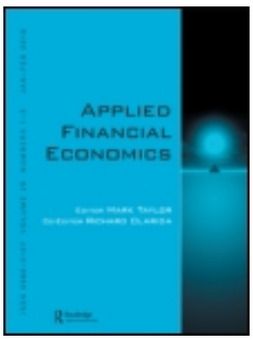

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An analysis of exchange traded notes tracking errors with their underlying indexes and indicative values

Rajarshi Aroskar* and Willaim A. Ogden

Department of Accounting and Finance, University of Wisconsin-Eau Claire, 105 Garfield Ave., Eau Claire, 54701, USA

This study employs five commonly used methods to estimate tracking errors between iPath Exchange Traded Notes (ETNs) and their respective indexes. Commodity ETNs perform well in tracking their respective indexes. This performance is not dependent on whether the ETN tracks a single commodity index, a sector or a composite index. Currency and emerging market ETNs do not track their underlying indexes nearly as well.

Keywords: commodities; ETNs; ETFs; tracking

JEL Classification: G10; G20

I. Introduction

Exchange Traded Notes (ETNs) provide investors with diversification opportunities and enables them to enact numerous bespoke investment strategies. ETNs are uncollateralized debt instruments that offer a return equal to that of an index. In contrast, an Exchange Traded Fund (ETF) takes long positions in its underlying assets. Without the expenses associated with taking collateralized positions, ETNs offer exposures to various asset classes at comparatively lower costs than ETFs. While the risk inherent with ETFs is due to changes in the value of the underlying assets, ETN investors incur the credit risk of the issuing bank. The lower risk of ETFs relative to ETNs is often cited as one of the reasons that the size of the ETN market is only a fraction of the ETF market. The ETF Industry Association (2011) compiled a list of Assets Under Management (AUM) for ETFs and ETNs. As of November 2011, the report listed 1161 ETFs with a total of $1.06 trillion AUM while 203 ETNs had $14.7 billion AUM. A total of 11 banks issued ETNs with four banks sponsoring 88% and two banks accounting for 67% of the AUM, with Barclay's iPath ETNs having 45% of ETN AUM (2011).

Ian Merrill, Director for Investor Solutions at Barclays Capital in New York argues, 'Credit risk is something certain investors have an appetite for, and an uncollateralised product is not necessarily a bad thing if you get access without tracking error' (Nowakowska, 2011). The purpose of this study is to examine the tracking performance of ETNs. We sample 25 iPath ETNs that had sufficient historical data in order to conduct a thorough analysis.

II. Literature Review

Studies involving tracking errors commonly compare a benchmark return to that of a fund that is

*Corresponding author. E-mail: aroskar@uwec.edu

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attempting to provide a return that is either identical to or greater than that of the benchmark. One common situation is a fund manager attempting to maintain a return that exceeds a given index's return. Roll (1992) notes that many sponsors of actively-managed funds focus on the volatility of the fund's tracking error (difference between the returns of the fund and the benchmark index). A skilled fund manager is expected to generate a consistently positive tracking error. Accordingly, the managers will create portfolios that minimize Tracking Error Volatility (TEV) but are not necessarily mean-variance (EV) efficient. If the benchmark portfolio is inefficient (most are Roll argues), the TEV portfolio will also be inefficient. If the benchmark index is not efficient, a fund manager will improve the total return EV by constraining the portfolio beta to less than 1.0. Jorion (2003) proves that a fund sponsor with a diverse group of TEV managed funds will not as a whole be EV inefficient. He suggests that fund sponsors should move away from the TEV criterion and have managers focus their efforts on managing total risk. For funds that maintain TEV portfolios, he suggests adding a total risk constraint.

Blume and Edelen (2004) provides evidence that the lowest tracking errors for S&P 500 index funds are from indexers that follow an exact replication strategy. The lowest tracking error over Blume's study period was from Barclay's Equity Index Fund, which varied between -3.0 to $+7.0$ basis points. Madura and Ngo (2008) note that a large ETF that tracks an index can experience lower tracking error efficiency because its trading may affect the pricing of the components of the index it is attempting to mimic. An ETF cannot adjust its long positions as quickly as the index can. This is not an issue with ETNs because they do not hold long positions in the indexes that they track.

ETNs commonly offer a return equal to that of a single commodity or commodity sector rather than a diverse portfolio of assets. Thus, ETN returns are likely not EV efficient. However, this would not preclude an investor from including ETN's as part of an EV efficient portfolio. Tracking errors for ETNs are expected to be zero (the expected returns on an ETN and the index it tracks are ideally equal).

Wright *et al*. (2010) provide various reasons for mispricing ETNs which can lead to tracking errors. Among them, ETNs are similar to zero coupon debt instruments and hence should trade at a discount to the face value. The share creation and redemption process is not fluid. The issuer has the sole responsibility of issuing any additional shares, which they do at infrequent time intervals. Also for any early redemption, investors must provide at least a day's notice (in many cases a week). Delays in the creation and redemption can lead to a mispricing in the ETNs.[1]

Diavatopoulous *et al*. (2010) find that prices of ETNs are significantly higher than their respective indicative values. They attribute the deviation from the indicative values to uninformed, return-chasing investors and the system of creating of new shares.

The ETN market is relatively new and the ETN tracking efficiency has not been previously studied. The most similar product that has been studied extensively is ETFs. Tracking efficiency and performance of ETFs with respect to their underlying indexes have been studied by Cresson *et al*. (2002), Elton *et al*. (2002), Gastineau (2004), Gallagher and Segara (2006), Rompotis (2008), Svetina and Wahal (2008), Avellaneda and Zhang (2009), Shin and Soydamir (2010), Wong and Shum (2010) and Chu (2011).

The ETF based studies follow similar investigations of index fund tracking. Frino and Gallagher (2001) find that on an average, over their sample period, S&P 500 index funds out-performed actively-managed funds after taking expenses into account.

Index funds gained popularity due to their low cost and the diversification that they provide, which is achieved by tracking an index. However, index funds like other mutual funds can be traded only at the end of the day. ETFs and ETNs on the other hand can be traded at any time during the day. This makes the ETFs useful for implementing short positions as noted by Gastineau (2008).

Kostovetsky (2003) notes that index funds face tracking errors due to bid–ask spreads and other liquidity costs, in-and-out trading, cash drag, dividend policies and rebalancing costs due to index changes or corporate activity. Accordingly, an index fund may offer lower returns than the index that it tracks. Elton *et al*. (2002) find that Standard & Poor's Depositary Receipts (SPDRs) underperform their corresponding index, the S&P 500, by 28 basis points and the S&P 500 index funds by an average of 18 basis points. Despite this, SPDRs is the most actively traded hedging instrument.

Harper *et al*. (2006) in comparing Closed-End country Funds (CEFs) and ETFs representing foreign markets, find that ETFs have a higher mean return and better Sharpe measure than the CEFs. They suggest that investors can increase risk-adjusted returns by including ETFs in their internationally diversified portfolios.

[1] For a detailed discussion, see Wright *et al*. (2010).

Shin and Soydemir (2010) find tracking errors of 26 ETFs to be significantly different from zero and persistent. Higher tracking errors are also evident in ETFs that attempt to track global emerging markets. Blitz and Huij (2011) find that ETFs that utilize statistical replication have higher tracking errors when compared to ETFs that fully replicate their respective indexes. Tracking errors vary across international markets. Chu (2011) provides evidence that international ETFs trading in Hong Kong have higher tracking errors than ETFs that trade in the US and Australia. Gallagher and Segara (2006) find that ETFs that track the Australian indexes have lower tracking errors than ETFs that track the US indexes.

Wong and Shum (2010) find positive tracking errors for 15 world ETFs in both bullish and bearish markets. They also find that ETFs that track the same index but trade in different markets perform differently.

Nwogugu (2010) finds substantial tracking errors in leveraged/inverse ETFs and synthetic funds. Avellaneda and Zhang (2009) suggest that leveraged ETFs are unsuitable for buy-and-hold investors because they must rebalance the funds periodically. However, they find that a weekly rebalancing would allow these leveraged funds to replicate the returns of the underlying index.

Unlike ETFs, ETNs attempt to replicate the index using futures or other derivative contracts. Thus, ETNs may have lower costs related to bid–ask spreads and rebalancing costs due to index changes or corporate activity. Lower costs should improve tracking performance. This study investigates the tracking efficiency of ETNs using four measures: the SD of the spreads between ETN and index returns, the Mean Absolute Deviations (MAD) between ETN and index returns and the slope and R^2 found by regressing ETN returns on index returns. The same measures are also applied to the differences between the returns of the same ETNs and their respective posted Indicative Value (IV) returns. The objective of this study is to evaluate whether investors can expect the same returns by holding the ETNs rather than purchasing the commodities that the ETNs are designed to track. Lower tracking errors result in more accurate exposure for investors.

This study investigates the tracking errors of ETNs. Most tracking error studies compare ETF returns to those of their underlying stock indexes. The ETNs in the current study track returns of single commodities, commodity sectors, broad-based commodity indexes, currency indexes and an emerging equity market.

We find that ETNs in general have low tracking errors with their respective indexes. Most commodity ETN returns have a low MAD and SD, a regression slope close to 1.0 and high R^2 with their indexes. Thus, commodities ETNs track their indexes well. In contrast, currency ETNs have relatively higher SDs and lower R^2 with their corresponding indexes. Hence, currency ETNs do not track nearly as well. Thus, investors who seek returns equal to those offered by an index should be aware that all ETNs do not track equally well.

The rest of the study is organized in the following way. First, data and methodology are described, followed by empirical results and concluding remarks.

III. Data

Data for this research include 25 iPath ETNs issued by Barclays. Daily price data for the ETNs was obtained from National Association of Securities Dealers Automated Quotations (NASDAQ). Daily IVs and index data were obtained from iPath. Descriptive statistics of returns from the ETNs, their respective indexes and IV are given in Table 1. The data ranges from 25 June 2008 (the first trading day for which data are available for some ETNs) until 4 March 2011, a total of 700 observations. Included are ETNs that track single commodities (natural gas, oil, metals and softs), broad-based commodity indexes, commodity sectors, currencies and one emerging market ETN. Descriptive statistics include the mean, SD and Augmented Dickey–Fuller (ADF) statistic (Said and Dickey, 1984) for each ETN. We reject the null hypothesis of unit roots for all sample ETN returns.

The ETN market is relatively new. Hence, many had no traded contracts early in the data set. On days without trades, the ETN price is the price from the previous day, while the index that it tracks may incur a change in value. This may introduce tracking errors. To evaluate the effects of days without trades, we also analysed a more recent subset of the data within which zero trading days were less frequent. This reduced data set includes 316 trading days between 4 January 2010 and 4 March 2011.

IV. Methodology

Tracking error has been measured using several methods in previous studies. Wong and Shum

Table 1. Descriptive statistics of returns

		ETN			Index			IV		
	Symbol	Mean	SD	ADF*	Mean	SD	ADF*	Mean	SD	ADF*
Single commodities										
Natural gas	GAZ	−0.003	0.030	−27.46	−0.003	0.031	−29.39	−0.003	0.032	−29.36
Oil	OIL	−0.001	0.029	−26.77	−0.001	0.029	−27.15	−0.001	0.030	−27.11
Aluminum	JJU	0.000	0.021	−28.23	0.000	0.018	−26.88	0.011	0.013	−26.88
Copper	JJC	0.000	0.025	−28.26	0.000	0.025	−28.86	0.000	0.026	−28.87
Lead	LD	0.001	0.031	−25.61	0.001	0.032	−24.61	0.001	0.032	−24.61
Nickel	JJN	0.001	0.031	−26.59	0.001	0.031	−25.52	0.001	0.032	−25.52
Tin	JJT	0.001	0.027	−26.00	0.001	0.025	−24.75	0.001	0.025	−24.77
Platinum	PGM	0.000	0.022	−25.05	0.000	0.019	−24.34	0.000	0.019	−24.34
Softs										
Cocoa	NIB	0.000	0.022	−28.07	0.000	0.022	−28.11	0.000	0.022	−28.09
Coffee	JO	0.001	0.020	−28.26	0.001	0.019	−26.65	0.001	0.019	−26.65
Cotton	BAL	0.001	0.025	−27.06	0.001	0.022	−25.14	0.001	0.022	−25.15
Sugar	SGG	0.001	0.027	−26.73	0.001	0.027	−26.92	0.001	0.028	−26.94
Broad-based commodities										
Dow–Jones CI	DJP	0.000	0.016	−27.54	0.000	0.015	−27.10	0.000	0.016	−27.01
S&P GSCI	GSP	−0.001	0.021	−27.41	−0.001	0.021	−27.27	−0.001	0.021	−27.25
Commodity sectors										
Agriculture	JJA	0.000	0.018	−27.12	0.000	0.017	−26.42	0.000	0.017	−26.42
Energy	JJE	−0.001	0.023	−27.97	−0.001	0.022	−27.95	−0.001	0.023	−27.94
Grains	JJG	0.000	0.021	−27.35	0.000	0.020	−26.79	0.000	0.020	−26.79
Industrial metals	JJM	0.000	0.022	−28.22	0.000	0.021	−27.79	0.000	0.021	−27.77
Livestock	COW	0.000	0.011	−27.45	0.000	0.010	−26.28	0.000	0.010	−26.28
Precious metals	JJP	0.001	0.017	−26.10	0.001	0.017	−25.32	0.001	0.017	−25.32
Softs	JJS	0.001	0.018	−27.18	0.001	0.017	−25.54	0.001	0.018	−25.52
Currencies										
Euro	ERO	0.000	0.011	−31.09	0.000	0.008	−24.76	0.000	0.008	−24.70
British pound	GBB	0.000	0.011	−27.89	0.000	0.010	−16.99	0.000	0.010	−17.05
Japanese yen	JYN	0.000	0.009	−28.52	0.000	0.008	−26.79	0.000	0.009	−26.82
Emerging markets										
India	INP	0.001	0.030	−28.94	0.001	0.025	−25.28	0.001	0.025	−25.27

Note: *Denotes rejects the null hypothesis of unit roots at a significance level of 1%.

(2010) measure tracking error as the difference between index and ETF returns. However, the positive and negative durations may underestimate the error. Gallagher and Segara (2006) use mean absolute tracking error as follows:

$$TE_i = \frac{\sum_{t=1}^{n} |e_{it}|}{n}, \quad \text{or} \quad \text{MAD} \tag{1}$$

where

e_{it} $R_{it} - R_{bt.}$
R_{it} the daily return on the ETN price in period t.
R_{bt} the daily return on the corresponding index b in period t.
n the number of observations in the given period.

Another method used by Gallagher and Segara (2006), Shin and Soydemir (2010) and Chu (2011) is the SD of the difference in returns of the security and its corresponding benchmark

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

Frino and Gallagher (2001) and Rompotis (2008) use SE of the following regression:

$$R_{i,t} = \alpha + \beta R_{b,t} + e_t \tag{3}$$

Pope and Yadav (1994) argue that SE of the regression is a flawed measure of tracking error unless it equals 1.0. Hence, Chu (2011) measures tracking accuracy as the regression R^2 value of the above equation.

The current study estimates tracking errors between the ETN price and its underlying index value as measured by the SD and MAD of return differences, the slope resulting from regressing ETN

returns on index returns and the regression R^2. Lower MAD and SD values, a higher regression R^2 and a regression beta close to 1.0 indicate a lower tracking error. The regression beta provides a statistical test of tracking error. The null hypothesis is that the regression beta equals 1.0. The Wald and Durbin–Watson (DW) statistics are presented for all regressions. These methods are also applied to measure the tracking error between each ETN and its IV. ETNs should track their respective IVs as accurately as they track their respective indexes.

Each of the four measures is applied to all 25 ETNs. We analyse the tracking error within four subcategories: individual commodity ETNs, broad-based commodities and sector ETNs, currency ETNs and an emerging market ETN.

In addition to the above four tracking error measures, we also analyse the distribution of the differences between the ETN prices and their respective IVs. A narrower distribution of price differences indicates less TEV.

V. Results

General findings

Table 2 presents the MAD, SD and regression coefficients (Equations 1, 2 and 3, respectively) against the ETN's underlying indexes (Panel A) and IVs (Panel B). For the regression coefficients, the R^2, Wald and DW statistics are also included. Livestock has the lowest MAD of the ETN returns with the index (0.0025) while tin has the highest (0.0151). Based on the spread between ETN and IV returns, the lowest is livestock (0.0025) while the highest is tin (0.0162). The ETN with the lowest SD of return differences from its index is livestock (0.0034) and the highest is tin (0.0394). Between the ETN and IV, the lowest SD is livestock (0.0034) while the highest is aluminum (0.0276). The ETNs with a regression slopes closest to 1.0 are the Dow–Jones commodity index (1.0098 with the index) and livestock (1.0054 with the IV) while the farthest from 1.0 is tin (0.5320 and 0.5286 regressed against the index and IV, respectively). We reject the null hypothesis that the slope is to 1.0 at the 5% level for all ETNs against their indexes except for coffee, cotton, the Dow–Jones commodity index, the S&P GSCI and livestock. Against their IVs, we reject the null hypothesis that the slope is equal to 1.0 for all ETNs except cotton, agriculture, grains and livestock. The British pound has the lowest R^2 (0.2295 and 0.2286 against the index and IV, respectively) and is the only ETN in the study that has a significant DW statistic. The highest R^2 is grains (0.9473 and 0.9476 against the index and IV, respectively).

Single commodity analysis

The best tracking single commodity ETN depends upon which measure is selected. Oil has the lowest SD (0.0089 with the index and 0.0092 with the IV). Coffee has the lowest MAD (0.0046 with both the index and the IV) and the highest R^2 (0.9063 with the index and 0.9068 with the IV). The regression coefficient closest to 1.0 is cotton (0.9824 with the index and 0.9752 with the IV). We reject the null hypothesis that the slope is equal to 1.0 at the 5% level for all single commodities except coffee and cotton against the index and cotton against the IV.

The poorest tracking single commodity ETN is tin. It has the highest MAD (0.0161 with the index and 0.0162 with the IV), highest SD (0.0258 with the index and 0.0259 with the IV), the lowest slope (0.5320 with the index and 0.5286 with the IV) and the lowest R^2 (0.2476 with the index and 0.2479 with the IV).

Broad-based commodities and sector funds analysis

Identifying the best tracking broad-based commodity or sector fund depends upon which tracking measure is chosen. Livestock has the lowest MAD (0.0025 with the index and the IV) and SD (0.0034 with the index and the IV). The Dow–Jones commodity index (1.0098 with the index) and the livestock sector fund (1.0054 with the IV) have the regression slopes closest to 1.0. The grains sector ETN has the highest R^2 (0.9473 with the index and 0.9476 with the IV). The poorest tracking broad based or sector fund is the softs ETN. It has the highest SD (0.0145 for with the index and the IV), the highest MAD (0.0097 with the index and the IV), the lowest slope (0.7009 with the index and 0.6953 with the IV) and the lowest R^2 (0.4470 with the index and 0.4462 with the IV).

Currencies

As measured by the SD, MAD and R^2, the Japanese yen is the best tracking currency. It has the lowest SD (0.0076 with the index and 0.0077 with the IV) and MAD (0.0054 with both the index and the IV) and the highest R^2 (0.3690 with the index and 0.3697 with the IV). The euro has the slope closest to 1.0 (0.7154 with the index and 0.7031 with the IV). The poorest tracking currency is the British pound which has the highest SD (0.0100 with the index and 0.0101 with the IV), the highest MAD (0.0065 with the index and the IV), the lowest slope (0.5833 with the index and

Table 2. Tracking returns with the index and IV full data set

Symbol	SD[b]	MAD[a]	Slope	R^2	Wald	DW
Panel A: ETN versus index full data set						
GAZ	0.0128	0.0085	0.8921	0.833	50.83***	2.05
OIL	0.0089	0.0052	0.9329	0.906	34.88***	3.04
JJU	0.017	0.0106	0.7393	0.41	60.20***	2.43
JJC	0.0106	0.0069	0.9014	0.831	41.04***	3.09
LD	0.0185	0.0133	0.8222	0.686	71.18***	2.62
JJN	0.0161	0.0115	0.8728	0.752	44.77***	3.02
JJT	0.0258	0.0161	0.532	0.248	177.50***	2.50
PGM	0.0111	0.0068	0.9571	0.734	3.86**	2.36
NIB	0.0098	0.0068	0.9089	0.807	29.27***	2.85
JO	0.0189	0.0046	0.9772	0.867	2.46	2.67
BAL	0.013	0.0084	0.9824	0.734	0.62	2.80
SGG	0.0099	0.0067	0.9424	0.874	18***	2.81
DJP	0.0039	0.0027	1.0098	0.939	1.02	3.06
GSP	0.0056	0.0037	0.9883	0.929	1.26	3.09
JJA	0.0044	0.003	1.0215	0.939	4.79**	2.86
JJE	0.0115	0.007	0.8741	0.752	43.89***	2.82
JJG	0.0048	0.0033	1.024	0.947	6.85***	2.97
JJM	0.0124	0.0077	0.8717	0.692	33.99***	2.86
COW	0.0034	0.0025	1.0234	0.894	3.05**	2.88
JJP	0.0115	0.0071	0.7761	0.586	81.94***	2.73
JJS	0.0145	0.0097	0.7009	0.447	102.60***	2.56
ERO	0.0094	0.0057	0.7154	0.296	49.46***	2.83
GBB	0.0100	0.0065	0.5833	0.23	105.93***	1.71**
JYN	0.0076	0.0053	0.6415	0.369	127.30***	2.71
INP	0.0224	0.0155	0.8511	0.473	19.09***	2.67
Panel B: ETN versus IV full data set						
GAZ	0.0133	0.0089	0.856	0.829	95.07***	2.06
OIL	0.0092	0.0053	0.9	0.907	83.91***	3.04
JJU	0.0276	0.0107	0.732	0.41	64.55***	2.16
JJC	0.0107	0.0069	0.888	0.831	55.11***	3.09
LD	0.0185	0.0134	0.817	0.686	76.84***	2.63
JJN	0.0162	0.0116	0.858	0.752	57.73***	3.02
JJT	0.0259	0.0162	0.529	0.248	182.71***	2.50
PGM	0.0111	0.0069	0.951	0.734	5.05**	2.36
NIB	0.0098	0.0068	0.902	0.808	34.69***	2.85
JO	0.0191	0.0046	0.968	0.867	4.87***	2.88
BAL	0.0129	0.0084	0.975	0.734	1.24	2.80
SGG	0.0099	0.0067	0.934	0.874	24.44***	2.81
DJP	0.0043	0.0028	0.977	0.927	5.04**	3.07
GSP	0.0057	0.0037	0.957	0.929	18.09***	3.09
JJA	0.0044	0.003	1.007	0.94	0.45	2.86
JJE	0.0117	0.007	0.856	0.752	59.97***	2.82
JJG	0.0048	0.0032	1.008	0.948	0.77	2.97
JJM	0.0125	0.0077	0.858	0.692	42.97***	2.86
COW	0.0034	0.0025	1.005	0.893	0.17	2.88
JJP	0.0115	0.0071	0.772	0.586	86.18***	2.73
JJS	0.0145	0.0097	0.695	0.446	107.85***	2.56
ERO	0.0095	0.0058	0.703	0.285	49.47***	2.84
GBB	0.0101	0.0065	0.576	0.229	112.01***	1.72**
JYN	0.0077	0.0053	0.635	0.37	134.73***	2.71
INP	0.0225	0.0156	0.827	0.473	27.28***	2.70

Notes: [a]MAD: Mean Absolute Deviation of the tracking error as follows: $TE_i = \frac{\sum_{t=1}^{n} |e_{it}|}{n}$
where
$e_{it} = R_{it} - R_{bt.}$
R_{it} = the daily return (expressed as a decimal) on the ETN price in period t.
R_{bt} = the daily return (expressed as a decimal) on the corresponding index b in period t.
n = the number of observations in the period.
[b]SD is the difference in returns of the ETN and IV: $TE_{\sigma,i} = \sqrt{\frac{\sum_{t=1}^{n} \left(e_{i,t} - \bar{e}_i\right)^2}{(n-1)}}$.
Tracking accuracy is measured as the R^2 of $R_{i,t} = \alpha + ßR_{b,t} + e_t$.
** and *** denote test statistic significance at the 5 and 1% levels, respectively.

0.5759 with the IV) and the lowest R^2 (0.2295 with the index and 0.2286 with the IV). For all currency ETNs, we reject the null hypothesis that the regression slope is equal to 1.0.

Emerging market ETN

Since Barclays offered only one emerging market ETN (India) during the sample period, we compare its tracking with other ETNs rather than within a general grouping. India's SDs (0.0224 and 0.0225 with the index and the IV, respectively) are among the highest of all ETNs, while the MAD (0.0155 and 0.0156 with the index and the IV, respectively) is the second highest of all ETNs, lower than only tin. With respect to regression slope (0.8511 and 0.8272 with the index and IV, respectively) and R^2 (0.4725 and 0.4728 with the index and IV, respectively), the India emerging market ETN tracks its index and IV more closely than the currencies track theirs, but worse than all other ETNs except tin.

Tracking the index versus tracking the IV

All but a few ETNs track the index better than they track the IV. The only exceptions are cotton with a marginally higher SD and grains with a marginally higher MAD. The agriculture, livestock and grains ETNs have slopes that are farther away from 1 with the index when compared to the IV. All other ETNs track the index better regardless of which tracking measure is used. All currency and the emerging market ETNs track the index better than the IV for all measures.

Analysis of trades after 1 January 2010

In Table 3, Panels A (ETN versus index) and B (ETN versus IV), we reduce the dataset to include only observations that occur after 1 January 2010. Prior to that date, many of the newly offered ETNs had numerous days in which no trades occurred. Hence, the dataset's closing prices on days without trades are the same as the previous day's price. As a result, the ETNs do not track their indexes and IVs as well as they do on days in which trades occur. After 1 January 2010, some ETNs continue to have days without trades. All currency ETNs, aluminum, energy, precious metals, lead and tin ETNs have days without trades in the reduced data set. However, the number of nontrading days as a percentage of the total number of trading days is lower when compared to the entire data set.

General findings. Both SD and MAD exhibit improved tracking in the reduced dataset when compared to applying these measures to the entire dataset. The only exception is the natural gas ETN (lower SD and MAD in the full dataset). R^2 for all ETNs except natural gas, lead, commodity index, livestock, British pound and the Japanese yen have increased when compared to the full data set. Thus, for most ETNs, tracking improves in the reduced dataset. Only natural gas exhibited serial correlations.

The Dow–Jones commodity index has the lowest SD (0.0028 with respect to both the index and IV) while lead has the highest (0.0151 and 0.0152 with the index and IV, respectively). The Dow–Jones commodity index also has the lowest MAD (0.0020 with respect to both the index and IV) while lead again has the highest (0.0116 and 0.0117 with the index and IV, respectively). The livestock ETN has the regression slope closest to 1.0 with the index (0.9882). With IV, the Dow–Jones commodity index's slope is closest to 1.0 (0.9944). The British pound has a regression slope furthest from 1.0 (0.4805 and 0.4757 with respect to the index and IV, respectively). The British pound has the lowest R^2 (0.2148 and 0.2171 against the index and IV, respectively) while the highest is grains (0.9482 and 0.9485 against the index and IV, respectively).

Single commodity ETNs. Among the single commodities, oil is the best tracking ETN with the index based upon SD, MAD and R^2. It has the lowest SD of return deviations (0.0047), the lowest MAD (0.0034) and the highest R^2 (0.9385). The regression slope for coffee is closest to 1.0 (0.9870). We cannot reject the null hypothesis that coffee's slope is equal to 1.0. Oil has the best tracking performance with the IV using all four measures. It has the lowest SD and MAD (0.0046 and 0.0033, respectively), the highest R^2 (0.9389) and its slope is closest to 1.0 (0.9935). We cannot reject the null hypothesis that oil's slope is equal to 1.0.

Tin was the poorest tracking single commodity with the index and IV based upon the regression slope and R^2 measures (0.8323 and 0.5896, respectively). With IV, the tin's slope and R^2 are 0.5896 and 0.5903, respectively. Lead is the poorest tracking single commodity based upon the SD (0.0151 and 0.0152 with the index and IV, respectively) and the MAD (0.0116 and 0.0117 with the index and IV, respectively). The tracking performance for both commodities improved with the reduced dataset when compared to the full dataset. Only natural gas exhibited significant positive serial correlation.

Broad-based commodities and sector ETNs. Among the broad-based commodities and sectors, the Dow–Jones commodity index tracks well. It has the lowest

Table 3. Tracking returns with the index and IV reduced data set

Symbol	SD	MAD	Slope	R^2	Wald	DW
Panel A: ETN versus index reduced data set						
GAZ	0.013	0.009	0.854	0.725	24.16***	1.75*
OIL	0.005	0.003	1.042	0.939	7.84***	3.10
JJU	0.01	0.007	0.918	0.702	5.87**	2.97
JJC	0.007	0.005	0.95	0.853	5.03**	3.10
LD	0.015	0.012	0.874	0.664	12.95***	2.82
JJN	0.012	0.009	0.878	0.755	18.64***	2.95
JJT	0.012	0.009	0.832	0.59	18.3***	2.66
PGM	0.007	0.005	0.906	0.746	9.71***	2.64
NIB	0.007	0.005	0.948	0.854	5.39**	2.83
JO	0.005	0.004	0.987	0.931	0.74	2.50
BAL	0.012	0.008	1.107	0.787	10***	2.89
SGG	0.008	0.006	0.974	0.926	2.74*	2.99
DJP	0.003	0.002	1.03	0.937	3.86**	3.15
GSP	0.004	0.003	1.059	0.93	12***	3.03
JJA	0.004	0.003	1.057	0.94	14.24***	2.98
JJE	0.007	0.004	0.93	0.8	7.08***	2.99
JJG	0.004	0.003	1.052	0.948	13.77***	2.94
JJM	0.007	0.005	0.969	0.842	1.75	2.92
COW	0.003	0.002	0.988	0.892	0.37	2.91
JJP	0.007	0.004	0.862	0.71	19.72***	3.00
JJS	0.01	0.007	0.882	0.687	12.77***	2.63
ERO	0.007	0.005	0.642	0.36	55***	2.58
GBB	0.007	0.005	0.481	0.215	100***	1.92
JYN	0.007	0.005	0.578	0.294	70***	2.76
INP	0.012	0.009	0.757	0.449	26***	2.70
Panel B: ETN versus IV reduced data set						
GAZ	0.014	0.009	0.7976	0.723	52***	1.75*
OIL	0.005	0.003	0.9935	0.939	0.21	3.10
JJU	0.01	0.008	0.9046	0.701	8.19***	2.28
JJC	0.007	0.005	0.9332	0.853	9.33***	3.10
LD	0.015	0.012	0.862	0.663	15.85***	2.82
JJN	0.012	0.009	0.8626	0.755	24.54***	2.95
JJT	0.012	0.009	0.8324	0.59	20.80***	2.66
PGM	0.007	0.005	0.895	0.746	12.33***	2.64
NIB	0.007	0.005	0.9327	0.854	9.28***	2.83
JO	0.005	0.004	0.9744	0.932	614***	2.95
BAL	0.012	0.008	1.0952	0.787	8.73***	2.89
SGG	0.008	0.006	0.9613	0.926	6.33**	2.99
DJP	0.003	0.002	0.9944	0.937	0.146	3.16
GSP	0.004	0.003	1.0157	0.93	0.987	3.03
JJA	0.004	0.003	1.0352	0.94	5.69**	2.98
JJE	0.007	0.004	0.8981	0.801	16.2***	2.99
JJG	0.004	0.002	1.0273	0.949	4.09**	2.94
JJM	0.007	0.005	0.9505	0.842	4.54**	2.92
COW	0.003	0.002	0.9651	0.892	3.39*	2.91
JJP	0.007	0.004	0.8514	0.709	23.32***	3.00
JJS	0.01	0.007	0.8718	0.687	15.39***	2.63
ERO	0.006	0.005	0.6842	0.402	44***	2.63
GBB	0.007	0.005	0.4757	0.217	105***	1.92
JYN	0.007	0.005	0.5681	0.298	76***	2.76
INP	0.012	0.009	0.7355	0.448	33***	2.63

Notes: See notes in Table 2.
*, ** and *** denote test statistic significance at the 10, 5 and 1% levels, respectively.

SD and MAD (SD with the index and IV are 0.0028 and 0.0020, respectively). Its slope with the IV is closest to 1.0 (0.9944 and not significantly different from 1.0) and the second highest R^2 with the IV (0.9373). The highest R^2 with both the index and IV is grains (0.9485 and 0.9482, respectively). For the index, the closest slope to one is for livestock (0.9882 and is not significantly different than 1.0). For all broad-based commodity indexes and sector notes, tracking performance improved in the reduced data set.

The worst tracking performance with the index and the IV is by livestock. It has the highest SD (1.03% and 1.04% with the index and IV, respectively), the highest MAD (0.0072 with the index and IV) and the lowest R^2 (0.6868 and 0.6869 with the index and the IV, respectively). The farthest slope from 1 is for precious metals (0.8618 and 0.8514 with the index and the IV, respectively). For the broad-based commodity and sector ETNs, tracking performance improved in the reduced data set.

Currency ETNs. Among the currencies, the euro has the best tracking performance with the IV using the MAD and SD, respectively. It also has the best performance with the index using the SD (0.65%) and the Japanese yen has the best performance with index using MAD (0.0047). As indicated by the regression slope and R^2, the poorest tracking currency is the British pound (slopes of 0.4805 and 0.4757 with the index and IV, respectively, and R^2 (0.2148 and 0.2171 with the index and IV, respectively). The tracking of the British pound using these two measures was poorer in the reduced data set when compared to the full data set.

Emerging market ETN. India's SDs (0.0123 and 0.0124 with the index and the IV, respectively) are among the highest of all ETNs, while the MAD (0.0093 and 0.0094 with the index and the IV, respectively) is the second highest of all ETNs, lower than only lead. With respect to regression slope (0.7569 and 0.7355 with the index and IV, respectively) and R^2 (0.4490 and 0.4484 with the index and IV, respectively), the India emerging market ETN tracks its index and IV more closely than the currencies track theirs, but worse than all other ETNs.

Distribution of closing price deviations from IV

The price of an ETN and its associated index are often quite different. As an example, on 25 June 2008, the aluminum ETN's beginning nominal price was set at \$50.00. It closed that day at \$49.43 while the index it tracked had a same day closing price of \$169.304. Aluminum's IV on that day was \$49.42. Thus, observing the distribution of closing price deviations between an ETN and the index it tracks reveals nothing of interest, while the deviations from the ETN's IVs are useful in assessing tracking performance. A zero deviation indicates perfect tracking and a narrower distribution around a zero deviation indicates better tracking than a broad distribution. Table 4 shows the distribution of closing price deviations from IVs for the entire dataset while Table 5 has the distribution for the reduced data set. In both tables, using a significant Jarque–Bera (JB) statistic we reject the null hypothesis of a normal distribution for all ETNs, except cocoa.

General analysis. As shown on Table 4, the livestock ETN has the narrowest distribution of deviations from its IV. 40% of the closing prices have \$0.00 deviations and 87% are within +/−\$0.10 of IV and 100% are within +/− \$0.50. The India emerging market ETN has the widest distribution. Only 5% of the closing prices have \$0.00 deviations, 14% are within +/−\$0.10 and 54% within +/− \$0.50. For all ETNs, the skewness statistic is positive, indicating a positive price bias between the ETNs and their respective IVs.

As shown in Table 4, the livestock ETN has the narrowest distribution of deviations from its IV. 40% of the closing prices have \$0.00 deviations and 87% are within +/−\$0.10 of IV and 100% are within +/− \$0.50. The India emerging market ETN has the widest distribution. Only 5% of the closing prices have \$0.00 deviations, 14% are within +/−\$0.10 and 54% within +/−\$0.50.

Single commodity ETNs. Among the single commodities, oil has the narrowest distribution of price deviations from IV. 40% of the closing prices have no deviation and 79% are within +/−\$0.10 and 98% of the deviations are within +/−\$0.50. Lead and tin have the widest distributions, with only 6% and 9%, respectively with no deviations from their IVs; 25% of lead's and 24% of tin's deviations are within +/− \$0.10. Lead has 78% of its closing prices within a +/− \$0.50 deviation while tin has 75%.

Broad-based commodities and sector ETNs. Livestock has the narrowest distribution of closing price deviations from IV (the distribution is described in the 'General analysis' section). The widest distribution is the softs with 11% of its closing prices having no deviation, 32% within +/−\$0.10 and 83% within +/−\$0.50.

Table 4. Percentage of observations having dollar deviations between the ETN price and the IV (full data set)

$ Difference	GAZ	OIL	JJU	JJC	LD	JJN	JJT	PGM	NIB	JO	BAL	SGG	DJP
−1.75	0%	0%	0%	0%	1%	0%	3%	0%	0%	0%	1%	0%	0%
−1.5	0%	0%	0%	0%	1%	0%	1%	0%	0%	0%	0%	0%	0%
−1.25	0%	0%	0%	0%	2%	0%	2%	0%	0%	0%	0%	0%	0%
−1	0%	0%	0%	0%	3%	0%	3%	0%	0%	0%	1%	0%	0%
−0.5	1%	1%	3%	2%	10%	4%	12%	1%	3%	1%	2%	5%	0%
−0.4	1%	1%	2%	1%	4%	3%	3%	1%	2%	1%	2%	2%	0%
−0.3	1%	2%	4%	4%	6%	4%	4%	1%	4%	1%	3%	6%	1%
−0.2	1%	3%	6%	6%	6%	9%	6%	3%	5%	5%	4%	7%	1%
−0.1	5%	10%	14%	13%	10%	11%	8%	11%	12%	11%	12%	9%	7%
0	14%	40%	14%	22%	6%	18%	9%	23%	18%	25%	19%	13%	31%
0.1	26%	30%	14%	20%	9%	15%	8%	24%	18%	22%	17%	14%	44%
0.2	17%	6%	16%	15%	7%	16%	7%	13%	14%	18%	15%	12%	12%
0.3	8%	3%	11%	8%	8%	9%	7%	7%	11%	8%	8%	9%	2%
0.4	6%	1%	5%	5%	6%	4%	5%	3%	6%	4%	4%	7%	1%
0.5	5%	2%	3%	1%	7%	4%	7%	3%	2%	1%	3%	4%	0%
0.6	3%	0%	2%	1%	3%	2%	3%	1%	1%	1%	2%	3%	0%
0.75	3%	0%	2%	1%	3%	1%	4%	2%	1%	1%	2%	3%	0%
1	4%	0%	2%	0%	4%	0%	3%	0%	1%	1%	2%	1%	0%
2	6%	1%	2%	0%	5%	0%	5%	3%	1%	0%	2%	1%	0%
4	0%	0%	1%	0%	0%	0%	2%	4%	0%	0%	1%	0%	0%
Skew	0.38	0.20	0.49	0.24	0.70	0.28	0.79	1.23	0.30	0.23	0.58	0.41	0.37
Kurt	1.74	1.31	3.33	−0.23	−1.26	−0.32	0.15	4.56	−0.18	0.93	3.53	−0.02	−22.61
JB	801*	9700*	19 843*	448*	2475*	82*	382*	20 248*	2380*	6528*	36 262*	2796*	9 347 603*

$ Difference	GSP	JJA	JJE	JJG	JJM	COW	JJP	JJS	ERO	GBB	JYN	INP
−1.75	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	2%
−1.5	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	1%
−1.25	0%	0%	0%	0%	0%	0%	0%	1%	0%	1%	1%	1%
−1	0%	0%	0%	0%	1%	0%	1%	1%	0%	1%	0%	4%
−0.5	0%	1%	2%	1%	2%	0%	4%	7%	4%	7%	6%	9%
−0.4	1%	0%	2%	0%	1%	0%	1%	3%	2%	3%	2%	3%
−0.3	0%	1%	2%	1%	3%	0%	5%	3%	6%	3%	6%	3%
−0.2	1%	2%	4%	3%	6%	2%	6%	7%	7%	6%	8%	4%
−0.1	7%	12%	7%	10%	10%	6%	10%	10%	12%	10%	13%	5%
0	33%	29%	30%	33%	19%	40%	17%	11%	17%	17%	18%	5%
0.1	39%	28%	32%	32%	17%	41%	20%	10%	19%	20%	15%	4%
0.2	13%	20%	10%	13%	20%	9%	12%	13%	12%	10%	11%	4%
0.3	3%	6%	4%	5%	12%	1%	8%	8%	7%	6%	6%	6%
0.4	1%	1%	2%	2%	4%	0%	4%	7%	5%	5%	4%	5%
0.5	1%	0%	1%	0%	2%	0%	3%	4%	2%	2%	3%	5%
0.6	0%	0%	1%	0%	1%	0%	2%	3%	2%	2%	1%	6%
0.75	1%	0%	1%	0%	1%	0%	2%	4%	2%	2%	1%	7%
1	0%	0%	1%	0%	1%	0%	1%	3%	1%	1%	2%	8%
2	0%	0%	0%	0%	0%	0%	2%	4%	1%	2%	1%	15%
4	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	4%
Skew	0.14	0.16	0.25	0.16	0.28	0.09	0.43	0.58	0.39	0.47	0.39	1.02
Kurt	0.30	−0.68	0.18	−0.66	−1.28	−1.10	0.48	0.76	−2.51	0.22	0.71	0.76
JB	3650*	6388*	4810*	22 356*	1584*	2025*	2933*	861*	26 186*	1177*	1179*	289*

Notes: Dollar deviations (ETN price – IV) are reported between ETN price and IV. Each row represents the percentage of the total number of observations corresponding to the stated dollar deviation.
*Denotes that we reject the null hypothesis that the sample of dollar deviations comes from a normal distribution at a significance level of less than 1%.

Table 5. Percentage of observations having dollar deviations between the ETN price and the IV (reduced data set)

$ Difference	GAZ	OIL	JJU	JJC	LD	JJN	JJT	PGM	NIB	JO	BAL	SGG	DJP
−1.75	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	1%	0%	0%
−1.5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%
−1.25	0%	0%	0%	0%	2%	0%	0%	0%	0%	0%	1%	0%	0%
−1	0%	0%	0%	0%	4%	1%	2%	0%	0%	0%	1%	1%	0%
−0.5	0%	0%	3%	1%	12%	4%	10%	0%	2%	1%	2%	5%	0%
−0.4	0%	0%	2%	3%	5%	3%	3%	1%	2%	1%	1%	2%	0%
−0.3	0%	0%	3%	3%	5%	2%	3%	1%	4%	1%	2%	5%	0%
−0.2	0%	1%	8%	6%	5%	9%	8%	4%	4%	6%	4%	8%	0%
−0.1	0%	8%	16%	12%	8%	11%	9%	15%	13%	11%	12%	9%	5%
0	12%	47%	20%	22%	7%	17%	9%	28%	17%	27%	23%	15%	33%
0.1	36%	37%	16%	21%	11%	17%	8%	25%	19%	19%	14%	11%	48%
0.2	16%	5%	15%	16%	7%	15%	9%	11%	15%	16%	11%	9%	12%
0.3	10%	1%	10%	7%	6%	9%	10%	4%	11%	8%	6%	10%	1%
0.4	7%	0%	4%	7%	6%	4%	8%	2%	7%	6%	5%	7%	0%
0.5	6%	0%	2%	1%	6%	3%	7%	1%	3%	1%	2%	4%	0%
0.6	3%	0%	1%	1%	3%	3%	4%	0%	2%	2%	3%	3%	0%
0.75	3%	0%	1%	1%	3%	1%	4%	1%	0%	1%	4%	5%	0%
1	3%	0%	0%	0%	4%	0%	2%	1%	0%	1%	3%	2%	0%
2	4%	0%	0%	0%	4%	0%	2%	3%	0%	0%	4%	2%	0%
4	0%	0%	0%	0%	0%	0%	0%	2%	0%	0%	2%	0%	0%
Skew	2.28	0.01	−0.18	−0.20	−0.19	−0.57	0.24	4.42	−0.05	0.43	3.11	−0.27	−0.63
Kurt	9.37	4.20	4.17	4.01	3.61	4.53	5.60	27.03	3.24	4.98	24.75	5.20	9.00
JB[a]	809.5*	18.82*	19.79*	15.46*	6.77*	47.64*	92.13*	8632.36*	0.93	61.5*	6740.1*	67.69*	494.98*

$ Difference	GSP	JJA	JJE	JJG	JJM	COW	JJP	JJS	ERO	GBB	JYN	INP
−1.75	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%
−1.5	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	1%
−1.25	0%	0%	0%	0%	0%	0%	0%	2%	0%	0%	0%	1%
−1	0%	0%	0%	0%	0%	0%	1%	1%	0%	1%	0%	3%
−0.5	0%	0%	0%	0%	2%	0%	3%	5%	3%	5%	5%	8%
−0.4	0%	0%	0%	0%	1%	0%	2%	1%	2%	3%	3%	2%
−0.3	0%	0%	1%	0%	3%	0%	3%	2%	6%	4%	7%	2%
−0.2	0%	2%	3%	1%	6%	0%	5%	7%	7%	7%	9%	4%
−0.1	5%	10%	6%	6%	10%	2%	11%	8%	9%	8%	12%	6%
0	41%	29%	41%	35%	18%	38%	21%	12%	17%	18%	15%	5%
0.1	41%	30%	40%	41%	19%	52%	23%	12%	22%	22%	14%	5%
0.2	11%	20%	6%	12%	19%	6%	12%	12%	13%	13%	12%	4%
0.3	1%	5%	1%	3%	12%	1%	7%	10%	8%	5%	8%	9%
0.4	0%	2%	2%	0%	5%	0%	3%	8%	6%	5%	6%	3%
0.5	0%	0%	0%	0%	2%	0%	3%	5%	2%	1%	3%	5%
0.6	0%	1%	0%	0%	1%	0%	1%	3%	3%	2%	1%	6%
0.75	0%	1%	0%	0%	1%	0%	2%	5%	2%	2%	2%	9%
1	0%	0%	0%	0%	0%	0%	1%	3%	1%	1%	2%	8%
2	0%	0%	0%	0%	0%	0%	0%	3%	1%	1%	2%	16%
4	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	4%
Skew	−0.81	2.16	0.29	4.63	−0.24	0.45	−1.96	−0.14	0.41	−0.09	1.61	0.52
Kurt	8.90	18.73	8.68	44.35	4.19	7.83	16.25	6.69	5.00	5.12	11.81	4.60
JB[a]	492.57*	3505.12*	428.56*	23 647.1*	21.77*	317.32*	2514.61*	180.45*	61.55*	59.7*	1157.75*	48.25*

Notes: See notes in Table 4.
[a]Jarque and Bera (1980).

Currency ETNs. The euro has marginally the narrowest distribution of closing price deviation from IV with 17% having a \$0.00 deviation, 48% within +/−\$0.10 and 84% within +/−\$0.50. The British pound and Japanese yen distributions are very similar except for the yen having 40% within +/−\$0.10.

Emerging market ETN. The India emerging market ETN has the widest distribution of all ETNs as described in the 'General analysis' section.

General analysis reduced dataset. As shown in Table 5, the oil ETN has the narrowest distribution of deviations from its IV. 47% percent of the closing prices have zero deviations and 93% are within +/−\$0.10 of IV and 100% are within +/−\$0.50. In addition to oil, the commodity index (broad-based), the S&P GSCI, energy sector and livestock sector ETNs all have 100% of their deviations within +/−\$0.50 (compared to only livestock in the full dataset). Similar to the full dataset, the India emerging market ETN has the widest distribution. Only 5% of the closing prices have \$0.00 deviations, 16% are within +/−\$0.10 and 53% within +/−\$0.50. While all ETNs in the full dataset are positively biased, several have negative biases in the reduced dataset. Skewness for ETNs in the reduced dataset on average indicates a higher positive bias when compared to the entire dataset.

Single commodity ETNs. Among the single commodities, oil has the narrowest distribution of price deviations from IV (see the 'General analysis' section for a description of the distribution). Lead and tin have the widest distributions, with only 7% and 9%, respectively with no deviations from their IVs; 26% of lead's and 27% of tin's deviations are within +/− \$0.10. Lead has 78% of its closing prices within +/−\$0.50 deviation while tin has 84%.

Broad-based commodities and sector ETNs. Livestock has the narrowest distribution of closing price deviations from IV with 38% having \$0.00, 91% within +/−\$0.10 and 100% within +/−\$0.50. The widest distribution is the softs with 12% of its closing prices having no deviation, 32% within +/−\$0.10 and 82% within +/−\$0.50.

Currency ETNs. The euro has marginally the narrowest distribution of closing price deviation from IV with 17% having a \$0.00 deviation, 48% within +/−\$0.10 and 94% within +/−\$0.50. The British pound and Japanese yen distributions are very similar except for the yen having 40% within +/− \$0.10.

Emerging market ETN. As with the full dataset, the India emerging market ETN has the widest distribution of all ETNs as described in the 'General analysis' section.

In Tables 4 and 5, all ETNs have more positive than negative deviations. On average, 24% of deviations are negative while 55% are positive in the full dataset (Table 4) and 21% and 56%, respectively for reduced dataset (Table 5). Of the 25 ETNs, 18 have more \$0.00 deviations, 23 have more deviations within +/−\$0.10 and 18 have more deviations within +/−\$0.50 in the reduced dataset when compared to the full dataset. We conclude that the distributions are narrower in the reduced dataset which suggests that the deviations are less volatile in the most recent data.

Summary of results

Our analyses indicate that overall, ETNs track their respective IVs and indexes well. For the full dataset, the average SD and MAD are 0.0118 and 0.0074, respectively. The average regression slope and R^2 are 0.86 and 0.69, respectively. All ETNs have a positive bias in returns when compared to their indexes or IVs. ETN returns are more often greater than those of their respective indexes or IVs.

Currency ETNs as a group do a poor job tracking of their respective indexes. They have relatively high SDs and very low R^2.

As the products have matured, their tracking efficiency with the corresponding indexes has improved. In the reduced dataset, the average SD and MAD are 0.0077 and 0.0056, respectively. The average regression slope and R^2 have improved to 0.90 and 0.74, respectively. In the reduced dataset (the most recent data), ETNs still have a positive bias in their returns when compared to their indexes or IVs. Thus, as the products have matured, investors continue to price them above their respective indexes and IVs.

Currency ETN tracking has improved in the reduced dataset when compared to the entire dataset. However, as a group, they do not track as well as any other group except the emerging market.

In order to provide a basis for assessing the magnitude of the ETN tracking errors, we compare them to tracking errors from previous studies of ETFs. Table 6 summarizes the average SDs, MADs and R^2 from the ETNs of the current study and the same statistics for ETFs from the Rompotis (2008) traded on the US exchanges and Chu (2011) traded

Table 6. Average tracking statistics

	SD	MAD	R^2
Full dataset[a]			
ETNs			
Single commodities	0.0151	0.0099	0.6749
Softs	0.0129	0.0066	0.8204
Commodity indexes	0.0048	0.0032	0.9340
Commodity sectors	0.0089	0.0058	0.7511
Currencies	0.0090	0.0058	0.2980
Emerging market	0.0224	0.0155	0.4725
All ETNs full dataset	0.0118	0.0074	0.6869
Reduced dataset[b]			
ETNs			
Single commodities	0.0101	0.0073	0.7465
Softs	0.0081	0.0057	0.8744
Commodity indexes	0.0033	0.0024	0.9334
Commodity sectors	0.0059	0.0041	0.8311
Currencies	0.0067	0.0048	0.2897
Emerging market	0.0123	0.0093	0.4490
All ETNs reduced dataset	0.0077	0.0055	0.7389
Exchange traded index ETFs			
US exchanges[c]	0.0057	0.0038	0.894
Hong Kong exchanges[d]	0.0183	0.0195	0.573

Notes: [a]Calculated using results from Table 2.
[b]Calculated using results from Table 3.
[c]Rompotis (2008).
[d]Chu (2011).

on the Hong Kong exchange. The broad-based commodity ETNs had smaller tracker errors than the ETFs. Tracking errors for other groups of ETNs on average were similar to the errors for ETFs that traded on US exchanges and lower than those for ETFs that traded on the Hong Kong exchange.

VI. Conclusion

ETNs are a recent addition to exchange traded products and the market has grown in the recent past. They provide investors with opportunities to earn returns that follow a specific commodity, commodity sector or broad-based commodities index. This is the first study that investigates the tracking performance of ETNs to their respective indexes and IVs. It employs standard methodologies for measuring tracking performance. We find that most ETNs track their respective indexes very well. Currency ETNs and the emerging market ETN do not track their respective indexes and IVs nearly as well as the other ETNs in the study. Also, ETNs have a positive bias in prices when compared to their underlying IVs.

Since 1 January 2010, ETNs in this study have tracked their respective indexes more closely than they did when they were first offered. This implies that the tracking performance of the ETNs has improved as they have matured. The positive bias is still present in the most recent prices.

When compared to ETFs, ETNs have a competitive price advantage because they do not hold long positions in the underlying indexes. The lack of collateralized positions does not appear to affect tracking performance. ETNs track their underlying indexes nearly as well as ETFs track even though trading volumes are substantially larger for ETFs (which should lead to improved tracking). The credit risk associated with ETNs will always be an issue to investors, but the results of this study suggest that risk of tracking errors should not impede wider acceptance of ETNs.

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