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by

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A New Principal-Component Approach to Measure the Investor Sentiment

Terence Tai-Leung Chong[1], Bingqing Cao[2] and Wing Keung Wong[3]

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Abstract: This paper develops a new market sentiment index for the Hong Kong stock market, one of the largest stock market in the world. The components of the sentiment measure include the turnover ratio, short-selling volume, money flow, HIBOR and return of the U.S. and Japanese markets. We also include the Shanghai and Shenzhen Composite index in our measure to capture the influence of Chinese markets on the Hong Kong market. A threshold regression model using the sentiment index as a threshold variable is estimated to capture the state of the Hong Kong stock market. It is also found that the trading rule which sells (buys) the HSI or S&P/HKEx LargeCapIndex when the sentiment index is above (below) the upper threshold value can beat the buy-and-hold strategy.

Keywords: Principal component analysis; Market sentiment; CSI 300; Threshold model

AMS Classifications: 62H25

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1. Introduction

Over the past four decades, there has been an increasing interest in the study of investor sentiment, of which a number of studies have demonstrated that it can be used as a tool to forecast market volatility. Zweig (1973) suggests that a discount on closed-end funds reveals the expectations of individual investors. Lee et al. (1991) find that reductions of closed-end funds can be used as an indicator for shifts in individual traders' sentiment. The returns change according to their sentiment, as small stocks and closed-end funds are mostly held by individuals. Neal and Wheatley (1998) find a positive relationship between small firms' expected returns and fund discounts, while no correlation is found between large firms' expected returns and fund discounts. Simon and Wiggins (2001) and Wang (2001) suggest that measures of market sentiment can be used to forecast stock returns and their volatility. Recently, Chen et al. (2010) developed a market sentiment index for the Hong Kong stock market from 1998 to 2006. They use the principal-component method to form a linear index with factors such as the short selling volume, market turnover, Hong Kong Interbank Offered Rate (HIBOR), relative strength index, money flow index, and the indexes of foreign equity markets.

Chen *et al*. (2010) do not account for the Chinese stock market in their sentiment measure, although the market has grown rapidly over the past decade in terms of turnover and market capitalization. Capitalization of the Chinese Stock Market increased by 798% from 2002 to 2012, ranking second largest among G20 countries behind Indonesia. Qiao et al. (2008) reveal the existence of unidirectional volatility spillover effects between the two A-share markets in China and the Hong Kong stock market. Sun and Zhang (2009) find an increased interdependence and strengthening of the financial integration between China and Hong Kong, as evidenced by more volatility spillovers between the two stock markets. Also, the conditional correlation between China and Hong Kong has outweighed their conditional correlations with the United States. Zhou et al. (2012) show that since 2005, the volatility of the Chinese market has had a significant positive impact on world equity markets, including that of Hong Kong. The volatility interactions among the markets of China, Hong Kong, and Taiwan are noted to be more prominent than that of the Chinese, Western, and other Asian

markets.

This paper develops a new market sentiment index for the Hong Kong stock market using the principal-component method, including the CSI 300 index of the Chinese equity market and the seven other factors that are adopted by Chen *et al*. (2010). We focus on the post-2008 financial crisis period, which is excluded in their study. After obtaining the market sentiment index, we apply the multivariate threshold model developed by Tsay (1998) to capture the movement of the stock index. The Hansen (2000) likelihood ratio is employed to test whether there is a significant threshold effect and the results will be compared with the Hang Seng Index. We also use the sentiment index as a threshold variable in a threshold regression model to capture the state of the Hong Kong stock market. Finally, a trading rule is developed and compared with the buy-and-hold strategy to test the out-of-sample performance of our index.

2. Data and Methodology

2.1 Data

The data is retrieved from several financial sources online. Historical daily turnover and prices of the Hang Seng Index (HSI) from 1 December 2008 to 31 December 2012 are obtained from Quamnet. Data for the short-selling volume is obtained from Yahoo Finance. The daily Hong Kong Interbank Offered Rate (HIBOR) is acquired from the Hong Kong Monetary Authority. Historical data for the S&P 500, the Nikkei 225, and the CSI 300 indices are gathered from Yahoo Finance. The stock market sentiment index will be estimated using the principal-component method.

2.2 Principal-component Model

Our investor sentiment index includes the following eight factors:

$$SMT_t = \alpha + \beta_1 TR_t + \beta_2 SST_t + \beta_3 RS_t + \beta_4 MF_t + \beta_5 HIBOR_t + \beta_6 SP_{t-1} + \beta_7 JAP_{t-1} + \beta_8 CSI_{t-1} \quad (1)$$

where

SMT_t is the stock market sentiment index;

TR_t is the turnover ratio;

SST_t is the short-selling turnover ratio;

RS_t is the relative strength index;

MF_t is the money flow index;

$HIBOR_t$ is the Hong Kong Interbank Offered Rate;

SP_t is the return of the S&P 500 index;

JAP_t is the return of the Nikkei 225 index;

CSI_t is the return of the CSI 300 index.

The descriptions of the above variables are provided as follows.

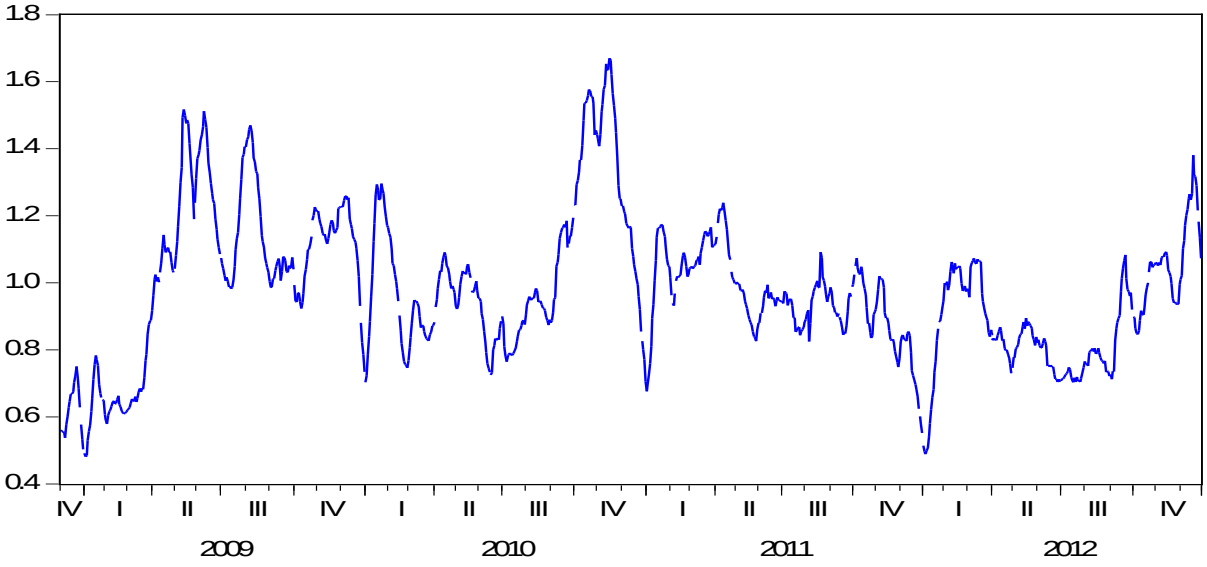
2.2.1 Turnover Ratio (TR)

The turnover ratio is included in the sentiment measurement model because it measures the stock market's trading activity. Findings concerning the relationship between turnover and stock market trend suggest that a larger turnover is usually associated with a price rise, whereas a small turnover is associated with a price fall (Ying, 1966). In other words, the turnover rate is high in a booming market but low in a bear market. Therefore, the turnover rate is defined as:

$$TR_t = 100 \times \frac{VM10t}{VM250t} \quad (2)$$

where VM10t is the average turnover for the past 10 trading days and VM250t is the average turnover for the past 250 trading days. Figure 1 plots the turnover ratio (TR).

Figure 1: Turnover Ratio



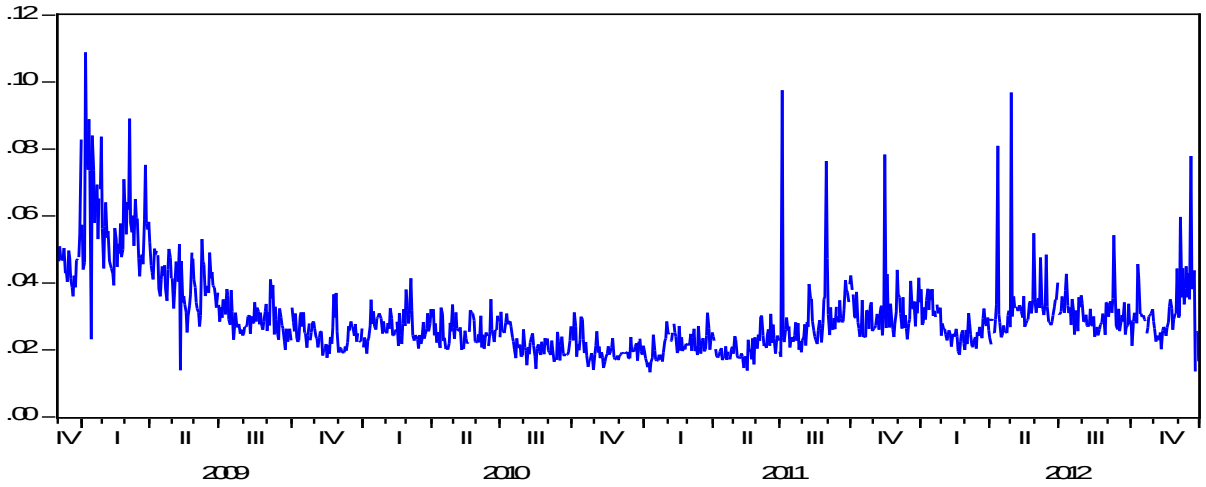
2.2.2 Short-selling Turnover Ratio (SST)

Short-term negative information can affect expected profitability and subsequently change investors' sentiment. Therefore, we include the number of short-selling trades as a proxy for the amount of negative information in the sentiment model. The short-selling turnover ratio is defined as the amount of short-sold shares divided by the number of shares traded in one day.

$$SST_t = \frac{short-selling\ volume_t}{turnover_t} \tag{3}$$

where short-selling volume is the amount of stock shares sold short and turnover is the total amount of stock shares traded. The changes of SST are shown in Figure 2.

Figure 2 : Short-selling Turnover Ratio



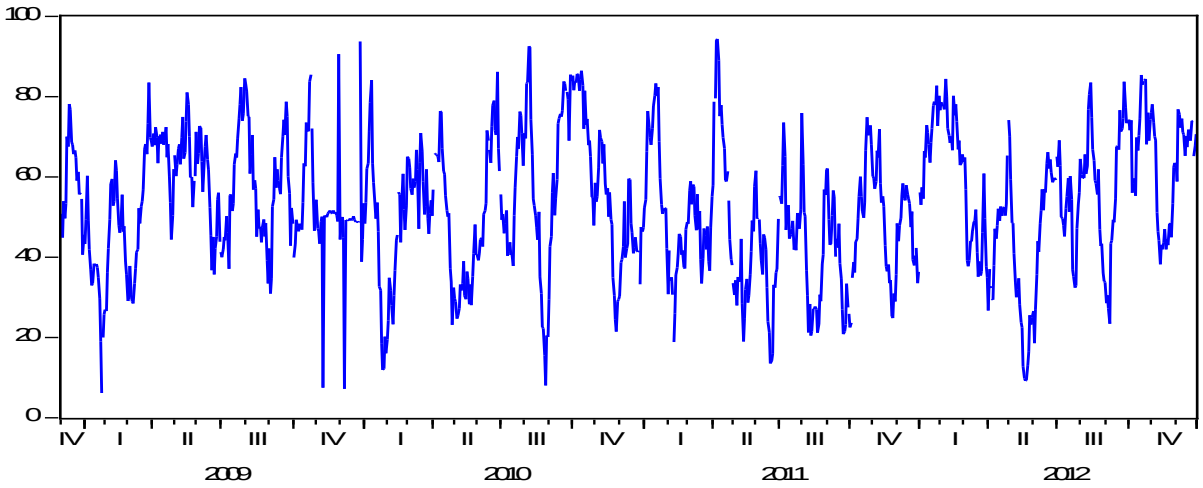
2.2.3 Relative Strength Index (RS)

The RSI is used to indicate buying and selling activities in a stock market. Traditionally, the market is considered overbought when the value of RSI is above 80, while a RSI below 20 suggests the market is oversold. Here, we add up the positive stock price difference from the past 14 days and divide it by the sum of the absolute value of price change in the same period to obtain the RSI index:

$$RS(14)_t = 100 \times \frac{\sum_{i=1}^{14}(P_{t-i}-P_{t-i-1})_+}{\sum_{i=1}^{14}|P_{t-i}-P_{t-i-1}|} \quad (3)$$

where $(P_{t-i} - P_{t-i-1})_+ = P_{t-i} - P_{t-i-1}$ if $P_{t-i} - P_{t-i-1} > 0$, otherwise = 0. The relative strength index is plotted in Figure 3.

Figure 3: Relative Strength Index



2.2.4 Money Flow Index (MF)

The Money Flow Index (MF) contains the information of both daily stock price and turnover. Joubert and Mason (1992) suggest that an increase in money flow may indicate the end of the stock market trend. To obtain the MF, we define

$$Daily\ Price = \frac{low + high + close}{3}\ . \tag{4}$$

We then define the money flow as:

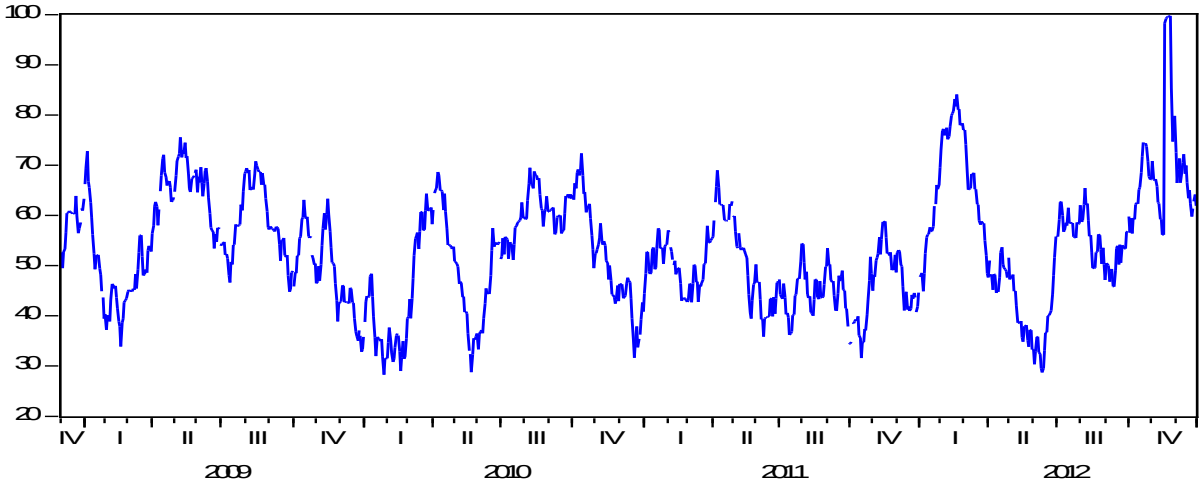
$$Money\ Flow = Daily\ Price \times Turnover. \tag{5}$$

The money flow is defined as positive if the daily price is lower in the previous day. If the price is higher in the previous day, the money flow is negative. We compute the positive money flow and negative money flow in the past 30 days. The money flow index is defined as:

$$MF = 100 \times \frac{Positive\ Money\ Flow_{30}}{Positive\ Money\ Flow_{30} + Negative\ Money\ Flow_{30}}. \tag{6}$$

Figure 4 shows the movement of MF in our sample period.

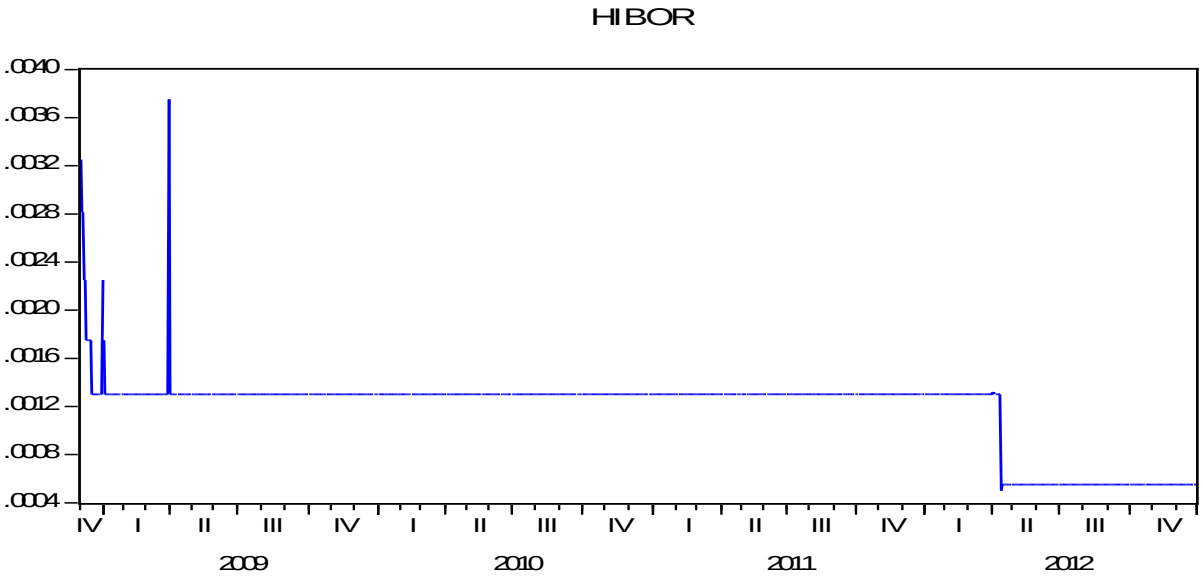
Figure 4: Money Flow Index



2.2.5 Hong Kong Interbank Offered Rate (HIBOR)

HIBOR is used here to show the investment cost. The HIBOR from 2008 to 2012 is plotted in Figure 5.

Figure 2 : Hong Kong Interbank Offered Rate



2.2.6 The Performance of Other Equity Markets

Lee (2006) shows that both the U.S. and Japanese stock markets significantly affect the Hong Kong stock market. Keong (2010) finds that China's stock market had a minor influence on Hong Kong before the 2008 financial crisis, but the two markets became more integrated after that period. Tuan and Ng (2011) conclude that, before and after the financial crisis, a number of favorable economic policies by the Chinese government gradually led to economic integration between Hong Kong and China. For example, the Individual Visit Scheme of 2003, which allows residents of major Chinese cities to visit Hong Kong on an individual basis, has spurred economic growth in Hong Kong. By 2009, tourism services accounted for 18% of the Hong Kong service exports and still records positive growth during the post-2008 crisis period. Hong Kong also benefits from its continuously improving bilateral trading environment with China and other Asian countries, such as the Closer Economic Partnership Arrangement (CEPA) and ASEAN 10+1, which is evident by an increase of external trade of commodities and services. The gradual opening of China's financial sector and the expansion of cross-border operations, particularly the service industry (CEPA I-VI, 2003-2008), provide increasing opportunities for investors in Hong Kong. Thus, we include the daily return of CSI 300 of China, S&P 500 of the U.S., and Nikkei 225 of Japan in our sentiment measure. Their return series are defined as follows:

$$\begin{aligned} SP_t &= \ln S\&P500_t - \ln S\&P500_{t-1} \\ JAP_t &= \ln NIKKEI_t - \ln NIKKEI_{t-1} \\ CSI_t &= \ln CSI300_t - \ln CSI300_{t-1} \end{aligned} \tag{7}$$

Figure 6 shows the return of these three stock markets.

Figure 3: Return Series of U.S., Japan and Mainland China Stock Markets

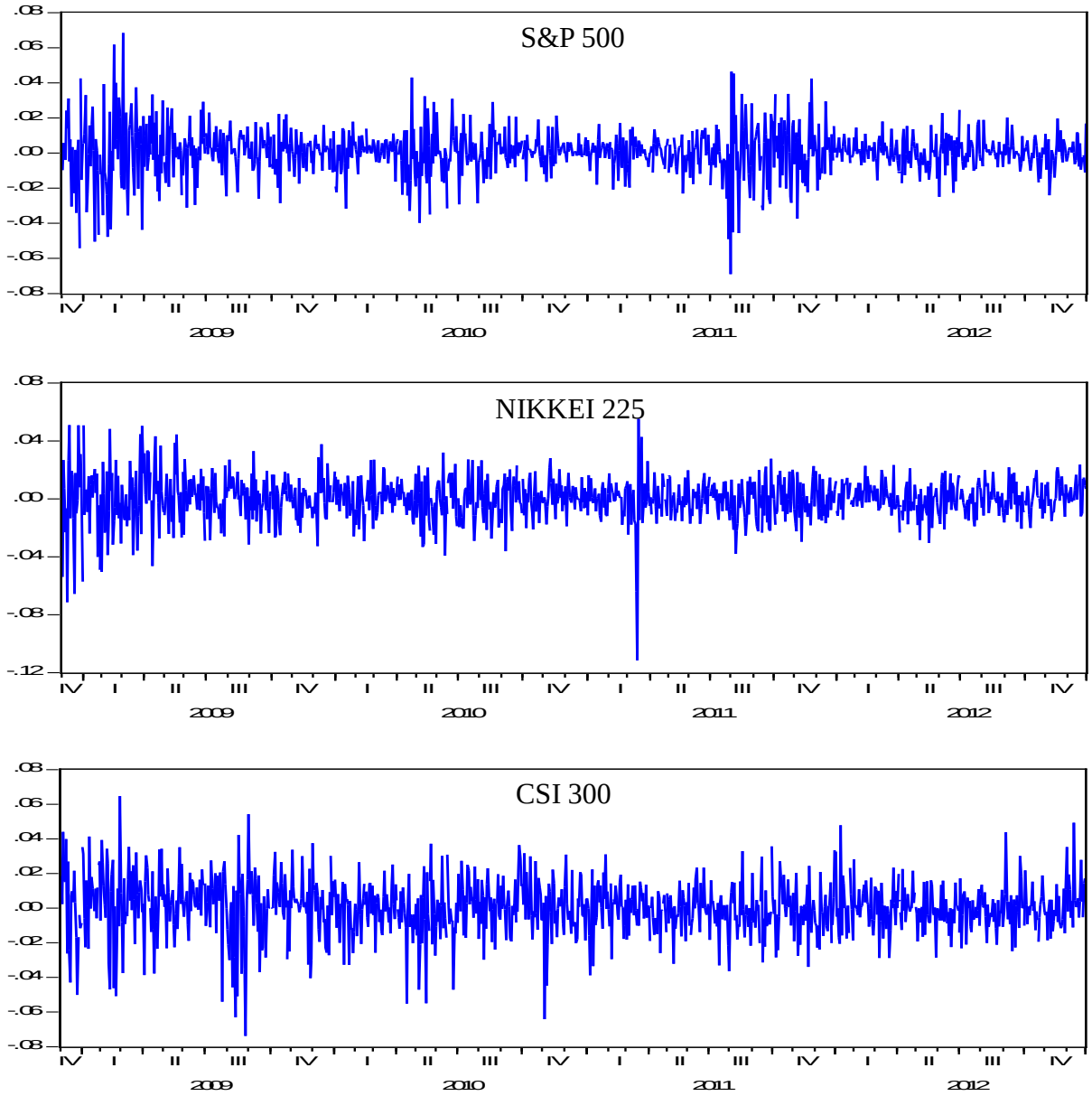


Table 1 summarizes the statistics of each factor included in the sentiment index developed in this paper.

Table 1: Summary Statistics of Each Factor of Sentiment Index

	Mean	**Median**	**Standard Deviation**	**Max**	**Min**
TR	0.9767	-0.9692	0.2169	1.6704	0.4812
SST	0.0288	-0.0265	0.0128	0.1089	0.0000
RS	52.7766	-52.1763	16.8371	94.3290	6.1151
MF	53.1706	-53.0895	11.5256	99.7486	28.2920
HIBOR	0.1190	-0.1300	0.0306	0.3800	0.0500
SP	0.0004	-0.0004	0.0138	0.0684	-0.0935
JAP	0.0001	0.0000	0.0143	0.0552	-0.1115
CSI	0.0003	-0.0003	0.0158	0.0646	-0.0737

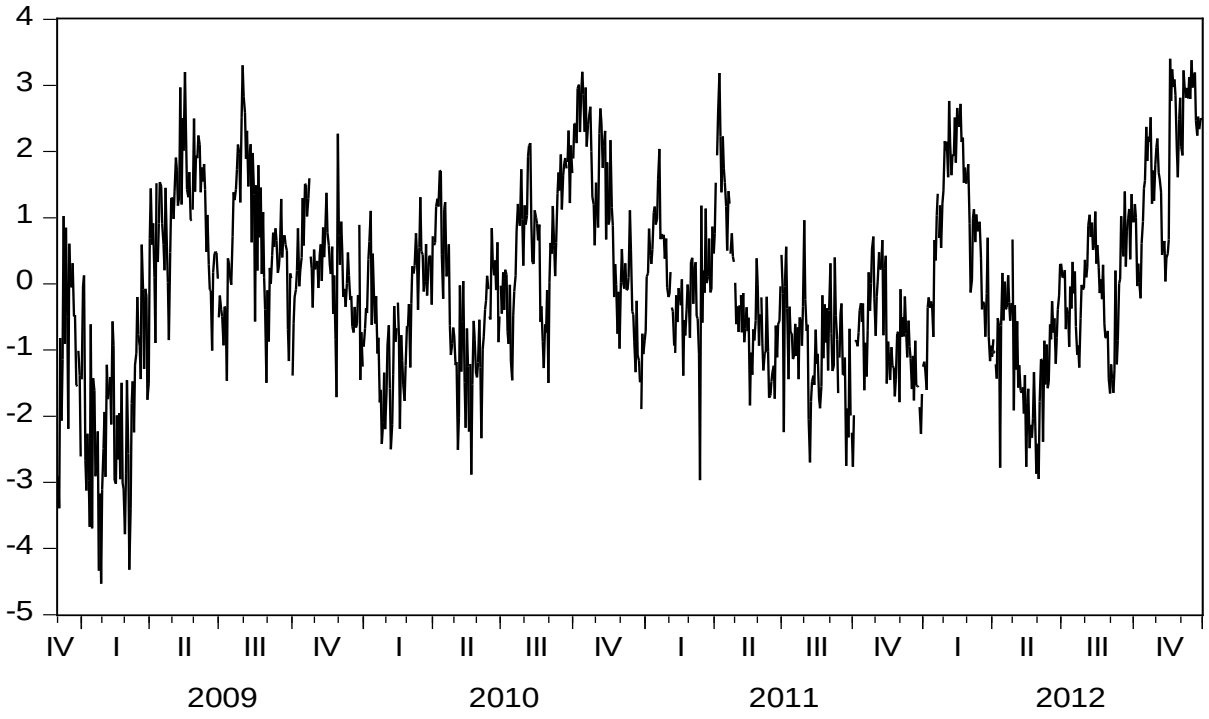
3. The Estimation Result

The stock market sentiment index, denoted by SMT_t, is the first principal component of the previously stated eight variables. The estimation result is as follows:

$$SMT_t = -4.77 + 1.98\ TR_t - 28.57\ SST_t + 0.03\ RS_t + 0.05\ MF_t - 3.30\ HIBOR_t + 7.88\ SP_{t-1} + 19.96\ JAP_{t-1} + 11.96\ CSI_{t-1}$$

The market sentiment is positively related to the stock turnover but negatively related to the short-selling activities. The RSI and MF are both positively related to SMT; an increase in HIBOR will lower sentiment in the stock market. The performance of the U.S., Japanese, and mainland Chinese stock markets all positively affects Hong Kong's stock market sentiment. Figure 7 plots the movement of the stock market sentiment index.

Figure 4: The Sentiment Index (SMT)



The maximum and the minimum of SMT are 3.405 and -4.533, respectively. Figure 7 indicates three extreme low values of the sentiment index, which all appeared in early 2009 (two in January and one in March) when RSI also reached its minimum point of 6.115. Prices in the Hong Kong stock market continued to drop for several days at those points, which caused a low value of the 14-day RSI. Overall, most sentiment values fall in a range from -4 to 4.

4. Applications of the Sentiment Index

4.1 Classifying the Hong Kong Stock Market States

A number of previous studies have classified different states of the stock market (Fabozzi and Francis, 1977; Kim and Zumwalt, 1979; Pagan and Sossounov, 2003; Lunde and Timmermann, 2004). In this paper, we use the multivariate-threshold model (Tsay, 1998) to identify the market states. The model is as follows:

$$y_t = \begin{cases} f_1(y_{t-1}, y_{t-2}, \ldots, \epsilon_{1t}|\theta_1), & \text{if } SMT_{t-1} \leq \gamma_1 \\ f_2(y_{t-1}, y_{t-2}, \ldots, \epsilon_{2t}|\theta_2), & \text{if } \gamma_1 < SMT_{t-1} \leq \gamma_2 \\ f_3(y_{t-1}, y_{t-2}, \ldots, \epsilon_{3t}|\theta_3), & \text{if } \gamma_2 < SMT_{t-1} \end{cases}$$

where y_t is the stock return, defined as

$$y_t = 100 \ln\left(\frac{P_t}{P_{t-1}}\right)$$

$f_i(\cdot)$ are well-defined functions with $f_i(\cdot) \neq f_j(\cdot)$ for any $i \neq j$, θ_i is a finite-dimensional parameter for any *i*, and ϵ_{nt} is the error term.

We use SMT_{t-1} as the threshold variable and estimate the following threshold model with two thresholds:

$$y_t = \begin{cases} \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + \cdots + \alpha_m y_{t-p} + \epsilon_{1t}, & \text{if } SMT_{t-1} \leq \gamma_1 \\ \beta_0 + \beta_1 y_{t-1} + \beta_2 y_{t-2} + \cdots + \beta_m y_{t-p} + \epsilon_{2t}, & \text{if } \gamma_1 < SMT_{t-1} \leq \gamma_2 \\ \varphi_0 + \varphi_1 y_{t-1} + \varphi_2 y_{t-2} + \cdots + \varphi_m y_{t-p} + \epsilon_{3t}, & \text{if } \gamma_2 < SMT_{t-1} \end{cases}$$

The two threshold values of our estimation are -1.238 and 1.390, respectively. These two values divide the market states into three regimes. The result of the estimation is

$$y_t = \begin{cases} -0.028 + 0.392y_{t-1} + 0.136y_{t-2} + 0.326y_{t-3} + \epsilon_{1t} & \text{if } SMT_{t-1} \leq -1.238 \\ -0.045 + -0.583y_{t-1} + 0.191y_{t-2} + 0.194y_{t-3} - 0.012y_{t-4} + 0.017y_{t-5} + \epsilon_{2t} & \\ & \text{if } -1.238 < SMT_{t-1} \leq 1.390 \\ 0.129 + 0.526y_{t-1} + 0.309y_{t-2} + 0.050y_{t-3} + \epsilon_{3t} & \text{if } 1.390 < SMT_{t-1} \end{cases}$$

Table 2 shows the percentage of points in each regime.

Table 2: The Percentage of Points in Each of the Three Regimes

	Low regime	**Middle regime**	**High regime**
Regime range	$SMT_{t-1} \leq -1.238$	$-1.238 < SMT_{t-1} \leq 1.390$	$1.390 < SMT_{t-1}$
Points in the regime	17.79%	65.81%	16.4%

We conducted the Hansen (2000) likelihood ratio test to test for threshold effects. The results are shown in Table 3.

Table 3: The Likelihood Ratio Test Result

Threshold value	-1.238	1.390
Observed test value**	29.898	33.042
Bootstrap critical value	12.771	21.899

** at the 5% significance level

The observed test values are greater than their corresponding bootstrap critical values; therefore, both thresholds are significant at the 5% level. We also compare the sentiment index (SMT) with daily Hang Seng Index (HSI) from 1 December 2008 to 31 December 2012, and the result is plotted in Figure 8.

Figure 8: The Sentiment Index and Hang Seng Index (HSI) from 2008 to 2012

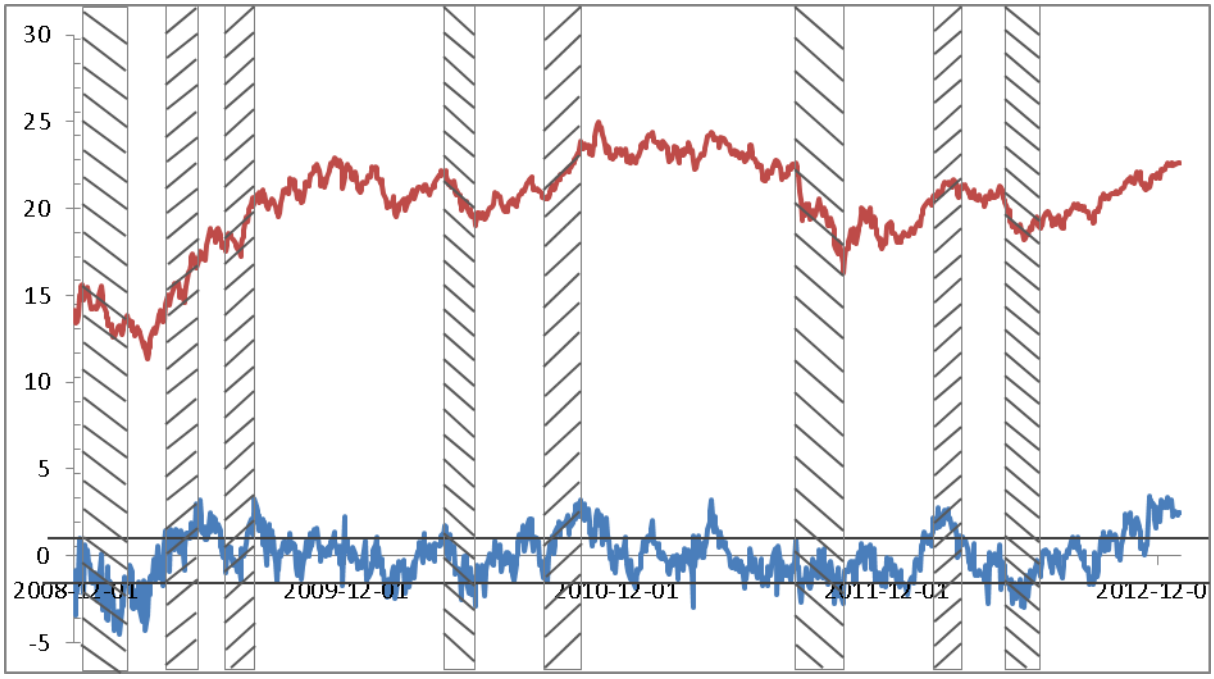


Figure 8 shows that the investor sentiment has a significant positive impact on the return of stock index futures. The period when the sentiment index is below (above) the lower (upper) threshold value for a significant length of time is shaded. Note that when the value of SMT is larger than 1.390, the trend of HSI is upward. If the value SMT is smaller than -1.238, then HSI faces downward pressure for most of the time.

4.2 Forecasting

Following Chen et al. (2010), we define a trading rule based on the sentiment index to test whether or not it can be used to forecast the market. The developed trading rule serves to sell (buy) the stock when the sentiment index is bigger (smaller) than 1.390. The total sample size used for prediction is *T=1010*, and we divide these samples into two groups, *p* and *q*, where *p=810* and *q=200*. Here we apply rolling sample $\{y_{t-p+1}, y_{t-p}, \cdots, y_t\}$ of size *p* to estimate the previously mentioned threshold model, and then predict a sequence of

one-step-ahead forecasts $\{\hat{y}_{t+1}\}_{t=p}^{T-1}$, allowing us to have 200 forecasting results using the sentiment index.

The applied trading strategy is to sell the Hang Seng Index or S&P/HKEx LargeCap Index when the predicted sentiment index SMT_{t-1} is larger than 1.39, and buy the index if the SMT_{t-1} is smaller than 1.39. We compare the mean of the forecasted return (MFTR) of these forecasting results with the buy-and-hold strategy. The MFTR is defined as:

$$MFTR = \frac{1}{n} \sum_{t=m+1}^{T} \text{sign}(1.390 - SMT_t) y_t$$

The MFTR of the buy-and-hold strategy is:

$$MFTR = \frac{1}{n} \sum_{t=m+1}^{T} y_t$$

We apply these two trading rules on HSI and S&P/HKEx LargeCap Index, respectively. The HKEx LargeCap Index contains 25 stocks representing the large-cap universe for Hong Kong, covering approximately 75 percent of the total market capitalization of the Hong Kong stock market. Table 4 reports the forecast results of these two strategies.

Table 4: The Average Daily Profit of Each Trading Rule

Trading rule	MFTR
SMT (HSI)	0.106
SMT (Largecap)	0.030
Buy-and-hold (HSI)	0.034
Buy-and-hold (Largecap)	-0.010

Note that for both the HSI and the S&P/HKEx LargeCap index, the SMT-based strategy achieves higher daily profit than the buy-and-hold rules. Our result shows that for the HSI the daily profit of the SMT-based strategy is 0.106%, comparing with 0.034% of the buy-and-hold trading rule. For the S&P/HKEx LargeCap Index, the SMT-based trading strategy earns 0.030% on average, while the buy-and–hold strategy loses 0.010% from 2008 to 2012.

5. Conclusion

This paper uses the principal-component method to generate a sentiment measure of the Hong Kong stock market in the post-2008 financial crisis period. The components of the sentiment measure includes the turnover ratio, short-selling volume, money flow, HIBOR and return of the U.S. and Japanese markets. We also include the Shanghai and Shenzhen Composite index in our measure to capture the influence of Chinese markets on the Hong Kong market. The results show that our sentiment index has a positive relationship with the turnover, RSI, MF, and performance of the three foreign stock markets, while it is negatively associated with short-selling volume and HIBOR. The sentiment index is used as a threshold variable in a threshold model to identify the states of the Hong Kong stock market. The result of Hansen's (2000) likelihood ratio test shows that the two threshold values are significant at the 5% level, dividing Hong Kong's stock market into three regimes. After comparing the sentiment with the Hang Seng Index (HSI), it is observed that when the sentiment index is above (below) the upper (lower) threshold, the HSI generally goes upward (downward). It is also found that the trading rule which sells (buys) the HSI or S&P/HKEx LargeCapIndex when the sentiment index is above (below) the upper threshold value can beat the buy-and-hold strategy.

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