The Informational Behavior of the Currency Exchange Traded Funds during the Financial Crisis

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Abstract

This paper studies the behavior of six major currency ETFs and their respective spot and futures markets during the U.S. financial turmoil. Using minute-by-minute data and two criteria to identify the peak of the crisis, the findings indicate while all spot and futures currency markets lead the ETFs markets significantly, the information shares across the non-crisis and crisis periods are statistically significantly different. In general, both the spot and the futures markets lose some degrees of their leadership positions to their corresponding ETFs markets in the crisis period. Most of the information shares of the currency ETFs in the crisis period are statistically significantly larger than those in the non-crisis period. Further, the magnitudes of the information shares are dynamic and shift across the two periods. The leadership positions of both the spot and the futures currency markets relative to their associated ETFs are consistently reaffirmed, and to a large extent are similar. Under more tranquil conditions, the spot and the futures currency markets possess *more* dominant leadership positions relative to their corresponding ETFs markets.

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1. INTRODUCTION

Currency exchange traded funds (ETFs) have expanded rapidly and have had substantial growth during the last five years or so. Starting with a mere eight funds in 2008,[1] there are now close to 80 active funds with wider breadth and scope.[2] The rapid development of these funds could be attributed to a spectrum of factors that range from expanded globalization dimensions of the market to restrictions on actual currency movements. The latter often arises from country currency constraints, blocking funds, and even an avoidance of perceived money laundering. The majority of the current currency ETFs is European (close to 30 funds), followed by Asia-Pacific (23 funds), the U.S. (9 funds), Canada (5 funds), and Latin America (2 funds). Currency ETFs with other scopes and risk exposures, such as currency basket ETFs (6 funds), have also provided a more diversified venue for the investors.

Huge amounts of currency transfers, mostly between the EU and the U.S., were made in the ensuing months past the 2008 financial crisis. While nearly all markets were in turmoil post this event, the currency ETFs , the currency futures, and the currency spot markets were subject to the additional factors that went far beyond the norm of activities and transfers in these markets, e.g., huge (unilateral) governmental transfers. The distressing news from equity markets was so dominant that it overshadowed the swings in these three markets. This calls the need for a more in-depth investigation of these markets, hence, the relevance of this paper. We aim to analyze the informational behavior of the ETFs , the futures, and the spot in foreign exchange markets during this global financial crisis. More specifically, this study focuses on the leadership role of the currency ETFs market relative to their underlying currency futures and

currency spot markets. The relative positions of the futures and spot currency markets are already well documented in the literature. In contrast, there is a lack of empirical evidence on currency ETFs , particularly in light of their increasing growth and importance in today's markets, and, above all, during such most recent, unique, and abnormal period as the U.S./global financial crisis.

Several studies have examined the leadership positions of different markets through a price discovery process. Notable in the list is the analyses of spot markets and their corresponding derivatives products (see, for instance, Cheung and Ng (1990), Chan (1992), Fleming, Ostdiek, and Whaley (1996), Poskitt (2009), and De Boyrie, Pavlova, and Parhizgari (2012)). The conclusions of these studies are mixed. For instance, there are substantial indications that the response of the futures markets to the new information arrival is quicker than that of the associated equity markets due to the requirement of a smaller capital margin (the so-called "leverage hypothesis"). However, there is no consensus in this regard, and in some cases contradictory positions have even been reached. Some findings attribute larger behavioral role to the spot market, arguing that options markets lag their corresponding spot markets due to smaller trading costs in the spot markets (the so-called "trading cost hypothesis"). Based on these prior experiments and a lack of empirical evidence on the ETFs markets that are rapidly growing, we posit that, in general, when pairing two markets such as currency ETFs and currency spot or currency ETFs and currency futures, the outcome should be left open. Theoretically, a causality direction may be hypothesized, but that still requires empirical tests to verify its validity.For example, Fleming et al. (1996) show that the S&P 500 futures prices lead the S&P 100 index put and call options. De Boyrie et al. (2012), on the other hand, conclude that a mixed outcome for

price discovery should be expected, since the underlying factors may not necessarily be all the same and at all times.

Within the context of the above domain of analyses and considering the rapidly growing importance of the ETFs markets, we examine the informational behavior of the currency ETFs relative to their underlying spot and futures exchange rates for the currencies of six developed economies, i.e., Australian dollar(AUD), Canadian dollar(CAD), Swiss franc (CHF), Euro (EUR), British pound (GBP), and Japanese yen (JPY). Given that these are major worldwide currencies and are widely traded, they are expected to provide an excellent representation of the markets for the currency ETFs , currency spot, and currency futures, particularly during a period of turmoil that initially engulfed the developed economies (rather than the developing ones), and thereby affected their ETFs and their currencies.

Our main objective is to examine the informational role of the ETFs , the futures, and the spots in major foreign exchange markets during selected periods surrounding the peak of the 2008 financial crisis in the U.S. Although equity ETFs have been the subject of some studies, the currency ETFs have rarely been analyzed. This paper is expected to shed some light on the behavior of the currency ETFs markets through a price discovery process relative to both the currency futures and the currency spot markets. Our results indicate that the currency ETFs contribute to their corresponding spot and futures markets, though by relatively small amounts. Further, the behavior of these markets surrounding the crisis is not uniform. More specifically, the leadership positions of some currencies in both the spot and the futures markets seem to be diminished in the crisis compared to the non-crisis periods.

The remainder of this paper is as follows. Section 2 provides a review of pertinent literature. Section 3 introduces the methodology that is employed. Section 4 provides

information on the sources of the data, and briefly discusses them. Section 5 introduces two approaches for the determination of the non-crisis and crisis periods. Section 6 includes the empirical results. The last section presents the summary and conclusions.

2. PRIOR LITERATURE

In a frictionless market, asset prices in different trading platforms or derivatives prices on the same underlying assets are perfectly correlated; there exists no lead-lag relationship. Notwithstanding this theoretical position relying on the evidence suggested by Glosten and Milgrom (1985), Easley, and O' Hara (1987) show that informed trading in one particular market reveals new information arrival, and this subsequently leads prices in other markets. The role of informed traders is explained by four mainhypotheses, namely, the leverage, the trading cost, theuptick rule, and the market-wide information.[3]Relevant to these four hypotheses and to our methodology in this paper is the field of price discovery. Hence, a brief review of this topic isprovided in the ensuing paragraphs.

Previous studies have employed price discovery with varied analyses and scopes. We consider five separate areas as follows.

First, a common and traditional approach to price discovery has been the study of the relation betweenequity markets and their corresponding derivatives markets. For instance, Tse (1999), employing minute-by-minute data for the Dow Jones Industrial Index and its futures, finds that the futures market does better in the price discovery process. This finding confirms previous evidence on the leadership position of the futures market relative to other selected markets (see, for example, Ng (1987), Herbst et al. (1987), and Chan (1992)). In general, the evidence in the U.S. markets on the relation betweenthe equity and its corresponding futures

marketsdocuments that the futures market offers a better price discovery than its corresponding equity market. Further, this evidence is not limited only to the U.S. markets. International evidence on a number of selected relations is also already investigated.[4]

The second area in the price discovery studies considers different trading platforms or system providers. Theissen (2002) compares the price discovery between open outcry and screen electronic trading platforms in the Frankfurt Stock Exchange. His outcome depends on the type of data used. He finds that the leadership of the two systems is almost similar when transaction data is used, but the screen trading system seems better when midpoint quotes are employed. A similar prior study on the superior leadership of electronic trading system is Grünbichler et al. (1994). Also, Poskitt (2009) compares two different electronic trading service providers in foreign exchange markets, namely theGLOBEX and the Reuter D3000. His findings indicate that, in general, Reuter D3000 leads GLOBEX.

The third area of the price discovery analyses has been in commodities markets. Yang, Bessler, and Leatham (2001) separate several types of the U.S. agricultural futures contracts on storability basis. This disaggregation does not seem to play a significant role in the price discovery mechanism. Their results indicate that futures prices are biased estimates of their corresponding cash prices. Tse and Xiang (2005), studying energy futures markets, investigate the relation between regular futures and E-mini futures contracts on natural gas and crude oil. In the sample they consider, although E-mini futures accounts for less than one percent of the volume of the regular futures contracts in each asset,[5] it contributes significantly to price discovery. The E-mini market possessesmore than 30 percent information shares generated by Hasbrouck's(1995) and Gonzalo and Granger's (1995) methodologies. These findings are reaffirmed by Pavabutr and Chaihetphon (2010), who study the regular and mini gold futures

contracts in the Multi Commodity Exchange of India. Their daily results show the dominant role of mini gold futures contract with over 30 percent information shares.

The fourth area of the price discovery analyses has been in foreign exchange markets. De Jong, Mahieu, and Schotman (1998) study the efficiency of the Japanese yen/Deutsch mark and their implied exchange rate of theJapanese yen/United States dollar and the Deutsch mark/United States dollar. They find price discovery in direct quotes of the Japanese yen/Deutsch mark,and attribute it to the presence of substantial noises in the data on the United States dollar. Tse, Xiang, and Fung (2006), using floor and electronic trading systems for the Euro and the Japaneseyen futures markets, find that GLOBEX electronic trading is more efficient andprovides most of the price discovery in the Euro. Nevertheless, Rosenberg and Traub (2009) contradict most previous findings. They show that the spot exchange market possesses larger information share than its corresponding futures market. They attribute it to more transparency in the spot market over the period of their study.

The last area of the price discovery analyses focuses on the role of ETF markets. This market has become increasingly important and has attracted investors' interest during recent years. Tse and Erenburg (2003) employ the Nasdaq index and its ETF (QQQ) in different exchanges:the AMEX, the NYSE, and the ECNs (Electronic Communication Networks). Using TAQ data, price discovery starts from theECNs, then from the NYSE, and finally from the AMEX. Subsequently, Tse, Bandyopadhyay, and Shen (2006) provide further evidence on the DJIA index and its ETF (DIA), regular futures, and E-mini futures. The largest contribution in price discovery is from the E-mini futures market, followed by the ETF market, and the regular futures market, respectively. Moreover, the electronic ETF trading platform (Archipelago: ArcaEX) is dominant in price discovery over the AMEX.

To conclude this brief review, there are some consistent empirical evidences on the price discovery process. First, futures market leads its corresponding spot market,[6] and spot market leads its corresponding options markets. Second, electronic trading platforms contribute to price discovery greater than open outcry platforms. Third, E-mini futures contracts provide relatively large information share, although the relative trading volume therein is substantiallysmaller than in the regular futures contracts.[7]Last, the ETF market does provide some degrees of price discovery function, albeit with inconclusive results.

3. METHODOLOGY

Two well-established methodologiesthat are often employed in the price discovery studies are Hasbrouck's (1995) information share and Gonzalo and Granger's (1995) permanent-transitory component. These two venues show the contribution of an asset (market or trading platform) to the price discovery process, and the starting point in both isresorting to a vector error correction model (VECM).

To study the role of the price discovery process between the currency ETFs markets and the corresponding currency futures and currency spot markets, we employ Hasbrouck's (1995) information shares.[8] The basic concept relies on the notion that when two time series are cointegrated, their price innovations share a common component. The information share is then defined as the contribution of one market's innovation to the total innovation in the common efficient price.

Given that the first difference of most time series data is usually stationary (I(0)), Engle and Granger's (1987) error correction model is presented as:

$$\Delta p_t = \mu + \sum_{k=1}^{K} \Gamma \Delta p_{t-k} + \alpha\beta' p_{t-1} + \epsilon_t \quad (1)$$

where$p_t = (E_t, S_t)'$are the nonstationary (I(1)) but cointegratedprices of a currency ETF (E_t) and a currency futures *or* a currency spot (S_t). Throughout, we represent the currency ETFs market by $E_t$and *both* the currency futures and spot markets by S_t. The parametersμ, α,β, and Γ are vectors with (2 x 1), (2 x 1), (2 x 1), and (2 x 2) dimensions, respectively. The term $\epsilon_t$is the error vector with mean zero, (2 x 1) dimensions, and with variance-covariance matrixofΩ. The sign Δ is the difference operator and β is the cointegrating vector.The parameters in the vectors of $\alpha$and$\beta$are estimated in the VECM'serror correction estimation process. The parametersα'*s* are sometimes referred to as 'adjustment coefficients' or 'alpha estimates'. The notation *K* is the Schwarz optimal lag-length.

A variant representation of the vector error correction model (VECM) as specified in relation (1) may be stated for our specified markets on a currency ETF (E_t) and a currency futures *or* acurrency spot (S_t) as follows:

$$\Delta E_t = a_1 + \alpha_1 z_{t-1} + \sum_{k=1}^{K} b_{ETF,k} \Delta E_{t-k} + \sum_{k=1}^{K} c_{ETF,k} \Delta S_{t-k} + \varepsilon_{ETF,k} \quad (2)$$

$$\Delta S_t = a_2 + \alpha_2 z_{t-1} + \sum_{k=1}^{K} b_{S,k} \Delta E_{t-k} + \sum_{k=1}^{K} c_{S,k} \Delta S_{t-k} + \varepsilon_{S,k} \quad (3)$$

where the error correction term is z_{t-1} and is equal to E_{t-1}in relation (2) and S_{t-1} in relation (3). The notation S_t in both relations, and its use as a subscript in relation (2), represents <u>*both*</u> the spot and the futures market.

The VECM representation given in the above relations can be presented as a common trend representation model as:

$$p_t = p_0 + \iota C \sum_{i=1}^{t} \epsilon_{t-i} + C(L)\epsilon_t \tag{4}$$

where $p_0$is a constant vector. ι is a column vector of ones. *C(L)* is a matrix polynomial in the lag operator. $\iota C \sum_{i=1}^{t} \epsilon_{t-i}$ is the common random walk component for all prices, and $C(L)\epsilon_t$ is the transitory component with zero mean and stationary covariance.

Hasbrouck's (1995) information share is the proportion of the innovations of market *j* to the total innovation of the common efficient price. If the price innovations between markets are not correlated, the information share (IS) of the market *j* is presented as:

$$IS_j = \frac{c_j^2 \Omega_{jj}}{\boldsymbol{c\Omega c'}} \tag{5}$$

where $\boldsymbol{c}$is the common row vector of the impact matrix in the common trend representation.[9]If the price innovations between markets are correlated, the information share (IS) of the market *j* is presented as:

$$IS_j = \frac{\left([cH]_j\right)^2}{\boldsymbol{c\Omega c'}} \tag{6}$$

A Cholesky factorization of Ω is used to obtain the lower triangular matrix such that Ω = *HH'*, where *H* is the innovation matrix from relation (2) when$j=E_t$,or relation (3) when$j = S_t$. The higher the information share, the larger the market impounding the new arrival of information.

4. DATA DESCRIPTION AND SOURCES

Six major currency ETFs (CurrencyShares) and their corresponding currency futures and currency spot rates over four separate periods surrounding the peak of the financial crisis in

2008 are considered. The surrounding periods are pairwise non-overlapping and balanced in length. The data are minute-by-minute throughout the analyses.

CurrencyShares is an exchangetraded fund (ETF),wherein the market price of a foreign currency is quoted in terms of the United States dollar.[10]The ETF shares are traded on the NYSE Arca. The purpose of these shares is to reflect, primarily, the pricesof foreign currencies in terms of the United States dollar. The prices of currency ETFs and their corresponding futures and spot ratesare all expressed by the same type of quotations, i.e., the so-called 'indirect' quotations in terms of one unit of USD.

The minute-by-minute data for the currency ETFs (CurrencyShares) and their associated currency futures and spot exchange rates are from TradeStation. Though the spot exchange marketsprovide 24-hour trading information, weekends and holidays[11] are excluded from these markets in order to preserve consistency and synchronization with the ETFs markets.In addition, the data in the currency futures and the spot exchange markets are truncated before 9:30 A.M. and after 4:00 P.M on each day. These hours match the operating hours in the ETFs markets. All hours (minutes) are the U.S. Eastern time zone (EST). Thus, the three sets of the data (the ETFs , futures, and spot) are all fully synchronized. Currency futures series are constructed using and rolling over near term contracts.[12]The spot exchange rates and currency futures are all quoted in terms of the United States dollars per the foreign currency in order to match with the CurrencyShares quotations.

The six currency ETFs , their corresponding currency futures, as well as spot exchange rates, their market symbols, and the ETFs inception dates are summarized below.

Currencies	ETFs	Spot / Futures Rates	ETFs InceptionDates
Australian dollar	FXA	AUDUSD	June 21, 2006
Canadian dollar	FXC	CADUSD	June 21, 2006
Swiss franc	FXF	CHFUSD	December 9,2005
Euro	FXE	EURUSD	June 21, 2006
British pound	FXB	GBPUSD	June 21, 2006
Japanese yen	FXY	JPYUSD	February 12, 2007

5. The Designation of the Non-Crisis and Crisis Periods

In order to identify the pre-recession or non-crisis period, two approaches are followed. First, we draw upon the announcement by the Business Cycle Dating Committee, National Bureau of Economic Research (NBER), which states that the U.S. economy entered a recession in December 2007 (Labonte, 2009). Second, we consider the lowest points of the U.S. stock markets as indicated by their major stock indices, namely the Dow Jones, the S&P500, and the NASDAQ.[13] These two approaches yield four separate sample periods that are non-overlapping pairwise surrounding the peak of the U.S. financial crisis.

To avoid confounding our analysis and, in particular, to bypass the need to consider the effect of "other" variables that often should be incorporated in longer-term analysis, we limit the period of the study in each approach (the NBER or the DJ/S&P500/NASDAQ) to 18 months of minute-by-minute coverage surrounding the peak of the financial crisis. The 18-month period is divided into two balanced nine months.

When the NBER identification of the crisis point is used, the data coverage starts at 9:30 A.M. on April 1, 2007, and ends at 4:00 P.M. on September 30, 2008. The first nine months of this period are referred to as the pre-recession or non-crisis period (April 1, 2007-December 31,2007), and the second nine months are referred to as the recession or crisis period (January 1, 2008-September 30, 2008).

When the U.S stock market identification of the crisis point is used, the lowest points in the three major U.S. stock markets, namely the Dow Jones, the S&P 500, and the NASDAQ, are on November 21, 2008, at 11:08 A.M. EST. The overall sample period surrounding this point is from 9:30 A.M. on March 1, 2008, to 4:00 P.M. on August 31, 2009, with the non-crisis and crisis periods identified, respectively, as 9:30 A.M. on March 1, 2008, to 11:07 A.M. on November 21, 2008, and 11:08 A. M. on November 21, 2008, to 4:00 P.M. on August 31, 2009.

6. EMPIRICAL RESULTS

To manage this section, the analyses and discussion of the empirical results are divided into five sub-sections. Sub-section 6.1 presents a sample of the results of the VECM estimation process. Sub-section 6.2 contains the information shares for the entire sample under the NBER criterion. Sub-section 6.3 is on the information shares during the non-crisis and crisis periods under the NBERcriterion. Sub-section6.4provides the information shares for the entire sample and for the non-crisis and crisis periods, all under the criterion of the lowest points in the U.S. stock markets. Finally, sub-section 6.5 presents the analyses and the information shares when the currency futures market is employed in lieu of the currency spot market. Throughout, the results of the non-crisis and crisis periods are statistically compared. The coverage in the sub-sections 6.1 to 6.4 is exclusively on the results of the spot exchange markets and their corresponding currency ETFs markets. The sub-section 6.5 focuses on the outcome of pairwise currency futures vis-à-vis their associated currency ETFs .

6.1. Vector Error Correction Model

After assuring the presence of the cointegrationand stationarityof the variables in their first differences,[14] we start our analysis by estimating the vector error correction model (VECM) as defined in the relations (2) and (3). The final aim is to identify the price discovery process in the spot and the futures foreign exchange markets vis-a-visthe currency ETFs markets. The number of optimal lag lengths is obtained by Schwarz Bayesian Criterion (SBC), which is equal to 12 lag-length in most cases. The estimation of the VECM in this section is prerequisite to the computation of the information shares in the next section.

As an example of the above step, Table I presents the results of the VECM estimation for only the AUD/FXA, *spot* Australian dollar (AUD) and its corresponding ETF (FXA). Similar estimation procedure is undertaken for all other pairs of the spot currencies and their associated ETFs as well as the futures currencies and their associated ETFs . Because of the voluminous results of the VECM estimation, we present only the results of the first two lags in Table I.

The error correction terms (α) of both the AUD and theFXA are negative, and statistically significant for only FXA. This shows that an increase in the previous period error leads to a decrease in the current period FXA price. Further, the statistical insignificance of the negative error correction term of the AUD shows that this market does not seem to yield a clear response to the prior equilibrium error. The lagged difference terms measure the short-run dynamics between the AUD and the FXA. Considering the statistical significance of the estimated coefficients again, the first two lagged coefficients of the AUD influence the current FXA price, but those of the FXA do not influence the current AUD price. A number of other points could be made on these estimated results.[15]The overall effect on price discovery, however, will be dictated by the joint influence of all the estimated results and in particular by the

estimated innovation matrices of the relations (2) and (3) and the estimated error correction model parameters (see relation (6)).

6.2. Information Shares in the Overall Sample under the NBERCriterion

Panel Aof Table 2 reports the computed information shares of the *spot* exchange rates and their corresponding CurrencyShares ETFs for the entire sample under the NBER criterion.[16] The results show that the spot exchange rates contribute up to 90 percent to the price discovery mechanism. These estimates are based on the mid-points between the upper and the lower bounds of the estimated information shares. We posit that the significant contribution of the spot exchange rates to the price discovery process arises from increased transparency in foreign exchange markets,[17] as well as from recognized and established groups of active units and traders in these markets, especially from institutional investors. To sum up this sub-section, our findings indicate that the spot foreign exchange markets play a highly significant role in the price discovery mechanism, while the ETFs markets provide a relatively small contribution. In other words, the spot exchange markets heavily lead the ETFs markets. This underscores that the ETFs markets behave as passive instruments, and are thus fairly suitable to be employed as hedging instruments. Our findings are the same across all currencies and ETFs .

6.3. Information Shares during the Non-crisis and Crisis Periods under the NBER Criterion

Panels B and C of Table 2 present information shares over the non-crisis and crisis periods under the NBER criterion, respectively.Two main conclusions are drawn. First, in general, the ranges between the upper and the lower bounds over the non-crisis period

are*narrower* than those in the crisis period. This may be attributed to the lower volatility and uncertainty in the non-crisis period. Second, the behavior of the currencies during the non-crisis and crisis periods are not the same, and on the basis of the results the currencies could be divided categorically into two groups: relatively more powerful or stable currencies (the CAD, CHF, and GBP) and the currencies that appear relatively more susceptible to the turmoil of the financial crisis (the AUD, EUR, and JPY). The first group of currencies shows more leading roles during the crisis period, whereas the currencies in the latter group lose some of their leadership positions. The information shares of the spot exchange rates of the second group are *lower* in the crisis period than in the non-crisis period. The leadership of the spot marketsin this group is diluted due to the increased uncertainty and volatility in the crisis period. For the first group of currencies, their information shares improve by approximately 0.002 to 0.053 in the crisis period, indicating a more active leadership role for the spot currencies in this group. The EUR spot average information share in the crisis period is the smallest, and shows the largest diminishing information share compared with the non-crisis period. This could have arisen, in particular, as a result of a few public lump-sum currency transfers from the U.S. treasury to the European Central Bank and other financial institutions during the crisis period.

Comparing the entire sample period with the non-crisis and crisis periods, two clear conclusions emerge. First, consistent with the two sub-periods, the information shares of the spot currencies during the entiresample period remain still relatively high. Second, the confounding effects of mixing the two periods result in estimates of the information shares that fall in the ranges (not necessarily averages) of the corresponding information shares of the two periods. Obviously, the differences between the two periods will be washed away, or at best averaged out.

In general, for the currencies that are relatively more susceptible to the turmoil of the financial crisis, the currency ETFs perform relatively better over the crisis period. This reflects the closer association of the ETFs with the equity markets and could be taken as a market signal for potential profitability/loss prevention in the ETFs markets that could have been available in the downside equity markets. Equally, it could reflect the increased uncertainty and volatility in the more transparent spot currency markets.

We further investigate statistically the difference in the market leadership between the non-crisis and crisis periods. Table III presents the results of the paired *t*-test values of the information shares between the non-crisis and crisis periods. Most of the *t*-values of the boundaries and the average information share values are statistically significant, showing that the leadership roles of the instruments have statistically changed over these two periods. More specifically, the leadership roles of the EUR and the JPYare statistically relatively decreased over the crisis period, while those of the CHF and the GBPare statistically relatively increased. In other words, in the crisis period, their corresponding ETFs do better for the EUR and the JPY and do worse for the CHF and the GBP in the price discovery process.[18]

6.4. Information Shares for the Entire Sample and for the Non-crisis and Crisis Periods under the Criterion of the Lowest Points in the U.S. Stock Markets

In this sub-section we further examine the information shares using the lowest points in the U.S. stock markets as the criterion for the peak of the U.S. financial crisis. Since a financial crisis is often measured by a downward movement in a major stock market, it is logical to check whether the roles of the spot foreign exchange rates and their corresponding ETFs remain the same in periods surrounding the peak of the financial crisis. As discussed in Sections 4 and 5, we

use 11:08 A.M. on November 21, 2008, as the peak of the financial crisis in the U.S. stock markets.[19] Thus, the non-crisis and crisis periods based on this criterion are 9:30 A.M. on March 1, 2008, to 11:07 A.M. on November 21, 2008, and 11:08 A.M. on November 21, 2008, to 4:00 P.M. on August 31, 2009, respectively. This alternative choice of the periods yields nine months before and nine months after the peak of the crisis, and is lengthwise fully consistent with our prior sample selection under the NBER alternative. Further, this consistency between the two alternative samples is not only a logical prerequisite to our comparative analyses, but also makes such analyses easier across the experiments and the statistical tests.

Panels A, B, and C of Table IV present the upper bounds, the lower bounds, and the average information shares over the entire sample, non-crisis, and crisis periods, respectively. Comparing the non-crisis with the crisis periods in Table IV, the information shares of the spot currency markets are consistently lower in the crisis period. Comparing across the two criteria (the NBER and the lowest points in the stock markets shown in Tables II and IV), in general, the spot currency markets possess smaller information shares under the stock markets criterion. These results are consistent across the overall samples and the crisis periods.[20] Within the non-crisis periods, as may have been expected, the results under the stock markets criterion are roughly similar to those under the NBER criterion. One group of currencies (the CAD, CHF, and GBP) that we term as being relatively stable or more powerful appears to command even higher leadership positions during the non-crisis period.

Some clear conclusions based on the above results are drawn as follows. First, it appears that the criterion of the lowest points in the U.S. stock markets is a better representative for the peak of the U.S. financial crisis. Second, the magnitudes of the information shares are dynamic, and they could shift across non-overlapping and even across partially overlapping periods. Our

two overall alternative samples (under the criteria of the NBER and the lowest points in the U.S. stock markets) overlap for a period of approximately seven months (March 1 to September 30, 2008) over the entire sample length of 36 months of minute-by-minute data. Third, the equity markets are more in harmony with the ETFs markets, since the leadership positions of the latter under the stock markets criterion are now improved. This is *not* an argument in favor of the winners or losers in one market or the other, but rather the leadership positions of the currency ETFs vis-à-vis the spot foreign exchange markets under the two alternative data periods.

Finally, Table V provides some statistical tests on the differences in the leadership positions across the non-crisis and crisis periods. The differences in the leadership positions of the majority of the currencies and their associated ETFs are statistically significant. These results are consistent with the prior outcomes that emerge under the NBER alternative (see Table III). A somewhat different situation, however, is also now present. Based on the average information shares, the *t*-statistics for the AUD and the CAD are now statistically significant, whereas those for the EUR and the JPY are not. Another clear conclusion is that the leadership positions of the currencies may slightly change across non-overlapping and even partially overlapping periods. These changes could be attributed to the differences in the volatility and uncertainty across the periods. In general, our findings indicate that under more stable and tranquil conditions, the spot foreign exchange markets possess *more* dominant leadership positions relative to their associated ETFs markets.

6.5.Analyses and Information Shares when Employing the Currency Futures

In this sub-section, we replicate the entire analyses of the above sub-sections (6.1 through 6.4) while using the currency futures in lieu of the spot exchange rates. Our focus now is on the

currency ETFs and their corresponding currency futures. In light of the recent mixed results on the leadership positions of the spot market relative to the futures market, an in-depth analysis of the ETFs vis-a-vis the futures market is also warranted. Our main intention is to investigate the relation of the ETFs markets with an additional, and highly relevant, underlying market. Some studies (for example, Rosenberg and Traub (2009)) show the inferior leadership role of currency futures relative to their spot markets. A lack of consensus on this position prompts an inquiry as to whether such conclusion would hold for currency ETFs , i.e., whether the currency futures market is less effective than the spot exchange market in its leadership position. Thus, it should be interesting to examine this point by matching the currency futures markets with their ETFs markets. Alternatively, given the well-established close relation between the currency spot and the currency futures markets, this sub-section provides a check on our results in sub-sections 6.1 to 6.4 on currency spot and currency ETFs .

Our results show that the information shares obtained from the currency futures markets are not, in most cases, much different from the spot currency markets. Though there are some variations between the two sets of results, overall the spot and the futures markets seem to hold the same position relative to the ETFs market. We conclude that both the spot and the futures foreign exchange markets possess larger informational role in the price discovery mechanism than their associated currency ETFs . The information shares during the non-crisis and crisis periods using either the spot or the futures rates remain roughly the same.

Since the results of the information shares using thecurrency futures vis-à-vis the currency ETFs are very similar to those between the currency spot and the currency ETFs , a subset of the results are provided in the Appendix.[21]

7. SUMMARY AND CONCLUSIONS

This paper examines the behavior of six major currency ETFs and their corresponding foreign exchange spot and futures rates using intraday data on four separate (non-overlapping and partially overlapping) periods surrounding the 2008 U.S. financial crisis. Minute-by-minute data over an entire period of 36 months are employed in different designated nine-month sub-periods in the analyses. Two alternative criteria, i.e., the NBER and the lowest points in the U.S. equity markets, are employed to pinpoint the peak of the U.S. financial crisis. The behavior of the currency ETFs and their corresponding FOREX spot and futures markets and in particular their efficienciesareanalyzed through a price discovery process wherein pairwise markets are matched. Additionally, the behavior of these markets over the non-crisis and crisis periods are statistically compared.

The resultsof the *overall* samples under the two alternative sample selections indicate that currency spot and futures markets make a greater contribution to the price discovery, while the associated ETFs markets play relatively a small role. Thus, the spot foreign exchange markets, as well as the futures currency markets, lead the currency ETFs markets significantly. The leadership positions of the spot and the futures markets vis-à-vis the ETFs market are roughly the same.

The results across the non-crisis and crisis periods are, in general, in conformity with the overall samples, though the information shares are not identical in theirsizes of leadership contributions. Some shifts in the magnitudes of the information shares are observed, though throughout the superior roles of foreign exchange spot rates or currency futures over their corresponding currency ETFs are observed. In general, under the two alternative sample selections, the spot and the futures markets lose some degrees of their leadership positions to the

ETFs markets in the crisis periods. Most of the information shares of the currency ETFs in the crisis periods are statistically significantly larger than those in the non-crisis periods. An interpretation of these results is that the spot exchange and the currency futures markets are more transparent and spot or futures prices can incorporate new information very efficiently when the markets are more stable. Some degrees of volatility and uncertainty thatare often attributed to the equity markets seem to be present in the ETFs market as well. These attributes seem to play a role in the price discovery process, resulting in some improvements in the ETFs leadership positions in the crisis-periods.

The results for the most part areuniformlyconsistent when the leadership positions of the currency ETFs markets vis-à-vis their associated currency spot and futures are analyzed.

A few clear conclusions also arise from our empirical analyses. First, the magnitudes of the information shares are dynamic, and they change across the non-overlapping and even across the partially overlapping periods. Second, the U.S. equity markets appear more in harmony with the ETFs markets, since the leadership positions of the U.S. ETFs markets under the stock marketscriterion show some improvements that are statistically significant.Third, under more stable and tranquil conditions, the foreign exchange currency markets (both spot and futures) possess more dominant leadership positions relative to their associated ETFs markets.Finally, the small information shares of the currency ETFs suggest a potential for the role of these markets as hedging instruments and passive indexing in other relevant markets. These are the subjects of future studies.

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TABLE I

Sample of the Estimated Error Correction Model for the Spot Exchange Rate and the Corresponding Currency Exchange Traded Fund

This table presents as an examplethe results of a bivariate VECM for only the spot Australian dollar (AUD) and its corresponding ETF (FXA). Similar estimation procedures are undertaken for all other pairs of the currency spots and currency futures with their associated currency ETFs . High frequency (minute-by-minute) data are employed. Through an iterative process, the estimation is repeated over the minutes for each day and for all pairs of currencies/ ETFs in each sample period. In all cases, the optimal lag is obtained by Schwarz Bayesian Criterion (SBC). In this instance, 12 lags for AUD/FXAareselected. Due to space limitation, this table presents only the first two lags. The *t*-statistics are shown in parentheses and the symbols *, **, and *** indicate statistical significance at the 10 percent, 5 percent, and 1percent, respectively.

	α	ΔAUD_{t-1}	ΔAUD_{t-2}	ΔFXA_{t-1}	ΔFXA_{t-2}
AUD	-0.000	0.002	0.001	-0.000	0.000
	(-0.36)	(0.82)	(0.47)	(-0.66)	(0.10)
FXA	-0.002***	21.654***	16.556***	-0.168***	-0.152***
	(-14.57)	(74.21)	(55.83)	(-67.12)	(-59.94)

TABLE II

Information Shares of Spot Exchange Rates and Currency ETFs
under the NBERRecession Date Designation

This table presents information shares over different time periods:the entire sample (Panel A), the non-crisis period (Panel B), and the crisis period (Panel C). These periods are selected based on the NBER recession date announcement (see sections4 and 5). The CurrencyShares ETFs are minute-by-minute trade prices. The spot exchange rates are the mid-quotes of the minute-by-minute bid and ask prices. Using these high frequency data, the upper and the lower bounds of the information shares are estimated for each day in the sample and are then averaged out. The average information share is the arithmetic mean of the paired upper and lower bounds.

Panel A: Entire sample period (9:30 A.M., April 1, 2007, to 4:00 P. M. September 30, 2008)

Information Shares	Upper Bound	Lower Bound	Average
Currencies			
AUD	0.971	0.909	0.940
CAD	0.973	0.913	0.943
CHF	0.960	0.901	0.930
EUR	0.979	0.788	0.884
GBP	0.943	0.894	0.918
JPY	0.979	0.832	0.906
CurrencyShares ETFs			
FXA	0.091	0.029	0.060
FXC	0.087	0.027	0.057
FXF	0.099	0.040	0.070
FXE	0.212	0.021	0.116
FXB	0.106	0.057	0.082
FXY	0.168	0.021	0.094

Panel B: Non-crisis period (9:30 A. M., April 1, 2007, to 4:00 P. M., December 31, 2007)

Information Shares	Upper Bound	Lower Bound	Average
Currencies			
AUD	0.963	0.922	0.943
CAD	0.964	0.919	0.942
CHF	0.941	0.904	0.922
EUR	0.976	0.908	0.942
GBP	0.913	0.872	0.892
JPY	0.980	0.888	0.934
CurrencyShares ETFs			
FXA	0.078	0.037	0.057
FXC	0.081	0.036	0.058
FXF	0.096	0.059	0.078
FXE	0.092	0.024	0.058
FXB	0.128	0.087	0.108
FXY	0.112	0.020	0.066

Panel C: Crisis period (9:30 A. M., January 1, 2008, to 4:00 P. M., September 30, 2008)

Information Shares	Upper Bound	Lower Bound	Average
Currencies			
AUD	0.979	0.896	0.937
CAD	0.982	0.907	0.944
CHF	0.980	0.897	0.939
EUR	0.982	0.668	0.825
GBP	0.973	0.916	0.945
JPY	0.978	0.777	0.877
CurrencyShares ETFs			
FXA	0.104	0.021	0.063
FXC	0.093	0.018	0.056
FXF	0.103	0.020	0.061
FXE	0.332	0.018	0.175
FXB	0.084	0.027	0.055
FXY	0.223	0.022	0.123

TABLE III

Test of Equality of the Information Sharesbetween the Non-Crisis and Crisis Periods under the NBER Recession Date Designation

This table presents paired *t*-statistic values on the equality of the information shares across the non-crisis and crisis periods. These periods are selected based on the NBER recession date announcement (see sections4 and 5).Note that due to the methodological construction, the results of the average information shares of the CurrencyShares ETFs are mirror images of their corresponding spot exchange rates, albeit opposite in sign by design. The symbols *, **, and *** indicate statistical significance at the 10 percent, 5 percent, and 1 percent, respectively.

Information Shares	Upper Bound	Lower Bound	Average
Currencies			
AUD	-2.56**	2.74***	0.69
CAD	-3.01***	1.35	-0.38
CHF	-5.16***	0.61	-1.97**
EUR	-1.73*	14.53***	12.88***
GBP	-5.64***	-3.47***	-4.59***
JPY	0.46	8.71***	7.63***
CurrencyShares ETFs			
FXA	-2.74***	2.56**	-0.69
FXC	-1.35	3.01***	0.38
FXF	-0.61	5.16***	1.97**
FXE	-14.53***	1.73*	-12.88***
FXB	3.47**	5.64***	4.59***
FXY	-8.71***	-0.46	-7.63***

TABLE IV

Information Shares of Spot Exchange Rates and Currency ETFs
under the Criterion of the Lowest Points in the U.S. Stock Markets

This table presents information shares over different time periods: the entire sample (Panel A), the non-crisis period (Panel B), and the crisis period (Panel C). These periods are selected based on the criterion of the lowest points in the U.S. stock markets (see sections4 and 5). TheCurrencyShares ETFs are minute-by-minute trade prices. The spot exchange rates are the mid-quotes of the minute-by-minute bid and ask prices. Using these high frequency data, the upper and the lower bounds of the information shares are estimated for each day in the sample and are then averaged out. The average information share is the arithmetic mean of the paired upper and lower bounds.

Panel A: The entire sample period (9:30 A.M., March 1, 2008, to 4:00 P.M., August 31, 2009)

Information Shares	Upper Bound	Lower Bound	Average
Currency			
AUD	0.981	0.834	0.907
CAD	0.984	0.869	0.926
CHF	0.977	0.881	0.929
EUR	0.986	0.598	0.792
GBP	0.982	0.869	0.926
JPY	0.981	0.741	0.861
CurrencyShares ETFs			
FXA	0.166	0.019	0.093
FXC	0.131	0.016	0.074
FXF	0.119	0.023	0.071
FXE	0.402	0.014	0.208
FXB	0.131	0.018	0.074
FXY	0.259	0.019	0.139

Panel B: Non-crisis period (9:30 A. M., March 1, 2008, to 11:07A.M., November 21, 2008)

Information Shares	Upper Bound	Lower Bound	Average
Currencies			
AUD	0.977	0.882	0.930
CAD	0.984	0.902	0.943
CHF	0.981	0.894	0.937
EUR	0.982	0.604	0.793
GBP	0.979	0.922	0.950
JPY	0.978	0.751	0.865
CurrencyShares ETFs			
FXA	0.118	0.023	0.070
FXC	0.098	0.016	0.057
FXF	0.106	0.019	0.063
FXE	0.396	0.018	0.207
FXB	0.078	0.021	0.050
FXY	0.249	0.022	0.135

Panel C: Crisis period (11:08 A. M.,November 21, 2008, to 4:00 P. M., August31, 2009)

Information Shares	Upper Bound	Lower Bound	Average
Currencies			
AUD	0.985	0.785	0.885
CAD	0.985	0.835	0.910
CHF	0.973	0.868	0.921
EUR	0.991	0.592	0.791
GBP	0.985	0.817	0.901
JPY	0.984	0.731	0.857
CurrencyShares ETFs			
FXA	0.215	0.015	0.115
FXC	0.165	0.015	0.090
FXF	0.132	0.027	0.079
FXE	0.408	0.009	0.209
FXB	0.183	0.015	0.099
FXY	0.269	0.016	0.143

TABLE V

Tests of Equality of the Information Share between the Non-Crisis and Crisis Periods under the Criterion of the Lowest Points in the U.S. Stock Markets

This table presents paired *t*-statistic values on the equality of the information shares across the non-crisis and crisis periods. These periods are selected based on the criterion of the lowest points in the U.S. stock markets (see sections4 and 5). Note that due to the methodological construction, the results of the average information shares of theCurrencyShares ETFs are mirror images of their corresponding spot exchange rates, albeit opposite in sign by design. The symbols *, **, and *** indicate statistical significance at the 10 percent, 5 percent, and 1 percent, respectively.

Information Shares	Upper Bound	Lower Bound	Average
Currencies			
AUD	-2.25**	7.91***	6.49***
CAD	-0.42	5.94***	4.97***
CHF	1.45	2.27**	2.23**
EUR	-3.41***	0.44	0.09
GBP	-2.30**	8.90***	7.66***
JPY	-1.55	1.19	0.83
CurrencyShares ETFs			
FXA	-7.91***	2.25**	-6.49***
FXC	-5.94***	0.42	-4.97***
FXF	-2.27**	-1.45	-2.23**
FXE	-0.44	3.41***	-0.09
FXB	-8.90***	2.30**	-7.66***
FXY	-1.19	1.55	-0.83

Appendix Table I.A

Information Shares of Currency Futures and Currency ETFs
under the NBER Recession Date Designation*

This table presents information shares of pairwise currency futures and currency ETFs over different time periods: the entire sample in Panel A, the non-crisis period in Panel B, and the crisis period in Panel C. These periods are selected based on the NBER recession date announcement (see sections 4 and 5). The CurrencyShares ETFs and the currency futures are minute-by-minute trade prices. Currency futures series are constructed using and rolling over near term contracts. The upper and the lower bounds of the information shares are estimated for each day in the sample and are then averaged out. The average information shares are the arithmetic means of the paired upper and lower bounds.

Panel A: Entire sample period (9:30 A.M., April 1, 2007, to 4:00 P. M. September 30, 2008)

Information Shares	Upper Bound	Lower Bound	Average
Currencies Futures			
AUD	0.949	0.875	0.912
CAD	0.949	0.870	0.910
CHF	0.942	0.874	0.908
EUR	0.968	0.770	0.869
GBP	0.923	0.872	0.898
JPY	0.959	0.795	0.877
CurrencyShares ETFs			
FXA	0.125	0.051	0.088
FXC	0.130	0.051	0.090
FXF	0.126	0.058	0.092
FXE	0.230	0.032	0.131
FXB	0.128	0.077	0.102
FXY	0.205	0.041	0.123

Panel B: Non-crisis period (9:30 A. M., April 1, 2007, to 4:00 P. M., December 31, 2007)

Information Shares	Upper Bound	Lower Bound	Average
Currencies Futures			
AUD	0.942	0.892	0.917
CAD	0.941	0.883	0.912
CHF	0.912	0.871	0.892
EUR	0.963	0.886	0.924
GBP	0.892	0.852	0.872
JPY	0.951	0.841	0.896
CurrencyShares ETFs			
FXA	0.108	0.058	0.083
FXC	0.117	0.059	0.088
FXF	0.129	0.088	0.108
FXE	0.114	0.037	0.076
FXB	0.148	0.108	0.128
FXY	0.159	0.049	0.104

Panel C: Crisis period (9:30 A. M., January 1, 2008, to 4:00 P. M., September 30, 2008)

Information Shares	Upper Bound	Lower Bound	Average
Currencies Futures			
AUD	0.956	0.859	0.908
CAD	0.957	0.857	0.907
CHF	0.971	0.877	0.924
EUR	0.973	0.652	0.813
GBP	0.955	0.893	0.924
JPY	0.968	0.748	0.858
CurrencyShares ETFs			
FXA	0.141	0.044	0.092
FXC	0.143	0.043	0.093
FXF	0.123	0.029	0.076
FXE	0.348	0.027	0.187
FXB	0.107	0.045	0.076
FXY	0.252	0.032	0.142

*The expanded results of the information shares using the currency futures are available upon request.

Endnotes

[1]Rydex Investments Currency Shares ETFs. See also David Bogoslaw, "Smarter Ways to Make Currency Plays," BusinessWeek, February 11, 2008.

[2]Specifica, Inc., http://etf.stock-encyclopedia.com/category/currency-etfs.html

[3] Chu, Hsieh, and Tse (1999) provide an excellent explanation of these four hypotheses and informed trading.

[4] For country-specific international studies, see, for example, Grünbichler et al. (1994) for Germany, Abhyankar (1995) for the U.K., Iihara et al. (1996) for Japan, Shyy et al. (1996) for France, De Jong and Donder (1998) for the Netherlands, Zhong et al. (2004) for Mexico, and Rittler (2012) for the European Union.

[5]E-mini futures has had substantial growth in recent years and currently accounts for a substantially higher percent of the overall futures market.

[6] Some exceptions do exist. See, for instance, Poskitt (2009) and Rosenberg and Traub (2009).

[7] This statement applies to the periods of the studies reviewed. In general, the volume of electronic trading has been increasing, while the volume of floor trading has been decreasing.

[8]De Jong (2002) concludes that Hasbrouck's (1995) information share is a more accurate estimator for the information generated in each asset. However, some studies show that the results from Gonzalo and Granger (1995) are qualitatively similar to Hasbrouck's information share (see, for example, Poskitt (2009)).

[9] See Hasbrouck (1995) on page 1181 for further explanation.

[10] According to the prospectus of CurrencyShares, "… each CurrencyShares Trust issues shares that represent units of fractional undivided beneficial interest in, and ownership of, the Trust. Shares may be purchased from each Trust only in one or more blocks of 50,000 Shares, called

"Baskets". The Trusts issue shares in Baskets on a continuous basis to authorized participants (Depository Trust Company participants that are registered broker-dealers or other securities market participants, such as a bank or other financial institution, that are not required to register as a broker-dealer to engage in securities transactions, and that has entered into a Participant Agreement with the Trustee). It is expected that shares of each Trust will be offered and sold to the public by authorized participants at varying prices in U.S. Dollars to be determined by reference to, among other things, the market price of the currency held by the particular Trust and the trading price of the shares on the NYSE Arca at the time of each sale. Authorized Participants will not receive from the Trust, the Sponsor or any of their affiliates, any fee or other compensation in connection with the sale of shares, although they may receive commissions or fees from investors who purchase shares through their commission- or fee-based brokerage accounts." (Source: www.currencyshares.com).

[11] There are 13 holidays in the entire sample data: Good Friday (April 6, 2007, and March 21, 2008), Memorial Day (May 28, 2007, and May 26, 2008), Independence Day (July 4, 2007, and July 4, 2008), Labor Day (September 3, 2007, and September 1, 2008), Thanksgiving Day (November 22, 2007), Christmas Day (December 25, 2007), New Year's Day (January 1, 2009), Martin Luther King Day (January 21, 2009), and President Day (February 18, 2009).

[12] The more liquid and more active near-term futures is a good representation of the activities in the futures markets.

[13] The reason for using the lowest point in the U.S. equity markets is due to the fact that the 2008 crisis that started from the fixed income markets spread significantly into the equity markets. The resultant turmoil in the U.S. equity markets was so great that it spread out quickly and

globally. Moreover, it is common to refer the sustained downward movements in an equity market as the beginning of a recession period.

[14] The results of the stationarity and cointegration tests are available upon request.

[15] These relate, for the most part, to the econonmetric aspects of the estimated coefficients and other statistical measures, e.g, short- and long-term attributes, cointegration rank(s), DWs, adjusted R squares, etc.

[16] The results of the currency futures vis-à-vis the currency ETFs are included in sub-section 6.5.

[17] Our argument is consistent with Rosenberg and Traub (2009), who attribute larger information shares in the spot exchange market to more transparency in this market.

[18] We note that due to the methodological construction, the results of the average information shares of the CurrencySharesETFs are mirror images of their corresponding spot exchange rates, albeit opposite in sign by design.

[19] The lowest points in the three major U.S. stock markets, namely, the Dow Jones, the S&P 500, and the NASDAQ, were on November 21, 2008, at 11:08 A.M. EST.

[20]GBP is the only exception in the overall sample.

[21] The expanded results of the information shares using the currency futures are available upon request.