) implies the existence of big seller), and the yellow lines are either the \(\bar{a}_7(t, 3)\) in negative (no big buyer) or the \(-\bar{a}_6(t, 3)\) in positive (no big seller). Aligning the top and bottom sub-figures in each Figs. 10.1 to 10.20 we can see in what scenarios the buy or sell actions are committed, which give us useful information about the strengths (catching up the price increases or avoiding the price declines) and the weaknesses (negative return buy/sell cycles or missing the price rise opportunities) of the FollowBB strategy. From Tables 4.1 to 4.4 we have the following observation:

**Observation 3**: The biggest gains of the buy/sell cycles are much larger than the biggest losses of the buy/sell cycles. More specifically, the five biggest gains are 47.9% (Cycle No. 6 HK0004), 29.95% (Cycle No. 3 HK0005), 28.58% (Cycle No. 4 HK0006), 19.45% (Cycle No. 3 HK0386) and 19.08% (Cycle No. 5 HK1398), whereas the five biggest losses are -11.89% (Cycle No. 3 HK2628), -10.78% (Cycle No. 2 HK0857), -10.3% (Cycle No. 2 HK0883), -9.96% (Cycle No. 3 HK0388) and -9.83% (Cycle No. 1 HK0941). This suggests that the FollowBB strategy has the capability of avoiding big losses while at the same time does not miss the big gains. A problem of the Buy-and-Hold strategy is that it cannot escape from the big losses when the stocks are clearly in very bad situations.
Fig. 10.1: Top: HK0005 daily closing $p_t$ from 2011-07-04 to 2013-06-28 and buy (green), sell (red) points using Strategy 1 FollowBB. Bottom: 3-day moving average of $-a_6(t)$ and $a_7(t)$; green=big buyer ($\bar{a}_7 > 0$); red=big seller ($-\bar{a}_6 < 0$); yellow=trend follower ($\bar{a}_7 < 0$ or $-\bar{a}_6 > 0$).

Fig. 10.2: Same as Fig. 10.1 for HK0939 (FollowBB).
Fig. 10.3: Same as Fig. 10.1 for HK0941 (FollowBB).

Fig. 10.4: Same as Fig. 10.1 for HK1398 (FollowBB).
Fig. 10.5: Same as Fig. 10.1 for HK3988 (FollowBB).

Fig. 10.6: Same as Fig. 10.1 for HK0883 (FollowBB).
Fig. 10.7: Same as Fig. 10.1 for HK0857 (FollowBB).

Fig. 10.8: Same as Fig. 10.1 for HK0013 (FollowBB).
Fig. 10.9: Same as Fig. 10.1 for HK0386 (FollowBB).

Fig. 10.10: Same as Fig. 10.1 for HK2628 (FollowBB).
Fig. 10.11: Same as Fig. 10.1 for HK0001 (FollowBB).

Fig. 10.12: Same as Fig. 10.1 for HK0016 (FollowBB).
Fig. 10.13: Same as Fig. 10.1 for HK0388 (FollowBB).

Fig. 10.14: Same as Fig. 10.1 for HK0002 (FollowBB).
Fig. 10.15: Same as Fig. 10.1 for HK2318 (FollowBB).

Fig. 10.16: Same as Fig. 10.1 for HK0003 (FollowBB).
Fig. 10.17: Same as Fig. 10.1 for HK0004 (FollowBB).

Fig. 10.18: Same as Fig. 10.1 for HK0006 (FollowBB).
Fig. 10.19: Same as Fig. 10.1 for HK2388 (FollowBB).

Fig. 10.20: Same as Fig. 10.1 for HK0011 (FollowBB).
Table 4.1: Details of buy-sell cycles using the FollowBB strategy over the two years from 2011-07-04 to 2013-06-28 for HK0005, HK0939, HK0941, HK1398 and HK3988.

| Cycle No. | HK0005 | HK0939 | HK0941 | HK1398 | HK3988 |
|-----------|--------|--------|--------|--------|--------|
| 1         | Buy: 2011-07-21 Price=74.91 Sell: 2011-08-05 Price=71.75 Return: -4.21% | Buy: 2011-10-28 Price=5.35 Sell: 2012-03-21 Price=5.56 Return: 3.92% | Buy: 2011-07-25 Price=69.25 Sell: 2011-08-09 Price=62.44 Return: -9.83% | Buy: 2011-07-08 Price=5.35 Sell: 2011-07-12 Price=5.02 Return: -6.16% | Buy: 2012-01-12 Price=2.75 Sell: 2012-03-23 Price=2.82 Return: 2.54% |
| 2         | Buy: 2011-10-27 Price=66.51 Sell: 2012-04-12 Price=65.96 Return: 0.82% | Buy: 2012-03-29 Price=5.46 Sell: 2013-05-09 Price=5.21 Return: -4.57% | Buy: 2011-08-10 Price=65.51 Sell: 2012-05-30 Price=74.41 Return: 13.58% | Buy: 2011-10-19 Price=3.76 Sell: 2011-11-28 Price=3.93 Return: 4.52% | Buy: 2012-06-26 Price=2.72 Sell: 2012-07-12 Price=2.64 Return: -2.94% |
| 3         | Buy: 2012-09-06 Price=66.87 Sell: 2013-05-28 Price=86.9 Return: 29.95% | Buy: 2012-10-15 Price=5.53 Sell: 2013-06-13 Price=5.53 Return: 0.97% | Buy: 2012-06-26 Price=77.88 Sell: 2012-08-17 Price=78.64 Return: 1.06% | Buy: 2012-01-13 Price=4.69 Sell: 2012-03-07 Price=4.74 Return: 1.06% | Buy: 2012-08-06 Price=2.85 Sell: 2012-08-31 Price=2.68 Return: -5.96% |
| 4         | Buy: 2013-05-21 Price=81.95 Sell: 2013-05-22 Price=81.32 Return: -0.76% | | Buy: 2013-05-21 Price=81.95 Sell: 2013-05-22 Price=81.32 Return: -0.76% | Buy: 2012-08-20 Price=4.24 Sell: 2012-09-05 Price=3.88 Return: -8.49% | Buy: 2012-10-16 Price=2.92 Sell: 2013-06-07 Price=3.36 Return: 15.06% |
| 5         | | | | Buy: 2012-09-07 Price=4.14 Sell: 2013-06-11 Price=4.93 Return: 19.08% | |
| 6         | | | | Buy: 2013-06-28 Price=4.89 Sell: 2013-06-28 Price=4.89 Return: 0% | |

| Accumulated Return | HK0005 | HK0939 | HK0941 | HK1398 | HK3988 |
|--------------------|--------|--------|--------|--------|--------|
| 23.4%              | -0.8%  | 2.6%   | 8%     | 7.7%   |        |

| Buy&Hold Return    | HK0005 | HK0939 | HK0941 | HK1398 | HK3988 |
|--------------------|--------|--------|--------|--------|--------|
| 5%                 | -8.3%  | 20.9%  | -9.9%  | -7.5%  |        |
Table 4.2: Details of buy-sell cycles using the FollowBB strategy over the two years from 2011-07-04 to 2013-06-28 for HK0883, HK0939, HK0013, HK0386 and HK2628.

| Cycle No. | HK0883 | HK0857 | HK0013 | HK0386 | HK2628 |
|-----------|--------|--------|--------|--------|--------|
| 1         | Buy: 2011-07-19 Price=16.59 Sell: 2011-07-21 Price=15.48 Return: -6.69% | Buy: 2011-07-08 Price=10.77 Sell: 2011-07-12 Price=10.13 Return: -5.94% | Buy: 2011-10-21 Price=64.75 Sell: 2012-05-09 Price=68.54 Return: 5.85% | Buy: 2011-07-25 Price=3.96 Sell: 2011-08-04 Price=3.8 Return: -4.04% | Buy: 2011-07-15 Price=25.63 Sell: 2011-08-05 Price=23.67 Return: -7.64% |
| 2         | Buy: 2011-07-22 Price=15.91 Sell: 2011-08-05 Price=14.27 Return: -10.3% | Buy: 2011-07-13 Price=10.29 Sell: 2011-08-08 Price=9.18 Return: -10.78% | Buy: 2012-07-04 Price=68.33 Sell: 2012-11-01 Price=75.76 Return: 10.87% | Buy: 2011-09-23 Price=3.82 Sell: 2012-04-10 Price=4.34 Return: 13.61% | Buy: 2011-10-18 Price=18.74 Sell: 2011-10-19 Price=18.49 Return: -1.33% |
| 3         | Buy: 2011-10-27 Price=14.39 Sell: 2011-12-14 Price=13.52 Return: -6.04% | Buy: 2011-09-21 Price=8.79 Sell: 2011-09-22 Price=8.46 Return: -3.75% | Buy: 2012-11-19 Price=75.47 Sell: 2013-06-28 Price=81.01 Return: 7.34% | Buy: 2012-08-06 Price=4.01 Sell: 2013-04-16 Price=4.79 Return: 19.45% | Buy: 2011-12-01 Price=20.59 Sell: 2011-12-20 Price=18.14 Return: -11.89% |
| 4         | Buy: 2012-01-18 Price=14.71 Sell: 2012-03-20 Price=15.4 Return: 4.69% | Buy: 2011-10-10 Price=8.54 Sell: 2011-12-15 Price=8.41 Return: 1.52% | | Buy: 2012-01-20 Price=21.71 Sell: 2012-03-09 Price=20.54 Return: -5.38% |
| 5         | Buy: 2012-10-18 Price=15.37 Sell: 2013-01-11 Price=15.6 Return: 1.49% | Buy: 2012-01-31 Price=10.55 Sell: 2012-03-20 Price=10.4 Return: 1.42% | | Buy: 2012-11-02 Price=23.68 Sell: 2012-11-16 Price=21.99 Return: -7.13% |
| 6         | | Buy: 2012-04-30 Price=10.94 Sell: 2012-05-07 Price=10.19 Return: -6.85% | | Buy: 2012-11-21 Price=22.19 Sell: 2013-02-19 Price=23.58 Return: 6.26% |
| 7         | Buy: 2012-09-21 Price=9.82 Sell: 2013-02-05 Price=10.26 Return: 4.48% | | | Buy: 2013-04-18 Price=19.86 Sell: 2013-06-03 Price=19.7 Return: -0.8% |

Accumulated Return: -16.4%  -23.7%  26%  30.2%  -25.7%

Buy&Hold Return: -23.8%  -23.2%  1.5%  32%  -32.5%
Table 4.3: Details of buy-sell cycles using the FollowBB strategy over the two years from 2011-07-04 to 2013-06-28 for HK0001, HK0016, HK0388, HK0002 and HK2318.

| Cycle No. | HK0001 | HK0016 | HK0388 | HK0002 | HK2318 |
|-----------|--------|--------|--------|--------|--------|
|           | Buy: 2011-10-24 | Buy: 2011-10-12 | Buy: 2011-11-08 | Buy: 2011-07-29 | Buy: 2011-07-26 |
|           | Price=87.29 | Price=92.68 | Price=124.67 | Price=66.19 | Price=77.55 |
|           | Sell: 2012-03-21 | Sell: 2012-03-29 | Sell: 2012-03-21 | Sell: 2011-08-08 | Sell: 2011-08-04 |
|           | Price=97.35 | Price=107.86 | Price=125.7 | Price=62.37 | Price=72.2 |
|           | Return: 11.52% | Return: 16.37% | Return: 0.82% | Return: -5.77% | Return: -6.89% |
| 2         | Buy: 2012-07-17 | Buy: 2012-07-06 | Buy: 2012-09-11 | Buy: 2011-09-06 | Buy: 2011-10-17 |
|           | Price=97.53 | Price=92.76 | Price=105.63 | Price=66.62 | Price=56.55 |
|           | Sell: 2012-07-25 | Sell: 2012-10-29 | Sell: 2013-02-26 | Sell: 2011-11-22 | Sell: 2011-12-21 |
|           | Price=94.92 | Price=103.01 | Price=134.27 | Price=64.25 | Price=51.5 |
|           | Return: -2.67% | Return: 11.05% | Return: 27.11% | Return: -3.55% | Return: -8.93% |
| 3         | Buy: 2012-08-13 | Buy: 2012-10-30 | Buy: 2013-05-20 | Buy: 2012-03-13 | Buy: 2012-01-19 |
|           | Price=106.34 | Price=103.78 | Price=132.52 | Price=64.38 | Price=59.6 |
|           | Sell: 2013-02-05 | Sell: 2013-02-05 | Sell: 2013-06-20 | Sell: 2012-03-20 | Sell: 2012-03-26 |
|           | Price=118.62 | Price=120.29 | Price=119.32 | Price=62.73 | Price=59.75 |
|           | Return: 11.54% | Return: 15.9% | Return: -9.96% | Return: -2.56% | Return: 0.25% |
| 4         | Buy: 2012-08-13 | Buy: 2012-10-30 | Buy: 2013-05-20 | Buy: 2012-03-13 | Buy: 2012-01-19 |
|           | Price=106.34 | Price=103.78 | Price=132.52 | Price=64.38 | Price=59.6 |
|           | Sell: 2013-02-05 | Sell: 2013-02-05 | Sell: 2013-06-20 | Sell: 2012-03-20 | Sell: 2012-03-26 |
|           | Price=118.62 | Price=120.29 | Price=119.32 | Price=62.73 | Price=59.75 |
|           | Return: 11.54% | Return: 15.9% | Return: -9.96% | Return: -2.56% | Return: 0.25% |
| 5         | Buy: 2012-08-13 | Buy: 2012-10-30 | Buy: 2013-05-20 | Buy: 2012-03-13 | Buy: 2012-01-19 |
|           | Price=106.34 | Price=103.78 | Price=132.52 | Price=64.38 | Price=59.6 |
|           | Sell: 2013-02-05 | Sell: 2013-02-05 | Sell: 2013-06-20 | Sell: 2012-03-20 | Sell: 2012-03-26 |
|           | Price=118.62 | Price=120.29 | Price=119.32 | Price=62.73 | Price=59.75 |
|           | Return: 11.54% | Return: 15.9% | Return: -9.96% | Return: -2.56% | Return: 0.25% |
| 6         | Buy: 2012-08-13 | Buy: 2012-10-30 | Buy: 2013-05-20 | Buy: 2012-03-13 | Buy: 2012-01-19 |
|           | Price=106.34 | Price=103.78 | Price=132.52 | Price=64.38 | Price=59.6 |
|           | Sell: 2013-02-05 | Sell: 2013-02-05 | Sell: 2013-06-20 | Sell: 2012-03-20 | Sell: 2012-03-26 |
|           | Price=118.62 | Price=120.29 | Price=119.32 | Price=62.73 | Price=59.75 |
|           | Return: 11.54% | Return: 15.9% | Return: -9.96% | Return: -2.56% | Return: 0.25% |
| 7         | Buy: 2012-12-17 | Buy: 2012-12-23 | Buy: 2013-05-15 | Buy: 2013-05-15 | Buy: 2013-05-15 |
|           | Price=63.9 | Price=64.95 | Price=60.55 | Price=60.55 | Price=60.55 |
|           | Sell: 2013-02-21 | Price=64.95 | Sell: 2013-05-16 | Price=59.9 | Return: 1.64% |
| 8         | Buy: 2013-05-15 | Buy: 2013-05-15 | Buy: 2013-05-15 | Buy: 2013-05-15 | Buy: 2013-05-15 |
|           | Price=60.55 | Price=60.55 | Price=60.55 | Price=60.55 | Price=60.55 |
|           | Sell: 2013-05-16 | Price=60.55 | Sell: 2013-05-16 | Price=59.9 | Return: 1.64% |

Accumulated Return:

| HK0001 | HK0016 | HK0388 | HK0002 | HK2318 |
|--------|--------|--------|--------|--------|
| 21.1%  | 49.8%  | 15.4%  | -10.8% | -17.9% |

Buy&Hold Return:

| HK0001 | HK0016 | HK0388 | HK0002 | HK2318 |
|--------|--------|--------|--------|--------|
| -3.6%  | -8.1%  | -26%   | -0.8%  | -36.4% |
Table 4.4: Details of buy-sell cycles using the FollowBB strategy over the two years from 2011-07-04 to 2013-06-23 for HK0003, HK0004, HK0006, HK2388 and HK0011.

| Cycle No. | HK0003                  | HK0004                  | HK0006                  | HK2388                  | HK0011                  |
|-----------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| 1         | Buy: 2011-07-08 Price=11.95 Sell: 2011-08-05 Price= 11.35 Return: -5.02% | Buy: 2011-07-18 Price=50.74 Sell: 2011-08-05 Price=49.85 Return: -1.75% | Buy: 2011-07-28 Price=57.72 Sell: 2011-08-08 Price=52.8 Return: -8.52% | Buy: 2012-01-12 Price=17.71 Sell: 2012-05-17 Price=20.1 Return: 13.49% | Buy: 2012-01-20 Price=91.75 Sell: 2012-05-25 Price=96.28 Return: 4.93% |
| 2         | Buy: 2011-10-28 Price=11.64 Sell: 2012-05-16 Price=12.03 Return: 3.35% | Buy: 2012-01-31 Price=41.98 Sell: 2012-03-07 Price=41.36 Return: -1.47% | Buy: 2011-09-08 Price=56.05 Sell: 2011-10-13 Price=52.6 Return: -6.15% | Buy: 2012-06-13 Price=20.84 Sell: 2012-10-29 Price=22.36 Return: 7.29% | Buy: 2012-06-29 Price=100.65 Sell: 2012-07-24 Price=99.98 Return: -0.66% |
| 3         | Buy: 2012-07-09 Price=13.99 Sell: 2012-11-14 Price=15.97 Return: 14.15% | Buy: 2012-04-30 Price=44.07 Sell: 2012-05-07 Price=41.93 Return: -4.85% | Buy: 2012-03-07 Price=52.92 Sell: 2012-03-21 Price=52.37 Return: -1.03% | Buy: 2012-12-18 Price=23.13 Sell: 2013-01-02 Price=23.41 Return: 1.21% | Buy: 2012-08-01 Price=103.3 Sell: 2012-11-09 Price=111.98 Return: 8.4% |
| 4         | Buy: 2012-12-10 Price=17.28 Sell: 2013-06-06 Price=17.53 Return: 1.44% | Buy: 2012-05-08 Price=42.26 Sell: 2012-05-09 Price=41.64 Return: -1.46% | Buy: 2012-05-10 Price=53.8 Sell: 2013-05-30 Price=69.18 Return: 28.58% | Buy: 2013-01-18 Price=24.75 Sell: 2013-06-05 Price=24.66 Return: -0.36% | Buy: 2013-01-24 Price=119.43 Sell: 2013-04-16 Price=120.91 Return: 1.23% |
| 5         | Buy: 2012-06-12 Price=41.43 Sell: 2012-06-13 Price=40.61 Return: -1.97% | | | | |
| 6         | Buy: 2012-07-17 Price=42.06 Sell: 2013-03-21 Price=62.21 Return: 47.9% | | | | |
| 7         | Buy: 2013-04-08 Price=66.55 Sell: 2013-06-11 Price=66.1 Return: -0.67% | | | | |
| Accumulated Return | 13.7% | 30.7% | 9.2% | 22.8% | 14.1% |
| Buy&Hold Return | 61.7% | 24.3% | 23.4% | 15% | 1.6% |

Up to now in this section the test intervals were all two years. We now show the daily market values of the portfolios using FollowBB, RideMood or Buy&Hold, after deducting the transaction costs, for the test interval being the whole six years from 03-07-2007 to 26-06-2013. Consider the portfolio scheme in Fig. 8 and let \( V_X(i, t) \) be the market value of the investment on stock \( i \) at trading day \( t \) using strategy \( X \) after
deducting the transaction costs. Suppose there have been \( N_{i,t} \) completed buy-sell cycles before day \( t \) for stock \( i \) and let \( p_{i,k}^{\text{buy}} \) (\( p_{i,k}^{\text{sell}} \)) be the buy (sell) price of the \( k \)'th buy-sell cycle for stock \( i \). Then, if the investment on stock \( i \) at day \( t \) is in the “cash” status in Fig. 5 (Fig. 12), we have

\[
V_X(i,t) = \frac{IM \times w(i)}{\sum_{j=1}^{20} w(j)} \left( \prod_{k=1}^{N_{i,t}} \frac{p_{i,k}^{\text{sell}}}{p_{i,k}^{\text{buy}}} \right) (1 - 0.108\%)^{N_{i,t}} (1 - 0.288\%)^{N_{i,t}} \quad (22)
\]

where \( \frac{IM \times w(i)}{\sum_{j=1}^{20} w(j)} \) is the initial money given to stock \( i \) and 0.108\% (0.288\%) is the buy-side (sell-side) cost (see Footnote 5); if the investment on stock \( i \) at day \( t \) is in the “stock” status in Fig. 5 (Fig. 12), we have

\[
V_X(i,t) = \frac{IM \times w(i)}{\sum_{j=1}^{20} w(j)} \left( \prod_{k=1}^{N_{i,t}} \frac{p_{i,k}^{\text{sell}}}{p_{i,k}^{\text{buy}}} \right) \left( \frac{p_{i,t}^{\text{buy}}}{p_{i,t}^{\text{buy}}} \right) (1 - 0.108\%)^{N_{i,t}} (1 - 0.288\%)^{N_{i,t}} \quad (23)
\]

where \( p_{i,t} \) is the price of stock \( i \) at day \( t \). According to our simple portfolio scheme in Fig. 8, the market value of the portfolio at day \( t \), \( V_X(\text{port},t) \), is simply the summation of the \( V_X(i,t) \)'s of the 20 stocks:

\[
V_X(\text{port},t) = \sum_{i=1}^{20} V_X(i,t) \quad (24)
\]

Fig. 11 plots the \( V_X(\text{port},t) \) for \( X = \text{FollowBB} \) (green), \( X = \text{RideMood} \) (red) and \( X = \text{Buy&Hold} \) (blue) with initial money IM=100 for all the three portfolios, where \( t = 0 \) is the day 03-07-2007 and the last \( t \) is the day 28-06-2013.

From Fig. 11 we see that the FollowBB and RideMood strategies outperform the Buy&Hold strategy in all days except the first year from the middle of 2007 to the middle of 2008 when the market was in the “irrational exuberance” (Shiller, 2006) status. To obtain a summary of the portfolio performance of the trading strategies, we take the average of each curve in Fig. 11 to get the average portfolio value of strategy \( X \) defined as:

\[
aV_X(\text{port}) = \frac{1}{N} \sum_{t=1}^{N} V_X(\text{port},t) \quad (25)
\]

and its standard deviation:
where is the number of trading days from 03-07-2007 to 28-06-2013. For \( X = \text{FollowBB} \), \( X = \text{RideMood} \) and \( X = \text{Buy\&Hold} \), the corresponding \( aV_X(\text{port})'s \) are 121, 121.5 and 113, respectively, and the \( sdv(aV_X)'s \) are 15, 15.3 and 17, respectively. That is, if you put the same amount of initial money IM=100 units to the three portfolio schemes, the average returns you expect to get, after deducting the transaction costs, are: \((121-100)/100=21\% \) for FollowBB, \((121.5-100)/100=21.5\% \) for RideMood, and \((113-100)/100=13\% \) for Buy\&Hold; and their standard deviations are: 15/100=15\% for FollowBB, 15.3/100=15.3\% for RideMood, and 17/100=17\% for Buy\&Hold. In other words, if one switched from the Buy\&Hold scheme to the FollowBB or RideMood schemes, then on average the profit would increase \((21\%-13\%)/13\%=61.5\% \) for switching to FollowBB and \((21.5\%-13\%)/13\%=65.3\% \) for switching to RideMood; and at the same time to enjoy the profit increase, the risk would reduce \(|15\%-17\%|/17\%=11.7\% \) for switching to FollowBB and \(|15.3\%-17\%|/17\%=10\% \) for switching to RideMood. These profit increases and risk reductions are consistent with the results in Table 3.

![Fig. 11: Daily market value of the portfolios after deducting the transaction costs using FollowBB (green), RideMood (red) and Buy\&Hold (blue) from 03-07-2007 to 28-06-2013.](image-url)
4. Strategy 2: Ride-the-Mood (RideMood)

The basic idea of the Ride-the-Mood (RideMood) strategy was discussed in the Introduction and the detailed algorithm is now given in Fig. 12, where

\[
\bar{a}_6(t, 5) = \frac{1}{5} \sum_{i=0}^{4} \hat{a}_6(t - i), \quad \bar{a}_7(t, 5) = \frac{1}{5} \sum_{i=0}^{4} \hat{a}_7(t - i)
\]  

(27)

are the 5-day moving averages of the estimated parameters \( \hat{a}_6(t) \) and \( \hat{a}_7(t) \) which are obtained from the parameter estimation algorithm (11) to (13) with \( \lambda = 0.95, \gamma = 10, n=3 \) and \( w=0.01 \).

![Diagram](image_url)

Fig. 12: The buy-sell cycle of Strategy 2: Ride-the-Mood (RideMood).
We have already seen the good performance of the RideMood strategy in the last section and here we simply restate the results: Figs. 7.1 to 7.5 show the annual returns of the RideMood strategy (red curves) over the 198 test intervals in Fig. 6 for the 20 stocks in Table 1, and Table 2 gives the means and standard deviations of these returns; Fig. 9 plots the annual returns of the portfolio scheme of Fig. 8 using the RideMood strategy (red curve) over the 198 test intervals in Fig. 6, and Table 3 gives the mean and standard deviation of these returns; and Fig. 11 illustrates the daily market values of the portfolio, after deducting the transaction costs, using the RideMood strategy (red curve) over the six years from 03-07-2007 to 28-06-2013. We see from Table 3 that if an investor switched from Buy&Hold to RideMood, the annual net return would increase from 5.7% to 9.36% --- an increase of 64%; and this net return increase is achieved with less uncertainty --- the standard deviation is reduced from 15% for Buy&Hold to 10.4% for RideMood: a decrease of 30%. Putting all these results together, we arrive at the following general conclusions:

- FollowBB and RideMood have similar performance, with RideMood being slightly better than FollowBB;
- Both FollowBB and RideMood are much better than Buy&Hold.

Finally, similar to Figs. 10.1 to 10.20 and Tables 4.1 to 4.4, we show in Figs. 13.1 to 13.20 the buy/sell details of the 20 stocks using the RideMood strategy over the two-year interval 04-07-2011 to 28-06-2013, where the top sub-figures plot the daily closing prices of the 20 stocks (each figure for one stock) over the test interval and the buy (vertical green lines) sell (vertical red lines) points, the bottom sub-figures plot \( \overline{\text{mood}}(t, 5) = \bar{a}_7(t, 5) - \bar{a}_6(t, 5) \), and Table 5 gives the returns of all the buy/sell cycles in Figs. 13.1 to 13.20. Again, these figures and the data in the table give us much detailed information about the operations of the RideMood strategy in different scenarios. ("A picture is worth a thousand words.")
Fig. 13.1: Top: HK0005 daily closing $p_t$ from 2011-07-04 to 2013-06-28 and buy (green), sell (red) points using Strategy 2 RideMood. Bottom: 5-day moving average of $a_7(t) - a_6(t)$; green: $\bar{a}_7(t, 5) > \bar{a}_6(t, 5)$ (big buyer stronger than big seller); red: $\bar{a}_7(t, 5) < \bar{a}_6(t, 5)$ (big buyer weaker than big seller).

Fig. 13.2: Same as Fig. 13.1 for HK0939 (RideMood).
Fig. 13.3: Same as Fig. 13.1 for HK0941 (RideMood).

Fig. 13.4: Same as Fig. 13.1 for HK1398 (RideMood).
Fig. 13.5: Same as Fig. 13.1 for HK3988 (RideMood).

Fig. 13.6: Same as Fig. 13.1 for HK0883 (RideMood).
Fig. 13.7: Same as Fig. 13.1 for HK0857 (RideMood).

Fig. 13.8: Same as Fig. 13.1 for HK0013 (RideMood).
Fig. 13.9: Same as Fig. 13.1 for HK0386 (RideMood).

Fig. 13.10: Same as Fig. 13.1 for HK2628 (RideMood).
Fig. 13.11: Same as Fig. 13.1 for HK0001 (RideMood).

Fig. 13.12: Same as Fig. 13.1 for HK0016 (RideMood).
**Fig. 13.13**: Same as Fig. 13.1 for HK0388 (RideMood).

**Fig. 13.14**: Same as Fig. 13.1 for HK0002 (RideMood).
Fig. 13.15: Same as Fig. 13.1 for HK2318 (RideMood).

Fig. 13.16: Same as Fig. 13.1 for HK0003 (RideMood).
Fig. 13.17: Same as Fig. 13.1 for HK0004 (RideMood).

Fig. 13.18: Same as Fig. 13.1 for HK0006 (RideMood).
Fig. 13.19: Same as Fig. 13.1 for HK2388 (RideMood).

Fig. 13.20: Same as Fig. 13.1 for HK0011 (RideMood).
### Table 5: Returns of the buy-sell cycles using the RideMood strategy over the two years from 2011-07-04 to 2013-06-28 for the 20 stocks.

| Cycle No. | HK0005 | HK0939 | HK0941 | HK1398 | HK3988 | HK0883 | HK0857 | HK0013 | HK0386 | HK2628 |
|-----------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| 1         | 1%     | -5.94% | 0.83%  | -3.92% | -2.03% | -6.58% | -3.45% | -9.58% | -3.79% | -1.14% |
| 2         | 1.19%  | 13.69% | -1.89% | -5.67% | 2.54%  | 0.54%  | -3.87% | 14.3%  | 15.36% | -16.02%|
| 3         | -0.88% | -5.95% | -1.44% | 1.06%  | -2.14% | 11.15% | -1.44% | -0.84% | -1.71% | -4.69% |
| 4         | 5.94%  | 11.61% | 9.13%  | -6.29% | -2.88% | -1.85% | 8.4%   | 0.36%  | 0.53%  | -0.67% |
| 5         | -4.03% | -0.65% | -0.24% | 24.48% | -5.3%  | -4.85% | -4.41% | 21.7%  | 27.06% | -4.75% |
| 6         | 3.25%  | -0.72% | -5%    | 22.46% | -1.67% | -3.57% | -1.32% | -1.75% | 2.69%  | -2.97% |
| 7         | 25.4%  | -1.6%  | 0.19%  | 2.63%  | 0.53%  | 2.97%  |        |        |        |        |
| 8         | 0.28%  | -1.6%  | 0%     | 1.23%  | -3.59% | -2.47% | -5.43% |        | -2.97% | 2.19%  |
| 9         |        |        |        | -3.89% | -1.51% | 9.62%  | 1.73%  | 3%     |        |        |
| 10        |        |        |        |        |        |        |        |        |        |        |
| 11        |        |        |        |        |        |        |        |        |        |        |
| 12        |        |        |        |        |        |        |        |        |        |        |
| 13        |        |        |        |        |        |        |        |        |        |        |
| 14        |        |        |        |        |        |        |        |        |        |        |
| 15        |        |        |        |        |        |        |        |        |        |        |
| Accumulated Return | 33.7% | 11.5% | 3.7%  | 1.7%  | 13.6% | -7.7% | -20.9% | 23.5%  | 39.3%  | -25.1% |
| Buy&Hold Return    | 5%    | -8.3% | 20.9% | -9.9% | -7.5% | -23.8% | -23.2% | 1.5%   | 32.2%  | -32.5% |
Table 5: Continued.

| Cycle No. | HK0001   | HK0016   | HK0388   | HK0002   | HK2318   | HK0003   | HK0004   | HK0006   | HK2388   | HK0011   |
|-----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| 1         | -5.88%   | 1.05%    | -0.49%   | -0.82%   | -8.14%   | -2.57%   | -5.23%   | 0.43%    | -4.86%   | 5.85%    |
| 2         | -8.66%   | 3.12%    | 1.4%     | 0.5%     | 0.69%    | -9.43%   | -0.57%   | -1.62%   | -3.01%   | 1.15%    |
| 3         | 13.88%   | 30.85%   | -1.11%   | -4.57%   | 21.61%   | 2.64%    | 15.92%   | -4.33%   | 12.42%   | 7.08%    |
| 4         | -4.77%   | -7.47%   | -5.09%   | -2.13%   | -7.66%   | 4.24%    | 0.68%    | -0.62%   | -1.59%   | 4.55%    |
| 5         | 15.9%    | -4.26%   | 31.39%   | -2.16%   | -1.8%    | 15.35%   | -5.39%   | 0.43%    | 13.84%   | -0.03%   |
| 6         | 7.86%    | -4.01%   | -7.07%   | -1.71%   | -1.92%   | 4.36%    | -3.7%    | 16.14%   | -0.87%   | -1.03%   |
| 7         | -4.12%   | 1.4%     | 0.5%     | 0.69%    | 0.69%    | -9.43%   | -0.57%   | -1.62%   | -3.01%   | 1.15%    |
| 8         | -0.6%    | 31.39%   | -2.16%   | -1.8%    | 15.35%   | -5.39%   | 0.43%    | 13.84%   | -0.03%   | -1.03%   |
| 9         | 0.31%    | -0.37%   | -3.13%   | -0.98%   | -3.55%   | -0.29%   | -0.2%    | 11.9%    | 20.8%    | 15.6%    |
| 10        | 0.31%    | -0.37%   | -3.13%   | -0.98%   | -3.55%   | -0.29%   | -0.2%    | 11.9%    | 20.8%    | 15.6%    |
| 11        | 0.31%    | -0.37%   | -3.13%   | -0.98%   | -3.55%   | -0.29%   | -0.2%    | 11.9%    | 20.8%    | 15.6%    |
| 12        | 0.31%    | -0.37%   | -3.13%   | -0.98%   | -3.55%   | -0.29%   | -0.2%    | 11.9%    | 20.8%    | 15.6%    |
| 13        | 0.31%    | -0.37%   | -3.13%   | -0.98%   | -3.55%   | -0.29%   | -0.2%    | 11.9%    | 20.8%    | 15.6%    |
| 14        | 0.31%    | -0.37%   | -3.13%   | -0.98%   | -3.55%   | -0.29%   | -0.2%    | 11.9%    | 20.8%    | 15.6%    |
| 15        | 0.31%    | -0.37%   | -3.13%   | -0.98%   | -3.55%   | -0.29%   | -0.2%    | 11.9%    | 20.8%    | 15.6%    |
| Accumulated Return | 11.9%   | 20.8%    | 15.6%    | -13.8%   | -6.3%    | 19.9%    | 35.4%    | 17.3%    | 17.2%    | 19.8%    |
| Buy&Hold Return     | -3.6%   | -8.1%    | -26%     | -0.8%    | -36.4%   | 61.7%    | 24.3%    | 23.4%    | 15%      | 1.6%     |
5. Concluding Remarks

Based on the testing over 198 two-year intervals uniformly distributed across the six-year period from 03-July-2007 to 28-June-2013 which includes a variety of scenarios such as the strong rise in late 2007 due to “irrational exuberance” (Shiller, 2006), the big decline during the 2008 financial crisis (Lo, 2012), the recovery in 2009 after the panic (Buffett, 2008) and the “ordinary” (or problem-accumulating (Song, 2014)) years from 2010 to 2013, the average annual returns of the Follow-the-Big-Buyer (FollowBB), Ride-the-Mood (RideMood) and Buy-and-Hold (Buy&Hold) strategies, after deducting the transaction costs, are 8.4%, 9.36% and 5.7%, respectively. This means that if a fund manager switched from the Buy&Hold strategy to the FollowBB or RideMood strategies during this period, the net profits on average would increase (8.4%-5.7%)/5.7%=47% or (9.36%-5.7%)/5.7%=64%, respectively. For funds with large sums of money, these profit advances are significant.

The FollowBB and RideMood strategies proposed in this paper have the following characteristics:

- They are very general. The only information they need is the price data of an asset up to the current time: \(\{p_0, p_1, \ldots, p_t\}\). The asset can be anything: the stocks of different countries, commodities, fixed income securities, foreign exchange products, derivatives, ...; and the sampling interval can be one-day, one-hour, 10-minute, 1-minute, 3-second, .... As long as the traders of the asset use technical analysis in their decision making processes, the models of this paper are relevant and the trading strategies could be tried.

- They are easy to implement. You simply put the price data \(\{p_0, p_1, \ldots, p_t\}\) into the parameter estimation algorithm (11)-(13) and make your buy/sell decisions based on the estimated parameters according to the simple flow-charts in Figs. 5 and 12; it takes just a few lines of MATLAB codes to implement these computations.

- They have good reason to succeed. They do not predict returns, in fact they do not predict anything of the future; they simply follow the footprints of the big buyers and the big sellers: if the big buyers succeed, they succeed; if the big buyers fail, they fail. As long as you believe supply-demand determines prices (Bouchaud, Farmer and Lillo, 2008), their philosophy is well-justified.
There is a famous joke widely told among economists (Lo, 2004): One day an economics professor and his student were strolling down the street and they came upon a $100 bill lying on the ground, and as the student reached down to pick it up, the professor said: “Don’t bother --- if it were a genuine $100 bill, someone would have already picked it up”. Just because so many people are brainwashed by this Efficient Market Hypothesis (Fama, 1970; Malkiel, 2012), there are many real $100 bills lying on the ground untouched. So go ahead to pick it up (Lindsey and Schachter, 2007; or you may use the methods of this paper), it’s real (Soros, 2003; Tharp, 2007).

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