Price Discovery Across Geographic Locations in the Foreign Exchange Market

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- *A new class of exchange rate models focuses on the institutions and trading behaviour of market participants in the foreign exchange market in an environment where private information is dispersed.*
- *The average information content of trades is measured in two relatively liquid foreign exchange markets: the US-dollar/Australian-dollar market and the US-dollar/Canadian-dollar market.*
- *Evidence presented in this article suggests that, in addition to dealers operating in the world's largest foreign exchange commercial centres, dealers domiciled in a country whose currency is being traded have superior information about the fundamental or long-run value of the exchange rate.*

* The research reported in this article is summarized from a working paper written by the author (D'Souza 2007).

In the foreign exchange market—the world's largest financial market—access to information about the future direction of the exchange rate can be extremely valuable. With average daily turnover that surpassed US$3 trillion in April 2007 (BIS 2007), it is important that foreign exchange (FX) markets are efficient and liquid if participants are to make sound international trade, investment, and consumption decisions.[1]

Unlike equity markets, where some investors may have more precise information on the business operations and conditions of a company, information about the exchange rate is assumed to be public and simultaneously available to all interested participants. This assumption of market efficiency, which is common in the academic literature, reflects the belief that relevant information about the exchange rate is related to macroeconomic variables such as foreign and domestic nominal interest rates, inflation rates, and output levels. It also reflects the belief that, globally, FX dealers have access to similar, real-time news feeds that broadcast new information about these variables immediately after it is released.

Since earlier models of exchange rate determination based on macroeconomic fundamentals had little success in explaining exchange rate movements, some recent models have departed from the assumption of

1. Market liquidity refers to the ability of market participants to quickly execute large trades without causing a significant movement in prices, while informational efficiency in financial markets is a measure of the speed with which all public and private information is reflected in prices. See Bauer (2004) for a detailed discussion of market efficiency.

efficient markets.[2] In particular, these newer models focus on market microstructure, i.e., the trading behaviour of market participants and the institutions of the FX market in an environment where private information is dispersed. Several studies, including Evans and Lyons (2002) and Payne (2003), provide empirical support for the hypothesis that FX order flow, a measure of buying or selling pressure in the market and a key variable in the microstructure literature, can explain up to two-thirds of the variation in exchange rate returns.

Customer orders are a key element of these models and are assumed to be the catalyst for all subsequent interdealer trading. Evans and Lyons (2007), for example, suggest that individual customer trades in FX markets contain bits of information about the underlying fundamentals that drive movements in the exchange rate. Their theory is based on the assumption that these pieces of information, taken together as part of aggregated order flow, are able to convey information to dealers about the state of the macroeconomy. The information is conveyed as dealers engage in price discovery, the process in which relevant information is reflected in prices (or exchange rates).

Order flow is a valuable source of information that can be used to attract additional customers.

An FX dealer trading with a customer is in a position to learn about, or acquire, private information. Although some individual orders may not be very informative, when trading is frequent or the quantity traded is significant, a dealer can adjust his or her perception of the customer's overall observed order flow. Dealers will also try to deduce the customer order flow of other dealers through interdealer trades. This aggregate measure of order flow is a valuable source of information that can be used to attract additional customers who also want to obtain better forecasts of future exchange rate movements. It also conveys information about the fundamental value of the exchange rate (Evans and Lyons 2007).

This article examines the impact of a trader's geographic location on price discovery.[3] Recent empirical evidence confirms that certain market participants in the foreign exchange market are better informed than others about the future direction of the exchange rate. The trades of financial institutions, for example, are more informative than those of non-financial firms.[4] It has been suggested as well that major international financial centres such as New York, London, and Tokyo, which operate during the core business hours in North America, Europe, and Asia, respectively, may have a natural advantage in the intermediation of trades (Gaa et al. 2001).[5] Simply by operating during the hours when potential customers are conducting their business operations, dealers may be able to increase their involvement in customer deals. Furthermore, many international financial institutions devote significant amounts of capital to their trading desks in these locations.[6]

This article takes a market microstructure approach to account for the flow of information in the FX market.[7] It focuses on the US-dollar / Australian-dollar and the US-dollar / Canadian-dollar FX markets—the fourth and sixth largest currency markets (CAD and AUD will hereafter be used to represent these exchange rates and their respective FX markets.)[8] Results from studies focusing on the largest FX markets, such as the markets for the US dollar / euro or the US dollar / Japanese yen, may not accurately represent the majority of FX markets operating in the global marketplace.[9]

2. Meese and Rogoff (1983), for example, show that the macroeconomic variables that are the basis of the asset-model approach do not move exchange rates as predicted. Bailliu and King, in their review (2005) of the literature in this area, suggest that models based on macroeconomic fundamentals have had little success at explaining or forecasting exchange rate movements because of the simplifying assumptions that they use.

3. Covrig and Melvin (2002) find that interdealer quotes from Japanese traders lead quotes in the rest of the US-dollar / Japanese-yen market, while Sapp (2002) finds that banks in several European and U.S. locations exhibited price leadership in the former US-dollar / German-mark market.

4. See Bjønnes, Rime, and Solheim (2005); Fan and Lyons (2003); Froot and Ramadorai (2002); and Osler, Mende, and Menkhoff (2006).

5. Hong Kong and Singapore also have a significant market share of global FX trading, especially during Asian trading hours (BIS 2007).

6. The ability to offer competitive quotes to customers is also an important factor in determining a dealer's share of customer-dealer trades. The formation of a dealer's quotes will be related to how effectively dealers manage their inventories and any undesired positions. D'Souza and Lai (2006) illustrate how market-making activities are influenced by the risk-bearing capacity of a dealer, which is itself determined by the amount of risk capital allocated to this activity by each financial institution.

7. Theoretical research suggests that the strategic behaviour of informed and uninformed market participants affects price dynamics. See Grossman and Stiglitz (1980); Kyle (1985); and Glosten and Milgrom (1985).

8. The U.S. dollar is always the base currency used for conversions.

9. The CAD and AUD markets examined in this article represent 4 per cent and 6 per cent of total FX currency volumes, respectively. The largest FX markets, the US-dollar / euro, US-dollar / Japanese yen, and US-dollar / British pound sterling, account for 27 per cent, 13 per cent, and 12 per cent, respectively, of total trading in all currency markets (BIS 2007).

Given the relatively small and open nature of the Australian and Canadian economies, firms, investors, and even consumers may spend significant resources on managing foreign exchange risk (Bank of Canada 2008). These relatively liquid markets are analyzed so that the results can be compared over a sample period with similar external market conditions.

The research reported here also provides insight into a related concern. The growing importance of global financial trading centres and the ensuing competition for order flow is raising questions about the long-run viability of "national" financial markets. In light of this, can dealers domiciled in smaller national markets provide value to their customers via information about future movements in exchange rates similar to that supplied by those in the larger global marketplaces?[10]

The article begins with a brief overview of the institutions of the FX market, followed by a description of the methodology used for the study. The empirical analysis that follows examines the relationship between trades initiated in different locations and exchange rate returns to determine the information content of trades. Evidence on the significance of geographic location and hours of operation is presented in the summary of the results. The article concludes with a summary of the findings.

The Structure of FX Markets

In the spot FX market, trades take place between customers and dealers, or between dealers in the interdealer segment of the market. Customers are the financial and non-financial firms that are the end users of foreign exchange currencies used for settling imports or exports, investing overseas, hedging business transactions, or speculating. It is important to note that customers do not necessarily reside in the dealer's geographic location.

Interdealer trading accounts for between 40 per cent and 60 per cent of total trading in the FX market, since dealers manage their inventories by trading with each other.[11] In this segment of the market, trades are executed either directly or via an interdealer broker (IDB) to ensure anonymity. IDBs match the best orders among dealers and disseminate dealer quotes to the market without revealing the identity of the dealer.[12]

Unlike equity exchanges, trades in the FX market occur continuously around the clock.

Unlike equity exchanges, which have fixed opening and closing hours, trades in the FX market occur continuously around the clock. Since customers may be located across different time zones, trading must be organized in a decentralized fashion. Important differences are thus thought to exist in the dynamics of trading and liquidity provision across time and markets. This study is unique in that it simultaneously accounts for both the location from which a trade is initiated and the regional business hours in each location.[13]

Methodology

Completed transactions are analyzed, rather than the indicative quotes used elsewhere in the literature.[14] The data set includes all market orders executed with a single IDB in the CAD and AUD markets over the 2-year period from 1 October 2000 to 30 September 2002. This is unique because, in addition to the transacted exchange rate and the volume associated with each trade, the data set discloses the geographic location of the initiator of the trade (i.e., the country where the market order was entered into the IDB's electronic trading platform). This information is necessary to establish whether dealers in one location have an informational advantage over those in another location.

Trades from over 30 countries were initiated on the IDB in both the Canadian and Australian currency markets. For most countries, fewer than a handful of trades are executed per day, on average. The following analysis focuses only on trades initiated in Australia, Canada, Japan, the United Kingdom, and the United States. Australia, Canada, and the United States are included in the analysis, since their own

10. While the existence of an established domestic trading centre offers some clear employment and spin-off benefits, access to global capital markets, and possibly to cheaper capital, are also beneficial.

11. The share of interdealer broker (IDB) trading fell from 59 per cent in 2001 to 53 per cent in 2004 and 43 per cent in 2007 (BIS 2007).

12. Brokers are pure matchmakers and do not take positions. Electronic brokers have taken market share from both voice brokers and direct trading. According to Rime (2003), electronic brokers are now the main trading channel in the interbank market.

13. D'Souza (2007) illustrates why it is necessary to break up the 24-hour day into five separate, non-overlapping regional time zones.

14. The proprietary trade data were obtained from a large IDB in the FX market.

currency forms part of at least one of the currency pairs examined. Japan and the United Kingdom are included because both Tokyo and London, like New York, have historically been considered large FX commercial centres.[15]

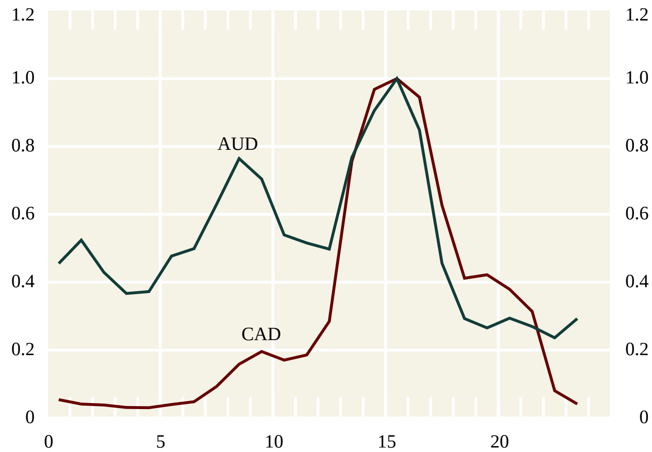
To calculate order flow, trades must be categorized as either buyer initiated or seller initiated. Trades are signed according to the following rule: If a transaction occurs above the prevailing mid-quote, it is regarded as buyer initiated; otherwise, it is signed as a seller-initiated trade.[16] Trades are signed as +1 if Canadian or Australian dollars are sold by the trade initiator, and as –1 if Canadian or Australian dollars are purchased. Order flow in each location is then determined by summing up the signed trades in each 5-minute interval. Midpoints of bid / ask quotes, which are observed at the end of each 5-minute interval, are used to generate a series of exchange rate returns. The analysis is completed in Greenwich Mean Time (GMT).[17]

Trading in the FX market occurs throughout the day. Chart 1 illustrates the intraday pattern of hourly trades across the 24-hour clock.[18] Note that, for the CAD market, trade activity peaks after the opening of business hours in North America (around 15:00 GMT). As business hours wind down in North America, trading falls. In the AUD market, at least two peaks in trades are associated with morning trading in London and New York. A third, smaller peak occurs during Asian hours.

Since some financial centres are open while others are closed, it is necessary to analyze exchange rates and trades separately across a variety of time periods over the 24-hour day. Based on an examination of trading volumes initiated around the world, we adopt the breakdown of regions proposed by Cai, Howorka, and Wongswan (2006) for the US-dollar / euro and US-dollar / Japanese yen markets. Periods in which the business hours of one region overlap those of another are separated from periods in which only a single region has regular business hours. Table 1 lists the five regional time zones (Asia, Asia-Europe, Europe, Europe-North America, and North America), as well as the specific hours for each zone outside of, and during, daylight savings time (DST).

Chart 1

Hourly Trading Activity Index for the CAD and AUD Markets, Greenwich Mean Time



Increased levels of FX trading activity in each geographic location across time zones reflect the beginning of regular business activity in that location. Daily trading indexes are presented in Table 2. Most trades initiated in Australia and Japan occur during Asian hours, while most trades initiated in Canada and the United States take place during North American hours. Interestingly, a large proportion of U.K.-initiated trades occur during the overlapping Asia-Europe and Europe-North America time zones. Trading in the CAD market is dominated by trades initiated in Canada, the United States, and the United Kingdom. These trades make up 75 per cent of all trades in the CAD market. U.S. and U.K. trades also account for the majority of

Table 1

Regional Business Hours, Greenwich Mean Time

Trading region (duration)	No daylight savings	Daylight savings
Asia (9.5 hours)	22:00-07:30	21:00-06:30
Asia-Europe (1.5 hours)	07:30-09:00	06:30-08:00
Europe (3.5 hours)	09:00-12:30	08:00-11:30
Europe-North America (4.5 hours)	12:30-17:00	11:30-16:00
North America (5 hours)	17:00-22:00	16:00-21:00

15. Data indicating the city centre from which trades are initiated were not available.

16. Intraday quote data for CAD and AUD exchange rates were obtained from Olsen and Associates <http: / / www.oanda.com> and were collected from various real-time data feeds. If a transaction occurs precisely at the mid-quote, it is signed using the previously transacted exchange rate, which is determined by using the following tick test: The trade is buyer initiated if the sign of the last non-zero exchange rate change is positive.

17. National holidays and weekends are excluded from the analysis. Weekends begin on Fridays at 22:00 GMT and end on Sundays at 22:00 GMT.

18. Chart 1 accounts for changes to and from daylight savings time (DST).

Table 2

Index of Average Daily Trading Initiated Across Locations

U.S. trading in North America = 100

Regional time zone	Location of trade initiation				
	Australia	Canada	Japan	United Kingdom	United States
CAD					
Asia	21.7	1.2	15.6	2.6	7.6
Asia-Europe	2.5	0.0	3.2	20.2	2.4
Europe	2.2	8.3	0.9	58.6	8.2
Europe-North America	0.2	219.1	0.7	61.9	158.7
North America	2.0	118.7	1.3	3.1	100.0
AUD					
Asia	261.5	0.1	36.0	8.9	8.3
Asia-Europe	25.5	0.0	5.0	72.7	1.1
Europe	27.7	1.1	2.4	156.4	5.8
Europe-North America	41.0	16.1	0.5	177.9	156.7
North America	49.3	9.0	4.8	9.9	100.0

trades initiated in the AUD market after Asian hours. Surprisingly, Japanese-domiciled trading desks tend to be a small player in each of these markets.[19]

Empirical Analysis

The methodology allows for an examination of the relationship between trades initiated in multiple locations and exchange rate returns. Multivariate regression analysis (see Box) is used to determine the informational content of trades.[20] The impact of order flow, characterized by the location in which a trade is initiated, cannot be determined from a single regression. All variables are endogenous, and causality between the different order flows and exchange rates may occur in multiple directions. For example, while an unexpected purchase of foreign currency by a trader may lead to a change in the exchange rate, the causality may also work in the other direction: An unexpected increase in the exchange rate could influence purchases of a foreign currency by other market participants. Alternatively, trades initiated in the United Kingdom may serve as a catalyst for trades initiated in the United States or Canada. The methodology is robust to modelling assumptions and is also able to characterize the dynamics of trades and exchange rate returns.

Theoretically, exchange rates can be assumed to consist of two elements: an informationally efficient price and an element reflecting frictions in the trading process. While new fundamental information will lead to a permanent revision in the market's valuation of the exchange rate, effects arising from trading-friction illiquidity will be short lived and transitory. Empirically, the long-run response of the exchange rate to a trade will depend on whether or not that trade was initiated by an informed trader with private fundamentals-based information.

Two summary measures of trade informativeness developed by Hasbrouck (1991a, b) are calculated from the estimates of a reduced-form vector autoregression (VAR): the long-run accumulated impulse response of exchange rate returns to shocks in each order-flow variable, and the proportion of the permanent variation in the exchange rate explained by each order-flow variable. The latter is derived from a variance decomposition of exchange rate returns.

Results

The summary measures of trade informativeness are presented in Tables 3 and 4. In each table, the information content of trades in the CAD market is presented in the first panel, while those for the AUD market are presented in the second panel.[21] Impulse-response functions are presented in terms of percentages (e.g., 0.10 represents a 0.10 per cent long-run change in the exchange rate). To make the exposition clearer, summary-measure estimates are not reported if they are not statistically significant at the 5 per cent level.[22]

Trades initiated in Canada, the United Kingdom, and the United States have the largest impact on the CAD exchange rate. The size of the impact is largest during normal business hours in each country. A buyer-initiated trade innovation placed by a Canadian-domiciled trader has a long-run impact of at least 0.066 per cent

19. With the recent popularity of carry trades, trading volumes in the Australian-dollar / Japanese yen market have increased substantially. Despite this, Japan accounts for a relatively small proportion of these trades (BIS 2007). A currency carry trade is usually defined as a leveraged cross-currency position designed to take advantage of interest rate differentials and low levels of volatility.

20. This methodology is also used by D'Souza, Lo, and Sapp (2007) to examine European and Canadian government bond markets.

21. Since the ordering of each VAR may affect the results, all possible rankings of the order-flow variables are considered. The lowest impact of the long-run cumulative exchange rate resulting from each trade innovation is reported across all regional time zones. Twenty 5-minute periods (or, 100 minutes) is found to be sufficiently long.

22. A parametric bootstrap procedure (1,000 replications) is used to calculate standard errors for both impulse-response functions and variance decompositions.

Empirical Methodology

A vector autoregression (VAR) is estimated to determine the sources of exchange rate variation. A VAR is a linear specification in which each variable is regressed against lags of all variables.[1] Let z_t denote the vector of variables,

$$z_t = [x_{it}, \ldots x_{mt}, r_t],$$

where x_{it} is the order flow calculated from trades initiated in the i'th location, and r_t is the percentage exchange rate return over the 5-minute interval. There are m locations in total. The VAR specification can be written as

$$z_t = A_1 z_{t-1} + A_2 z_{t-2} \ldots + A_p z_{t-p} + v_t, \qquad (1)$$

where p is the maximum lag length, and v_t is a column vector of serially uncorrelated disturbances with variance-covariance matrix Σ.[2] Coefficient estimates and the associated variance-covariance matrices can be obtained from least-squares estimation. The model captures the dynamic relationships between all variables. It also allows for lagged endogenous effects.

Impulse-response functions represent the expected future values of the system conditional on an initial disturbance, v_t, and can be computed recursively from equation (1):

$$E[z_t + z_{t+1} + \ldots z_{t+\infty} | v_t].$$

The long-run impact of a trade innovation on the cumulative exchange rate return measures the fundamental information in a variable and the first summary measure of trade informativeness examined in this article:

$$E[r_t + r_{t+1} + \ldots r_{t+\infty} | v_t].^3$$

If the innovation in the permanent component of an asset price is denoted as w_t, its variance, σ_w^2, will be a measure of the variation in the permanent component of exchange rate returns:

$$\sigma_w^2 = var(E[r_t + r_{t+1} + \ldots r_{t+\infty} | v_t]). \qquad (2)$$

Since the covariance matrix will not be diagonal, the right-hand side of equation (2) will involve terms reflecting the contemporaneous interaction of the disturbances. The variance of the permanent component of the exchange rate can be written as

$$\sigma_w^2 = \sigma_{x1}^2 + \ldots \sigma_{xm}^2 + \sigma_r^2,$$

where σ_{xi}^2 corresponds to the incremental contribution of the i'th order-flow variable. Relative contributions of each trade and exchange rate return variable to explaining the total variance in the permanent component of exchange rate returns are calculated by dividing both sides of the above equation by σ_w^2:

$$1 = \sigma_{x1}^2/\sigma_w^2 + \ldots \sigma_{xm}^2/\sigma_w^2 + \sigma_r^2/\sigma_w^2.$$

Each term on the right-hand side represents the second measure of trade informativeness analyzed in this article.[4]

1. See Hamilton (1994) for a complete discussion.

2. Intraday hourly exogenous dummies are also added to each equation of the VAR model to account for intraday seasonality. The Schwartz information criterion is used to determine the lag length across the system of equations.

3. Innovations in v_t are orthogonalized using a Choleski decomposition of the variance-covariance matrix.

4. The ordering of variables may affect the values of each summary statistic. In particular, placing a variable earlier in the ordering may increase its information share.

Table 3

Cumulative Response to Order-Flow Innovations in Each Location

Per cent returns, by location of trade initiation

Regional time zone	Location of trade initiation				
	Australia	Canada	Japan	United Kingdom	United States
CAD					
Asia	0.044	–	0.036	–	0.017
Asia-Europe	0.028	–	0.032	0.068	–
Europe	–	0.040	–	0.075	0.036
Europe-North America	–	0.059	–	0.011	0.051
North America	–	0.066	–	–	0.041
AUD					
Asia	0.118	–	0.030	0.015	0.036
Asia-Europe	0.066	–	0.026	0.091	0.016
Europe	0.048	–	0.010	0.105	0.017
Europe-North America	0.034	–	–	0.073	0.065
North America	0.067	0.047	–	0.041	0.096

Table 4

Variance Decomposition of Cumulative Returns in Each Regional Time Zone

Per cent of variation explained by order flow, by location of trade initiation

Regional time zone	Location of trade initiation				
	Australia	Canada	Japan	United Kingdom	United States
CAD					
Asia	10.0	–	6.7	–	1.4
Asia-Europe	7.1	–	9.8	42.8	–
Europe	–	13.2	–	45.8	10.8
Europe-North America	–	33.8	–	12.0	26.9
North America	–	48.5	–	–	20.1
AUD					
Asia	45.9	–	3.2	0.8	4.3
Asia-Europe	22.2	–	3.6	40.2	3.2
Europe	12.7	–	0.6	54.7	1.4
Europe-North America	7.3	–	–	31.4	25.3
North America	11.3	5.7	–	4.3	23.5

on the CAD exchange rate during North American hours. In contrast, U.S. trades during these same hours have a 0.041 per cent impact on the CAD exchange rate. Surprisingly, U.K. trades during European hours have a slightly larger long-run effect (0.075 per cent) than Canadian trades. During Asian hours, Australian and Japanese trades have a smaller influence. Interestingly, the U.K. trade effect is much larger before the start of the North American day, when Canadian and U.S. traders begin to make markets.

The variance-decomposition results mirror the qualitative results of the impulse-response functions. This is reassuring, since the two measures attempt to capture similar aspects of price discovery. During Asian hours, Australian and Japanese trades explain about 10 per cent and 7 per cent, respectively, of the permanent variation in the CAD exchange rate. Within Asian-European and European regional time zones, U.K. trades explain more than 40 per cent of the variation in the CAD exchange rate. This result is consistent with the perception of London as a major FX commercial centre. Once North America opens up for trading, Canadian and U.S. trades account for more than 60 per cent of the variation in the exchange rate. Interestingly, Canadian trades are unambiguously more informative than U.S. trades during North American hours.

Trades initiated in Canada, the United Kingdom, and the United States have the largest impact on the CAD exchange rate.

Similarly, Australian trades have a significantly larger impact on the AUD exchange rate than U.S. and U.K. trades during each country's respective business hours. An Australian trade during Asian hours has a permanent impact of 0.118 per cent on the AUD exchange rate. In contrast, U.K. trades during European hours have a 0.105 per cent long-run effect, while U.S. trades during North American hours have a 0.096 per cent effect. Results also illustrate that U.K. trades explain more than 50 per cent of the permanent variation in the exchange rate during European hours, while U.S. trades explain about 25 per cent of the variation during both European-North American and North American hours. Note that while Japanese and U.K. trades have similar effects on the AUD market during Asian hours, Japanese-initiated trades have a significantly smaller effect during the Asian-European overlapping period.

Across the CAD and AUD markets, results suggest that a local, or home-country, bias exists. Australian and Canadian trades explain about 50 per cent of the variation in the permanent component of exchange rate returns during core business hours. This result confirms the premise that dealers operating both at the same time and in the same geographic region as fundamentally driven customers have a natural informational advantage.

There are strong time-of-day effects associated with the informational content of trades. In particular, the long-run impact of a trade depends on which financial centres are operating at a specific moment in time. It is also noteworthy that trade informativeness is usually smaller at the opening and closing of a region's regular business hours. For example, in both markets, U.K.-initiated trades are less informative during the overlapping hours before and after core European business hours. Anecdotal evidence suggests that FX traders must "close out" their positions at the end of their business day. These end-of-day closing trades should therefore be less informative in terms of exchange rate fundamentals.

Conclusions

Since FX traders located across the globe have access to similar news sources, and since relevant information regarding the determination of the exchange rate is thought to be public, it is sometimes claimed that trades initiated in one location should not be more informative than trades initiated in another. Evidence presented here suggests that this hypothesis should be rejected. Overall, results point to a participant's location and hours of operation as two of the factors driving informed interdealer trading.

This article finds evidence to support the view that local traders in FX markets are better informed about the future direction of the exchange rate. Furthermore, dealers operating from within the largest FX commercial centres, such as the United Kingdom (London) and the United States (New York), though not Japan (Tokyo), are also asymmetrically informed, at least during their regular business hours in the CAD and AUD markets. Trades initiated during non-business hours, or from alternative locations, may be related less to fundamentals and more to temporary demands for liquidity.

A participant's location and hours of operation are two of the factors driving informed interdealer trading.

Barker (2007) discusses recent changes in the structure of the FX market, including adjustments to technology, greater participation by buy-side players in providing liquidity, and an overall reduction in transactions costs. As well, clients who understand the value of the information content of their trades are increasingly preventing dealers from exploiting their order flow. In light of the current transformation of the FX market, some caution must be exercised when drawing policy implications from the results presented above, which analyzed data covering an earlier period (2000–02). It is reasonable to assume that changes in openness, transparency, and liquidity have recently affected trading dynamics in this unregulated market. Consider the example of hedge funds, which have grown both in numbers and in the amount of capital under management. This capital can be rapidly deployed through the current trading structures of the FX market. Nevertheless, given the importance of speed in the execution of trades, there may be additional incentives for new participants to locate among the largest global financial centres.

Literature Cited

Bailliu, J. and M. R. King. 2005. "What Drives Movements in Exchange Rates?" *Bank of Canada Review* (Autumn): 27–39.

Bank for International Settlements (BIS) Monetary and Economic Department. 2007. "Triennial Central Bank Survey of Foreign Exchange and Derivatives Market Activity in April 2007: Preliminary Global Results." Basel: Bank for International Settlements.

Bank of Canada. 2008. "Summary of the Survey on Canadian Corporate Foreign Exchange Hedging." Notice, 7 January. Available at <http://www.bankofcanada.ca/en/notices_fmd/2008/not070108.html>.

Barker, W. 2007. "The Global Foreign Exchange Market: Growth and Transformation." *Bank of Canada Review* (Autumn): 3–12.

Literature Cited (cont'd)

Bauer, G. H. 2004. "A Taxonomy of Market Efficiency." Bank of Canada *Financial System Review* (December): 37–40.

Bjønnes, G. H., D. Rime, and H. O.Aa. Solheim. 2005. "Liquidity Provision in the Overnight Foreign Exchange Market." *Journal of International Money and Finance* 24: 175–96.

Cai, F., E. Howorka, and J. Wongswan. 2006. "Transmission of Volatility and Trading Activity in the Global Interdealer Foreign Exchange Market: Evidence from Electronic Broking Services (EBS) Data." Board of Governors of the Federal Reserve System, International Finance Discussion Paper No. 863.

Covrig, V. and M. Melvin. 2002. "Asymmetric Information and Price Discovery in the FX Market: Does Tokyo Know More about the Yen?" *Journal of Empirical Finance* 9 (3): 271–85.

D'Souza, C. 2007. "Where Does Price Discovery Occur in FX Markets?" Bank of Canada Working Paper No. 2007–52.

D'Souza, C. and A. Lai. 2006. "The Effects of Bank Consolidation on Risk Capital Allocation and Market Liquidity." *Journal of Financial Research* 29 (2): 271–91.

D'Souza, C., I. Lo, and S. Sapp. 2007. "Price Formation and Liquidity Provision in Short-Term Fixed Income Markets." Bank of Canada Working Paper No. 2007–27.

Evans, M. D. D. and R. K. Lyons. 2002. "Informational Integration and FX Trading." *Journal of International Money and Finance* 21 (6): 807–31.

———. 2007. "Exchange Rate Fundamentals and Order Flow." National Bureau of Economic Research (NBER) Working Paper No. 13151.

Fan, M. and R. K. Lyons. 2003. "Customer Trades and Extreme Events in Foreign Exchange." In *Monetary History, Exchange Rates and Financial Markets: Essays in Honour of Charles Goodhart*, Volume 2, 160–79, edited by P. Mizen. Cheltenham, U.K.: Edward Elgar.

Froot, K. A. and T. Ramadorai. 2002. "Currency Returns, Institutional Investor Flows, and Exchange Rate Fundamentals." National Bureau of Economic Research (NBER) Working Paper No. 9080.

Gaa, C., S. Lumpkin, R. Ogrodnik, and P. Thurlow. 2001. "The Future Prospects for National Financial Markets and Trading Centres." Bank of Canada Working Paper No. 2001-10.

Glosten, L. R. and P. R. Milgrom. 1985. "Bid, Ask and Transaction Prices in a Specialist Market with Heterogeneously Informed Traders." *Journal of Financial Economics* 14: 71–100.

Grossman, S. J. and J. E. Stiglitz. 1980. "On the Impossibility of Informationally Efficient Markets." *American Economic Review* 70 (3): 393–408.

Hamilton, J. D. 1994. *Time Series Analysis*. Princeton: Princeton University Press.

Hasbrouck, J. 1991a. "Measuring the Information Content of Stock Trades." *Journal of Finance* 46: 179–207.

———. 1991b. "The Summary Informativeness of Stock Trades: An Econometric Analysis." *Review of Financial Studies* 4 (3): 571–95.

Kyle, A. S. 1985. "Continuous Auctions and Insider Trading." *Econometrica* 53 (6): 1315–35.

Meese, R. A. and K. Rogoff. 1983. "Empirical Exchange Rate Models of the Seventies." *Journal of International Economics* 14: 3–24.

Osler, C., A. Mende, and L. Menkhoff. 2006. "Price Discovery in Currency Markets." Universität Hannover Discussion Paper No. 351. Available at <http://www.wiwi.uni-hannover.de/Forschung/Diskussionspapiere/dp-351.pdf>.

Payne, R. 2003. "Informed Trade in Spot Foreign Exchange Markets: An Empirical Investigation." *Journal of International Economics* 61 (2): 307–29.

Rime, D. 2003. "New Electronic Trading Systems in Foreign Exchange Markets." In *New Economy Handbook*, 469–504, edited by D. C. Jones. Elsevier Science.

Sapp, S. G. 2002. "Price Leadership in the Spot Foreign Exchange Market." *Journal of Financial and Quantitative Analysis* 37 (3): 425–48.