Is Order Flow Correlated with Public Information?

A common critique of the microstructure approach to exchange rates is based on an alternative hypothesis under which public information causes adjustment in both price and order flow, with no causal relationship between price and order flow themselves. For example, macroeconomic news that is positive for the dollar causes the yen price of a dollar to go up and causes a relative increase in transactions initiated by dollar buyers. (This alternative hypothesis is distinct from the reverse causality hypothesis under which price increases cause buyer-initiated transactions—i.e., positive feedback trading; see the Note on Causality linked to <haas.berkeley.edu/~lyons>.)

Though intuitively appealing, this hypothesis is inconsistent with rational expectations. As long as expectations are rational, public news does not produce the positive concurrent correlation between order flow and price changes that one finds empirically. The reason is because—under rational expectations—public information is impounded in price instantaneously. At the new price, which embeds all the public information, there is no longer motivation for dollar buying relative to dollar selling. Sure, the change in price level may induce trading (i.e., unsigned volume), due perhaps to portfolio rebalancing, but one would not expect good news for the dollar to produce positive order flow in the aggregate (a relative increase in transactions initiated by dollar buyers).

If expectations are not rational such that price-setting marketmakers do not instantaneously impound all public information in price, then market participants would indeed execute dollar purchases against the marketmaker at "stale" prices, which would produce a positive concurrent correlation between order flow and price changes (as price gradually adjusts). For one to be sympathetic to this view one would have to be skeptical of a whole generation of rational-expectations econometrics.

Finally, consider the possibility that public macro news is not interpreted by all market participants the same way (in terms of its implication for the

exchange rate). This too is a departure from traditional modeling of public information in exchange rate economics (but a far more reasonable departure than the stale-price departure noted above). Under this scenario, price-setting marketmakers who need to clear the market need to determine the interpretations of other market participants (which they cannot know a priori, by assumption). How might they learn them? The answer from microstructure theory is that they learn from the sequence of submitted orders over time. In this case, price instantaneously adjusts to the marketmaker's rational expectation of the mean market interpretation, and then goes through a period of gradual adjustment to the sequence of transacted orders. Thus, in this (again, non-traditional) setting, causality in part goes directly from public news to price and in part goes from public news to order flow to price. Though catalyzed by public information, it is not the case that there is no causal relationship between price and order flow (as maintained by the critique of the microstructure approach outlined in paragraph one). For a model of exchange rate determination along these lines, see M. Evans and R. Lyons, "Why Order Flow Explains Exchange Rates," which is available at <haas.berkeley.edu/~lyons>.

I. From "FX Trading and Exchange Rate Dyanmics" (M. Evans, Journal of Finance, forthcoming)

The model uses data on (i) transaction prices, (ii) interdealer order flow, and (iii) trade intensity from direct interdealer trading in the DM/$. Transactions take two forms in the data. If a dealer initiating a conversation buys dollars, the transaction price equals the ask quote in DMs per dollar offered by the other dealer. I refer to this as the DM purchase price for dollars, p_t^a. If the dealer initiating a conversation sells dollars, the transaction price will equal the bid quote given by the other dealer. I refer to this as the DM sale price for dollars, p_t^b. Thus, the designation of a transaction price as a purchase or sale price depends on who initiates the transaction. Buyer-initiated trades take place at the purchase price while seller-initiated trades take place at the sale price. Order flow measures the direction of trade as the net of buyer-initiated orders and seller-initiated orders. Interdealer order flow is positive (negative) when a dealer initiating a bilateral conversation purchases (sells) foreign exchange at the ask (bid) quote. In the model, I focus on aggregate direct interdealer order flow, x_t, defined by the difference between the number of buyer-initiated orders and seller-initiated orders per period. Trade intensity, n_t, is defined as the number of trades per period.

Dealers receive information in two forms: common knowledge (CK) news and non-common knowledge (NCK) news. CK news is characterized by the simultaneous arrival of new information to all market participants and their homogeneous interpretation of its implications for equilibrium prices. In the FX market, CK news could come from brokers or in the form of a macroeconomic announcement. In the former case, all dealers would have to subscribe to the brokerage system and hold the same view of the relationship between the information displayed and market-wide transactions prices from direct interdealer trade. In the case of macroeconomic announcements, the news must be heard simultaneously and must be homogeneously interpreted. Dealers have access to NCK news from both public and private sources. When the news comes from a public source, it is simultaneously heard by all dealers, but they interpret its implications for equilibrium prices differently.[1] Many macroeconomic announcements may fall into this category because there is little consensus among practitioners or researchers on the link between exchange rates and macroeconomic fundamentals.[2] Direct interdealer transactions and customer orders are examples of NCK news that come from private sources.

One important implication of the market's structure is that dealers do not have CK information about direct interdealer trading. This lack of transparency in direct interdealer trading has an important implication for the behavior of transaction prices: At any moment, equilibrium in the market may be characterized by a distribution of prices for direct interdealer transactions. Standard models, (see, for example, Perraudin and Vitale (1995), Lyons (1997), and Evans and Lyons (2001)) rule out this possibility by assuming that each dealer quotes a publicly observed price at which she will trade any amount with any number of other dealers. In equilibrium, this leads dealers to quote a common price to avoid being arbitraged. In actual direct dealing, however, a dealer can quote a price to only one other dealer at a point in time. This restriction, and the lack

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[1] Brennan and Cao (1997) provide one theoretical rationale for this phenomena. They study a model where investors hold different priors about the value of assets. When public news arrives, better-informed investors change their valuation of the asset by more than the less well-informed investors.

[2] Consistent with this view, Cheung and Wong (1998) report survey data showing that market participants have diverse opinions on the importance of economic factors in the determination of exchange rates at different horizons.

of transparency, makes it possible for different dealers to quote different prices without opening themselves to arbitrage.[3]

To formalize this idea, the model assumes that equilibrium in the market at a point in time is described by a distribution of purchase prices and a distribution of sales prices. Let p_t^a and p_t^b denote observed prices drawn randomly from the respective distributions of purchase and sales prices at time t. These observed prices are related to the average transaction price, p_t, by

$$p_t^o = p_t + \omega_t^o, \tag{1}$$

for $o = \{a, b\}$. ω_t^a and ω_t^b are idiosyncratic shocks that identify the degree to which observed prices differ from the market-wide average. Their size depends on the identity of the dealers whose prices we observe. The model assumes that observed prices are drawn randomly and independently from the cross-sectional distributions of purchase and sale prices every period so that ω_t^a and ω_t^b are serially uncorrelated and independently distributed. This is a reasonable assumption in a market where there are a large number of dealers who can execute transactions at any time.

Shifts in the price distributions come from CK and NCK news. As in many trading models, including the multiple-dealer models of Lyons (1997), Evans and Lyons (2001) and Evans (2001), CK news shocks have an immediate and one-for-one effect on all transaction prices but no impact on order flow. Specifically, I assume that CK news, ε_t, and NCK news, v_t, change average prices and aggregate interdealer order flow according to

$$\Delta p_t = B(L)v_t + \varepsilon_t, \tag{2}$$

and

$$x_t = C(L)v_t, \tag{3}$$

where $B(L)$ and $C(L)$ are polynomials in the lag operator, L.[4] The CK and NCK news shocks, ε_t, and v_t, are assumed to be mutually independent, serially uncorrelated, and independent from the idiosyncratic shocks, $\{\omega_t^a, \omega_t^b\}$.

The intuition behind the effects of CK news, ε_t, on prices and order flow is straightforward. In the face of a CK news shock, any dealer failing to move quotes one-for-one will find himself subject to large inventory imbalances as other dealers take advantage of the misalignment between the quoted prices and their new valuation of the asset (at the margin). Thus, the risk associated with large inventory imbalances (due to unexpected future price changes) creates an incentive for all dealers to move their quotes one-for-one. This leaves the difference between the quote and the value of the asset to the initiating dealer unchanged. As a result, the distribution of transaction prices and quotes shift together because all transactions take place at the quoted prices, and there is no change in order flow. Equations (1) and (2) imply that CK news shocks have an immediate and one-for-one impact on all transactions prices.[5] Equation (3) shows interdealer order

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[3] Of course, the degree to which quotes differ at any point in time will depend on several factors, including the heterogeneity of customer order flows, dealer risk aversion, and the degree to which dealers view brokered trading as a substitute for direct trading. In Evans (2001), I present a model where heterogeneity in the customer orders received by different dealers, combined with the lack of transparency, leads to an equilibrium distribution of FX prices at which direct interdealer trading takes place.

[4] To derive an estimable model, I assume that the order flow process (3) is invertible so that NCK news shocks represent fundamental innovations to order flow; see Hamilton (1994).

[5] The specification of (2) also assumes that all CK shocks permanently affect the level of prices. This is not a completely

flow driven solely by NCK shocks.[6]

The effects of NCK news, v_t, on prices and order flow are more complex. NCK news will generally affect both prices and order flow with the exact dynamics, represented by $B(L)$ and $C(L)$ in (2) and (3), depending on the complex interaction of dealers. This is most easily understood by considering some illustrative examples. Suppose dealer A receives a customer purchase order for $10 million of foreign currency that the dealer fills from his existing inventory. If the dealer believes that the order contains no price-relevant information (see below), he may respond in one of three ways. He can (i) simply wait for another customer with an offsetting sell order; (ii) actively replenish his inventory by either initiating a direct bilateral trade or by submitting an order to a brokerage system; or (iii) passively replenish his inventory by raising the prices he quotes when another dealer initiates a bilateral trade. If he follows option (i), the customer order has no impact on interdealer order flow or transaction prices.[7] Under options (ii) and (iii), the dealer's actions generally will lead to order flow and price movements. In particular, if dealer A initiates a bilateral trade with dealer B and buys $10 million of foreign currency at B's ask quote, A's inventory imbalance will have been passed to B. At the same time, the transaction will have contributed $10 million to interdealer order flow. If dealer B decides to replenish his inventory passively according to option (iii), and dealer C is willing to sell him $10 million of foreign currency at his higher bid quote, this transaction will lead to higher prices and negative interdealer order flow (because dealer C initiated the transaction). In sum, therefore, dealer A's customer order will have generated positive and then negative interdealer order flow and a higher transaction price. To see how an alternative response pattern could arise, suppose dealer A decided to replenish his inventory passively according to option (iii). If dealer B initiates bilateral trade with A and sells him $10 million of foreign currency at his higher bid quote, the higher transaction price will be accompanied by negative order flow. Subsequent interdealer order flow will depend on dealer B's actions. For example, if B follows option (ii) and passes his inventory imbalance to dealer C, who just happens to have a customer wanting to sell $10 million of foreign currency, the interdealer order flow following the price change will be positive.

These examples illustrate how one source of NCK news, a customer order, can generate different response patterns for prices and interdealer order flow according to the actions taken by a sequence of dealers attempting to manage their inventories. Examples of response patterns can be similarly constructed for cases where customer orders are the source of NCK information about the future path of prices. This occurs when a dealer believes that his customer order signals a shift in aggregate customer demand for foreign currency. For example, Lyons (1997) notes that orders from customers engaged in international trade can be private

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innocuous assumption because, as macro models show, it is possible for public news to have a temporary effect on spot rates. However, given that the estimated speed of mean reversion in spot rates following such shocks is typically measured in months or longer, and (2) is designed to describe price changes over intervals of a few minutes, the assumption is reasonable from an empirical standpoint.

[6] The assumed absence of CK shocks from the order flow equation mirrors the identification scheme used by Hasbrouck (1991) in his study of specialist quotes and order flow on the NYSE. While Hasbrouck notes that specialist quote smoothing, the reporting of stale quotes, and the presence of stale limit orders could all invalidate this assumption in practice, none of these problems apply to data I use here. Another possibility is that lagged CK shocks affect order flow through the presence of feedback traders because their contribution to order flow depends systematically on past prices. There is, however, no direct empirical evidence in the literature of feedback trading in the FX market. Thus, the absence of CK shocks from (3) represents a weaker assumption in the context of the interdealer FX market than elsewhere.

[7] This option is unlikely to be part of an optimal trading strategy unless customer order flow is negatively autocorrelated. Empirical evidence in Lyons (1995) and Bjonnes and Rime (1998) indicates that dealers unwind inventory positions rather quickly.

signals on the shift in demand for foreign currency due to trade flows because the orders are received in advance of trade statistics.[8] Under these circumstances, a dealer receiving a customer order will revise his view about the prices at which he can trade with dealers and customers in the future. The model in Evans (2001) describes how customer orders carrying price-relevant NCK news affect prices and interdealer order flow (and produces specific forms for $B(L)$ and $C(L)$). Macroeconomic announcements also can be a source of NCK news to dealers because they hold differing views about their implications for equilibrium prices. In this case, the announcement will lead dealers to change their quotes and desired inventory positions by differing amounts. This will trigger order flow and price changes until inventories have been redistributed among dealers in an manner consistent with their new views about equilibrium prices.

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[8] Foreign exchange intervention by central banks represents another example of price-relevant NCK news. Because few central banks deal directly in the interbank market, most interventions are made by placing orders with FX dealers at one or more commercial banks (Peires 1997). Such an order would represent private information to the dealer about future interest rates, say, and, hence, the future path of prices.