Simple measures of market efficiency: A study in foreign exchange markets

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ABSTRACT

Previous studies on the stock market consider the degree of market efficiency to be an inverse of the predictive power of order flow. Following this notion, I propose simple market efficiency measures in foreign exchange (FX) markets. The first measure considers the market to be inefficient when positive (negative) order flows predict the appreciation (depreciation) of a base currency. The second measure considers whether predictions using order flow result in tangible gains. These measures are related to liquidity levels and information factors in FX markets, unlike the measures in previous studies.

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1. Introduction

Globally, the foreign exchange (FX) market is the largest financial market, with an average of approximately $5.3 trillion transactions per day (BIS, 2013). This large market has special characteristics. First, the market is composed of a handful of participants. In interdealer FX markets, trading is concentrated among a few of large financial institutions (King et al., 2013). Second, unlike a stock market, trading is not centralized in FX markets. Although the recent spread of the electronic broking system has centralized trading to some extent, no unique system is used to trade a certain currency pair, and decentralized transactions for one currency pair occur through different systems. Additionally, BIS (2010) reports that approximately 60% of trades still occur through non-electronic broking systems, and most of these trades are over-the-counter (OTC). A handful of participants engage in decentralized trading in the FX market, and Menkhoff et al. (2013) call this opaque market a "dark" one.

Does this dark market achieve informational efficiency? Compared with a stock market, is this market more (less) efficient? As reported in studies on stock markets (e.g., Chordia et al., 2005, 2008; Chung and Hrazdil, 2010), is a market's efficiency related to

its conditions, such as liquidity? These questions motivate this research on the EUR/USD and the USD/JPY markets.

To examine these questions, I propose measures of market efficiency in an FX market. The proposed measures contribute to the microstructure analysis in the following respects. First, these measures are available at high frequencies and help microstructure researchers. For example, when one considers one-minute order flow predictability, these proposed measures are available at every one-minute interval, allowing researchers to engage in high frequency analysis (e.g., Tables 3 and 5 in this study). Second, these proposed measures seem economically more relevant than previous ones when one considers the predictability of order flows given that one of the proposed measures ($EF2$) considers tangible gains from the order flow signal. Third, the proposed measures are simple for calculations and easily applied to research on other markets in which order flow information is available. Fourth, FX market efficiency has been discussed primarily in terms of uncovered interest rate parity (UIP) holding (see Sarno and Taylor (2002)), and I expect that the proposed measures provide additional insights into an analysis of FX market efficiency.

Because the measure proposed by the extant literature provides little information on the third question, I introduce alternative measures. To the best of my knowledge, this paper is the first to examine the issue of FX market efficiency using these measures. Previous studies on stock markets consider a market to be

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inefficient when a lagged order imbalance (net buyer-initiated trade) (OIB) predicts a current price change (Chordia et al., 2005, 2008; Chung and Hrazdil, 2010). Alternatively, I propose two simple measures of market efficiency. The first measure takes the value of 1 when lagged order flow is positive (negative) and the current base currency appreciates (depreciates), and 0 otherwise. The second measure takes the value of 1 when order flow brings tangible gains. These two measures are not based on conventional statistical criteria but on the practical predictive power of order flow and are correlated with liquidity proxies (effective spread and price impact) and information factors (information asymmetry and stealth trading). Moreover, a graphical analysis shows that the proposed measures decline largely around periods of financial turmoil, such as the bankruptcy of Lehman Brothers and the Eurozone crisis. This finding and the empirical results indicate that market efficiency deteriorates when market uncertainty becomes large and liquidity dampens.

When researchers approach the issue of market efficiency in an FX market, they consider that, in an efficient market, no information can predict a future FX rate change and that no excess returns exist. Regarding this issue, the vast body of literature reports persistent deviations from uncovered interest rate parity (UIP) and purchasing power parity (PPP) that indicate excess returns and inefficiencies in an FX market. Meanwhile, the following empirical studies provide economic interpretations and some justifications for the existence of excess returns. Mancini et al. (2013) construe the deviation from UIP as a premium for market liquidity risk. They find that high interest rate currencies depreciate sharply when FX market liquidity deteriorates and propose that excess returns (deviations from UIP) realized through short U.S. dollar positions and long positions in a high interest rate currency are premiums for the liquidity risk of holding such high interest rate currencies. Regarding PPP, Michael et al. (1997) use a smooth transition auto-regressive (STAR) model and support the transaction cost hypothesis as an explanation for deviations from PPP. Their STAR model suggests that the real FX rate (deviation from PPP) shows a mean-reverting pattern toward PPP through arbitrage once the deviation exceeds the transaction cost.[1] Moreover, many players use technical analysis to map past and current FX rates and trading volume data into trading decisions (Neely and Weller, 2012). Although the former two deviations may have some economic justifications, the last fact is inconsistent with the efficient market hypothesis, which denies the usefulness of past information to predict a future FX rate.

To examine market efficiency as information that predicts an FX rate, I consider order flows, which reflect net buyer-initiated trades and demand pressure (e.g., Evans and Lyons, 2002). Recent developments in the microstructure approach in an FX market motivate me to consider order flow as information because this approach proposes that order flow is the key variable to conveying information in an FX rate. Unlike traditional FX models that assume a representative agent, the microstructure approach considers heterogeneous agents whose trading processes affect an FX rate. Order flows aggregate different opinions among market participants and convey aggregated market expectations. Other things being equal, if participants are homogeneous, an increase in U.S. interest rates instantly changes the expectation of the representative agent through the UIP condition, and an FX rate archives its new equilibrium value without trading. Carlson and Lo (2006) use one-minute data for the DEM/USD and show that intensive trading and volatile rate changes followed an unexpected interest rate increase by the Bundesbank for the subsequent two

hours. This result suggests that heterogeneous traders have different opinions about that increase, and an FX rate gradually achieves its new equilibrium value through transactions. I consider this result to be inappropriate for the assumption of a representative agent, and heterogeneous agents should be adopted. Moreover, Ito et al. (1998) report information asymmetry in an FX market and support heterogeneous agents in the market. These results lead me to consider the microstructure approach for the issue of market efficiency.

When order flows are positive, buyer-initiated trades dominate seller-initiated trades. What motivates net buyers initiating their purchases: private information or the need for liquidity? If the order flow has a persistent effect on an FX rate, it is caused by private information. If the order flow is caused by a liquidity factor, that effect is transitory and the FX rate eventually moves back to its previous equilibrium level. Regarding this issue, the empirical evidence is mixed. Rime et al. (2010) find that order flow is significantly related to fundamentals and is a powerful predictor of a future FX rate. Their study confirms that order flow can raise tangible economic gains, which they evaluate using Sharp ratios and utility calculations. Froot and Ramadorai (2005) find that order flows are less related to long-term fundamentals, although they are related to short-term currency returns. King et al. (2013) suggest that the three mutually consistent theories of focus on a dealer's inventory management, a finite price elasticity of asset demand, and private information can explain the transit and persistent effects of order flows on an FX rate.

From where does private information originate? The three round model developed by Evans and Lyons (2002) assumes that private information comes from a dealer's customer (Round 1). In the interbank market (Round 2), the dealer who trades with its customer in Round 1 exploits that information and passes her inventories—originally from the customer in Round 1—to dealers to unwind it. In Round 3, a dealer who processes and is not reluctant to carry over these inventories trades with her customers to unwind her inventories. Because the customer's demand curve is downward, an FX rate should change with the direction of the order flows of the Round 1 customer. The literature finds evidence for the model of Evans and Lyons (2002), which deals with the customer as a source of private information. Menkhoff et al. (2013) examine the order flows of various end users and find that asset managers whose order flows have a persistent effect on the FX rate are informed traders. Moore and Payne (2011) find that the order flows of dealers belonging to large trading floors have a significant effect on an FX rate, a result that indicates that these dealers can access more customer order flows than other dealers. Osler et al. (2011) show that, when trading with their customers, dealers strategically narrow their quoting spreads to attract customers and obtain information. They also find that a dealer trades aggressively in the interdealer market after her customers trade to exploit information gained through such customer trading. This finding indicates that order flows in an interdealer market contain some information. Rime et al. (2010), who use interdealer order flows, support this view; interdealer order flows significantly predict a future FX rate change. I also postulate the informativeness of interdealer order flows and use these flows to measure the efficiency of FX markets. Fig. 1 shows that the predictive power of order flows is statistically significant even in short periods (one and two minutes). The short-lived predictive power of order flows indicates that the studied FX markets achieve some efficiency.

The remainder of this paper is organized as follows. Section 2 describes the data. Section 3 proposes two measures of market efficiency. Section 3 measures the proxies for liquidity and information asymmetry. Section 4 presents the empirical results and considers a proxy for the number of informed trades. Section 4

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[1] Chapters 2 and 3 of Sarno and Taylor (2002) provide surveys of the literature on UIP and PPP, respectively.