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Overreaction of index futures in Hong Kong

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Abstract

In this paper we show that the pricing error of index futures relative to its fair value can be used to identify investors' overreaction in index futures market. Specifically, when investors are overly pessimistic (optimistic), the prices of index futures are well below (above) their fair values. When the excess pessimism (optimism) is gone, the prices of index futures revert to catch up with their fair values. After taking into consideration transaction cost, execution time lag, and risk adjustment, profitable strategies can be developed to exploit this overreaction. We find that overreaction exists during intraday trading and market closing.

JEL classification: G14; G15
Keywords: Overreaction; Index futures; Investor sentiment; Pricing error

1. Introduction

Market overreaction observed by De Bondt and Thaler (1985) opens a new field of research in finance. They show that in the stock market a contrarian strategy which buys losers and sells winners based on their returns over a 3- to 5-year horizon performs well in subsequent holding periods of 3 to 5 years. Their finding not only provides insight on securities selection for practitioners, but also challenges the classical assumption of strict rationality on the part of investors. Recently new models of investor behavior have been proposed which attempt to explain the phenomenon of overreaction and underreaction in asset markets (e.g. Barberis et al., 1998; Daniel and Titman, 1997; Hong and Stein, 1999).

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In Brav and Heaton (2002), both "behavior" theories built on investor irrationality and "rational structural uncertainty" theories built on incomplete information about the structure of the economic environment are used to explain the overreaction and/or underreaction phenomena. As remarked by Hirshleifer (2001), it creates an exciting time for the field of asset pricing.

Overreaction phenomenon in the financial market can be explained by the finding in psychology reported by Tversky and Kahneman (1974) that people tend to make predictions using behavioral heuristic known as representativeness rather than Bayes' rule. This finding in psychology infers that investors in stock market overreact and make extreme predictions based on extrapolation of recent trends. As a result of that, excess returns can be earned by buying out-of-favor stocks. According to De Bondt and Thaler (1995), out-of-favor stocks include those with low past returns (e.g. De Bondt and Thaler, 1985), low price-earning (P/E) ratios (e.g. Basu, 1977), and low market/book ratios (e.g. De Bondt and Thaler, 1987; Fama and French, 1992). In other words, past returns, price-earning ratios, and market/book ratios are assumed to reflect investors' sentiment towards individual stocks and can be used to identify events of overreaction. When investors are overly pessimistic (optimistic) about certain stocks, they drive the stock prices down (up) to a level way beyond where they should be. Hence, these stocks may have very low (high) past returns, or low (high) price-earning ratios, or low (high) market/book ratios. Contrarian strategies may then work.

A key feature in an overreaction event is that the price level is way beyond where it should be. For stocks, we can use past return, price-earning ratio, or market/book ratio as proxies to determine what the price level should be and hence identify the event of overreaction. However, in cases where the intrinsic value can be objectively determined, the incidence of overreaction may be identified directly. For example, the fair value of a futures contract is related to the value of the underlying asset through the no-arbitrage relationship. The fair value can be determined objectively without any assumption on return distribution. Hence, the difference between the futures price and its fair value, called pricing error in this paper, may be used to identify investors' overreaction in index futures market. The main contribution of this paper to the literature is to discover this new indicator of investors' overreaction and confirm its usefulness through empirical tests in Hong Kong index futures market.

Recently, Fung et al. (2000) observe intraday price reversals when the futures market opens with a large change in price compared to the previous day's closing price. They use the change in price in comparison to the previous day's closing price to identify investors' overreaction. The measure of overreaction proposed in this paper, the relative pricing error, is different from that used in Fung et al. (2000). For example, it is possible to have large change in futures price at market opening but the mispricing is not large if the index value goes up according to the cost-of-carry model. In that case, it is interpreted as a signal of investors' overreaction in Fung et al. (2000) but not in this paper. Furthermore, the study of overreaction of index futures markets is not restricted to happen at market opening. In this paper we consider whether overreaction happens during intraday trading and market closing as well. Also, only intraday reversal is considered in Fung et al. (2000). However, in this paper, we further follow the price movement for another day and find that overreaction is so strong that the price reversals extend beyond intraday to the following day. As we show in Section 4.6.1, the overnight returns of futures market are not related to the indicator used in their paper. In this sense, the measure identified in this paper is more powerful than that used in Fung et al. (2000).

One interesting feature of index futures market is that it usually closes after the stock market closes. In other words, there are a few minutes when the futures market keeps on trading but the stock market trading stops. During these few minutes, trading of stocks is impossible, and arbitrage activities are naturally curbed. With the absence of arbitrage activities, the index futures can deviate from its fair value substantially. Hence, one may suspect that the pricing error at futures market closing can reflect investors' sentiment better than the pricing error at other time points. Indeed this is what we find in this paper.

In our view, carrying the overreaction study over to the futures markets is particularly meaningful. Many studies against market anomalies suffer from the drawback that profitable opportunities rarely exist after taking transaction cost into consideration. For both finance theorists and practitioners, it is essential to know whether profitable opportunities still exist after the deduction of transaction cost. Since transaction cost in futures markets is significantly lower than that in the stock market, it is easier to establish the economic significance of overreaction in a futures market, if there is any at all. For practitioners, the possibility of obtaining high leverage in futures market makes this study even more interesting. They may be interested in the economic significance of the trading strategy on top of its statistical significance. This paper contributes in demonstrating that the overreaction identified by this new measure is so strong that profitable opportunities exist even after taking into consideration transaction cost, execution time lag, and risk adjustment in the index futures market in Hong Kong.

2. Relative pricing error as an indicator of investor sentiment

2.1. Relative pricing error as an indicator of investor sentiment

According to Shiller (1981) and Summers (1986), the deviation of prices from market fundamentals can be caused by changes in investor sentiment regarding financial assets. In the stock market, it is difficult to track the deviation of prices from market fundamental since the latter is unobservable. However, in the case of a futures market, a futures contract is drawn on an underlying commodity, which is concurrently traded in the cash market. Thus, the pricing error, which equals to the difference of the futures price and its fair value, as derived from the "cost of carry" arguments, can be treated as a potential indicator of investor sentiment and can be used to identify overreaction events. Because of the presence of arbitrageurs, the pricing error has to stay within the arbitrage bounds and extreme values can rarely be observed. However, the story is different when the futures market keeps on trading after the stock market closes, which is common for most index futures contracts. When the futures market is active while the spot market is not, arbitrage activities are naturally curbed. If one is able to use the pricing error to identify intraday overreaction event, the disappearance of arbitrage bounds when stock market closes may further enhance such ability. Hence, it makes sense to study the effects of pricing errors both when the stock market is open and after the stock market closes. Rigorously speaking, the pricing error when the stock market is closed cannot be called a pricing error, as the futures price and the index value are not synchronous. In this paper we extend the definition of pricing error of futures market to cover the period when the futures market is open and the spot market is closed. During that period, the pricing error (PE) is defined as the difference between the futures traded price and its fair value based upon the index at stock market closing. Also, since it is the relative magnitude of a pricing error that is important, relative pricing error (RPE), which is the ratio of the pricing error to its fair value, will be used for analysis.

2.2. Overreaction throughout the day and at market closing

In the previous section, we identify the pricing error, or relative pricing error, as a possible indicator of investor sentiment. If overreaction exists, the pricing error should have some bearing on subsequent returns. Specifically, prices should be subjected to overreaction as hypothesized by researchers in behavioral finance. This hypothesis can be subjected to empirical tests. For a given time point t in a trading day, we can first single out those days in which the relative pricing error at the point t is exceptionally high (denoted by HRPE_t) or exceptionally low (denoted by LRPE_t). If the market overreacts, the futures return ($\mathrm{FR}_{i/t}$) from time t to time $t+i$ after a large (resp. small) pricing error should be negative (resp. positive). Thus, to test for investor sentiment, we can test the following pairs of hypotheses:

$$(\mathrm{S1})\begin{cases} \mathrm{H}_0 : E(\mathrm{FR}_{i/t} \mid \mathrm{LRPE}_t) = 0 \\ \mathrm{H}_1 : E(\mathrm{FR}_{i/t} \mid \mathrm{LRPE}_t) > 0 \end{cases}$$

$$(\mathrm{S2})\begin{cases} \mathrm{H}_0 : E(\mathrm{FR}_{i/t} \mid \mathrm{HRPE}_t) = 0 \\ \mathrm{H}_1 : E(\mathrm{FR}_{i/t} \mid \mathrm{HRPE}_t) < 0 \end{cases}$$

where $\mathrm{FR}_{i/t}$ refers to the futures return from time t to time $t+i$. Note that in this study, the point t and $t+i$ may happen in different days, which means that we not only consider intraday returns but also overnight returns in the futures market. The null hypothesis in S1 and S2 signifies that investor sentiment as measured by the relative pricing error does not have any effect on futures pricing.

One may argue that since stock price has a natural upward drift, the null hypothesis of zero return may not be appropriate. To counter this argument, we can contrast the futures return in time intervals with high relative pricing errors with that in time intervals with low relative pricing errors and test the following pair of hypotheses:

$$(\mathrm{S3})\begin{cases} \mathrm{H}_0 : E(\mathrm{FR}_{i/t} \mid \mathrm{LRPE}_t) - E(\mathrm{FR}_{i/t} \mid \mathrm{HRPE}_t) = 0 \\ \mathrm{H}_1 : E(\mathrm{FR}_{i/t} \mid \mathrm{LRPE}_t) - E(\mathrm{FR}_{i/t} \mid \mathrm{HRPE}_t) > 0 \end{cases}$$

Obviously, the rejection of H_0 in (S1), (S2) or (S3) indicates that there is overreaction in the futures prices in time intervals of extreme pricing errors and futures prices will reverse in the following intervals. Like most overreaction studies, the hypothesis (S3) that losers outperform winners is the main hypothesis to be tested. The hypothesis (S1), (S2) and (S3) are empirically tested for the Hang Sang Index Futures (HSIF) in Hong Kong for an intraday time point t and when t is the market closing. To test whether the means are equal or not, independent samples are observed in the two populations and the z-test for independent samples is used to determine whether the null hypothesis (S1), (S2) and (S3) are rejected or not. The sample sizes are more than 700 for the groups with positive and negative pricing errors. By the central limit theorem, because of the relatively large sample size, we do not need to make any assumption on the distribution of the futures return and the test statistic z is approximately normally distributed. To take care of the concern of high kurtosis as well as the concern that the central limit theorem needs independent observations, we perform the non-parametric Wilcoxon test. We find that the test results are not different from the parametric z-test (Tables 2 and 3) and choose to skip the results of the non-parametric test. In Section 4.2, we also carry out further non-parametric tests to preclude the possibility that overreaction is observed in a limited number of "sentimental days". The results are reported in Table 3.

2.3. Second part of the overreaction hypothesis

De Bondt and Thaler (1985) hypothesize that there is a "magnitude effect" in the overreaction phenomenon. In the context of the present paper, the second part of the overreaction hypothesis amounts to: "the larger the degree of sentiment, the larger the reversals." Such a statement can be subjected to empirical tests as follows. We regress the subsequent futures return on the relative pricing error. A negative regression slope is an indication that the "magnitude effect" is present. Results for such regressions are reported in Section 4.3.

2.4. Is the reversal economically significant?

So far we only test whether the reversals after extreme relative pricing errors are statistically significant. However, it is more meaningful if we can show that the reversals are also economically significant. For this purpose, we must take transaction cost into account. To arrive at a realistic transaction cost, we have to include not only commission but also market impact cost taking bid/ask spread and market depth into consideration. Since the overnight price reversal is greater than the intraday price reversal, we focus on the trading strategy utilizing overreaction at futures market closing. One may argue that by the time when investors are able to observe the relative pricing error, the futures market has already closed. To buy or sell the contract at market closing may not be feasible due to execution time lag. Furthermore, because of bid-ask spread, it may not be possible to complete a trade at the closing price. To counter this argument, we consider a trading strategy that delays the execution time of the contrarian strategy to the following morning's market opening. Moreover, to make the strategy executable in a real trading environment, we look at the group with positive pricing error and the group with negative pricing error. In this strategy, one does not need to know the distribution of relative pricing error. This also eliminates the possibility that this phenomenon is caused by panicky traders at market closing. Thus, the contrarian trading strategy is as follows: after the futures market closes with a positive (negative) RPE value on day s, sell (buy) the futures at the market opening of day $s+1$ and close out the position at the end of day $s+1$. The trading performance of this strategy is reported in Section 4.4.

2.5. Does overreaction arise from risk consideration

One may raise the question that the observed reversal is not due to overreaction but is due to the avoidance of the high risk subsequent to exceptionally high or low relative pricing errors. In other words, a contrarian strategy is profitable not because of investors' overreaction. It is profitable because the strategy user is willing to bear the upcoming high risk. In order to adjust for the risk of the contrarian strategy, we calculate its Sharpe Index and compare it with that of the buy-and-hold strategy. Results along this direction are reported in Section 4.5.

2.6. Alternative indicators of investor sentiment

2.6.1. Signal of overreaction at market opening

Fung et al. (2000) show that price reversals exist at market opening in some index futures markets. They find that the gap (difference between the futures price at market opening on day s and the futures price at market closing on day $s-1$) is negatively related to the futures return from market opening to 2 h into the trading on day s. One may wonder whether the phenomenon that we observe here is just the result of the intraday price reversals caused by investors' overreaction at market opening. Regression test is carried out in Section 4.6.1 to show that rebounds after overreaction at market closing still exist after controlling for gap opening in the following day.

2.6.2. Futures return as an indicator of investor sentiment

In the literature, there have been studies that test for investor overreaction in the futures market. For example, Ma et al. (1990) study the adjustment process of futures prices subsequent to the occurrence of significant events. Using statistically significant daily price changes as proxies for the arrival of significant events, they find that futures prices of agricultural commodities tend to overreact, whereas financial futures tend to underreact to significant events. To contrast our finding to that in Ma et al. (1990), we also try another sentiment indicator similar to theirs and also consistent with De Bondt and Thaler (1985). We use today's futures return as a sentiment indicator. Days with very high (resp. low) returns indicate bullish (resp. bearish) sentiment. Empirical results along this direction are reported in Section 4.6.2.

2.7. Does overreaction in spot market drive overreaction in futures market?[2]

We have demonstrated the existence of futures market overreaction detected by the new indicator, the relative pricing error at futures market closing. The pricing error is the difference between the futures closing price and its fair value based upon the index at stock market closing. A natural question is whether the overreaction in futures market observed here is caused by (at least partly) the overreaction in spot market. To answer this question, we analyze in more details the futures market's overreaction at market closing, which is stronger than the overreaction observed at other time points. Specifically, we investigate whether the cash market overreacts at closing. The autocorrelation of the daily returns of closing index is calculated to see whether there is overreaction in the cash market. We also look at days with extreme daily returns in the cash market and see whether there are reversals in index in the following days. The results are summarized and discussed in Section 4.7.

2.8. Relevant definitions

As explained in Section 2.1, the pricing error (PE_t) is calculated as follows:

$$\mathrm{PE}_t = F_t - S_t e^{(r_\mathrm{f}-d)T} \tag{1}$$

where F_t is the futures price at time t, S_t is the index value at time t, r_f is the risk-free rate, d is the dividend yield, and T is the time to maturity of the futures contract at time t. Because of the fluctuating index values and because it is the relative magnitude of the pricing error that is important, we define the relative pricing error (RPE_t) as follows:

$$\mathrm{RPE}_t = \mathrm{Log}\left[\frac{F_t}{S_t e^{(r_f-d)T}}\right]. \tag{2}$$

When the stock market is close, the relative pricing errors are calculated through Eq. (2) where F_t is the futures trading price and, S_t is the index value at stock market closing. In Section 4, we investigate the issue whether an extreme RPE value can be used as a sentiment indicator of market overreaction, to be followed by reversals. For analysis purpose, we also introduce other notations. We define the futures return from time t to time $t+i$ ($\mathrm{FR}_{i/t}$) as:

$$\mathrm{FR}_{i/t} = \mathrm{Log}\left(\frac{F_{t+i}}{F_t}\right). \tag{3}$$

We further define the close-to-close futures return on day $s+1$ (FRCC_{s+1}) as the return of futures from the market closing on day s to the market closing on day $s+1$, which is given by:

$$\mathrm{FRCC}_{s+1} = \mathrm{Log}\left(\frac{\mathrm{FC}_{s+1}}{\mathrm{FC}_s}\right) \tag{4}$$

[2] We thank the referee for pointing out this interesting aspect.

The futures price at futures market closing on day s is FC_s. The open-to-close futures return on day $s+1$, $FROC_{s+1}$, defined as the return of futures from the futures market opening on day $s+1$ to futures market closing on day $s+1$, is given by:

$$\mathrm{FROC}_{s+1} = \mathrm{Log}\left(\frac{\mathrm{FC}_{s+1}}{\mathrm{FO}_{s+1}}\right) \tag{5}$$

where FO_{s+1} is the futures price at futures market opening on day $s+1$.

3. Data

We choose to carry out the intraday overreaction study with the Hang Seng Index Futures (HSIF) contract in Hong Kong. The Hang Seng Index is the most popular market index for the Hong Kong stock Market. The HSIF contract was launched in 1986 and is currently one of the most actively traded index futures contracts in Asia. Tick-by-tick data from March 18, 1993 to December 29, 2000 are obtained from Hong Kong Futures Exchange. The tick-by-tick data before March 18, 1993 are not available. We look at various time points. But in this paper, we only report some of the intraday intervals for simplicity. For example, when the stock market runs from 10:00 a.m. to 12:30 p.m. and from 2:30 p.m. to 4:00 p.m., the time points studied are 10:00, 10:30, 11:30, 12:30, 14:30, 15:00, 16:00, and 16:15. The time point 16:00 is the time of index closing. The time point 16:15 is included because it is the time when the HSIF market closes.

For the investigation of profitable opportunity taking into consideration transaction cost, execution time lag, and risk adjustment, we choose to use daily closing and opening prices of the HSIF in Hong Kong. The data start from September 10, 1986.

All the futures data are for the spot month contract, the most liquid contract month (all 12 months). The last trading day of HSIF is also the expiration day. We use the Hong Kong Inter-bank Borrowing rates (HIBOR) as the risk-free rate. The dividend yields and the risk-free rates are obtained from DataStream.

From September 1, 1995 to June 28, 1996, the HSIF market closed only 5 min after the stock market closed. At all remaining days, the HSIF market closed 15 min after the stock market closed.

4. Empirical findings

4.1. Summary statistics

To study the intraday overreaction, we calculate relative pricing errors at market opening, at intraday intervals, index market closing, and futures market closing for HSIF. Statistical results of the relative pricing errors are summarized in Table 1. As can be deduced from Table 1, the mean relative pricing errors of HSIF at various time points are all negative but not significantly different from zero.

Table 1
Summary statistics of relative pricing errors of Hang Seng Index Futures at various time points

Time points t	10:01	10:30	11:00	11:30	12:00	12:30	14:31	15:00	15:30	Stock market closing	Futures market closing
Mean	– 0.0014	– 0.0009	– 0.001	– 0.0009	– 0.0009	– 0.0009	– 0.0014	– 0.001	– 0.0011	– 0.0014	– 0.0012
Standard deviation	0.0096	0.00583	0.00579	0.006	0.00579	0.0061	0.00638	0.00592	0.0059	0.007	0.0078
n	1745	1860	1839	1814	1813	1606	1657	1836	1844	1314	1614
Max	0.0361	0.01591	0.01565	0.01977	0.02156	0.0183	0.01764	0.01931	0.01621	0.0205	0.0254
Min	– 0.127	– 0.065	– 0.0615	– 0.0627	– 0.0616	– 0.0763	– 0.0829	– 0.0901	– 0.0895	– 0.0861	– 0.093

4.2. Price reversals of futures

We look at price reversals of futures with positive pricing errors and negative pricing errors at the following times of the day: market opening (10:01), every half-hour intervals, index market closing, and futures market closing. Take time 10:01 as an example, we first calculate the relative pricing errors at 10:01 for all days and divide days into two groups according to the signs of the relative pricing error at 10:01. We then calculate the mean subsequent futures returns in these two groups. Returns starting from 10:01 to the following time points are considered: to 10:30, 11:30, 12:30, 14:31, 15:00, stock market closing in the same day, futures market closing in the same day, stock market closing in the following day, and futures market closing in the following day. Similar calculation is repeated for the time point t. Mean subsequent futures returns starting from t to various time points of the same day and the following day are tabulated in Table 2.

In this section, we want to see whether the futures prices rebound after the relative pricing errors take on extreme values. For this purpose, we show in Panel A of Table 2 the means of the futures returns from time t to time $t+i$ ($\mathrm{FR}_{i/t}$) for the negative group (the group with negative relative pricing errors). The futures returns of the positive group (the group with positive pricing errors) are summarized in Panel B and the differences between the futures returns of the negative group and the futures returns of the positive group are summarized in Panel C. For example, the mean futures return for the negative group 1 at 10:01 is 0.073% from 10:01 to 10:30 (Panel A). The corresponding mean futures return for the positive group is -0.035% (Panel B). The difference in mean returns is 0.108% (Panel C). As shown in Panel A for the negative group, the futures prices stay about the same on the same day. No significant reversal is observed without overnight market closing. The futures returns until the end of the following day are all positive though, as shown in Panel A. Thus, reversals are observed in the following day. Take the time point at 10:30 as an example. The mean futures return from 10:30 to the futures market closing in the following day is 0.310%, much higher than all the intraday returns on the same day. As shown in Panel B for the positive group, the futures prices go up initially. Sizable reversals are observed about half-an-hour to one hour into the trading in the afternoon. In general, the futures returns are negative as shown in Panel B. The reversals also happen to be the greatest at the end of the following day. For example, the mean futures return from 10:30 to the futures market closing in the following day is -0.305%. The differences in mean returns of the negative group and the positive group are shown in Panel C. For example, the mean difference from 10:30 to the futures market closing in the following day is 0.615%. They follow similar pattern. They are mostly positive except the first few readings. Intraday reversals exist but in a much weaker way in comparison to reversals after market closing. Thus, the futures markets do reverse after extreme relative pricing errors, which can hence be treated as an indicator of investor sentiment.

We also test different criteria of extreme groups. We compare days with the lowest 20% values of relative pricing errors with days with the highest 20% values of relative pricing errors. The difference in futures return from futures market closing to the futures market closing in the following day is 0.689%. We also compare days with relative pricing errors below -0.5% with days with relative pricing errors above $+0.5\%$. The corresponding difference is 0.652%. The results are the same.

Table 2
Mean futures returns at various time points (days of negative relative pricing errors, positive relative pricing errors, and the difference)

Starting Time	Ending Time Point								
	1030	1130	1230	1431	1500	Index Closing	Futures Closing	Next Day Index Closing	Next Day Futures Closing
Panel A: Group of negative relative pricing errors									
1001	0.00073**	0.00074*	0.00061	0.00003	0.00013	0.00050	0.00065	0.00146	0.00156
1030		0.00014	0.00017	– 0.00006	0.00022	0.00087*	0.00106**	0.00286**	0.00310**
1130			– 0.00008	– 0.00040	– 0.00012	0.00048	0.00057	0.00239**	0.00257**
1230				– 0.00028	– 0.00006	0.00059*	0.00064	0.00207*	0.00242**
1431					0.00035*	0.00070*	0.00071*	0.00204**	0.00231**
1500						0.00049*	0.00048*	0.00233**	0.00265**
Index closing							– 0.00013	0.00157*	0.00217*
Futures closing								0.00209**	0.00267**
Panel B: Group of positive relative pricing errors									
1001	– 0.00035	– 0.00065*	– 0.00066*	– 0.00058	– 0.00081*	– 0.00076	– 0.00067	– 0.00114	– 0.00086
1030		– 0.00019	– 0.00055*	– 0.00078*	– 0.00134**	– 0.00157**	– 0.00154**	– 0.00319**	– 0.00305**
1130			– 0.00023	– 0.00033	– 0.00108**	– 0.00116**	– 0.00098*	– 0.00272**	– 0.00247**
1230				– 0.00003	– 0.00077**	– 0.00084**	– 0.00060	– 0.00201**	– 0.00195*
1431					– 0.00092**	– 0.00093**	– 0.00064*	– 0.00218**	– 0.00198**
1500						– 0.00014	0.00005	– 0.00184**	– 0.00183**
Index closing							– 0.00013	0.00157*	0.00217*
Futures closing								0.00209**	0.00267**
Panel C: Difference between the group of negative relative pricing errors and the group of positive relative pricing errors									
1001	0.00108**	0.00139**	0.00127*	0.00061	0.00094	0.00126	0.00132	0.00259*	0.00242*
1030		0.00033	0.00071*	0.00072	0.00156**	0.00244**	0.00260**	0.00604**	0.00615**
1130			0.00016	– 0.00007	0.00096**	0.00164**	0.00155**	0.00510**	0.00503**
1230			0.00010	0.00011	0.00092**	0.00167**	0.00157**	0.00563**	0.00586**
1431				– 0.00025	0.00070*	0.00143**	0.00123*	0.00407**	0.00437**
1500					0.00127**	0.00163**	0.00136**	0.00421**	0.00428**
Index closing						0.00062*	0.00043	0.00417**	0.00448**
Futures closing							– 0.00054	0.00334**	0.00443**

* Significant at 5% confidence level for testing hypothesis S1, S2, and S3.

** Significant at 1% confidence level for testing hypothesis S1, S2, and S3.

We plot the mean cumulative futures returns for the group of positive pricing errors and the group of negative pricing errors at 10:30 throughout the same day and the following day in Fig. 1. The other groups have similar pattern. It clearly shows that reversals exist. The reversals become significant around half-an-hour in the afternoon trading session following high (or positive) pricing error. However, in general, reversals are weak unless overnight returns beyond market closing are considered.

We then test whether the reversals are statistically significant. The results of testing the relevant hypotheses are also summarized in Table 2. Significance levels of 5% and 1% are used. The results in testing hypothesis in (S1) of no reversals when the relative pricing errors are negative are summarized in Panel A. Although the null hypothesis in (S1) of no rebound cannot be rejected for most of the intraday returns, it is rejected for returns to market closing in the following day. Most of the signs are in agreement with the alternative hypothesis that there is a rebound. On the other hand, as shown in Panel B, the null hypothesis (S2) of no reversals when the relative pricing errors are positive is rejected in most cases when one waits until half-an-hour in the afternoon trading session, indicating that there is strong evidence of overreaction when the relative pricing errors are positive. In testing for hypotheses (S3) which combines (S1) and (S2), we find that the null hypothesis of no rebound is rejected when one waits until half-an-hour in the afternoon trading session, as shown in Panel C. In other words, the futures return when the relative pricing error is negative is significantly higher than that when the relative pricing error is positive. But one has to wait until half-an-hour into the afternoon trading session before the reversals are significant, with the most significant part of reversals occurring in the following day.

One may wonder whether the rebounds are caused by a few outlying days. So we employ a non-parametric test to test for the proportion of positive returns. The hypotheses to be tested are similar to (S1), (S2) and (S3).

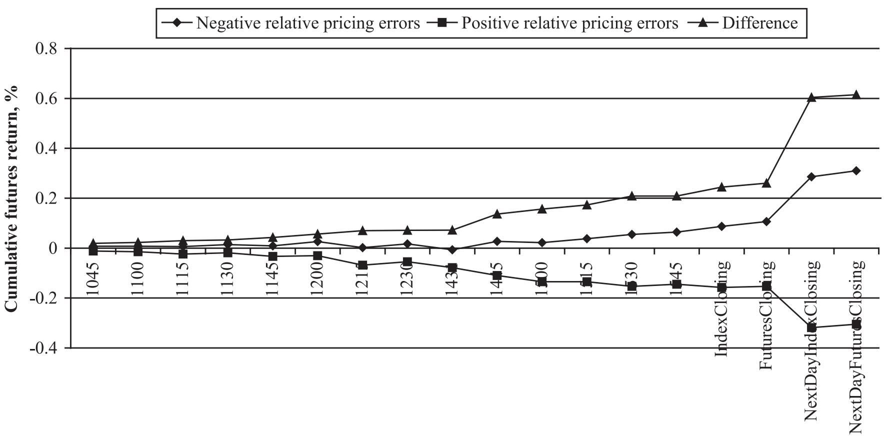

Fig. 1. Cumulative futures returns of Hang Seng Index Futures with relative pricing errors at 10:30.

The relevant hypotheses are:

$$(S1'):\begin{cases}\mathrm{H}_0: E(\mathrm{PPFR}_{i/t}\mid \mathrm{LRPE}_t)=0.5\\ \mathrm{H}_1: E(\mathrm{PPFR}_{i/t}\mid \mathrm{LRPE}_t)>0.5\end{cases},$$

$$(S2'):\begin{cases}\mathrm{H}_0: E(\mathrm{PPFR}_{i/t}\mid \mathrm{HRPE}_t)=0.5\\ \mathrm{H}_1: E(\mathrm{PPFR}_{i/t}\mid \mathrm{HRPE}_t)<0.5\end{cases},\ \text{and}$$

$$(S3'):\begin{cases}\mathrm{H}_0: E(\mathrm{PPFR}_{i/t}\mid \mathrm{LRPE}_t)-E(\mathrm{PPFR}_{i/t}\mid \mathrm{HRPE}_t)=0\\ \mathrm{H}_1: E(\mathrm{PPFR}_{i/t}\mid \mathrm{LRPE}_t)-E(\mathrm{PPFR}_{i/t}\mid \mathrm{HRPE}_t)>0\end{cases}$$

where $\mathrm{PPFR}_{i/t}$ represents the percentage of positive futures returns from time t to $t+i$. The results of the tests are summarized in Table 3. For simplicity, we only present the results for the cases where $t=10{:}30$ and $t=$ futures market closing. Basically, the results are similar. Thus, we can comfortably reject the possibility of problematic outliers, i.e. overreaction is not the results of a few outlying days.

In summary, the following observations can be made. (1) Overreaction is commonly observed during market opening, including the morning opening time of 1000 and the afternoon opening time of 1430. This is consistent with the finding of overreaction at market opening in Fung et al. (2000), even though they use a different measure. (2) Intraday overreaction is found to be not so suitable while trading is on going. (3) For non-opening time points, overreaction can be detected if overnight reversal is taken into consideration. The fact that reversal happens after the futures market closes points to the conclusion that overreaction during the day may persist until the futures market closes and will only be corrected after the overnight non-trading period.

4.3. Second part of overreaction hypothesis

To test whether the magnitude of the relative pricing error is related to the size of the reversals, we regress the futures returns on day $s+1$, FRCC_{s+1}, on the relative pricing error at futures market closing on day s, RPEFC_s, as follows:

$$\mathrm{FRCC}_{s+1}=\alpha+\beta\cdot\mathrm{RPEFCs}+\varepsilon_s. \tag{6}$$

We then test whether β is significantly less than zero. A negative β implies that the second part of the overreaction hypothesis is correct. The results are summarized in Table 4. The coefficient is -0.286, negative and significantly different from zero. The conclusion is that the lower the relative pricing error, the higher the futures return.

Table 3
Hypothesis testing for proportions of futures return at various times points for HSIF

Hypothesis tested	Groups tested	Starting time	Values of z-statistics for testing							
			Ending time							
			1130	1230	1431	1500	Index closing	Futures closing	Next day index closing	Next day futures closing
(S1′)	Negative RPE	10:30	− 1.785	− 1.163	− 1.189	− 1.331	− 2.835**	− 3.698**	− 3.769**	− 3.768**
(S2′)	Positive RPE	10:30	− 0.922	0.000	− 0.113	1.618	2.493**	1.915*	4.053**	3.855**
(S3′)	Negative vs. positive RPE	10:30	1.024	1.565	1.414	4.209**	7.542**	7.843**	11.131**	10.838**
(S1′)	Negative RPE	Futures closing							− 3.381**	− 4.312**
(S2′)	Positive RPE	Futures closing							4.335**	3.889**
(S3′)	Negative vs. positive RPE	Futures closing							10.994**	11.602**

*Significant at 5% confidence level.

**Significant at 1% confidence level.

Table 4
Regression results of futures return on relative pricing error

Intercept, α (p value)	$-2.2e-05$ (0.970)
Coefficient, β (p value)	-0.286 (0.000135)**
R-square	0.00917
n	1583

Dependent variable is the close-to-close futures return from futures market closing on day s to futures market closing on day $s+1$. Independent variable is the relative pricing error at futures market closing on day s.

$$\mathrm{FRCC}_{s+1} = \alpha + \beta \times \mathrm{RPEFC}_s + \varepsilon_s$$

** Significant at 1% confidence level.

4.4. Economic significance

In this section, we investigate whether rebounds after overreaction can be exploited to yield an economically significant contrarian trading strategy. To account for round-trip transaction cost, we use the values suggested by a market practitioner from Goldman Sachs: 0.125% for the Hong Kong futures market. These figures were presented by Mr. C. Eoyand in an ISI Cutting Edge Conference held in Hong Kong in 1997. To increase the sample size, we include the daily data of HSIF starting from September 10, 1986. The results are summarized in Table 5. A positive (negative) number denotes profit (loss). The contrarian strategies yield profit after transaction cost on days with negative relative pricing errors. The day-traded profit is 0.069%, significantly greater than zero. The results

Table 5
Profitability of open-to-close trading strategies under transaction cost

Panel A: Negative relative pricing errors	
Mean	0.00069
Standard deviation	0.01607
Max	0.09781
Min	-0.07441
n	1616
t value	1.734*
Panel B: Positive relative pricing errors	
Mean	-0.00014
Standard deviation	0.01429
Max	0.08607
Min	-0.10227
n	1495
t value	-0.383

If the previous day's relative pricing error is negative, the trading profit is the profit of longing the futures at market opening and unwinding the position at market closing on the same day. If the previous day's relative pricing error is positive, the trading profit is the profit of shorting the futures at market opening and unwinding the position at market closing on the same day. The transaction cost is 0.125% for the Hong Kong futures market. These include commissions and market-impact cost.

* Significant at 5% confidence level. The mean is zero in the null hypothesis.

are economically significant as well. The annualized return is about 19%. The profit of this strategy can be interpreted as the reward of taking an opposite position to the market sentiment. The strategy users buy when most people want to sell, and sell when most people want to buy.

4.5. Risk consideration

In order to assess the risk of the contrarian strategies derived from this study, we calculate the Sharpe Indexes for the buy-and-hold strategy with index and our contrarian strategy on days with negative sentiment. The results are summarized in Table 6.

The overall Sharpe index of this contrarian strategy is 0.0431, much higher than that of the buy-and-hold strategy, 0.0247. This shows that the return of the contrarian strategy is higher than the buy-and-hold strategy, even after risk adjustment.

Furthermore, we separate the sample period into five sub-periods. For each sub-period, we calculate the Sharpe indexes for the buy-and-hold strategy and the contrarian strategy. For comparison, we calculate the difference in Sharpe indexes as well. It does not appear that the effectiveness of the indicator discovered in this paper is concentrated in a particular period. The overreaction observed with this measure is not caused by some special events at particular time points in the sampling period or by the fact that market has not matured.

Although we fail to explain the excess return of the contrarian strategy using risk related reasons, it does not necessarily imply that such overreaction actually arises from investors' irrational behaviour. Recently Barberis (2000) points out that predictability might be affected by parameter uncertainty. Using rational models incorporating parameter uncertainty, Brav and Heaton (2002) show that both overreaction and underreaction can occur under rationality and it is difficult to distinguish between two

Table 6
Sharpe indexes for the buy-and-hold strategies and the contrarian strategies with Hang Seng Index Futures

Time periods	Sharpe index for strategy B	Sharpe index for strategy C	Difference (C − B)
Overall	0.0247	0.0431	0.0185
1	0.0322	0.1135	0.0813
2	0.0942	− 0.0011	− 0.0953
3	0.0303	0.1445	0.1141
4	− 0.0480	− 0.0572	− 0.0092
5	0.0231	0.0467	0.0236
Mean (for 1 – 5)	0.0264	0.0493	0.0229
S.D.	0.0505	0.0822	0.0817
Max	0.0942	0.1445	0.1141
Min	− 0.0480	− 0.0572	− 0.0953
n	5	5	5

This table tabulates the performance of the buy-and-hold strategy (B) and the contrarian strategy (C) of buying futures at market opening and closing it at market closing when the relative pricing error the previous day is negative. The transaction cost is 0.125% for the Hong Kong futures market. The transaction cost for the buy-and-hold strategy is assumed to be zero.

competing theories of financial anomalies: "behavioral" theories built on investor irrationality, and "rational structural uncertainty" theories build on structural parameter uncertainty.

4.6. Alternative indicators of investor sentiment

4.6.1. Signal of overreaction at market opening

Following the discussion on Section 2.6.1, we have to separate this price reversal from the reversal resulting from market gap. To achieve this aim, we perform the following multiple regression:

$$\mathrm{FROC}_{s+1} = \alpha + \beta_1 \mathrm{RPEFC}_s + \beta_2 \mathrm{GAP}_{s+1} + \varepsilon_{s+1} \tag{7}$$

where $\mathrm{GAP}_{s+1} = \log(\mathrm{FO}_{s+1}) - \log(\mathrm{FC}_s)$.

The regression results are summarized in Table 7, Panel A. The coefficient β_1 is negative and statistically different from zero. The gap has no effect on the futures return from opening to closing. This is not surprising since the effect of overreaction at market opening using the gap as an indictor only lasts about 2 h in the study of Fung et al. (2000). This shows that our finding still holds after we have controlled for the gap that may affect the day-trade return in the following day.

Table 7

Effects of relative pricing errors at futures market closing (RPEFC_s), gaps at futures market opening (GAP_{s+1}), futures returns (FRCC_s), and relative pricing errors at stock market closing (RPEFC_s) on the futures returns from futures opening to futures closing (FROC_{s+1})

Panel	Intercept	RPEFC_s	GAP_{s+1}	FRCC_s	RPESC_s	R-squared
A	−0.000143	−0.1992				0.008056
	(0.7859)	(0.001477)***				
	0.000132		0.04007			0.001162
	(0.7999)		(0.2282)			
	−0.00014	−0.1960	0.03500			0.00894
	(0.7904)	(0.001783)***	(0.2913)			
B	0.000136			−0.06095		0.006558
	(0.7931)			(0.00414)***		
	-7.09×10^{-5}	−0.1485		−0.03840		0.01013
	(0.8931)	(0.03377)**		(0.1054)		
C	−0.000112				−0.1677	0.004183
	(0.8331)				(0.02210)**	
	-6.33×10^{-5}	−0.3503			0.1976	0.009234
	(0.9050)	(0.01175)**			(0.2232)	
D	-1.06×10^{-5}	−0.2774	0.03836	−0.03336	0.1645	0.01076
	(0.9840)	(0.06070)*	(0.2490)	(0.1697)	(0.3240)	

Values of coefficients of independent variables in regression equations with p values in parentheses.

* Significant at 10% confidence level.

** Significant at 5% confidence level.

*** Significant at 1% confidence level.

4.6.2. Futures return as an indicator of investor sentiment

In this section, we try to answer the question whether the relative pricing error is more effective than the daily futures returns in reflecting investor sentiment. We run the following multiple regression:

$$\mathrm{FROC}_{s+1} = \alpha + \beta_1 \mathrm{RPEFC}_s + \beta_2 \mathrm{FRCC}_s + \varepsilon_{s+1}. \tag{8}$$

The regression results are summarized in Table 7, Panel B. The coefficient β_1 is negative and statistically different from zero. This shows that our finding still holds after we have controlled for the alternative measure of sentiment, i.e. the past futures returns. The effect of the futures return even disappears in the multiple regression. Our results show that today's futures return is not as effective as the relative pricing error in detecting investor sentiment. Our new measure, the relative pricing error, is more powerful than the traditional measure using past returns.

Why should today's relative pricing error be a better sentiment indicator than today's futures return? We like to point out two features unique to index futures markets. First, the prices of the underlying asset for a futures contract are observable and we can tell more precisely how overvalued a futures contract is. Second, trading of futures contracts continues after the stock market closes. Because arbitrage activities break down after the closing of the cash market, there is less constraint on futures pricing and investors can run wild. These two features give the relative pricing error a unique power to identify investors' overreaction. To verify the second reason, we compare the overnight futures return obtained with the relative pricing error at stock market closing and that obtained with the relative pricing error at futures market closing. As shown in Panel A of Table 2, the futures return following negative pricing error at futures market closing is 0.267%, which is higher than the 0.217% return following negative pricing errors at stock market closing. This also holds for the group with positive pricing error and the difference between the two groups, as shown in Panels B and C in Table 2.

We also regress the futures returns from futures market opening to futures market closing on day $s+1$, FROC_{s+1}, on the relative pricing error at futures market closing on day s, RPEFC_s, and the relative pricing error at stock market closing on day s, RPESC_s, as follows:

$$\mathrm{FROC}_{s+1} = \alpha + \beta_1 \times \mathrm{RPEFC}_s + \beta_2 \times \mathrm{RPESC}_s + \varepsilon_{s+1} \tag{9}$$

The results are shown in Table 7, Panel C. The futures return from market opening to market closing is negatively related to the relative pricing error at stock market closing the previous day and the relative pricing error at futures market closing the previous day, when regressed separately. However, when the two variables are used as independent variables together, the effect of the relative pricing error at stock market closing becomes insignificant. That clearly shows that overreaction does occur at stock market closing. However, overreaction occurs in a much greater way at futures market closing. This is consistent with all our findings so far. The phenomenon we observed here is not due to a few panicky investors or liquidity. Hence, with the relative pricing error at stock market closing, we already observe overreaction. The driving force is not the last 15 min of futures trading while stock market closes. The unique feature that futures market keeps on trading after stock market closing just makes this phenomenon more pronounced.

We run regression to see the combined effects of the relative pricing error and the alternative indicators of investor sentiment. As shown in Table 7, Panel D, the only variable that has significant effect is the relative pricing error at futures market closing. It clearly demonstrates that the indicator proposed in this paper is superior to the alternative indicators.

4.7. Does overreaction in spot market drive overreaction in futures market?

As mentioned in Section 2.7, we investigate whether the spot market overreacts in this horizon. The autocorrelation of the returns of daily closing index is 0.02607 with a p value of 0.2402. There is no evidence that the spot market overreacts. We look at days with returns higher (lower) than $+1\%(-1\%)$, $+2\%(-2\%)$, and $+3\%(-3\%)$. The return of the following day is calculated and checked to see whether it is different from zero. As shown in Table 8, the following days' returns are negative on days with returns lower than -1%, -2%, and -3%, and are positive on days with returns higher than $+1\%$, $+2\%$, and $+3\%$. There is no evidence that spot market overreacts. The overreaction in futures market identified by the relative pricing error is not caused by overreaction in spot market.

4.8. Alternative trading strategies

We look at some modified trading strategies in this section to exploit the relationships we find. First, we use the futures returns instead of the relative pricing errors at futures market closing. The trading strategy is to buy futures at market opening when the futures return in the previous day was negative and unwind the position at futures market closing on the same day. That gives a loss of 0.0187% after transaction costs. The trading strategy using the futures return is not as effective as that using the relative pricing errors.

Next, we look at whether new information revealed on day s after the signal on day $s-1$ has additional benefit. We separate the samples into two periods. The first period is in year 1996 and before. The second period is in year 1997 and after. We use the first period to find our modified strategies and use the second period as out-of-sample testing. Strategy A uses the signal of relative pricing errors on day $s-1$ without incorporating any new information on day s. Strategy B is similar to strategy A, except that it initiates the trade only when the relative pricing error at market opening on day s has not reversed.

Table 8
Index returns after days with extreme returns

Index returns on days	Lower than -3%	Lower than -2%	Lower than -1%	Higher than $+1\%$	Higher than $+2\%$	Higher than $+3\%$
Mean index return on the following days	−0.001877	−0.000678	−0.001267	0.002808	0.003708	0.001349
Number of days	96	193	419	482	214	93
t value	−0.4823	−0.3070	−1.047	3.335**	2.536*	0.596

* Significantly different from zero at 5% confidence level with two-tail test.

** Significantly different from zero at 1% confidence level with two-tail test.

That means investor sentiment at futures market closing remains the same when the trade is initiated in the following day. Otherwise, no trade is initiated. Strategy C is similar to strategy B, except that the position is unwind when the relative pricing error changes sign in the middle of the day. Unlike strategy B, one exercises the early unwinding option in strategy C. In the first period, the profits of strategies A, B, and C are 0.1336%, 0.2775%, and 0.1149%, respectively. Incorporating the new information at market opening improves the profitability of the trade significantly (both economically and statistically at 5% confidence level). Early unwinding does not help. In the second period, the profits of strategies A, B, and C are 0.1092%, 0.2653%, and 0.2707%, respectively. Incorporating the new information at market opening still improves the profitability of the trade significantly (both economically and statistically at 10% confidence level). The improvement with the early unwinding option is not statistically significant. Incorporating new information does seem to help.

5. Conclusion

In this paper we show that the relative pricing error in HSIF market at intraday time points and at market closing can be used to identify investors' overreaction. Specifically, we test the following conjecture. On days when investors are overly pessimistic, the prices of index futures are well below their fair values. When the excess pessimism is gone, the prices of index futures rebound. This phenomenon is especially pronounced at market closing than at any intraday time point. Hence, buying the index futures on days when the relative pricing error at futures market closing is negative earns a higher return than buying the index futures on days when the relative pricing error at closing is positive. It is found that the return of index futures is negatively related to the relative pricing error. We also find that the relative pricing error at futures market closing is a more effective indicator of investors' overreaction than the traditional measure using past futures return and the relative pricing error at stock market closing. Outliers, liquidity at market closing, and the presence of a few panicky investors at market closing are not the cause of the finding. Moreover, after taking into consideration transaction cost, execution time lag, and risk adjustment, profitable opportunities still exist.

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