



Frequency domain analysis of foreign exchange order flows

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ABSTRACT

Using a unique data set from the Bank of Canada, this paper presents the frequency domain analysis of a causal relationship between the Canada/US dollar exchange rate movements and currency order flows. The evidence shows that the existence as well as the direction of causality depends on the customer type, frequency, and time period.

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1. Introduction

Recent foreign exchange (FX) market microstructure literature has reported that currency order flows are powerful determinants and predictors of exchange rate returns (Evans and Lyons, 2002, 2005; Gradojevic, 2007). The major assumption underlying FX market microstructure models is that exchange rate movements are driven by order flow. The argument in favor of this assumption stems from the classical equity microstructure literature such as Glosten and Milgrom (1985) and O'Hara (1995): in rational markets, order flow should reflect innovations in dispersed information, rather than originating in "momentum" or "feedback trading" effects.¹ It is worth noting that if causality is not running only from order flow to price, the linear estimate of the size of price effects would be biased.

Only a select few papers have directly tested the causality assumption in FX markets (Killeen et al., 2006; Sager and Taylor, 2008; Boyer and van Norden, 2006) and the evidence was mixed. These contributions focused on testing the causality assumption

at one particular data frequency (typically daily). In financial markets, the data generating process (DGP) is a complex network of layers with each layer corresponding to a particular frequency. A successful characterization of such DGP should be estimated with techniques that account for intra- and inter-frequency dynamics (Dacorogna et al., 2001). By using a test for causality in the frequency domain from Breitung and Candelon (2006), this paper provides a complete inter-frequency characterization of the DGP governing the causality relationship between order flows and exchange rate returns.² Specifically, such an approach investigates whether the existence as well as the direction of causality is frequency-dependent. Also, the frequency domain causality analysis can identify the exact lag length between order flow and returns, regardless of the causality direction. More importantly, if the causality is found to run from order flows to prices, this in turn uncovers the speed at which information is aggregated and impounded into prices. These examinations complement and extend the current state of the FX market microstructure literature.

The frequency domain causality tests are performed on the Canada/US dollar returns, and financial and non-financial order flows. In the short run, there is very little evidence of a stable causal relationship between order flows and returns. The null hypothesis of no predictability of FX returns by spot order flows

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¹ Positive (negative) feedback trading is systematic buying (selling) in response to price increases, and selling (buying) in response to price decreases (Evans and Lyons, 2002).

² As the highest frequency for the Bank of Canada microstructure data is daily, intra-frequency investigation is left to future research, when an adequate data set becomes available.

is not rejected at weekly and shorter horizons, but it is rejected for financial order flows at horizons between 3 and 8 days. Two stable patterns emerge for frequencies with wavelengths longer than roughly 10 days. First, persistent reverse causality effects are observed for financial order flows, indicating that they are trend-following. Second, non-financial order flows are informative at medium and long horizons, which is in general consistent with the microstructure theory. In summary, it appears that the speed of information aggregation is much higher for financial customers, while it takes at least a month for information to be reflected in the price via non-financial order flows.

In the next section, the data are briefly presented. Section 3 discusses the findings and the final section concludes the paper.

2. Data description

The data are at a daily frequency, spanning the period between October 10, 1994 and September 30, 2005, and are obtained from the Bank of Canada. This represents a total of 2798 observations of daily returns (r_t) and order flows. If S_t denotes an exchange rate at time t , then $r_t = \log(S_t) - \log(S_{t-1})$.

The order flow data are daily trading flows (in Canadian dollars) for eight major Canadian commercial banks:

- Commercial client transactions (CC) include all transactions with resident and non-resident non-financial customers.
- Foreign institution transactions (FD) include all transactions with foreign financial institutions, such as FX dealers.

The CC transactions are motivated by trades in real goods and services, while the FD transactions are motivated by international portfolio considerations. These order flows represent approximately 40%–60% of all Canada/US dollar transactions. Using the definition from Lyons (2001), order flows are measured as the difference between the number of currency purchases (buyer-initiated trades) and sales (seller-initiated trades). *Ceteris paribus*, positive (negative) order flow should raise (lower) the Canada/US dollar spot closing rates (S_t), appreciating (depreciating) the USD. In the remainder of the paper the CC transactions will be referred to as non-financial order flows, while the FD transactions will be referred to as financial order flows.

3. Results

This section reports the results of causality tests in the frequency domain for two bivariate systems: one for each order flow and exchange rate returns. Both Dickey–Fuller and Phillips–Perron tests reject the null hypothesis of a unit root in all time series at the 1% significance level (p -value = 0.000). According to the AIC criterion, a VAR(6) model was selected for both systems.

As in Breitung and Candelon (2006), to assess the statistical significance of the causal relationship between exchange rate returns and order flows, the causality measure for the frequency ω is compared to the 5% critical value of a χ^2 -distribution with 2 degrees of freedom (5.99).

Fig. 1 presents the causality measure between non-financial order flows and exchange rate returns for all frequencies ($\omega \in (0, \pi)$) along with the 5% critical value that is represented with a horizontal dashed line. The top panel indicates that the null hypothesis of no causality is rejected when $\omega < 0.35$ which corresponds to frequencies with a wavelength of roughly more than four weeks (20 days). Thus, FX microstructure theory appears to be correct only at such horizons. In other words, it takes at least four weeks for customer order flows to become informative for the price. This shows that the relevance of non-financial order flow strongly depends on the horizon length.

The bottom panel of Fig. 1 reveals evidence of reverse causality in the short run for $\omega \in [0.6, 1.4]$ and $\omega > 2.2$. These findings explain the inability of non-financial order flows to predict returns for frequencies greater than 0.35 and stresses that forecasting exchange rates with order flows requires care. It can be concluded that linear exchange rate models that employ non-financial order flows produce unbiased estimates of the size of price effects at medium to long horizons.

The results for financial order flows are displayed in Fig. 2 and they are in stark contrast to the ones for non-financial transactions. Financial order flows are informative in the range $\omega \in [0.8, 2]$ corresponding to a cycle length between 3 and 8 days (top panel of Fig. 2). However, the bottom panel of Fig. 2 rejects the null hypothesis of no predictability for $\omega < 1.6$ thereby indicating bi-directional causality in the range $\omega \in [0.8, 1.6]$. Hence, for $\omega \in [1.6, 2]$ (lag horizon 3–4 days) the estimates support the FX microstructure causality assumption. In addition, over the range when non-financial order flow conforms with the causality assumption, financial order flows exhibit feedback trading effects. The findings that financial order flow is a poor predictor of exchange rate returns at longer horizons is consistent with Berger et al. (2008) who find that the association between interdealer order flow and exchange rate returns weakens at longer horizons.

Next, the paper considers the robustness of the results with respect to time period. The data is divided into three subsets according to Gradojevic and Neely (2008) as follows: 1994–1997 (821 observations), 1998–2001 (1012 observations), and 2002–2005 (965 observations).³ First, the relationship between non-financial order flow and exchange rate returns will be examined.⁴ The causal impact of non-financial order flows on exchange rate returns appears to be very sensitive to the time period. Although the 1994–1997 period resembles the results for the entire sample, causality is not observed for 1998–2001 and only in the very short run for 2002–2005 (when $\omega > 2.6$). Furthermore, reverse causality is not present in 1994–1997, but the figures for the other two periods are similar to the bottom panel of Fig. 1. In all, forecasting exchange rate returns with non-financial order flows at longer horizons does not violate the causality assumption of microstructure theory.

The robustness analysis for financial order flows identifies the 2002–2005 period as the one when transactions were not informative. The figures for the other two periods mirror the top panel of Fig. 2. Reverse causality for longer horizons is present in 1998–2001 and 2002–2005, but not in the 1994–1997 period. Therefore, it is important to note that the informativeness of financial order flows is sensitive to time period and frequency. Moreover, as the relationship between financial order flows and exchange rate returns tends to occasionally reflect feedback trading, special attention should be paid to forecasting at longer horizons.

It can also be noted that the 1994–1997 period was in line with the causality assumption for both order flow types, i.e., reverse causality effects were not observed and order flows were informative for the price. This period was characterized by stable exchange rates when the Canadian dollar traded in a relatively narrow range around 0.73 US dollars. The period of stability lasted until the heavy fluctuations in 1998 caused mainly by the economic crisis in emerging markets in Asia, Russian default, and the collapse of Long-Term Capital Management.

³ They utilized the test for the constancy of the log-likelihood on the same data set and found structural instability in 1998 and 2001.

⁴ For brevity, the results will be discussed without providing figures. The complete results can be obtained from the author upon request.

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