Price Discovery in the Foreign Exchange Futures Market

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Abstract

We examine the relative contributions to price discovery of the floor and electronically traded Euro FX and Japanese yen futures markets and the corresponding retail online foreign exchange spot markets. Globex electronic futures contracts provide the most price discovery in the Euro; the online trading spot market provides the most in the Japanese yen. The floor-traded futures markets contribute the least to price discovery in both the Euro and the Japanese yen markets. The overall results show that electronic trading platforms facilitate price discovery more efficiently than floor trading. Futures traders may also extract information from online spot prices.

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INTRODUCTION

The ability of futures markets to provide information about prices—price discovery—is an integral component of an efficient economic system. Futures facilitate price discovery by providing an open forum for public and private information held by various agents. Foreign currency futures, the first financial futures contracts in the U.S., began trading in the Chicago Mercantile Exchange (CME) trading pits in 1972. Since the late 1990s, traders have been able to conduct transactions in the pits or on the CME Globex electronic trading platform.

According to the Bank for International Settlements' Triennial Survey 2004, the global foreign exchange (FX) market is the world's largest financial market, with an average daily turnover of $1.9 trillion. The most recent innovation in the FX spot market is online trading platforms, which have attracted many retail traders. In April 2000, as the tech-stock sector started to melt down, Luke (2005) finds stock online traders flocked to the FX market, only to face a similar trading environment. Consequently, the online FX spot market began to expand significantly in 2001.

On a typical electronic platform, customers can see how their orders behave in relation to other orders— that is, whether theirs are the best priced buy and sell orders. We compare the price discovery process on floor-traded and Globex FX futures markets and the online FX spot markets.

Han and Ozocak (2002) show that FX futures are responsive to public information and are very liquid. Wang (2002) suggests that large FX futures players such as commercial dealers, commercial banks, and multinational corporations are also major players in other

FX-related transactions. Few researchers have systematically examined price discovery in the FX market, particularly in FX futures markets. Martens and Kofman (1998) show that, in 1993, before the introduction of Globex futures and online spot trading, FX floor-traded futures prices led Reuters' inter-dealer indicative spot quotes by one to three minutes.

Authors including Stoll and Whaley (1990) and Chan (1992) have found that stock index futures prices lead spot prices, indicating that the futures market disseminates information more rapidly than the underlying spot market. We examine FX futures price discovery in the Euro and Japanese yen markets for three months, May through July 2004. We focus on the relative importance of two dimensions of price discovery: type of instrument (futures vs. spot instruments), and trading mechanism (electronic vs. floor trading). Other authors have examined these issues separately.

We find that the Globex futures market plays a dominant role in price discovery for the Euro, while for the Japanese yen, retail electronic spot trades contribute more than both electronic and floor-traded futures. These results are consistent with Theissen (2002) and Hasbrouck (2003), who find that electronic markets contribute significantly to price discovery. The results also indicate that traders favor electronic systems because of immediacy and anonymity of trading.

DATA AND MARKET STRUCTURES

We examine the futures and electronic spot trades for $/Euro and Japanese yen/$, the two most actively traded currency pairs in both spot and futures markets. Our data cover the period from May 3 through July 30, 2004. We exclude Saturdays, Sundays, and two U.S. holidays: Memorial Day (May 30) and the day after Independence Day (July 5).

Futures Markets

Futures contracts on major currencies trade side-by-side on the CME trading floor (via open outcry) and the Globex electronic trading platform. Floor trading hours run from 7:20 a.m. to 2:00 p.m., Chicago time; Globex trades around the clock with a one-hour break for maintenance from 4:00 p.m. to 5:00 pm. Customer bids and asks are presented by pit brokers to other brokers in the pit. Trades are matched when prices are mutually acceptable to both buyers and sellers. Bids and offers are conveyed by voice and hand signals, and every trader acts as an auctioneer. Trading in the pit is not anonymous; a trader can choose with whom to trade when several traders are offering the same bid and ask price. This open outcry allows full and open competition among traders confronting each other.

In the screen-based trading of Globex, traders send buy or sell orders directly from their computers to an electronic marketplace offered by the CME. In essence, the trading screen replaces the trading pit, and electronic market participants replace the brokers in the pit. The Open Access policy implemented in 2000 eliminated membership requirements for trading on Globex.

Globex is a continuous auction system with automatic order matching in a central order book. It provides users real-time market prices (the CME Globex Book), including the availability of aggregate order volumes to buy or sell in the market at various price levels. Trading is anonymous; traders in the market will not be able to identify whose orders they are viewing or against whom they are trading. Execution follows strict price and time priority.

Average customer response on Globex is less than a second, while executions in open outcry trading take a few seconds. Globex screens are installed around the pits, and the trading floor systems are linked to Globex. Traders in the pits can use their Globex hand-held devices to conduct parallel electronic trading. The CME Clearing House clears, settles, and guarantees the performance of all transactions matched through execution facilities, including CME Globex. At CME, an increasing majority of traders prefer to trade electronically, and most members expect that the pits will eventually be closed or become inactive.

Kurov and Lasser (2004) and Tse and Bandyopadhyay (2006) observe that Globex trading enhances pricing transparency. Even during normal trading periods, there may be different prices simultaneously in different areas of the futures pit. All traders around the world with access to Globex, however, can see current bid and offer quotes and fill their orders at the best prevailing price on a time-priority basis.

One Euro contract represents 125,000 Euro, and one Japanese yen contract represents 12,500,000 yen. The electronic Euro (Japanese yen) futures market has a daily average volume of 58,913 (16,457) contracts, considerably higher than the floor-traded market, which has a daily average of 13,619 (10,027) contracts.

Although FX futures contracts are actively traded, only a small portion of total FX trading takes place in the futures market. Writing about the era when dealers traded with each other either directly or indirectly through voice-brokers, Harvey and Huang (1991) argue that the futures market is intimately linked to the interbank spot market: “In the interbank market, simultaneous trades often occur at different prices, so that the single price posted by the futures exchange becomes an important source of information to the traders who are typically active in both markets” (p. 546). This argument has become less tenable in the 1990s with the introduction of electronic brokers and a high degree of pricing transparency.

We use time and sales data for the CME open outcry market, which records trading prices only when there is a change. Prices are time-stamped to the second. The Globex time and sales data record every trade whether there has been a price change or not. Following Hasbrouck (2003), we use the active nearby futures contracts for both markets, until five trading days before maturity: the June 2004 contract for May 3 to June 7, 2004, and roll over to the September 2004 contract for June 8 to July 30, 2004.

Retail Online Spot Markets

We obtain electronic spot bid and ask quotes for the Euro and Japanese yen from Olsen and Associates, the most popular FX data vendor for academics. This database consists of intraday quotes from the CMC Group Plc's online platform. CMC spot quotes have a constant spread of 3 pips (or $0.0003), competitive with the interbank spreads. We use midquotes (averages of the bid and ask quotes) in the analysis. Such fixed spreads also include brokerage fees usually charged in other markets, and there is no good way to separate other fees from the true spread. Volume and trade data on this trading platform are not available.

The London-based CMC Group, the first to launch commission-free online retail trading in 1996, should provide a good representation of contributions to price discovery of all *retail* online spot trades, but arbitrage across online platforms is unlikely. Other popular retail online trading sites include FXCM, OANDA, and IFX Markets. Data and market share of these online sites are not publicly available.

The CMC online trading platform offers free 24-hour real-time spot quotes, Dow Jones News, and charting packages to subscribed users. Customers can deal in lot sizes as small as USD 10,000 (or equivalent), and margins are only 1% of the deal amount. Although the platform does not provide futures price information, retail online spot traders often watch for

FX futures price fluctuations by opening trading windows from multiple brokers. They try to deduce FX movements from futures markets. CMC customers are able to execute trades in a second against the displayed spot prices without requesting a quotation.

As Rime (2003) points out, many online platforms are organized as crossing networks that obtain their prices from other trading venues; therefore, there is no price discovery. The CMC online site, called Marketmaker (or Deal4Free), however, is similar to traditional direct trading with its own price discovery function. The online site mimics electronic brokers, but most often the site is a counterparty to all trades, so customers do not need to assume counterparty risk themselves.

The open and price-driven service ensures that dealers will not "read or shade," or quote prices based upon a particular customer's position, as the software provides complete price transparency. CMC may on its own choose the "shade quotes" to balance inventory by lowering (raising) the quotes when the market maker is long (short) relative to its preferred inventory level.

While retail electronic trading in the FX spot markets has been exploding, most of the trading is concentrated in the interbank market. Currently, two electronic brokering systems are used globally for interbank spot trading, one offered by Electronic Broker System (EBS) and one offered by Reuters (Dealing 2000-2). Euro/$ and yen/$ are traded primarily on EBS, while sterling/$ is traded mainly on Reuters (see Chaboud et al., 2004). The growth of liquid interbank electronic broker systems has also increased the pricing transparency of the FX markets and diminished the use of shade quotes for inventory adjustment. The EBS and Dealing 2000-2 data reflect firm and executable (not indicative) quotes, with data available only to subscribers.

METHODOLOGY

As futures prices and spot rates in the FX markets are driven by the same underlying information, they should be closely related. Significant divergences would provide traders with inter-market arbitrage opportunities and cause prices to converge to within a reasonable range. Thus, FX prices of electronic and non-electronic futures and spot trades should be cointegrated with one common stochastic factor.

There are two methods to measure price discovery shares by exploring the common factor: the Hasbrouck (1995) information share model, and the Gonzalo and Granger (1995) permanent-transitory model. The Gonzalo-Granger model measures the components of the common factor and the error correction processes; the Hasbrouck model examines price discovery in terms of the innovation variances of the common factor.

Both models can be derived from a vector error correction model (VECM) of n cointegrated time series $Y_t \equiv \{y_{it}\}$, of the form:

$$\Delta Y_t = \alpha\beta' Y_{t-1} + \sum_{i=1}^{k} A_i \Delta Y_{t-i} + \varepsilon_t \tag{1}$$

where α is the error correction vector, the A_t are $n \times n$ matrices of parameters, and ε_t is a vector of serially uncorrelated residuals with a covariance matrix $\Omega = \{\sigma_{ij}\}$. β is the cointegration vector spanned by the differentials of each pair of series. These results are estimated and tested using the Johansen (1991) tests.

The VECM can also be represented in an integrated form of a vector moving average:

$$Y_t = \iota\eta\left(\sum_{\tau=1}^{t} \varepsilon_\tau\right) + \Psi(L)\varepsilon_t \tag{2}$$

where ι is a column vector of ones, $\eta = (\eta_1, \cdots, \eta_2)$ is a row vector, and Ψ is a matrix polynomial with lag terms indicated by the lag operator L. The first expression in Equation (2) is the common factor component f_t, and the second portion is the transitory component, which does not have a permanent impact on Y_t. Hasbrouck (1995) demonstrates that the incremental component $\eta\varepsilon_t$ in (2) is the contributing factor to Y's common factor, and also defines the information share of a market as the proportional contributions of var($\eta\varepsilon_t$) to innovations in market.

A simplified form of the Hasbrouck (1995) information share for series that have a diagonal covariance matrix is:

$$IS_i = \frac{\eta_i^2 \sigma_i^2}{\eta \Omega \eta'} \tag{3}$$

if cross-equation residuals are uncorrelated. With significantly correlated residuals, Hasbrouck (1995) uses the Cholesky factorization of $\Omega = CC'$, where C is a lower triangular matrix, to eliminate the correlation. Estimates of information share vary according to the orderings of the variables in the Cholesky factorizations, and are given as

$$IS_i = \frac{([\eta C]_i)^2}{\eta \Omega \eta'} \tag{4}$$

where $[\eta C]_i$ is the ith element of the row of matrix ηC. Such varying estimates can provide the lower and upper bounds of a market's information share. Baillie et al. (2002) show further that the mean of the information shares from all orderings is a reasonable estimate of a market's price-discovery share.

Gonzalo and Granger (1995) decompose the common factor f_t itself into $f_t = \omega X_t$, which is a linear combination of the prices. The 1 × n vector of $\omega = (\omega_1, \cdots, \omega_n)$ is the common factor coefficient vector with the property that $\sum_{i=1}^{n} \omega_i = 1$, from which Harris, McInish, and Wood (2002) suggest that the ω_i can be heuristically treated as portfolio weights. ω_i is also orthogonal to the error efficient vector α.

Baillie et al. (2002) and De Jong (2002) show that the two common-factor models yield similar results only if the residuals in Equation (1) are uncorrelated and cross-sectional variances, σ_i^2, are similar. Substantial correlations among residuals can cause divergent results. Hasbrouck also shows that differences due to correlations of high-frequency data (e.g., one-second quotes) could be small, and thus the upper and lower bounds of information share are very close.

RESULTS

We examine the average frequency of price observations during the CME floor trading hours for 15-second, one-minute, and five-minute intervals (Panel A of Table I). A price from the floor is recorded only when the price is different from the previous one; there is actually more frequent floor trading than reflected in the price observations. The Globex futures market shows the most frequent trading, followed by the CMC electronic platform, and finally by the floor-based futures. While Globex is active enough for 15-second intervals in the Euro market with 7.8 observations per time interval, both the floor-traded futures and the CMC electronic retail spot average under one observation per interval. If we use one-minute intervals, we would omit many quotes from Globex, which has a frequency per interval of 31 observations for the Euro and 5 observations for the Japanese yen. Panel A also shows that

Globex is much more active (in terms of the number of quotes) than CMC in the Euro market, but both are similarly active in the yen market. If we use five-minute intervals, we further increase the number of observations per interval to about 18 for the CMC trading of Euro and yen.

Panel B also indicates that while about 45% of the 15-second intervals for the CMC Euro have no observations, only 10% and 0.3% of the one-minute and five-minute intervals have none. The variance analysis reported in Panel C shows that the futures pit and CMC spot market have similar volatility, and Globex is more volatile than either of them. Moreover, the less frequent the data, the less different the volatility. For the Euro market, the 15-second return variance of Globex is about five times the variance of the floor futures and the CMC spot, dropping to 2.0 times and 1.1 times with one-minute and five-minute sampling intervals, respectively. Similar results are experienced by the yen market.

The higher-frequency 15-second and one-minute samples may mistakenly allow us to infer some impact of the stable CMC prices on the volatile Globex prices, thus producing a downward bias to the contribution of the CMC in price discovery. Using five-minute samples can mitigate this potential estimation bias and make the CMC prices closer to the true spot-price variance.[1] Yet lower sampling frequency means that we discard more data from the more active markets with higher trading frequencies. This procedure would produce a downward bias on the price discovery role of the market with the more frequent trading. As the last part in Table I indicates, the lower the sampling frequency (or the longer the sampling time interval), the higher the contemporaneous return correlation between the markets. Hence, five-minute sampling may obscure the relative price dynamics of the markets.

[1] We thank a referee for this suggestion.

We estimate the price discovery results using 15-second, one-minute, and five-minute intervals for robustness checking. Intervals with no observations are filled in by using prices from the previous interval. Following Hasbrouck (2003) and Hendershott and Jones (2005), we estimate the price discovery process for each day during the futures market floor trading hours and average the results across days. Averaging the results can mitigate the effects of overnight price changes and the rollover of futures contracts. Because averages of the mean, lower bound, and upper bound information shares reported in Table II all suggest the same conclusion, we use only the mean to describe the results.

Panel A summarizes the Hasbrouck information share results for the Euro and the Japanese yen. When 15-second intervals are used, the Globex Euro futures contributes 57.9% of price discovery; followed by the CMC spot trades (30.9%), and the floor-traded futures (11.1%). In the Japanese yen market, retail electronic spot trades contribute 57.5%, more than both futures contracts combined: Globex futures (29.4%), and floor-traded futures (13.2%). CMC spot trading is associated with the highest price discovery in the yen market, but not in the Euro market, a result that is consistent with the results in Table I. It shows that CMC and Globex are similarly active in the yen, but CMC is much less active than Globex in the Euro.

When one-minute intervals are used, price discovery in the Euro from Globex drops to 41.5%, which is still greater than the retail electronic spot market (33.1%) and the floor futures (25.3%). Correspondingly, in the Japanese yen market, the CMC information share drops to 43%, which is still more than from either Globex (36.7%) or the floor futures (20.3%). Similarly, the five-minute analysis retains the order of contribution to price discovery: for the Euro, Globex (37.5%), followed by CMC (34.0%) and floor futures (28.5%); and for the Japanese yen, CMC (38.9%), followed by Globex (31.1%) and floor futures (30.0%).

When we compare the results of 15-second, one-minute, and five-minute intervals, the order of importance in price discovery does not change: Globex, CMC, and floor-based futures in the Euro market; and CMC, Globex, and floor-based futures in the Japanese yen market. In both Euro and yen markets, floor-traded futures contracts provide the least amount of price discovery. However, the difference in information shares between markets is less when lower-frequency data are used. These results are consistent with our conjecture that with a longer sampling time interval, when more observations are discarded from the more active markets, the differentials in price discovery shares are reduced.[2]

We should emphasize that price discovery is a *relative* concept. To say that a market provides more price discovery (or more of an information share) does not necessarily mean that this market is the initial or the ultimate source of information. We compare only the relative information discovery roles in the three specific markets. For instance, the results showing that Globex contributes the most information in Euro trading suggest merely that traders (or the prices from the trading system) in Globex react more quickly than traders in the other two markets to information coming from some sources during the CME trading hours.

Panel B of Table II demonstrates similar results using the permanent-component model. All the common-factor coefficients are also significantly different from zero according to the Gonzalo-Granger Q statistics ($p < 0.001$). Our results overall show the important role of retail electronic trades in the FX market. We also find that floor-traded FX futures contribute less to price discovery than electronic spot quotes.

CONCLUSIONS

We examine the relative contributions to price discovery of CME floor-traded futures, electronic Globex futures, and electronic retail online spot trading in the Euro and Japanese yen markets. Of the three markets, Globex futures contracts provide the most price discovery for the Euro while the retail online trading spot market provides the most for the Japanese yen. Floor-traded futures markets contribute the least to price discovery for both the Euro and Japanese yen markets. Our results are consistent with those in the Theissen (2002) and Hasbrouck (2003) studies on stock markets, in that electronic trading systems account for a greater share of price discovery than the floor trading system. The results suggest that traders favor electronic systems because of immediate and anonymous trading. Although retail online trading represents a small portion of FX spot trading, we find it important in price discovery. Foreign Exchange futures traders can enhance their price discovery processes by incorporating information from online spot trading. We expect that using interbank EBS data in future research will indicate that spot trading assumes a greater share in price discovery.

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[2] As suggested by the referee, the results could also be affected by the relative difference in volatility between markets using the 15-second, one-minute, and five-minute intervals.

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TABLE I
Average Frequency of Quotes and Variance Analysis of Returns
May–July 2004

	Euro			Japanese yen		
	15-second	One-minute	Five-minute	15-second	One-minute	Five-minute
Panel A: Frequency of Quotes[a]						
Floor futures	0.37	1.48	7.38	0.19	0.76	3.81
Globex futures	7.76	30.99	154.82	1.25	4.99	24.92
CMC electronic spot	0.94	3.77	18.82	0.91	3.64	18.17
Panel B: Proportion of Intervals with No Observations[a]						
Floor futures	0.711	0.351	0.042	0.837	0.547	0.131
Globex futures	0.098	0.005	0.000	0.479	0.136	0.004
CMC electronic spot	0.447	0.104	0.003	0.477	0.123	0.003
Panel C: Variance Analysis of Returns						
Variance of Returns (e-2)						
Floor futures	0.026	0.110	0.583	0.036	0.146	0.724
Globex futures	0.113	0.199	0.652	0.374	0.737	1.304
CMC electronic spot	0.026	0.101	0.547	0.033	0.133	0.686
Coefficient of Correlation						
Floor futures and Globex	0.279	0.579	0.855	0.202	0.353	0.695
Floor futures and CMC	0.651	0.845	0.959	0.683	0.814	0.935
Globex and CMC	0.307	0.625	0.873	0.225	0.385	0.727

[a]The floor trading records the price only when it is different from the previous one; therefore, the frequency (the proportion of missing intervals) of floor trading is greater (smaller) than reported.

TABLE II
Price Discovery in the Euro and Japanese Yen Futures and Retail Online Spot Markets
May─July 2004

	Euro			Japanese yen		
Panel A: Information Shares						
	Mean	Max	Min	Mean	Max	Min
15-second intervals						
Floor futures	0.111	0.213	0.038	0.132	0.215	0.063
Globex futures	0.579	0.761	0.426	0.294	0.411	0.192
CMC electronic spot	0.309	0.492	0.155	0.575	0.726	0.439
One-minute intervals						
Floor futures	0.253	0.501	0.080	0.203	0.381	0.073
Globex futures	0.415	0.691	0.196	0.367	0.576	0.197
CMC electronic spot	0.331	0.621	0.110	0.430	0.691	0.215
Five-minute intervals						
Floor futures	0.285	0.705	0.040	0.300	0.694	0.057
Globex futures	0.375	0.833	0.091	0.311	0.689	0.066
CMC electronic spot	0.340	0.816	0.042	0.389	0.813	0.099
Panel B: Permanent Components						
15-second intervals						
Floor futures	0.147			0.183		
Globex futures	0.519			0.229		
CMC electronic spot	0.335			0.589		
One-minute intervals						
Floor futures	0.303			0.276		
Globex futures	0.377			0.284		
CMC electronic spot	0.320			0.440		
Five-minute intervals						
Floor futures	0.215			0.259		
Globex futures	0.398			0.310		
CMC electronic spot	0.387			0.431		

The information shares are calculated by the Hasbrouck (1995); the permanent components by the Gonzalo and Granger (1995) model during the floor-trading hours. All the common-factor coefficients reported in Panel B are significantly different from zero according to the Gonzalo-Granger Q statistics ($p < 0.001$).