Order Flow-Based Microstructure Analysis of the Spot Exchange Rate in Zambia

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Keegan Chisha
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Bringing Rigour and Evidence to Economic Policy Making in Africa

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List of abbreviations and acronyms

AIC	Akaike Information Criterion
EUR	Euro
GBP	British Pound Sterling
FX	Foreign Exchange
GARCH	Generalized Autoregressive Conditional Heteroscedasticity
IFEM	Interbank Foreign Exchange Market
IRF	Impulse Response Functions
OLS	Ordinary Least Squares
RMSE	Root Mean Square Errors
SBC	Schwarz Bayesian Information Criterion
VAR	Vector Autoregressive
USD	United States Dollar
ZAR	South African Rand
ZMW	Zambian Kwacha

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Abstract

Traditional macroeconomic fundamentals have challenges in explaining nominal exchange rate movements at short horizons partly due to their inability to capture expectations. Using data from the Bank of Zambia, and an order flow-based microstructure model within a vector autoregressive (VAR) framework, this study establishes that order flows in the foreign exchange market in Zambia contain useful information in explaining daily exchange rate movements for the period 2016–2020. Daily order flows of four out of 18 different customer types are found to contain information content with the interbank, manufacturing, households, as well as wholesale and retail being the most important. Cross-market order flows contain less information to explain daily movements in the kwacha/US dollar exchange rate. The policy lesson from the empirical results points to the central bank paying attention to the demand requirements by the four identified segments of the foreign exchange market that can potentially drive up the exchange rate and generate inflationary pressures.

***Key words*:** Exchange rate; microstructure; order flow; VAR.

JEL classification codes: F30; F31; G14; G15.

1. Introduction

Understanding the drivers of the nominal exchange rate dynamics at short to medium horizons is important for the monetary authorities due to the influence of the exchange rate in inflation dynamics. For example, in Zambia, the pass-through to domestic prices from the depreciation of the kwacha is empirically established as a key driver of inflation (Chipili, 2021; Roger et al, 2017). Therefore, a better understanding of such proximate drivers improves the information set of the monetary authorities in generating near-term exchange rate forecasts that feed into medium-term inflation forecasts (Zgambo, 2015; Roger et al, 2017; Chisha, 2018).

In the post-1973 era of floating exchange rates, the drivers of the nominal exchange rate at short to medium horizons have, however, puzzled economists ever since Meese and Rogoff (1983) concluded that traditional macro-based fundamental models[1] could not beat a naïve random walk model at explaining nor predicting future exchange rates up to 12 months (Lyons, 2001)[2]. Subsequent attempts by researchers to convincingly overturn the Meese and Rogoff (1983) conclusions failed using both in-sample and out-of-sample fit criteria (Mcdonald and Taylor, 1994; Cheung et al, 2005; de Bruyn et al, 2012; Rossi, 2013; Chiliba et al, 2016; Ibhagui, 2019). Consequently, Obstfeld and Rogoff (2000) birthed the term "exchange rate disconnect puzzle" to describe the general poor performance of macro-based models in explaining exchange rate movements at short horizons. The disappointing performance of macro-based models stems from their inability to adequately capture dynamic expectations at short horizons (Evans and Lyons, 2002a; Evans and Rime, 2016). In part, this is due to three strong assumptions upheld in macro-based exchange rate models: symmetric information amongst players, homogeneity of players, and the irrelevance of the bolts and nuts of foreign exchange (FX) trading rules (Lyons, 2001).

Alternative exchange rate models with a market microstructure perspective relax the three restrictive assumptions underlying macro-models. The alternative models have demonstrated explanatory and forecasting power that far exceeds that observed in macro-based exchange rate models for developed economies (Evans and Lyons, 2002a, b; Bachetta and Wincoop, 2003; Rime et al, 2010; Evans and Rime, 2016; Ranaldo and Somogyi, 2018) and developing economies (de Medeiros, 2004; Wu, 2012; Duffuor et al, 2011; Zhang et al, 2013; Katusiime et al, 2014; Anifowose et al, 2017; Hoosain et al, 2017). Initially, microstructure models were thought to be relevant in explaining intra-day changes in exchange rates. However, the literature has shown that microstructure models can explain exchange rate movements beyond a day up to a year (Evans and Lyons, 2002a, b; Evans and Rime, 2016; Ranaldo and Somogyi, 2018). By virtue of relaxing the assumption of symmetric information and homogeneity of market players, microstructure foreign exchange models essentially model the economics of financial information that is described in a two-stage process (Lyons, 2001). In the first stage, market players with private information about underlying fundamentals back up their beliefs with actual money by initiating trades (buy or sell) in the foreign exchange market with FX dealers. In the second stage, the foreign exchange dealers learn about the underlying fundamentals from aggregated trades, update their expectations and reflect them in their pricing of foreign exchange. The net of buyer and seller-initiated FX trades gives rise to a variable called *order flow*. Order flow is a signed transaction volume that measures net buying pressure—essentially the transmission mechanism of information contained in the transaction volume to the price (Lyons, 2001). Thus, order flow is the key variable in microstructure models responsible for the high explanatory and forecasting power at short to medium horizons (Lyons, 1995, 2001; Evans and Lyons, 2002a).

From the preceding, dealers infer fundamentals from the aggregate order flows they receive. However, given market player heterogeneity, some order flows are informative while others are not. In microstructure theory, non-informative order flows have transitory effects on the price (Lyons, 2001). On the other hand, order flows with permanent effects on the price are understood to contain information that reflects underlying fundamentals. Transitory effects may arise due to market imperfections such as inventory control when there is reduced liquidity while permanent effects are due to information on underlying fundamentals (Hasbrouck, 1991). Empirically, distinguishing between transitory and permanent effects of order flows is usually done by estimating a Vector Autoregressive model (VAR) and testing if the innovations in order flows have long-term effects on the prices—whether the impulse response functions are statistically significant or not.

Literature on advanced markets has established that information contained in order flows is generally persistent; order flows from various customer types (differentiated order flows) have diverse impacts on the exchange rate, and that order flows in one currency market are transmitted to other currency markets (cross-market effects). In contrast, literature on developing markets has mostly focused on establishing the relevance of order flows in general. In addition, all the studies on developing and emerging markets use end-user customer order flows as opposed to interdealer[3] order flows despite the latter being at the center of wholesale price discovery (Bachetta and Wincoop, 2003). The existence of this gap may, in part, be explained by the challenge in accessing raw, unfiltered, and highly confidential transaction level data demanded by the microstructure approach[4] (Lyons, 2001; Sager and Taylor, 2008).

Establishing the type of information contained in order flows (transitory versus persistent) requires an empirical investigation which this study seeks to undertake on the foreign exchange market in Zambia. Only two known attempts by Kyamulanda

(2015) and Geda et al (2016) have applied a microstructure model to the spot kwacha-US dollar exchange rate in Zambia. However, these studies used distal proxy variables for order flows that are at variance with the typical measure of buying/selling pressure for order flow. Therefore, this study can be deemed as a benchmark in establishing the existence of information content in order flows (microstructure evidence) in explaining short- to medium-term movements in the spot kwacha/US dollar exchange rate that could also be relevant in near-term exchange rate forecast modelling. In particular, the study seeks to establish whether order flows in the FX market have transitory or persistent effects on the kwacha/US dollar exchange rate, whether order flows from various customer types convey different information on short-run movements in the kwacha/US dollar exchange rate, and whether cross-market order flows matter for the kwacha/US dollar exchange rate movements.

Using a VAR model for the period February 2016 to June 2020, the results indicate that order flows in Zambia contain information that explains daily exchange rate movements. Order flows from various customer types have different information content with the interdealer, manufacturing, wholesale and retail, as well as household order flows being the most important in that order. Cross-market order flows are, however, found to be less important in explaining changes in the kwacha/US dollar exchange rate. This study establishes a role, albeit limited, for microstructure models in explaining nominal exchange rate dynamics in Zambia, while Chiliba et al (2016) and Ibhagui (2019) conclude that macro-based fundamental models dismally fail to do so.

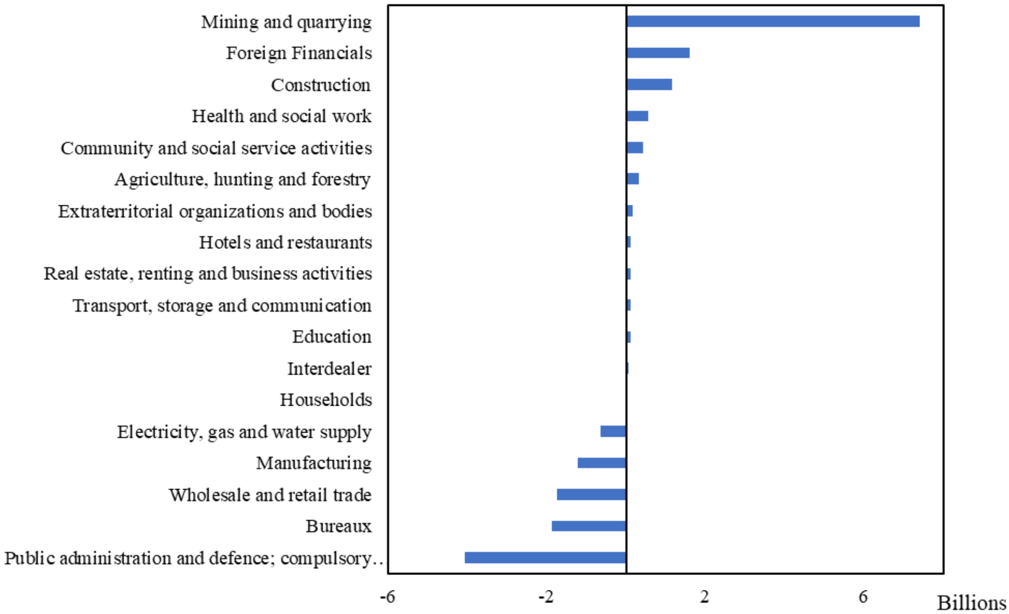
The rest of the paper is structured as follows. Section 2 presents a brief description of the foreign exchange market in Zambia. Section 3 summarizes the relevant literature. Section 4 presents the empirical model and the estimation method. Section 5 outlines data sources and description. The empirical results are discussed in Section 6. Section 7 concludes.

2. Structure of the foreign exchange market in Zambia

Both the current and capital accounts were fully liberalized in the early 1990s and a floating exchange regime adopted in 1994. This regime allows the central bank to intervene in the market to smooth out volatility in the exchange rate without influencing the underlying trend. However, Chipili (2014) established that the impact of central bank intervention on exchange rate volatility in Zambia is weak partly due to the small average size of intervention relative to the market turnover. In view of this, other domestic policy actions are required to reinforce intervention.

The FX market in Zambia is nascent with a limited role for brokers as most trades are directly conducted among dealers (interdealer) and/or between dealers and their clients (non-dealers). FX market players are classified by economic activity they engage in. Net suppliers of foreign exchange include exporters of goods and services: mining and quarrying; construction; agriculture, hunting and forestry; hotels and restaurants; transport storage and communication; and education, as depicted in Figure 1. There are also portfolio investors (foreign financial institutions), non-bank financial intermediation, health and social work, community and social services, and extraterritorial organisation and bodies that promote FX liquidity in the market. The demand-side mostly comprises public administration spending on the importation of petroleum products; bureaux; wholesale and retail trade; manufacturing; and electricity, gas and water supply. The household sector is unique: were net buyers of FX in the first three years from 2016 but turned net suppliers in the last two years of the sample. The interdealer sector of commercial banks is not included as demand and supply of FX net to zero by design.

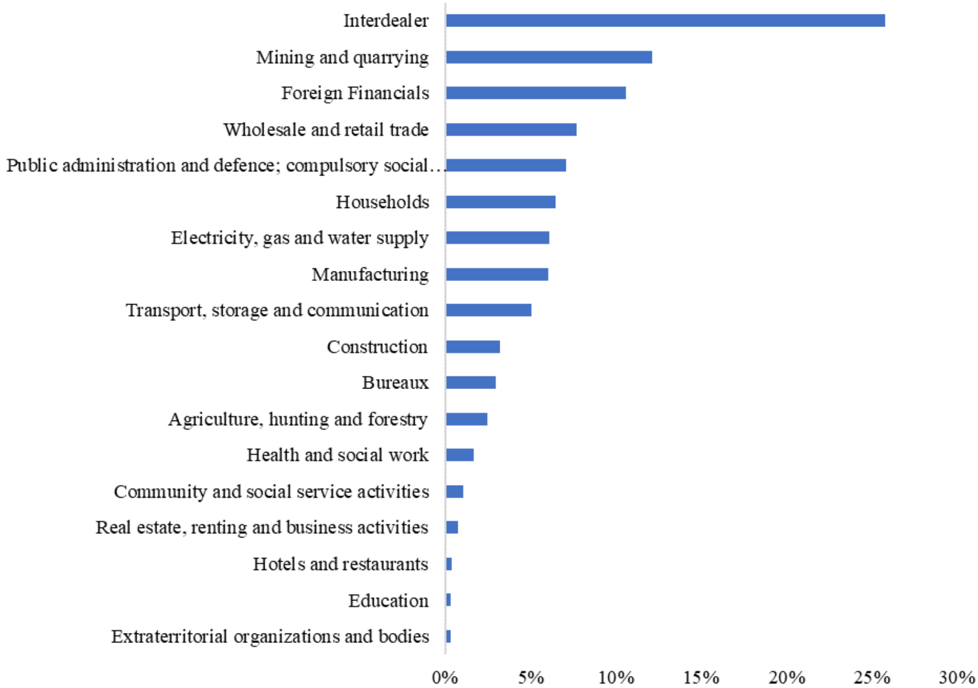
Figure 1: Net supply of USD by sector, 2016-2020 (USD million)



Source: Authors' own compilation.

Figure 2 shows that there is high concentration of liquidity as the top five sectors (interdealer, mining and quarrying, foreign financial institutions, non-bank financial services, as well as wholesale and retail trade) account for over 50% of market turnover. Nonetheless, the microstructure approach warrants the inclusion of all the sectors in the analysis since information content of order flows is not linearly related to the transaction volume. The importance of foreign aid as a source of FX liquidity has reduced over time and only accounted for about 18% of total inflows received by the Bank of Zambia during the period 2016–2020.

Figure 2: Sectoral share of total turnover (2016-2020)



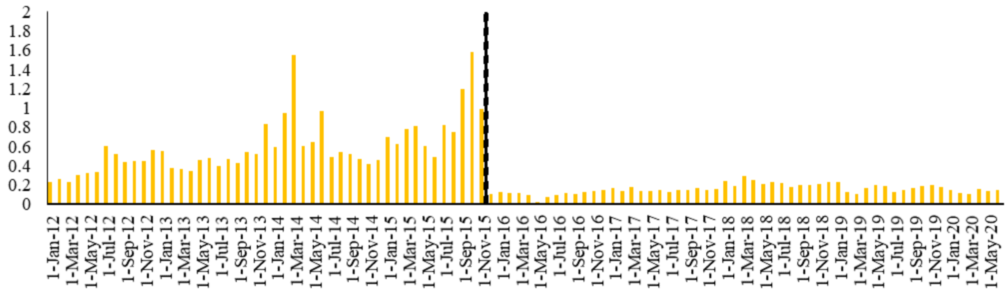
Source: Authors' own compilation.

Commercial banks are the authorized dealers who set the wholesale price in the interdealer market and their trading practices are governed by the Interbank Foreign Exchange Market Framework (IFEM) Rules established in July 2003.[5] All authorized dealers are required to maintain constant presence in the market during trading hours to provide firm two-way prices or quotes for prescribed marketable thresholds when requested by other dealers. The market opens at 0830 hours and closes at 1600 hours. There is no change in the price of foreign exchange during non-working hours such as nights, holidays and weekends. Holidays and weekends are, therefore, not included in the analysis in this study.

There is a cap on the maximum bid-offer spread that commercial banks are required to observe in order to avoid a market trading freeze due to adverse pricing from dominant players in a small market. Trading among dealers firstly occurs on the phone using a dedicated recordable line. Thereafter, trades are posted on an electronic platform authorized by the Bank of Zambia.

Prior to September 2015, trading was primarily conducted directly on the electronic platforms. However, an adverse exchange rate shock in September 2015 caused panic in the market and halted FX trading exacerbated by *hot-potato* trading. Hot-potato trading is responsible for the amplification of trading volumes in FX markets and describes a phenomenon where dealers, in response to an incoming customer order, keep passing unwanted FX positions in the interdealer market until a counterparty willing to accept it is found (Lyons, 2001). To rekindle the interdealer trading, market participants resorted to phone trading which has persisted since 2016. Thus, Figure 3 shows the presence of *hot-potato* trading evidenced by higher trading FX volumes before October 2015 and how the dominance of phone trading since then has resulted in reduced trading volumes by over 66%. According to Lyons (1997, 2001) hot-potato trading tends to reduce information content in order flows in interdealer trades.

Figure 3: Interbank turnover before and after October 2015 (USD billion)

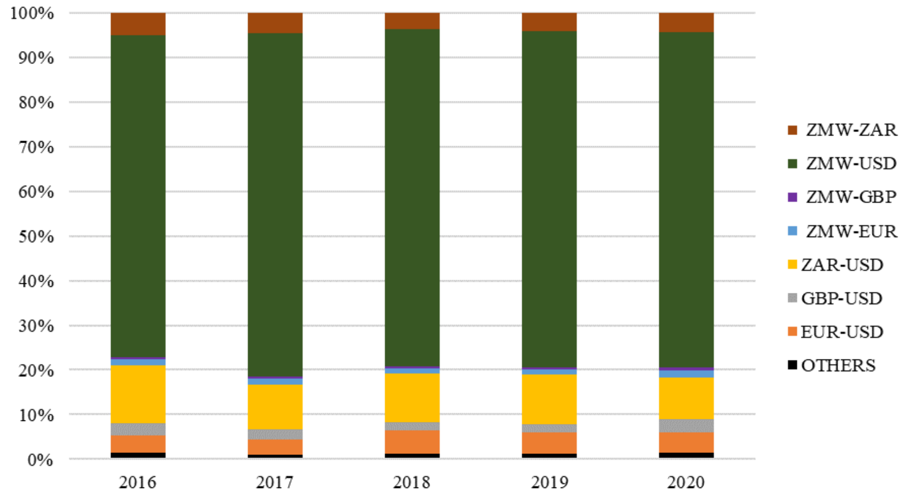


Source: Authors' own compilation.

Due to limited use of brokers, limit/stop orders are rarely conducted through a third party or done through a centralized electronic system as is practiced in developed FX markets. It is for this reason that the IFEM does not contain any formal rules governing limit and stop orders. Limit orders allow a client to set a minimum or maximum price a dealer is willing to buy or sell FX while stop orders allow clients to specify the price at which they would like to buy or sell FX. Although commercial banks allow their own customers to place limit/stop orders with them, there is no anonymity as these counterparties are already visible to the bank and are mostly price takers. Thus, limit/stop orders do not provide nuance to the price discovery process in the FX market in Zambia in the way they do in a typical market. This means that access to direct order flows from electronic trading platforms provides all the information needed to derive order flows in the FX market in Zambia. From June 2020, however, a policy was introduced requiring mining companies—largest supplier of foreign exchange—to pay all tax obligations directly in US dollars to the government through the central bank. This contributed to the significant reduction in interbank turnover (Figure 3).

Annual foreign exchange turnover (all segments of the market) averaged 94% of gross domestic product between 2016 and 2020. The most traded currency pairs—kwacha/pound sterling (ZMW-GBP); kwacha/euro (ZMW-EUR), kwacha/South African rand (ZMW-ZAR); pound sterling/US dollar (GBP-USD); euro/US dollar (EUR-USD); South African rand/US dollar (ZAR-USD) and kwacha/US dollar (ZMW-USD)—accounted for over 97% of total turnover with the ZMW-USD being the most traded currency pair (Figure 4).

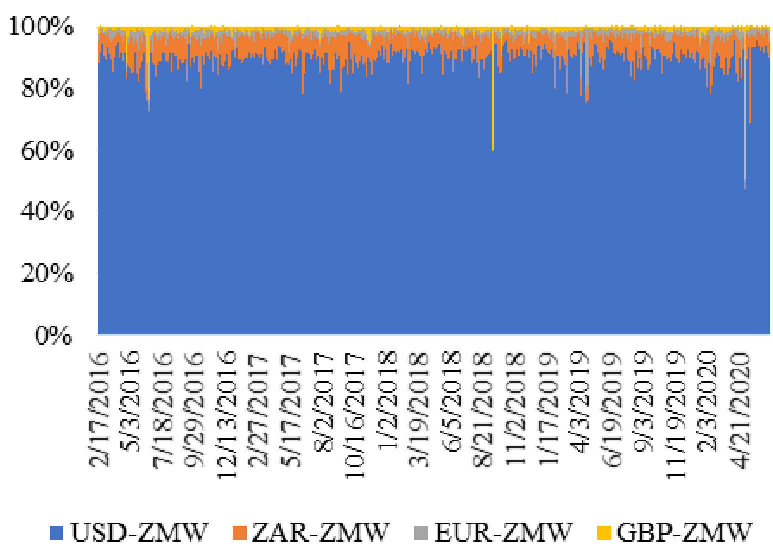
Figure 4: Share of major currency pairs in FX turnover in Zambia (2016-2020)



Source: Authors' own compilation.

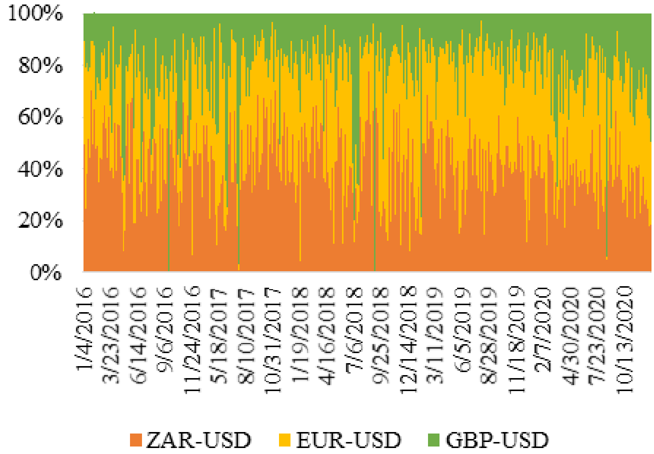
Across time, there is consistent daily trading in notably the USD-ZMW, ZAR-ZMW, EUR-ZMW and GBP-ZMW pairs and trading data is continuous (Figure 5). In addition, the USD-ZAR market accounts for the bulk of transactions in the cross-currency market (Figure 6).

Figure 5: Share of turnover by currency pair in the kwacha FX market (%)



Source: Authors' own compilation.

Figure 6: Share of currency pairs in cross-market (USD leg) turnover (%)



Source: Authors' own compilation.

It is not possible to disentangle commercial banks' proprietary order flows from non-dealer transactions. Ascertaining whether a bank is placing an order on behalf of a client or on its own behalf may not be straightforward. For practical purposes, all interdealer flows are ascribed to originate from the bank and not from respective clients.

3. Literature review

Evans and Lyons (1999, 2002a) developed a theoretical portfolio shift model that establishes order flow as the proximate driver of exchange rate movements at high frequency—daily up to a month. They formally demonstrated that the price change between trading days in period $t-1$ and t is given by;

$$S_t - S_{t-1} = \Delta S_t = r_t + \lambda x_t \quad , \ \lambda > 0 \tag{1}$$

Where: S_t is the price at the end of the current trading day; S_{t-1} is the price at the end of the previous trading day; r_t is the innovation from public information or flow of publicly available macroeconomic information over time—change in interest rates; x_t is the order flow on day t; and λ is a parameter capturing the aggregate risk-bearing capacity of the public.

Equation 1 is transformed into an estimable model by pinning down the information term r_t as the change in interest rate differential, i.e., $r_t \equiv \Delta(i_t - i_t^*)$, where i_t is the domestic nominal currency interest rate and i_t^* is the foreign currency nominal interest rate. Thus, Equation 1 is restated as;

$$\Delta S_t = \beta_1 \Delta(i_t - i_t^*) + \beta_2 x_t + \varphi_t \Delta S_t = \beta_1 \Delta(i_t - i_t^*) + \beta_2 x_t + \varphi_t \tag{2}$$

Where: ΔS_t is the exchange rate return, i.e., change in the logarithm of the spot exchange rate between day $t-1$ to day t; i_t is the domestic nominal interest rate; i_t^* is the foreign nominal interest rate; x_t is the order flow on day t; and φ_t is the error term. The interest rate differential proxies the flow of public macroeconomic information (Lyons, 2001).

Evans and Lyons (2002a) were the first to estimate Equation 2 as a single equation using the ordinary least squares (OLS) method for the Deutsche mark/US dollar and yen/US dollar currency pairs. When the exchange rate return was regressed on the interest rate differential only, the estimated coefficient was insignificant and the explanatory power was virtually zero. This demonstrated the low explanatory power of fundamental-based macro models. However, when the order flow variable was included, the interest rate differential coefficient became significant and the explanatory power rose to about 0.50. This confirmed the importance of omitted variable bias in model specification. Other researchers that estimated Equation 2 as a single equation obtained statistically significant coefficients for the order flow with the R^2 ranging from 0.15 to 0.60 (Danielson et al, 2011; Marsh and O'Rourke, 2005; Sager and Taylor, 2008; King et al, 2010; Della Corte et al, 2011; Cerrato et al, 2011).

Evidence on the significance of order flow from emerging and developing markets is relatively scanty, but exists for Brazil (de Medeiros, 2004; Wu, 2012), Ghana (Duffuor et al, 2011), Uganda (Katusiime et al, 2014), China (Zhang et al, 2013), South Africa (Hoosain et al, 2017), and Thailand (Anifowose et al, 2017). Wu (2012), Zhang et al (2013), and Anifowose et al (2017) used VARs while the rest estimate single equations with varying specifications. Regardless of the different specifications, all these studies included a sovereign risk premium variable as an additional variable in the model. The country risk premium is a catch-all variable for compensation of government moratorium, capital controls and other movements that may affect the return on foreign currency denominated assets within a developing country setting (de Medeiros, 2004). Country risk premium has been proxied by the difference in spreads of comparable sovereign bonds between a developing and advanced economy, and its inclusion in statistical models as a covariate has tended to improve the overall model explanatory power.

Broadly, studies on developing markets conclude that order flow is persistent and explains most of the variation in exchange rate returns besides the exchange rate itself (Wu, 2012; Duffuor et al, 2011; Zhang et al, 2013; Anifowose et al, 2017). In studies that estimated static regression models, the R^2 ranged between 0.15 to 0.40, which is relatively lower than those reported for advanced markets. This is partly attributed to the differences in market structures, significantly more central bank intervention in the FX market, as well as relatively less liquid markets that lead to more informational inefficiencies (Smyth, 2009; Zhang et al, 2013). In addition to contemporaneous effects, evidence on developing markets points to a lagged effect of order flow on the exchange rate. Duffuor et al (2011) indicated that the significant lagged effect of order flow may point to both the presence of the information content in order flow and market informational inefficiencies in emerging and developing markets.

Poor results from order flow-based microstructure models have been reported by Berger et al (2005) and Sager and Taylor (2008) with a virtually zero R^2 and insignificant coefficients for order flow. Two reasons may explain these disappointing findings. Firstly, commercially available data used in these studies obtained from electronic brokers is usually filtered and indexed for confidentiality. This data transformation process may lose valuable information with respect to price discovery. Secondly and more importantly, the single equation model estimated in these studies is highly likely to be misspecified because there is ample evidence of bi-directional Granger-causality between exchange rate returns and order flow (Sager and Taylor, 2008). Therefore, most studies estimating microstructure models have endogenized order flow in VAR frameworks due to the static nature of the single equation model (Equation 2). The added advantage of using VARs is that researchers can explicitly establish persistence or transiency of shocks to order flow. Studies that used VARs reported unequivocal evidence that order flows are persistent and that, besides the exchange rate itself, order flow explains the second largest proportion of variation in exchange rate returns ranging from 15% to 45% (Payne, 2003; Love and Payne, 2008; Wu, 2012; Chinn and Moore, 2011; Anifowose et al, 2017).

The empirical evidence presented thus far assumes that portfolio managers in currency markets only focus on one currency pair at a time. However, in portfolio allocation, order flows in one currency pair may contain information relevant for determining portfolio shifts, and therefore prices in another currency, i.e., cross-market effects (Danielson et al, 2011). Evans and Lyons (2002b) were the first to uncover the importance of these cross-market effects by extending Equation 2 to a multi-currency single equation model (nine-currency pairs) and found $\mathbf{R}^2$ greater than 0.65 in most cases. Other researchers that confirmed the importance of cross-market effects in improving the explanatory power of the Equation 2 specification are Marsh and O'Rourke (2005), Smyth (2009), Cerrato et al (2011), and Danielson et al (2011). However, none of the studies on developing markets identified in this study investigated the importance of cross-market effects.

Another important nuance to microstructure models is the distinction between differentiated and undifferentiated order flows. Modelling with undifferentiated (aggregate) order flows treats all the customers as having the same price impact (symmetric private information). In practice, some customers are more informed than others. Most studies (Marsh and O'Rourke, 2005; Cerrato et al, 2011; Evans and Rime, 2016) disaggregate order flow into four customer types: non-financial corporates, short-term fund managers, long-term fund managers, and private clients (households). The general conclusion is that differentiated order flow improves the explanatory power similar to the cross-market effect. Order flow from financial customers is found to be the most informative as it is positively correlated to the exchange rate returns, i.e., buying a currency expected to appreciate. Order flows from non-financial corporations are generally reported to be negatively correlated with exchange rates, exhibiting feedback trading—buying an appreciating currency or selling a depreciating currency—while those from private clients are mixed (Marsh and O'Rourke, 2005; Cerrato et al, 2011; Evans and Rime, 2016; Ranaldo and Somogyi, 2018).

To the best of the knowledge of the authors, the only known attempt to investigate the importance of differentiated order flow in developing markets is by Wu (2012). In this study, financial customers were found to be the most informed, but exhibited feedback trading as order flow was negatively correlated with exchange rate returns. This contrasts the findings for more advanced markets largely pointing to information aggregation inefficiencies in developing markets (Wu, 2012).

From the foregoing, this study contributes to the econometric literature by assessing whether the interdealer order flows in a foreign exchange market in Zambia, a developing market, contain useful information in explaining short-term exchange rate movements. This will also be the first study to assess the importance of order flows from various customer types, as well as the role of order flows from cross-markets within a developing economy foreign exchange market context.

4. Model specification and estimation method

The first application of the VAR model to the stock market to measure the transitory or permanent effect of order flows was by Hasbrouck (1991). The VAR model has been extended to foreign exchange microstructure analysis to determine the interaction between order flows and the exchange rate (Lyons, 2001). Within the VAR framework, order flow has persistent effects on the exchange rate if at least one of its impulse responses is statistically significant from zero (Payne, 2003). Otherwise, the order flow effect is deemed to be transient.

From the literature, the spot exchange rate, order flow and interest rate differential are standard features of any order flow-based model. While some studies in developing countries have also included a country risk premium variable, it is not included in this analysis because that information is already impounded in the interest rate differential for money market instruments.

Let Y_t represent a vector of variables of interest $Y_t = (s_t \quad x_t \quad id_t)'$ (3)

Where: s_t is the logarithmn of the spot exchange rate; x_t is order flow; and $id_t = (i_t - i_t^*)$ is the interest rate differential between domestic and foreign money market instruments.

The VAR (p) is, therefore, specified as

$$\Delta s_t = \sum_{i=1}^{p} \alpha_{11}^{i} \Delta s_{t-i} + \sum_{i=0}^{p} \alpha_{12}^{i} x_{t-i} + \sum_{i=1}^{p} \alpha_{13}^{i} \Delta id_{t-i} + \varphi_{1t}$$

$$x_t = \sum_{i=1}^{p} \alpha_{21}^{i} \Delta s_{t-i} + \sum_{i=1}^{p} \alpha_{22}^{i} x_{t-i} + \sum_{i=1}^{p} \alpha_{23}^{i} \Delta id_{t-i} + \varphi_{2t} \qquad (4)$$

$$\Delta id_t = \sum_{i=1}^{p} \alpha_{31}^{i} \Delta s_{t-i} + \sum_{i=1}^{p} \alpha_{32}^{i} x_{t-i} + \sum_{i=1}^{p} \alpha_{33}^{i} \Delta id_{t-i} + \varphi_{3t}$$

with

$$E(\varphi_{it}) = E(\varphi_{jt}) \text{ such that} = E(\varphi_{it}\varphi_{jt}) = 0 \; , \qquad \forall\, i \neq j$$
$$E(\varphi_{it}\varphi_{ih}) = E(\varphi_{it}\varphi_{jh}) = E(\varphi_{jt}\varphi_{jh}) = 0 \qquad \forall\, t \neq h \text{ and } i \neq j$$

This VAR (p) model set up is different from the standard reduced form VAR because the order flow is the only variable that contemporaneously relates to the exchange rate return underpinned by theoretical microstructure argument that price revisions are preceded by order flows and not vice-versa (Hasbrouck, 1991). This system of equations is exactly identified using Sims orthogonalization of an unidentified VAR system by assuming that the error terms have mean zero and are jointly serially uncorrelated (Ranaldo and Somogyi, 2018). While Ranaldo and Somogyi (2018) include dummy variables to control for time-fixed effects, they are not considered in this specification because there is weak evidence of the presence of day-of-the-week effects in exchange rate returns in the Zambian FX market (Chipili, 2013). Moreover, when dummies for time-fixed effects were included in alternative specifications, the results were not qualitatively different.

The optimal lag length p for the VAR is established using appropriate information criteria such as Akaike information criterion (AIC), Schwarz Bayesian information criterion (SBC) and the Hanan-Quinn information criterion.

To meet the first objective, each of the 18 sectoral order flows defined in Equation 5 are substituted in Equation 4 in separate VARs to determine if any of their respective impulse response functions are significantly different from zero:

$$x_t = x_t^{J \in C} \tag{5}$$

Where:

$$C = \left\{ \begin{array}{c} \textit{interdealer, agriculture, bureaux, consruction, community and social services,} \\ \textit{electricity gas and water supply, extraterritorial organizations, foreign financials,} \\ \textit{health and social work, hotels and restaurants, manufacturing, mining and quarrying,} \\ \textit{education, public administration, transport and communication,} \\ \textit{households, real estate and renting, wholesale and retail trade} \end{array} \right\}$$

This process aids in identifying the order flow with permanent or transitory impact on exchange returns.

For the second objective, the VAR model is extended to allow for heterogeneous price impacts of different customer types. The customer types selected for inclusion in the VAR are only those whose order flows have significant impulse responses in the first objective. Therefore, only one VAR is set up with n number of order flows such that:

$$n = \textit{number of order flows with significant impulse responses in individual VARs}$$

Variance decomposition is used to rank the customer order flows in terms of the extent to which they account for variation in the exchange rate.

To meet the third objective that assesses the importance of cross-market effects, the order flow definition is further extended to include order flows in other highly traded currency pairs other than the ZMW-USD ($K/\$$) pair: ZMW-ZAR (K/R). ZMW-EUR ($K/€$), ZMW/GBP ($K/£$), GBP-USD ($£/\$$), EUR-USD ($€/\$$) and ZAR-USD ($R/\$$). With this, order flow is measured as:

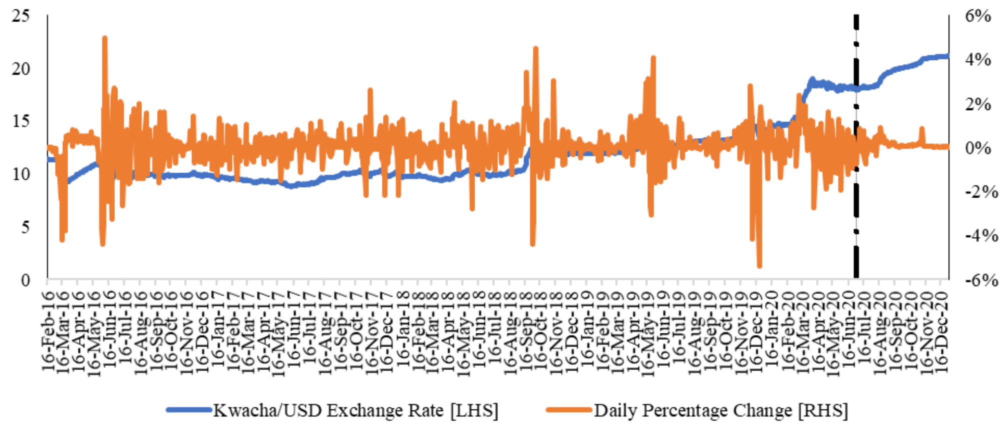
$$x_t = x_t^{K/\$}; x_t^{K/R}; x_t^{K/€}; x_t^{K/£}; x_t^{R/\$}; x_t^{€/\$}; x_t^{£/\$} \tag{6}$$

Impulse responses from order flow are generated to assess whether cross-market order flows matter for exchange rate determination by assessing if any are significant.

5. Data sources and description

Data on order flow disaggregated by customer type was obtained from the daily foreign exchange returns submitted by commercial banks to the Bank of Zambia and the Reuters Deal Tracker module. The Reuters FX trading system was first used in the Zambian FX market in February 2016. This, by default, sets the beginning of the sample to February 2016, and ends in June 2020. The sample ends in June 2020 because after June, government requirement that mining firms pay all tax obligations directly in US dollars through the central bank altered the flow of funds in the FX market and significantly reduced variations in the exchange rate (Figure 7).

Figure 7: Volatility in kwacha/US dollar exchange rate (2016-2020)

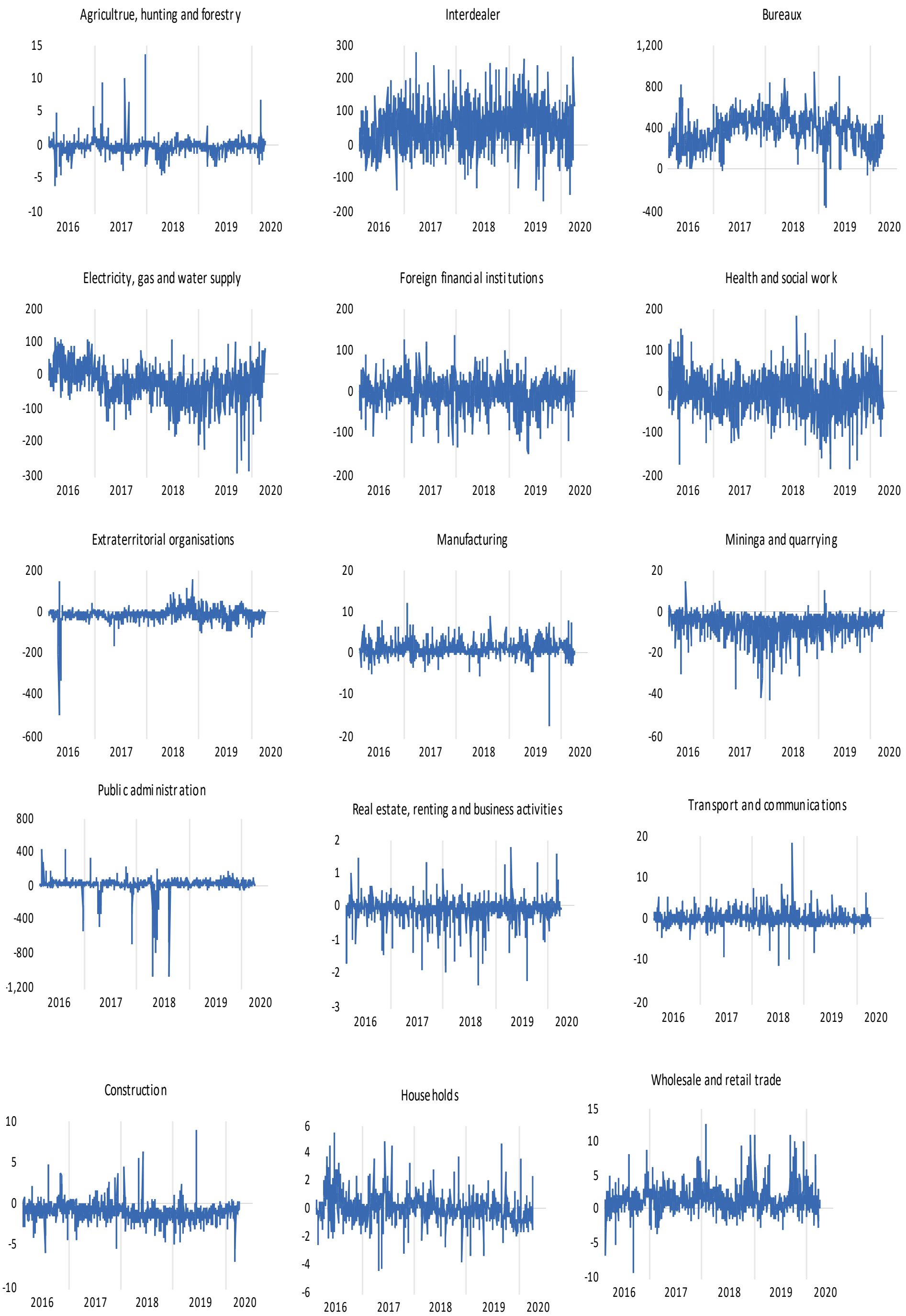


Source: Authors' own compilation.

All the interdealer deals are recorded on the Reuters platform. Typically, it is not obvious to determine the aggressive counterparty in interdealer transactions. However, access to the Reuters platform where interdealer deals are recorded makes it possible. In contrast, for transactions involving authorized dealers and their clients, the latter tend to be aggressive. To derive the order flow, transaction amounts are signed based on information about the initiating counterparty and type of transaction in the database.

The time plots for all the order flows are shown in Figure 8. The interdealer market, bureaux, wholesale and retail, public administration, manufacturing, and households broadly show net buying pressure of the US dollar as their graphs are positive over most of the sample period. Mining and quarrying and extraterritorial organizations sectors appear to dominate on the net selling pressure side. The rest, including health and social work, foreign financial institutions, real estate and renting business activities, as well as transport and communication, broadly show no specific bias to either net buying or net selling pressure. Further, the households, other business activities, mining and quarrying, electricity, gas and water supply, and hotels and restaurants order flows appear to indicate the presence of Generalized Autoregressive Conditional Heteroscedasticity (GARCH) effects as periods of low volatility are preceded by periods of low volatility and periods of high volatility are preceded by periods of high volatility.

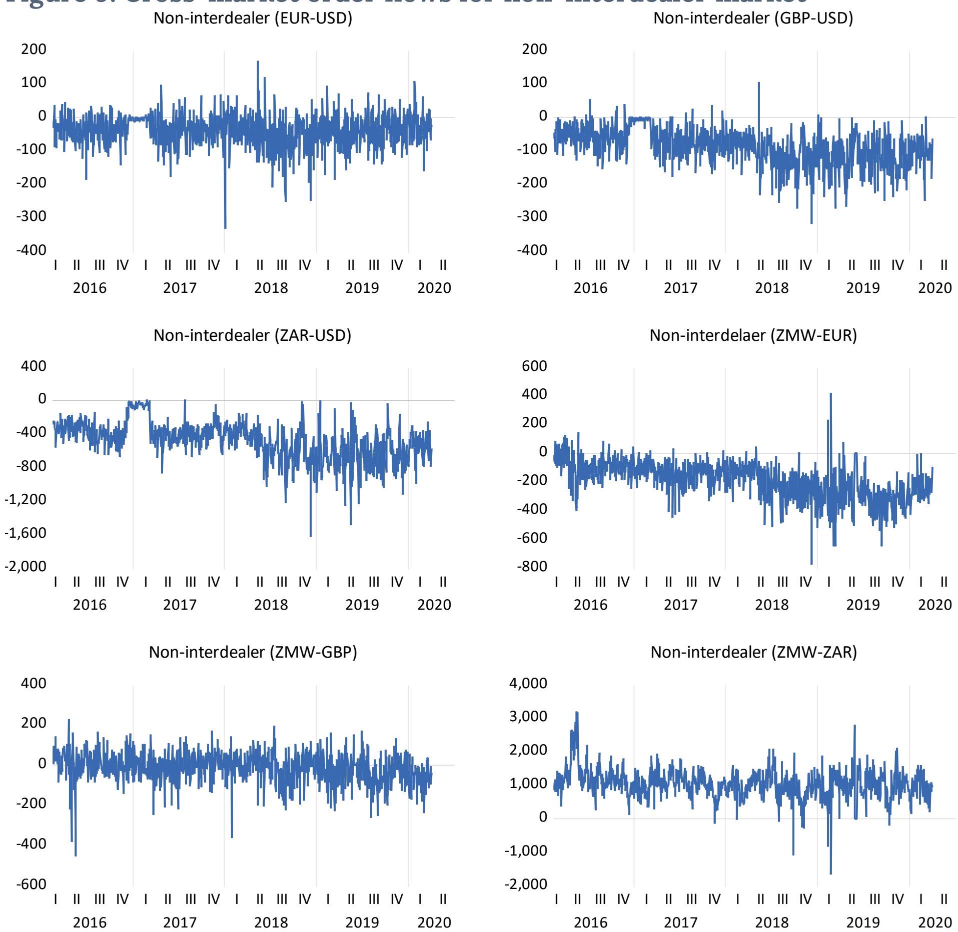
Figure 8: Evolution of order flows by customer type in the ZMW-USD market



Source: Authors' own compilation.

The associated time plots of interdealer and non-interdealer (an aggregate of all customer types except for the interdealer) for cross-market order flows in Figure 9 show that order flows have constant mean and are less volatile compared to the kwacha-US dollar order flows in Figure 8.[6]

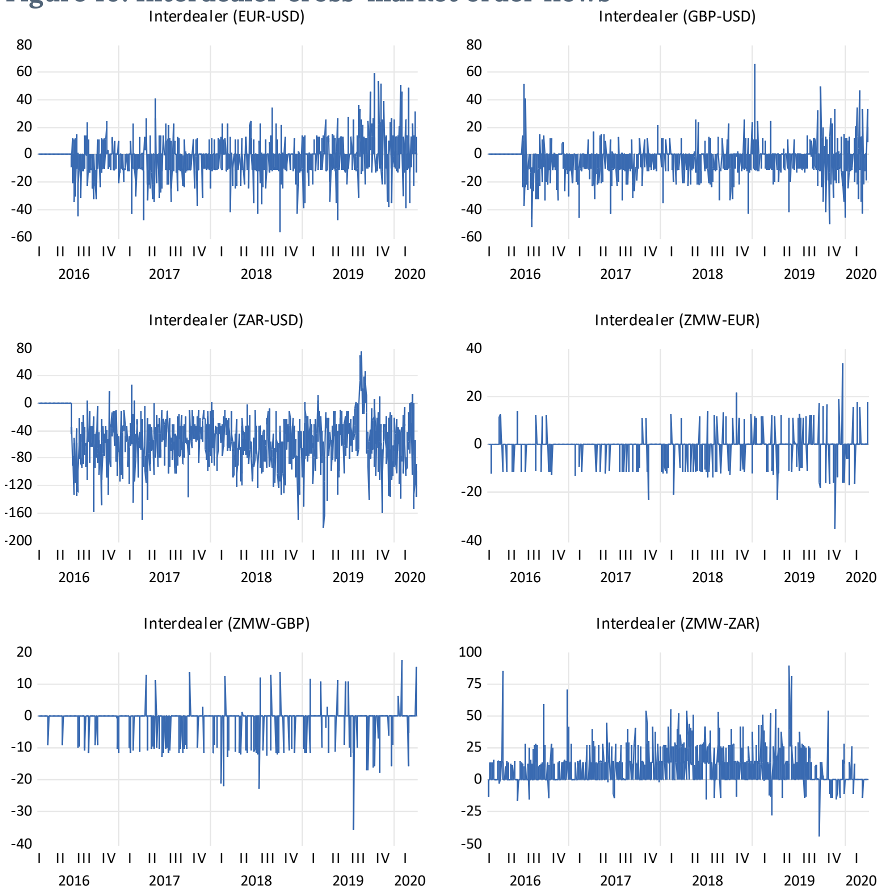
Figure 9: Cross-market order flows for non-interdealer market



Source: Authors' own compilation.

Figure 10 also depicts the interdealer cross-market order flows. All the order flows have constant mean with thin trading in the ZMW-EUR and ZMW-GBP as well as net selling pressure of the US dollar in the ZAR-USD market and net buying pressure on the kwacha in the ZMW-ZAR market. More volatility is observed in the ZAR-USD market followed by the EUR-USD, indicating possible GARCH effects.

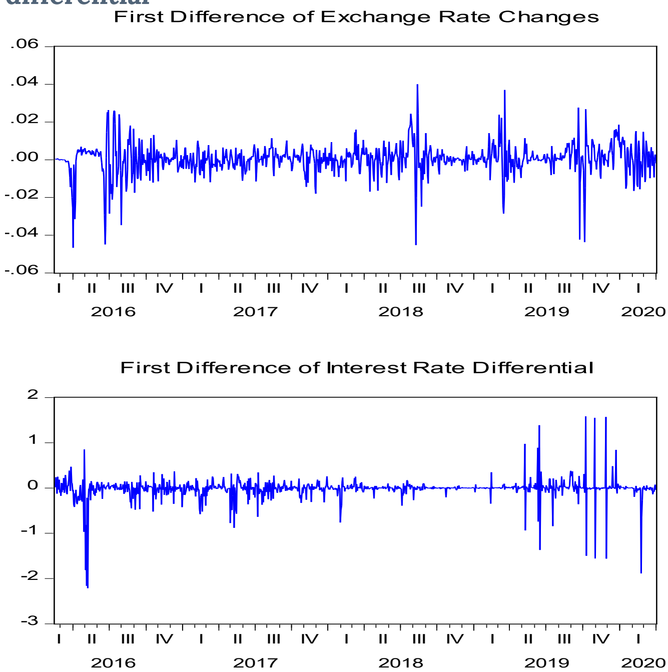
Figure 10: Interdealer cross-market order flows



Source: Authors' own compilation.

Daily nominal money market interest rates were obtained from the website of the United States Federal Reserve Bank and the Bank of Zambia for the respective currencies and used to derive the interest rate differential. The turnover in the kwacha interbank money market in 2020, from which the overnight interest rate is obtained, was about 84% of GDP[7], signifying a relatively active market. The evolution of the first difference in the exchange rate and changes in interest rate are shown in Figure 11. For the exchange rate, there are notable spikes in 2016, 2018 and 2019 attributed to shocks to the exchange rate. Besides these shocks, changes in the exchange rate are slightly biased towards depreciation (positive). However, some GARCH effects can be observed through eyeballing as periods of high volatility are followed by periods of high volatility and periods of low volatility are followed by low volatility. The swings in the interest rate differential are largely on account of movements in the overnight interbank kwacha loans. The period of relatively low volatility (2018–2019) was on account of stability in the kwacha overnight interbank rate partly due to market adjustments to a change in the monetary policy implementation framework which made prices (overnight interest rate) a trigger for central bank open market operations as opposed to being freely determined under the previous monetary targeting framework.

Figure 11: Evolution of exchange rate changes and changes in interest rate differential



Source: Authors' own compilation.

6. Empirical results and discussion

To establish the information content of order flows, we examine the impulse response functions of the exchange rate to shocks from order flows and interest rate differential. In microstructure literature, if at least one impulse is statistically significantly different from zero, then order flow has permanent effects (Hasbrouck, 1991; Payne, 2003).

From the 18 individual VARs estimated for each customer type, only four order flows for the interdealer, households, manufacturing, as well as wholesale and retail reveal a permanent impact on the exchange rate for the kwacha/US dollar market (Figure 12). The rest of the customer types from panel (e) to panel (s) in Figure 12 have insignificant impulses and, therefore, deemed to have transitory information content. Impulse response functions for the significant four order flows are interpreted to mean that unanticipated positive shocks (net buying pressure of the US dollar) to them lead to exchange rate depreciation and the shock dies out after the second trading day. A positive response in this instance suggests that buying pressure arising from the US dollar causes the kwacha to depreciate. Shocks to interest rate differential have statistically insignificant impulses and, therefore, do not contain information relevant to explaining exchange rate movement across all the 18 order flows.

Figure 12: Shocks from respective order flows and interest rate differentials

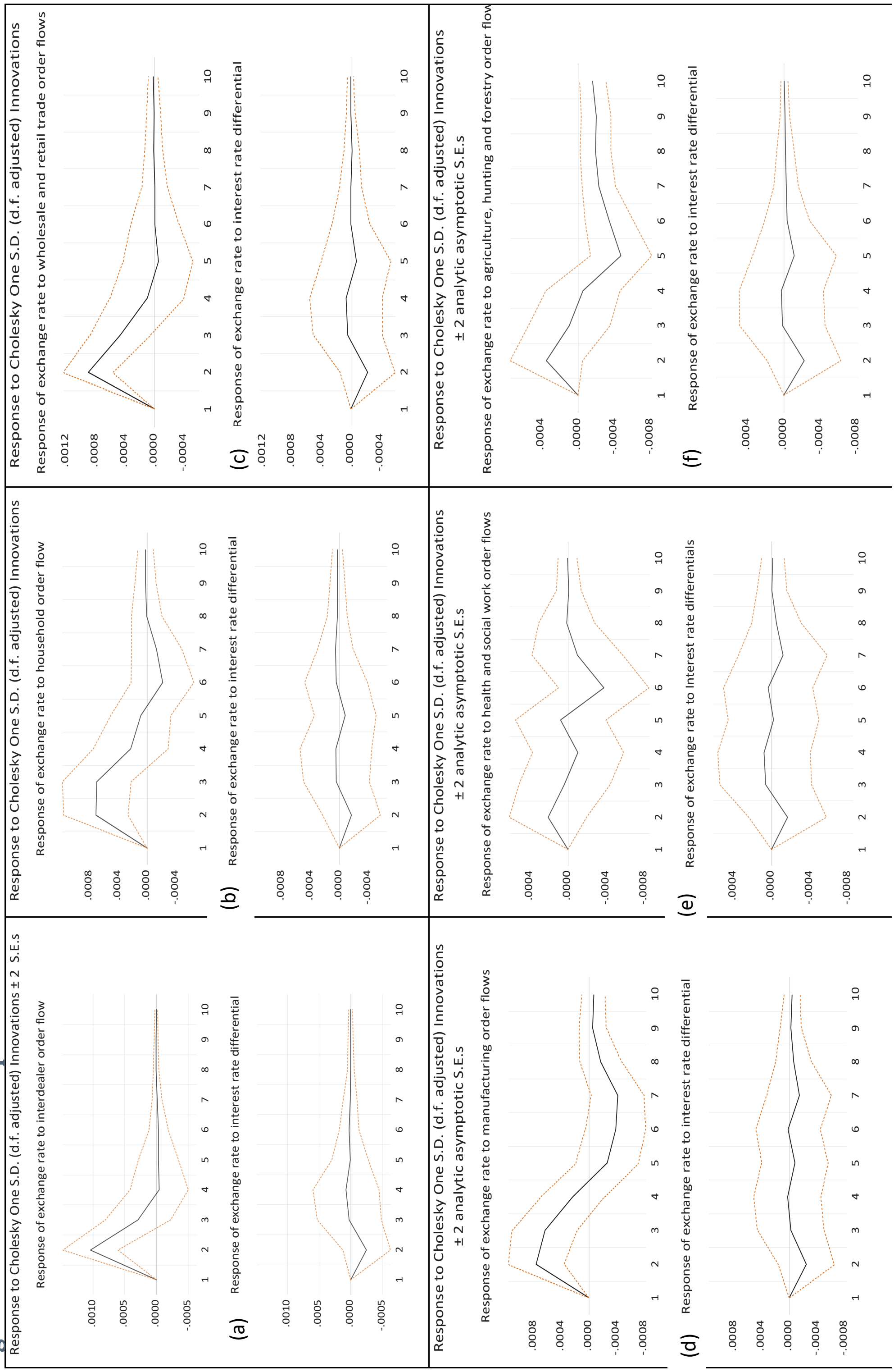


Figure 12 Continued...

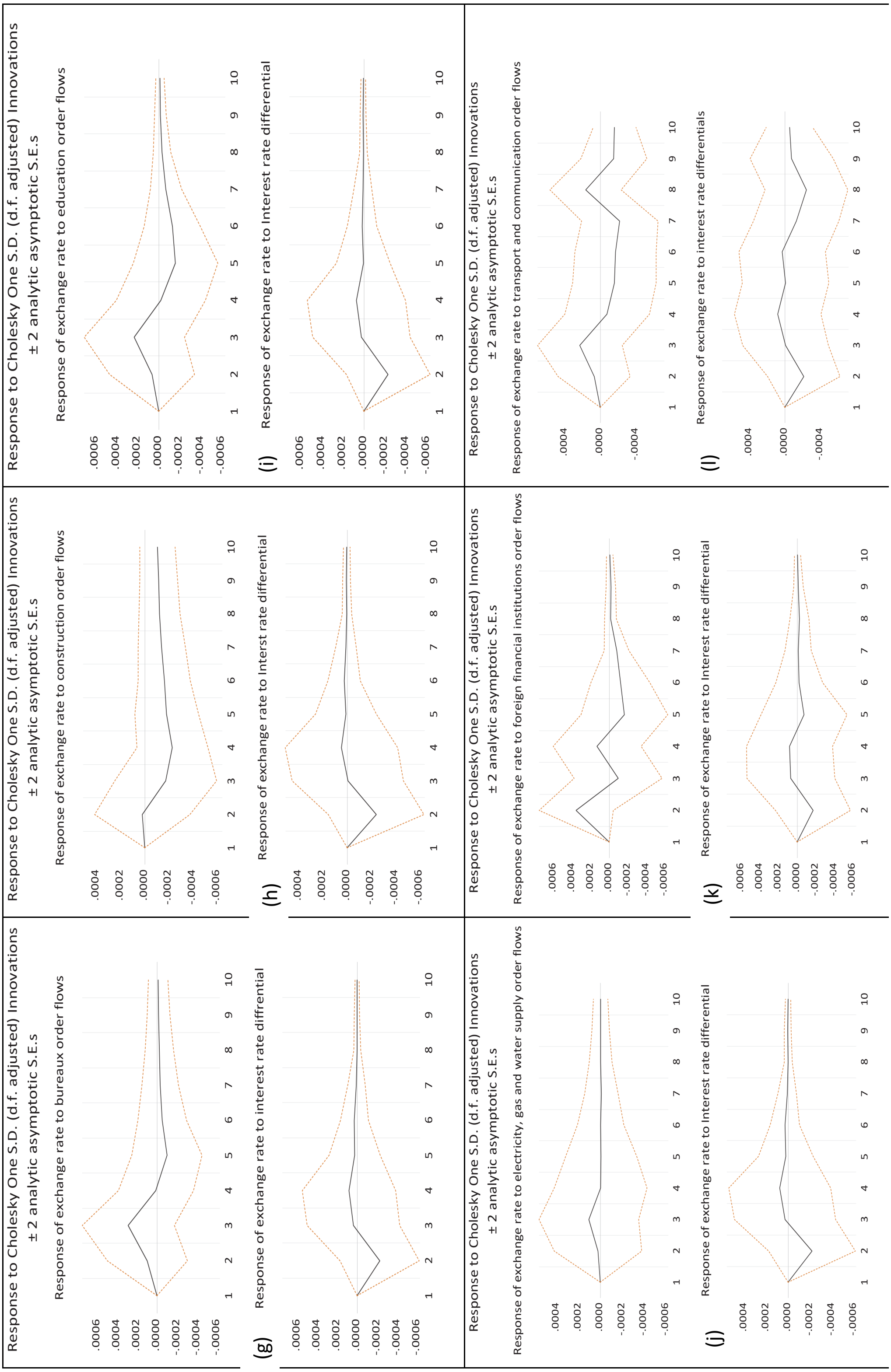
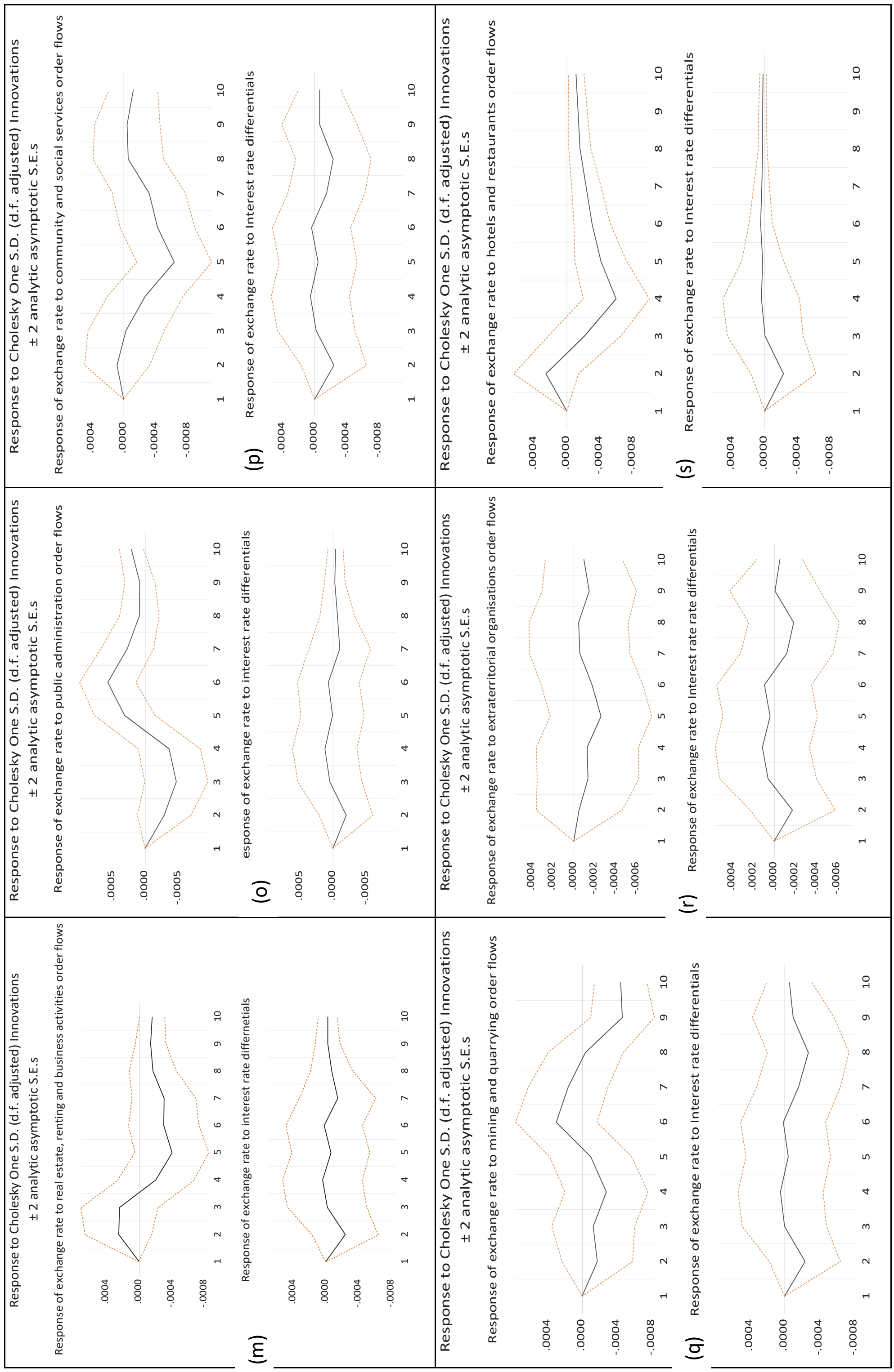


Figure 12 Continued...



Source: Authors' own computation.

While most studies broadly categorize order flows into four customer types—interdealer, foreign financial institutions, non-financial corporates, and households—this study uses a much richer and disaggregated data set. With this, manufacturing, wholesale and retail, as well as households are found to matter for changes in the exchange rate. It is possible that manufacturing firms, as well as wholesale and retail, are more financial savvy in making decisions to purchase foreign currency because their bottom line is influenced by the cost of imports largely driven by the exchange rate. Thus, their sensitivity to exchange rate fluctuations may force them to seek out information about fundamentals relevant to the exchange rate to minimize losses by purchasing a foreign currency before depreciation occurs.

In contrast, large FX players such as mining and quarrying (net supplier) as well as net buyers of FX like public administration (net purchaser) have intuitively insignificant impulse response functions largely because their order flows are predictable with high accuracy and lack the element of surprise. In microstructure theory, any information relevant to the exchange rate should be derived from the un-anticipated trade component and not total trade (Hasbrouck, 1991). This is because dealers can predict, with relatively high accuracy, when orders from these two sectors hit the market due to the imbedded cyclicality of their FX transactions. For example, foreign exchange flows from the mines are expected on specific dates in a month due to cut-off time to pay taxes. Similarly, the procurement of petroleum by the government tends to be done in a regular pattern, making demand for foreign exchange predicable to a large degree. In addition, despite a relatively high share of the mines and public administration in turnover, the volume of trades is not sufficient in conveying information as established in literature (Evans and Lyons, 2002a).

What drives order flows from the four sectors remains a pending question at the frontiers of microstructure literature. In theory, order flows could contain two possible types of information content: payoff information and/or discount rate information (Lyons, 2001). Payoff information may include expectations of future interest rate differentials while discount rate information refers to portfolio balance effects due to changes in risk preferences, changing hedging demands or changing liquidity demands. Anecdotally, it is, therefore, not farfetched to conjecture that the manufacturing, wholesale and retail trade, as well as households may convey information about changing hedging needs over time. However, this needs to be established empirically.

In the preceding section, it has been established that there is persistent information content in order flows from the interdealer, households, manufacturing, as well as wholesale and retail trade. This, however, does not imply that these order flows possess the same information content necessary to explain movements in the exchange rate. To establish whether the order flows from these customer types convey different information on short-run movements in the kwacha/US dollar exchange rate through variance decomposition analysis, Equation 4 is re-estimated to only include these four significant order flow variables.

Table 1 reveals that 93%-96% variations in the exchange rate are explained by own shocks in the short term (up to one-month). Besides own shocks, the interdealer order flow explains much of the variation in the exchange rate during the first four days relative to the manufacturing, household as well as wholesale and retail. The manufacturing order flow only becomes important from the fifth day in explaining the variation in the exchange rate. The wholesale and retail have the least influence on the variation in the exchange rate of the four significant order flows.

Table 1: Variance decomposition of order flows (ZMW-USD)

Period	S.E.	Exchange rate	Interdealer	Manufacturing	Wholesale and retail	Households	Interest rate differential
1	0.007819	96.23964	1.45908	0.669824	0.939422	0.584745	0.10729
2	0.007951	94.7024	1.585264	1.101006	1.127686	1.375545	0.108097
3	0.007965	94.41771	1.630269	1.164583	1.131114	1.548541	0.107782
4	0.008002	94.18561	1.61785	1.34293	1.121397	1.601688	0.130522
5	0.008024	93.80013	1.649413	1.680259	1.131587	1.608641	0.129973
6	0.008029	93.69836	1.653871	1.729265	1.165956	1.613113	0.139432
7	0.00803	93.6682	1.655452	1.731135	1.191051	1.613912	0.140253
8	0.008031	93.65469	1.656053	1.738566	1.195636	1.613744	0.141308
9	0.008033	93.62604	1.661149	1.756191	1.199937	1.615145	0.141539
10	0.007819	96.23964	1.45908	0.669824	0.939422	0.584745	0.10729
20	0.008037	93.52222	1.661698	1.843092	1.215431	1.615572	0.141981
30	0.008038	93.50303	1.661907	1.860202	1.217257	1.615650	0.141956

Source: Authors' own computations.

From the foregoing, order flows from different customer types have varied impact on the exchange rate movement, a conclusion reached by other studies both in developed (Marsh and O'Rourke, 2005; Cerrato et al, 2011; Evans and Rime, 2016; Ranaldo and Somogyi, 2018) and developing markets (Wu, 2012). That the exchange rate explains most of the variation in the exchange rate followed by the interdealer order flows is a finding echoed by others in the literature (Payne, 2003; Zhang et al, 2013; Evans and Rime, 2016; Anifowose et al, 2017). This study finds that, 93%-96% of the exchange rate variation explained by the exchange rate shock over a 30-day period is similar to Anifowose et al (2017) for Thailand, but differs from Zhang et al (2013) who report a wider range of 76%-90% over a 30-day period for China. The difference between our findings and Zhang et al (2013) could possibly be due to the relatively shallow FX market in Zambia compared to China. Our findings also differ from what is established in the literature that other financial institutions would explain a significant variation in the exchange rate after the interdealer order flow (Cerrato et al, 2011; Evans and Rime, 2016; Ranaldo and Somogyi, 2018; Wu, 2012).

In microstructure theory, dealers, regardless of where they operate from, are a significant source of private information because, as intermediaries, they can discern information from the incoming orders of the clients. The findings in this study imply that only the interdealer market plays the role of aggregating information in the FX market in Zambia, while foreign financial institutions may be passive providers of liquidity, especially that most of them have subsidiaries in Zambia and are usually an important source of liquidity. This is because, among the various order flows, the interdealer dominates in explaining a relatively larger proportion of variation in the exchange rate than the others, especially during the first four days. The passivity from the foreign financial institutions may be on account of the kwacha not being a widely convertible currency in regional foreign exchange markets compared to the South African rand, for example, which may limit its appeal for active use by foreign financial institutions. In addition, variance decomposition results show that the dominance of order flow may be time-dependent because initially, interdealer order flow is dominant, but after a week, manufacturing order flow explains a relatively larger part of the exchange rate variation. A switch of a similar nature is also observed between households and wholesale and retail trade from the first to the second day and onwards.

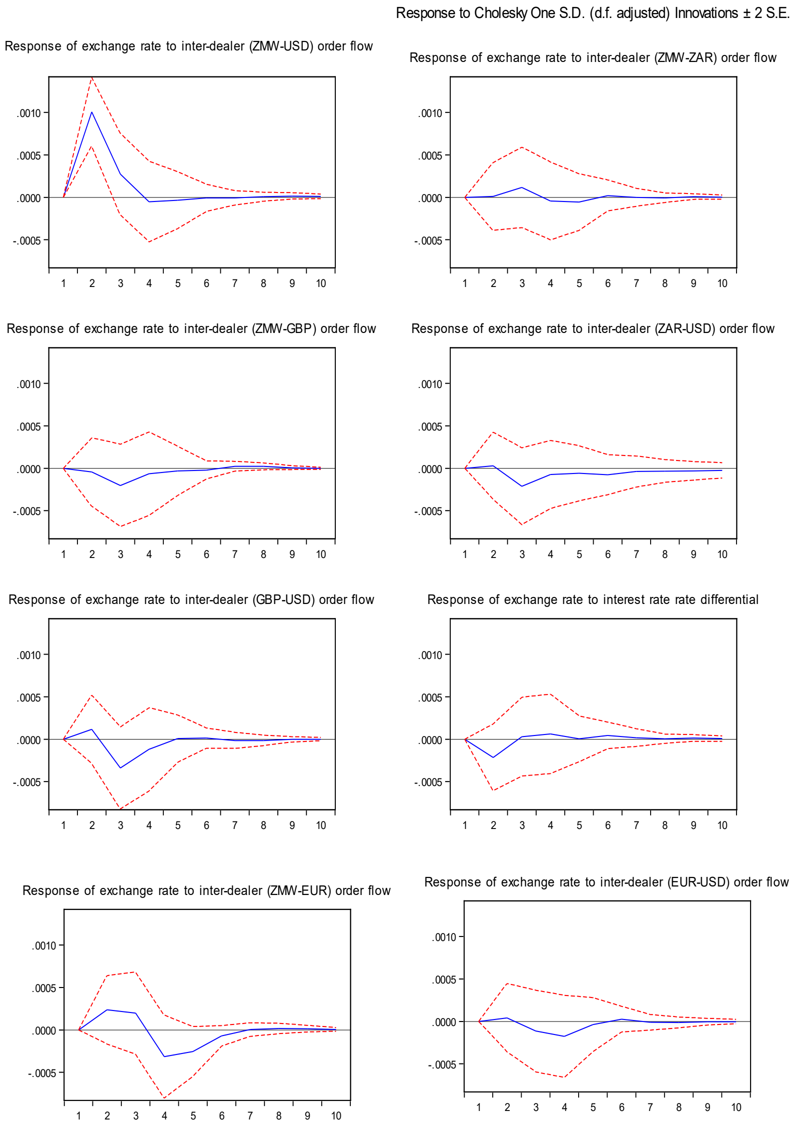
To ascertain the role of cross-market order flows in Zambia, two separate models (i.e., for the non-interdealer and interdealer) across the kwacha/US dollar (ZMW-USD), kwacha/South African rand (ZMW-ZAR), kwacha/euro (ZMW-EUR), kwacha/pound sterling (ZMW-GBP), South African rand/US dollar (ZAR-USD) euro/US dollar (EUR-USD), pound sterling/US dollar (GBP-USD) were estimated. It is found that cross-market order flows from the non-interdealer order flows do not matter as all impulse response functions except the ZMW-USD order flows are insignificant (Figure 13).

Figure 13: Cross-market (non-dealer) order flows

Source: Authors' own computations.

The conclusions are similar for interdealer order flows as all cross-market order flows have null impulses except the ZMW-USD order flow (Figure 14).

Figure 14: Shocks from interdealer cross-market order flows



Source: Authors' own computations.

Overall, cross-market order flows do not appear to be important in explaining short-term movements in the exchange rate in Zambia. This is contrary to existing evidence in the literature by Marsh and O'Rourke (2005), Smyth (2009), Cerrato et al (2011) and Danielson et al (2011) for developed markets. The non-informativeness of the non-interdealer cross-market order flows is expected since currency pairs other than the ZMW-USD may be demanded for temporary liquidity needs to meet obligations as opposed to conveying information on underlying fundamentals. However, the finding that the interdealer cross-market order flows are also non-informative is a little surprising given that dealers are expected to utilize any currency market to make profit by exploiting the information content that cuts across currency markets. This could be partly explained by the fact that only a few foreign owned banks actively participate in the cross-currency markets and usually meet cross-currency liquidity needs for a niche of their clientele from parent banks. Therefore, most of the trades in the cross-currency market in Zambia may be driven by liquidity needs as opposed to response from information about the macroeconomic fundamentals.

7. Conclusion

This study analysed dynamics in the spot exchange rate in Zambia using an order flow-based microstructure model. Specifically, the study considered whether there is permanent information content in order flows that can explain changes in the daily exchange rate, whether order flows from different customers convey different information, and whether cross-market order flows are important for exchange rate determination. These questions have not been fully exploited in the literature for developing countries due to the challenge of accessing raw confidential data needed in these studies. In addition, an interesting aspect of the FX market in Zambia is that hot-potato trading is absent during the sample period due to reliance on phone trading. This implies that the information content in order flows in Zambia is expected to be rich as it is not dampened by hot-potato trading. Therefore, this study is to the authors' best knowledge, the first known attempt to investigate the role of differentiated order flows and cross-market order flows with the special inclusion of the interdealer market in a developing country setting where hot-potato trading is absent.

Using a vector autoregressive model across 18 customer types over the period February 2016 to June 2020, the study established that four order flows, namely, interdealer, manufacturing, wholesale and retail trade, and households contain persistent information that explains the kwacha/US dollar exchange rate. Variance decomposition shows that, besides the exchange rate itself, the interdealer order flow explains more of the variation in the exchange rate than manufacturing, wholesale and retail, as well as household order flows during the first four days. However, manufacturing explains most of the variation from the fifth day. Wholesale and retail order flow has the least influence on the exchange rate.

Despite evidence of persistent information, the information content in these order flows is not as strong as that observed in developed markets and some developing markets even when the dominance of phone trading is expected to be associated with richer information content. This puzzle may require further investigation. Anecdotally, the shallowness of the FX market in Zambia may be associated with inefficiencies in the information aggregation processes (Smyth, 2009; Zhang et al, 2013).

Further, cross-market order flows do not appear to contain persistent information relevant for the kwacha/US dollar exchange rate movements regardless of whether interdealer or non-interdealer order flows are considered. This is not surprising given the low integration of the Zambian FX market and the Zambian kwacha in regional and global FX markets.

The policy implications from this study are that the central bank should pay attention to the demand requirements by the four sectors that can potentially drive up the exchange rate and generate inflationary pressures. Thus, understanding the foreign exchange needs by authorized dealers, manufacturers, wholesale and retail trades, as well as households, and the impact of their behaviour in the foreign exchange market would help improve the monetary authority's appreciation of the source of information on the fundamental drivers of the exchange rates. Assessing the quality of the information content in these order flows is, however, a separate empirical issue left for future research. For example, it would be useful to empirically investigate whether the information content in order flows can be exploited for economic gains by market players or indeed whether it can be useful for near-term exchange rate forecasting.

Notes

1 Traditional fundamental variables included in the macro-models are prices, output, money, interest rate differential, productivity differential, government debt, trade balance, and terms of trade.

2 In 41 out of 45 forecasts, the macro-based models produced root mean square errors (RMSE) that were, on average, 24% higher than those from a random walk model even when future realized values of macro-fundamentals were used (Meese and Rogoff, 1983).

3 Dealers are market makers in foreign exchange markets, and comprise resident commercial banks.

4 This challenge is also the reason why the growth of order flow-based micro-structure FX models has been lacklustre despite promising results.

5 The IFEM spells out the principles that govern the conduct of management and dealers of institutions participating in the FX market in Zambia. Compliance with the rules is necessary to ensure high standards of ethics and business conduct.

6 Noteworthy is the missing data for the EUR-USD, GBP-USD, and ZAR-USD order flows from January 2017 to June 2017.

7 This was about K232 billion or US$13.9 billion.

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Appendix

Table A1: Summary statistics

Variable	Mean	Median	Max	Min	Std. Dev.	Skewness	Kurtosis	Observations
Agriculture, hunting and forestry	(0.29)	(0.23)	13.64	(6.15)	1.13	3.09	40.29	1077
Bureaux	1.61	1.62	7.11	(2.44)	0.79	0.09	6.30	1077
Construction	(0.99)	(0.98)	8.91	(6.89)	1.12	0.99	14.19	1077
Education	(0.10)	(0.05)	1.23	(4.28)	0.29	(5.57)	72.22	1077
Electricity, gas and water supply	0.37	0.00	30.47	(16.72)	3.58	2.16	18.87	1077
Health and social work	(0.46)	(0.33)	13.35	(5.22)	1.03	4.61	63.21	1077
Households	0.02	(0.04)	5.50	(4.53)	0.99	0.68	7.37	1077
Hotels and restaurants	(0.11)	(0.08)	3.17	(1.41)	0.27	3.80	52.05	1077
Extraterritorial organizations and bodies	(0.13)	(0.05)	1.52	(3.22)	0.24	(3.13)	33.83	1077
Manufacturing	0.94	0.80	12.10	(17.84)	1.80	(0.33)	16.66	1077
Mining and quarrying	(6.34)	(5.00)	14.62	(42.44)	5.66	(1.73)	8.68	1077
Community and social service activities	(0.33)	(0.30)	11.05	(4.31)	0.67	8.39	139.52	1077
Public administration and defence	3.32	1.72	21.94	(7.66)	4.24	1.39	4.83	1077
Real estate and renting business activities	(0.10)	(0.07)	1.78	(2.40)	0.33	(1.49)	14.43	1077
Transport and communication	(0.07)	(0.31)	18.17	(11.43)	1.74	1.12	19.60	1077
Interdealer	1.54	1.25	190.00	(12.65)	6.55	22.18	638.56	1077
Foreign financials	0.11	(0.05)	96.77	(24.15)	4.71	8.80	175.46	1077
Wholesale and retail trade	1.40	1.19	12.71	(9.61)	1.91	1.05	8.89	1077
Interest rate differential	(0.02)	0.00	1.58	(2.21)	0.23	(2.52)	37.46	1077
Exchange rate return	0.00	0.00	0.04	(0.05)	0.01	(0.85)	10.38	1076

Note: All order flow variables are measured in millions of US dollars.

Source: Authors' own computations.

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