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Study on the tracking errors and their determinants: evidence from Hong Kong exchange traded funds

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This article presents the first study on the magnitude of tracking error and the determinants of tracking errors using the daily figures of the Exchange Traded Funds (ETFs) traded in Hong Kong stock market. In general, the results suggest that the tracking errors are comparatively higher than those documented in US and Australia. The magnitude of the tracking errors is also found to be negatively related to the size but positively related to the expense ratios of the funds, which are consistent with the previous studies.

I. Introduction

Hong Kong is one of the major financial centres in the world. Following the trend in many western countries, index funds are playing an increasingly important role in Hong Kong. Exchange Traded Funds (ETFs) combine the benefits of diversifying investment through index investing and the flexibility of trading ETFs any time in the stock market during the market's trading hours like trading stocks in stock market. ETFs have become increasingly popular because they represent a portfolio of securities designed to track the performance of an index, offering an efficient way to investors in obtaining cost-effective exposure. Moreover, ETFs have significantly lower transaction costs than the actively managed mutual funds; unlike the mutual funds, there is no subscription fee for ETFs. ETFs, which are tracking the indices not comprised of Hong Kong stocks, are even exempt from stamp duty. Additionally, ETFs may be traded through brokers, which is the same way as trading stocks and the liquidity are enhanced by the market makers. ETFs are eligible for short selling, which provide investment opportunities as the investors foresee that there will be a bear market in the near future.

The first ETF launched in Hong Kong is the Tracker Fund of Hong Kong, which was launched on 12 November 1999. Compared with other financial markets in western countries, the Hong Kong ETF segment is emerging. There are over 450 listed ETFs in US. However, there are only 18 listed ETFs available to the investors in Hong Kong at the end of 2008. Among the 18 ETFs traded in Hong Kong, eight of them are related to the Hong Kong and China markets, six are related to the other Asian stock markets and the remaining four are tracking the western stock markets. Besides these stock-related offerings, there are two ETFs tracking the fixed income indices and another ETF provides the investors exposure to the commodity prices. The most popular ETF in the recent years is iShares FTSE/Xinhua A50 China Tracker *via* participating the Chinese A-Share access products. The popularity of that ETF is majorly due to the restriction of foreign investors on investing directly in the Mainland A-Share market unless given a Qualified Foreign Institutional Investor (QFII) quota; therefore, such an ETF may provide an opportunity to the foreign investors to invest indirectly in China markets.

The objective of an ETF is different from that of actively managed funds in which index funds aim to

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replicate the return and risk of the underlying benchmark index. If an index fund is not able to replicate the return on a benchmark index perfectly, this fund is regarded as unable to meet its investment objective. Roll (1992) suggests that the level of tracking error may be an important criterion to assess an index fund performance because the fund's differential return may investigate that if the manager's investment process has been implemented successfully, even in the case of nonindexed equity funds. Pope and Yadav (1994) also agree that the tracking errors are crucial in structuring and managing index funds. The performance of an ETF is not guaranteed to be identical to the underlying tracking index which is because an index only represents a calculation derived from a portfolio of stocks that is not subject to the same market frictions faced by the ETFs.

The primary objective of this article is to examine the possible tracking error of the ETFs traded in Hong Kong, which may add further evidence on these pricing relationships in the Hong Kong stock market. This article is organized as follows. Section II provides a brief literature review of the studies on the performance of ETFs. Section III describes the data. Section IV explains the research methodology employed. Section V discusses the findings and the concluding remarks are offered in Section VI.

II. Previous Research

The literature on the performance of mutual funds is extensive in these several decades. Most of them confirm the inability of mutual funds to outperform the market benchmarks or indices (Jensen, 1968; Grinblatt and Titman, 1987, 1989; Lehmann and Modest, 1987; Malkiel, 1995; Gruber, 1996; Carhart, 1997). The findings of the studies on performance of mutual funds traded in other countries are consistent with the US evidence (Cai *et al.*, 1997; Hallahan and Faff, 1999; Sawicki and Ong, 2000; Bauer *et al.*, 2006).

Although the studies on the performance of active mutual funds are extensive, the studies on the performance of passive ETFs are few. Gruber (1996) is the first study done on the performance of index funds by using the Jensen alpha and documents that a sample of US S&P 500 index funds underperforms the benchmark index by approximately 0.202% per annum on an after-cost basis during the period 1990 to 1994. Frino and Gallagher (2001) extend the study on the performance of S&P 500 index funds between 1 March 1994 and 28 February 1999 by using the tracking error as a measure; the result shows that the sample funds underperform the market by 0.29% per annum on an after-cost basis, the tracking error of individual index fund averages from 0.039% to 0.110% per month before cost, and the mean tracking error is significantly higher in the months of January and May and is the lowest in June, and the authors hypothesize that the delay in receiving dividend and the change in S&P 500 index may be the factors explaining the tracking errors. Besides, the authors also suggest that the tracking errors are directly related to expenses, with lower expense ratios result in lower tracking errors. Frino and Gallagher (2002) extend their previous research to a sample of Australian index funds and documents a substantial higher tracking error ranging from 0.074% to 0.224% per month; and a regression model of tracking error on the hypothesized determinants confirms that the tracking error is positively and significantly related to fund cash flows, the cost of trading stocks in the index portfolio and the volatility of the benchmark; positively but insignificantly related to dividend yield of stocks comprising the index and the market capitalization percentage of stocks included and excluded from the index. Cresson *et al.* (2002) examines the tracking performance of a set of daily returns of S&P 500 index funds by applying a naive measure of tracking performance – fund R^2; it documents that the tracking performance measures based on the daily returns are substantially below the previous research that are based on monthly returns and a regression of transformed R^2 for each index fund on the determinants indicate the R^2 values are positively related to fund size and fund manager tenure.

III. Research Methodology and Data

Methodology: determining the magnitude of tracking errors

Roll (1992) suggests that the level of tracking error may be an important criterion to assess an ETF performance; Pope and Yadav (1994) also agree that the tracking errors are crucial in structuring and managing ETFs. Tracking error represents the difference between the performance of an ETF and that of its target index. Pope and Yadav (1994) suggest three different definitions of tracking error.

The first definition of tracking error is defined as the absolute difference in returns between the fund and the index, $TE_{AD,i}$. This definition provides a measure of the extent to which the returns on an ETF i ($R_{i,t}$) differ from the returns on the underlying benchmark index b ($R_{b,t}$) over the sample period, and treats any absolute deviation in returns as tracking error. This definition of tracking error is calculated as follows:

$$TE_{AD,i} = \frac{\sum_{t=1}^{n} |e_{i,t}|}{n} \quad (1)$$

where $e_{i,t} = R_{i,t} - R_{b,t}$, $R_{i,t}$ is the return of the ETF i in period t, $R_{b,t}$ is the return of the benchmark index b in period t and n is the number of periods.

The second way to measure the tracking error is by finding the SD of return differences between the ETF and the benchmark index, which is calculated as follows:

$$TE_{SD,i} = \sqrt{\frac{1}{n-1}\sum_{t=1}^{n}\left(e_{i,t} - \bar{e}_i\right)^2} \quad (2)$$

Using SD to measure the tracking error requires the assumption of serially uncorrelated return differences, $e_{i,t}$. This definition may not be appropriate for daily data because the daily returns almost certainly be serially correlated. The other shortcoming of this definition is that if a fund consistently underperforms or outperforms the target index by same magnitude, the tracking error measured by the SD may result in zero.

The third way to estimate the tracking error, which is denoted as $TE_{SE\_CAPM,p}$, may be found by the Standard Error of Regression (SER) in the estimate of Capital Asset Pricing Model (CAPM) as follows:

$$R_{i,t} = \alpha + \beta \cdot R_{b,t} + e_t \quad (3)$$

However, Pope and Yadav (1994) point out two problems underlying in this measure. If β is not exactly equal to 1, this measure may result in a value different from $TE_{SD,i}$; and this approach may overestimate the tracking error if the relationship in the Jensen model is not linear.

Cresson *et al.* (2002) extend the above three definitions of tracking error by using the value of R^2 of CAPM defined in Equation 3, which is denoted as $TE_{R-SQ\_CAPM,p}$. The authors suggest using the R^2 as the measure of tracking error also indicates the closeness to which the ETF mimics the respective benchmark index and it is a more straightforward measure.

The magnitude of the tracking error may indicate: (1) how closely the ETF is tracking its target index; and (2) the size of the cost that routinely erodes the ETF returns.

Methodology: determining determinants associated with tracking errors

The tracking errors of ETFs are regressed on selected operating characteristics of ETFs to determine whether the tracking errors are associated with the selected operating characteristics. Grinblatt and Titman (1989) find that fund size is inversely related to both hypothesized and actual returns, the authors suggest that larger funds may have lower transaction cost due to economies of scale, which results in better performance. Frino and Gallagher (2001) document that the tracking errors are positively related to expenses, which indicate lower expense ratios result in lower tracking errors. Thus, the variables regarding the operating characteristics of ETFs in this study should include the size of the ETFs measured by total assets in million HKD (*SIZE*), and the expense ratios which is defined as the expense of the funds in million HKD (*EXP*). To test the significance of these two variables in explaining tracking error, the following model with t-statistics adjusted for heteroscedasticity and autocorrelation using the procedures developed by White (1980) is estimated:

$$|TE_{i,t}| = \beta_0 + \beta_1 \cdot SIZE_{i,t} + \beta_2 \cdot EXP_{i,t} + \varepsilon_{i,t} \quad (4)$$

where $|TE_{i,t}|$ is the absolute value of tracking error measured by different definition in period t for fund i.

Data

This research analyses the tracking error of 18 ETFs for which daily prices are available for any complete year over the period 2004 to 2008. Inclusion in the sample also requires that the ETF is listing in Hong Kong Stock Exchange. The data of daily prices were obtained from DATASTREAM and were checked against the returns supplied directly by the investment managers. The sample of ETFs and the stock market index which is replicating are summarized in Table 1. The financial data of the operating characteristics are collected in the financial statements published annually by the managers and listing agents of ETFs. Different ETFs in the sample are replicating the performance of different benchmark index and the daily closing quotes of the respective index were also obtained from DATASTREAM. The study is free of survivorship bias.

Table 1. ETFs in the sample

Fund	Fund name	Stock code	Underlying index	Years with daily prices data
I	Tracker Fund of Hong Kong	2800	Hang Seng Index	2008, 2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000
II	Hang Seng H-Share Index ETF	2828	Hang Seng China Enterprises Index	2008, 2007, 2006, 2005, 2004
III	Hang Seng Index ETF	2833	Hang Seng Index	2008, 2007, 2006, 2005
IV	Hang Seng FTSE/Xinhua China 25 Index ETF	2838	FTSE/Xinhua China 25 Index	2008, 2007, 2006
V	iShares MSCI China	2801	MSCI China Index	2008, 2007, 2006, 2005, 2004, 2003, 2002
VI	iShares FTSE/Xinhua A50 China Tracker	2823	FTSE/Xinhua China A50 Index	2008, 2007, 2006, 2005
VII	iShares BSE SENSEX India Tracker	2836	BSE Sensitivity Index	2008, 2007
VIII	Lyxor ETF MSCI India	2810	MSCI India Index	2008
IX	Lyxor ETF MSCI World	2812	MSCI World Index	2008
X	Lyxor ETF MSCI Korea	2813	MSCI Korea Index	2008
XI	Lyxor ETF Japan (TOPIX)	2814	TOPIX	2008
XII	Lyxor ETF MSCI AC Asia-Pacific ex Japan	2815	MSCI AC (All Country) Asia-Pacific ex Japan	2008
XIII	Lyxor ETF MSCI Emerging Markets	2820	MSCI Emerging Markets	2008
XIV	Lyxor ETF NASDAQ-100	2826	NASDAQ 100 Index	2008
XV	Lyxor ETF Russia	2831	DJ Rusindex Titans 10	2008
XVI	Lyxor ETF MSCI Taiwan	2837	MSCI Taiwan Index	2008
XVII	WISE-CSI HK 100 Tracker	2825	CSI HK100 Index	2008
XVIII	WISE-CSI 300 China Tracker	2827	CSI 300 Index	2008, 2007

IV. Results

Tracking errors of ETFs

The tracking errors of each ETF included in this study for the entire sample period available are reported in Table 2. Based on the first definition of tracking error (TE_{AD}), the daily tracking error ranges from an average of 0.2786% to 2.1736% across ETFs; the tracking errors based on the SD of the return differences (TE_{SD}) range from 0.3942% to 3.5231%; as the tracking errors are computed based on the SER of the CAPM (TE_{AD_CAPM}), the daily tracking error of each ETF is between 0.3902% and 3.0923%. The results indicate that the Hong Kong ETFs fall well short of perfectly tracking the underlying indices and it seems that the funds have difficulty in achieving index returns. From the viewpoint of investors, the ETFs do not provide fully efficient tracking of the underlying index. The daily tracking errors of Hong Kong ETFs documented in this study are comparatively higher than those documented in US (0.039% and 0.110% per month) and Australia (0.074% and 0.224% per month). The tracking errors based on the first three definitions ($TE_{AD}, TE_{SD}, TE_{SE\_CAPM}$) documented in this study are based on daily figures, which differ from those reported in previous studies that mostly used monthly data (Frino and Gallagher, 2001, 2002).

The tracking error of each ETF that is based on the magnitude of R^2 of CAPM (TE_{R-SQ_CAPM}) is also reported in Table 2. The R^2 for the entire sample ranges from a low of 0.0000 to a high of 0.9417. The values of R^2 reported in this study differ from those documented by Frino and Gallagher (2001, 2002) in which the values of R^2 range from 0.997 to 1.000 in US and from 0.993 to 1.000 in Australian evidences, respectively; however, both of these two previous studies are based on the monthly returns. These results once again demonstrate the difference in measuring tracking error of ETFs using daily versus monthly return figures. A fair comparison is the daily tracking errors by employing R^2 of S&P 500 index funds documented in Cresson *et al*. (2002) with values ranging from 0.9052 to 0.9609. The values of R^2 documented in this study are substantially below the values documented in US and Australia. Substantial higher tracking errors in Hong Kong ETF reflects higher cost of trading the underlying portfolio of

Table 2. Tracking error of ETFs in the sample

Absolute difference in returns							Return differences		CAPM			
Fund	N	Mean (TE_{AD})	SD	Minimum	Median	Maximum	SD (TE_{AD})	Mean	SER (TE_{SE_CAPM})	α	β	R^2 (TE_{R-SQ_CAPM})
I	2383	0.2786	0.2789	0.0000	0.2101	3.5981	0.3942	0.0010	0.39020	0.0010	0.9650	0.9417
II	1320	0.3571	0.3594	0.0000	0.2672	4.1035	0.5067	0.0011	0.50691	0.0011	0.9998	0.9560
III	1116	0.2905	0.3450	0.0000	0.2035	3.1004	0.4511	0.0001	0.44884	0.0003	0.9739	0.9388
IV	930	0.6480	0.7821	0.0000	0.4137	7.3392	1.0159	0.0011	0.99421	0.0050	0.9137	0.8357
V	1850	0.7090	0.7545	0.0000	0.5071	8.3035	1.0354	0.0008	1.03572	0.0008	1.0003	0.7786
VI	1074	1.0796	1.3258	0.0000	0.6482	11.5069	1.7099	0.0223	1.70989	0.0232	0.9749	0.5849
VII	564	1.4863	1.5804	0.0000	1.0535	10.3106	2.1704	−0.0019	2.13176	−0.0140	0.8249	0.4600
VIII	439	1.5723	1.7082	0.0000	1.0779	12.1480	2.3226	−0.0391	2.28723	−0.0565	0.8266	0.4326
IX	445	1.4285	1.6145	0.0000	0.9007	10.3561	2.1568	−0.0062	1.81883	−0.0926	0.2782	0.0573
X	439	0.7974	1.2970	0.0000	0.3737	12.7786	1.5213	−0.0724	1.35599	−0.0484	1.3192	0.8171
XI	151	1.4625	1.2590	0.0000	1.1223	5.8986	1.9310	0.0981	1.46017	−0.0419	0.5718	0.5755
XII	445	0.8292	1.0127	0.0038	0.5455	8.6416	1.3095	0.0049	1.30854	−0.0006	0.9582	0.6597
XIII	151	1.9609	1.9932	0.0114	1.3949	11.8453	2.8007	−0.0055	2.61141	−0.1706	0.6638	0.3811
XIV	438	2.0190	2.3588	0.0000	1.4840	22.7401	3.1064	−0.0024	2.21651	−0.1041	−0.0009	0.0000
XV	422	2.1531	2.6111	0.0000	1.4072	22.8258	3.3858	−0.0309	3.09238	−0.1111	0.6225	0.3542
XVI	151	1.3213	1.7242	0.0009	0.8306	12.5650	2.1746	−0.0372	2.17688	−0.0119	1.0593	0.5931
XVII	164	2.1736	2.7675	0.0000	1.2330	14.5621	3.5231	0.0148	2.95730	−0.1978	0.4235	0.1876
XVIII	381	0.9376	1.0082	0.0000	0.5858	5.8745	1.3775	−0.0206	1.34127	−0.0434	0.8814	0.7607

Notes: Tracking errors are expressed in percentage terms from the inception of ETFs to 31 December 2008. N represents the number of observations for each ETF used in this study.

Table 3. Tracking error regressed on fund operating variables

Variables	Dependent variables TE_{AD}	TE_{SD}	TE_{SE_CAPM}	(TE_{R-SQ_CAPM})
Model 1: $\|TE_{i,t}\| = \beta_0 + \beta_1 \cdot SIZE_{i,t} + \beta_2 \cdot EXP_{i,t} + \varepsilon_{i,t}$				
Intercept	1.4534**	0.0219**	0.0201**	0.5742**
	(7.1067)	(7.2522)	(7.5189)	(6.5937)
SIZE	–3.91E–05**	–5.88E–07**	–5.54E–07**	1.28E–05**
	(–3.8045)	(–3.8201)	(–4.1296)	(3.0107)
EXP	0.0024**	3.53E–05**	3.76E–05**	−0.0005*
	(3.8537)	(3.6531)	(4.4551)	(−2.4299)
F-statistics	1.3948	1.4525	1.6480	0.9138
Model 2: $\|TE_{i,t}\| = \beta_0 + \beta_1 \cdot SIZE_{i,t} + \varepsilon_{i,t}$				
Intercept	1.4578**	0.0220**	0.0202**	0.5732**
	(7.3291)	(7.4914)	(7.7084)	(6.8259)
SIZE	−2.10E–05	−3.21E–07	−2.70E–07	8.54E–06
	(−1.2928)	(−1.3345)	(−1.1264)	(1.7114)
F-statistics	1.3710	1.4787	1.2567	1.4326
Model 3: $\|TE_{i,t}\| = \beta_0 + \beta_1 \cdot EXP_{i,t} + \varepsilon_{i,t}$				
Intercept	1.3031**	0.0197**	0.0180**	0.6233**
	(6.5775)	(6.6824)	(6.8029)	(7.7777)
EXP	0.0002	1.77E–06	5.96E–06	0.0002
	(0.2707)	(0.1827)	(0.7097)	(0.6902)
F-statistics	0.0102	0.0054	0.0757	0.0683

Notes: The dependent variable is the tracking error of all funds in the sample in 2008. The independent variables are the size of the index fund as measured by total assets measured in million HKD (*SIZE*) and the expense of the fund in million HKD (*EXP*). *t*-statistics are given within parentheses and have been adjusted for heteroscedasticity using White's (1980) method. * and ** denote test statistic significance at the 5 and 10% levels, respectively.

stocks in Hong Kong or higher cost of trading oversea stocks from Hong Kong ETF managers. The other possible reason of relatively higher tracking error is that most of the Hong Kong ETFs use synthetic investment tools to replicate the component stocks in the stock market index rather than hold the respective stocks directly.

As the ETFs are analysed individually, the funds numbered XIV, XV and XVII have high tracking errors and all of them are tracking either the emerging markets or new designed indices – DJ Rusindex Titans 10, NASDAQ 100 and CSI HK100 Index.

Determinants of tracking errors

Table 3 presents the results of regression analysis testing the significance of the determinants of tracking errors for the year 2008. All *t*-statistics are adjusted for heteroscedasticity and autocorrelation using White's (1980) procedure.

Model 1 includes all determinants, size and expense ratio of the funds. Regardless of the measurement of tracking error, the operating characteristics are significant at 0.01 level. Consistent with expectations, Table 3 points out that the coefficients for the size measured by total assets (*SIZE*) are negative as the tracking errors are measured by TE_{AD}, TE_{AD}, TE_{SD} or TE_{SE_CAPM} and positive as the tracking errors are computed by TE_{R-SQ_CAPM}; which indicate that larger funds produce smaller tracking errors. Model 2 is the simple regression including size only as the independent variable and it consistently indicates that larger funds have smaller tracking errors. This conforms our expectation that larger funds should have lower transaction cost in trading stocks due to the economies of scale and this produces lower tracking errors for larger index funds. However, the coefficients for *SIZE* become insignificant in that simple regression model. It is interesting that all regression coefficients in the multiple regression model (model 1) are significant but the model is not overall significant. The major reason may be the existence of multicollinearity among the independent variables.

Model 1 indicates positive coefficients for the expense ratios of the funds (*EXP*) as the tracking errors are measured by TE_{AD}, TE_{SD} or TE_{SE_CAPM}, and negative coefficients for the same independent variable as they are calculated by TE_{R-SQ_CAPM}, which is consistent with the results documented in Frino and Gallagher (2001) that the index funds with higher expense ratios should produce lower ability to capture the performance of the benchmark indices.

Model 3 is the simple regression model with *EXP* as the only independent variable. Similar to the other simple bivariate regression model (model 2), the coefficient becomes insignificant.

V. Conclusion

ETFs have grown in popularity since their first introduction to Hong Kong in 1999. This is the first study to examine the tracking errors of the ETFs traded in Hong Kong and the first study to find out the determinants of the tracking errors in Hong Kong ETFs. This study finds out that the magnitude of tracking errors of Hong Kong ETFs using daily figures are comparatively higher than those in US and Australia. It implies that the fund managers have difficulties in replicating the performance of the underlying indices by using the synthetic tools rather than investing the respective constituent stocks directly and the ETFs investors may face additional risk. The other implication is that the magnitude of tracking errors will become higher as the data employed are in daily basis. The magnitude of tracking errors are found to be negatively related to the size but positively related to the expense ratio of the ETFs. This conforms to the results found in other studies that large ETFs should have lower trading cost and thus lower the tracking errors due to the economies of scale; and the funds with higher expense ratio will produce higher tracking errors. The results reported here may raise the arguments on whether the passive funds may be a good alternative to the active managed funds, and if it is sensible for Hong Kong investors to rush into investing ETFs though the popularity of such investment vehicles has just been growing in these 2 years.

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