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Order Flow and Exchange Rate Dynamics: An Application to Emerging Markets

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Abstract

The paper examines short-run exchange rate dynamics in an emerging market based on the recent microstructure framework of foreign exchange markets where the main explanatory variable is the order flow of end-user customers. The study makes two main contributions to the literature: it modifies the basic microstructural FX model to take account of key features of the majority of emerging markets, namely the existence of a black market for FX and the presence of market inefficiencies; and it uses a unique database covering almost the complete Ghanaian market, and for a long time span compared to previous studies. We find that the unexpected component of order flow has a positive and long-lived effect on the official exchange rate in both stable and crisis periods, consistent with the basic microstructural approach. The price-impact of unexpected order flow is related to the level of liquidity in the market. Expected order flow also impacts the exchange rate, suggesting inefficiencies in the market.

JLE: F31,
Keywords: Order Flow, Foreign Exchange Markets, Exchange Rates, Forex Microstructure

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1. Introduction

This study explains the behaviour of the exchange rate in Ghana, using the recently developed microstructure framework of foreign exchange markets. This is one of the very few studies to apply such a framework to an emerging market.[1] One key premise of the microstructure approach is the explanatory role of order flow in the behaviour of the exchange rate. Order flow can be thought of as net buying pressure on a currency. Several papers have demonstrated that high frequency changes in major exchange rates can be explained by order flows through the FX markets. Our paper examines whether order flow in the Ghanaian FX market has similar explanatory power.

The study uses a unique database that covers over 80% of the customer order flow of the Ghanaian FX market between 2000 and 2007.[2] Compared to much previous work using customer order flow, our data span a longer period and are sourced from all of the key market-makers in the Ghanaian FX market.[3] Importantly, our study takes into account the unique features of emerging markets, namely the existence of a black market for foreign exchange and the possibility of slow adjustments to information due to market inefficiencies.

We find that once the special features of the market are taken into account, there is strong evidence that customer order flows can explain movements in the Ghanaian exchange rate. Flows into the U.S. dollar result in a depreciation of the local currency in the official FX market. The magnitude of the impact of flows depends on the liquidity levels in the market, but even in the most favourable conditions the impacts are statistically significant, economically large and long-lasting.

The paper is structured as follows. Section 2 reviews the literature. Section 3 provides the main characteristics of the Ghanaian FX market and their impact on the role of order flow as a transmission mechanism for private information. Section 4 presents the data and methodology. Section 5 reports the empirical evidence, while Section 6 summarises and concludes the paper.

2. Review of the literature

[1] The only two other studies on emerging markets that we have located are by Wu (2006) for Brazil and Gereben, et al. (2006) for Hungary.
[2] The data were provided through contacts at the Central Bank of Ghana.
[3] Evans and Lyons (2002a) and Marsh and O'Rourke (2005), for example, use customer order flow data from single market-makers (Citibank and RBS, respectively).

Foreign exchange microstructure research has been motivated by the need to understand exchange rate dynamics at short horizons.[4] The dominant exchange rate models of the recent decades take a macro perspective and come from the macro modelling tradition and have some relative value at long horizons. The search to find a new framework to explain short-run exchange rate dynamics has led to the micro-structural approach to exchange rates, which takes into account the currency trading process that is usually ignored in macro models. In a micro setting, information is assumed to be dispersed and heterogeneous agents can have different information sets. The trading process itself is not transparent and agents may have access to private information about fundamentals or non-fundamental variables that can be exploited in the short-run. Consequently the transactions of better-informed agents may have a larger effect on exchange rates than those of uninformed agents. Thus, the microstructure approach not only recognises private information as being important for exchange rate determination but also takes into account how differences between agents and trading mechanisms affect exchange rates. (see Evans and Lyons, 2002a). This is in contrast to macro models, which assume that all relevant information is commonly known and all participants are the same.[5]

Thus, one of the most important explanatory variables in the microstructure approach to exchange rates is order flow. Order flow, as defined by Evans and Lyons (2002a) refers to "net of buyer-initiated and seller initiated orders; it is a measure of net buying pressure." Order flow consists of 'signed' transaction volumes. In our application, when a participant initiates a transaction by buying (selling) foreign currency in exchange for base currency, the order has a positive (negative) sign.

By observing order flow, a participant might be able to have an idea of the sort of information others may hold. For example, if an initiator's expectation based on his particular information set is that the base currency will fall, this will lead to a sale of the base currency in exchange for the foreign currency. This order flow provides information to other participants, including market-makers, and might result in the strengthening of the foreign currency. Order flow is viewed as a transmission mechanism through which information is transmitted to price. The extent to which order flow is informative depends on the factors that cause it. It is most informative when it transmits private information about macroeconomic fundamentals that is

[4] For a survey of the theoretical and empirical literature see Osler (2009).
[5] Earlier works on FX microstructure have used surveys of FX market participants to support strong heterogeneity of expectations and an increasing diffusion of expectations.

scattered among agents. By aggregating information in this way, order flow establishes a connection between macroeconomic fundamentals and exchange rate movements. On the other hand, order flow is less informative when it is as a result of inventory control activities in reaction to liquidity shocks. Nevertheless, the importance of order flow in exchange rate determination does not mean that it is the underlying cause of exchange rate movements. Rather it is a proximate cause with information being the underlying cause.

The relatively impressive explanatory power of order flow has been confirmed by several microstructure studies. For example, Evans and Lyons (2002a) propose a portfolio shifts model which focuses on the information content of order flow. It is a hybrid model which combines both micro and macro variables. A unique feature of the model is that it allows the use of daily frequency data. According to this model, daily exchange rate movements depend on signed order flow and changes in the interest rate differential. Under the model's null hypothesis, causality runs strictly from order flow to price. The change in interest differential is preferred to other macro determinants because its data is available at a daily frequency and it is usually the main variable in exchange rate determination models.[6] Using interdealer order flow data to analyse the contemporaneous relationship between order flow and exchange rate movements for the DM/USD and JPY/USD over 81 days, they find the order flow coefficient to be significant and positively signed for both exchange rate equations. This means that net dollar purchases leads to an increase in DM and JPY prices of dollars. The model explains about 64% and 46% of movements in the DM/USD and YEN/USD respectively. Importantly, exchange rate movements are mainly explained by order flow, while changes in interest rates account for very little. The paper concludes that a net order flow of $1bn leads the USD to appreciate by 0.5%.

This contemporaneous relationship between interbank order flow and the exchange rate has been confirmed in other studies and for different currency order flow combinations. For example, for the deutschmark see Lyons (2001), Payne (2003); for the Euro see Breedon and Vitale (2004) and Berger et al. (2009), for the Japanese Yen see Evans and Lyons (2002a); for the British pound sterling see Berger et al. (2009); and for several other European currencies see Evans and Lyons (2002b).

Interbank order flows primarily reflect the risk management activities of the banks in the network as they respond to their end-user customer order flows. In an attempt to get

[6] We should expect a positively signed interest differential where the interest rate differential is the non-dollar interest rate minus the US interest rate.

closer to the flows that start the price discovery process, some researchers have analysed customer order flows as seen by individual banks. See, for example, Carpenter and Wang (2003), Froot and Ramadorai (2005), Evans and Lyons (2005a), Marsh and O'Rourke (2005). Many of these studies disaggregate the customer order flow according to the nature of the customer. Broadly, such papers find that financial customer order flow is positively correlated with exchange rate movements, whilst non-financial customer order flow is negatively correlated. The latter finding is difficult to understand and the interpretation, often, is that while financial customer flows contain price relevant information, non-financial customers follow high frequency negative feedback trading rules which induces a negative correlation at lower frequencies.[7]

The key question addressed in this paper is: Do the main results from the microstructure approach to modelling advanced FX markets also hold for emerging FX markets? There are only a couple of studies which have examined the role of order flow in emerging FX markets. Gereben et al. (2006) examine the role of customer order flow in the Hungarian forint market. Their study is mainly based on the Evans and Lyons (2002a) framework. They test whether order flow contributes to explaining exchange rate changes and identify the roles played by the different participants for which they have data (domestic non-market making banks, domestic non-banks, the central bank, foreign banks and foreign non-banks). Results indicate that purchases of domestic currency by foreign banks, foreign non-banks and the central bank cause an appreciation in the Hungarian currency relative to the euro, while the coefficients of the domestic banks and non-banks are not significant. Order flows from foreigners and the central bank therefore have incremental information content.

Wu (2006) studies the behaviour of order flow and its influence on the official exchange rate dynamics in Brazil, using data of daily customer transactions over the period July 1999 to June 2003. Customers are divided into commercial customers, financial customers and the central bank. Wu's model is similar to that of previous microstructure models but with two key changes. First, Wu favours a general equilibrium model where customers' demand for FX is induced by macro fundamentals, including contemporaneous changes in the exchange rate. Second, FX dealers do not have to close with zero net positions at the end of each trading day. These dealers may decide to provide extra liquidity in the case where there is an imbalance between customer buy and sell orders, but they charge a risk premium. It is this premium that

[7] Evans and Lyons (2005) discuss the nature of disaggregated order flow in detail and explain negative correlations differently.

drives the correlation between flows and exchange rates rather than information content of flows. The model predicts a two-way relationship between customer order flow and exchange rates, which is confirmed by the empirical results.

In our study we start with the basic model of Evans and Lyons (2002a) and modify it to take into account potential market inefficiencies and the existence of a parallel black market in Ghana. The black market for foreign exchange is a widespread phenomenon in emerging markets. Our analysis, based on proprietary data covering almost the whole market, confirms the importance of customer order flow in explaining short-run exchange rate dynamics in Ghana. In particular, we find the contemporaneous relationship between order flows and exchange rates as suggested by previous studies. However, we also observe a lagged interaction between order flow and exchange rates. These lagged effects are likely due to delays in the price transmission mechanism associated with inefficiencies in the aggregation of private information due to the characteristics of the Ghanaian FX market. Order flow has a long term impact on exchange rates in the official market, while its impact on the black market is only temporary. Additionally, the study confirms the connection between the price impact of the order flow and the degree of liquidity in the FX market.

3. Main Characteristics of the Ghanaian FX market

To give an indication of the size of the Ghanaian FX market, average daily market turnover between January and August 2007 was approximately $38m. It is a spot market with no forward FX market. Unlike the major currencies (with liquid markets) that are traded worldwide, a small currency like the Ghanaian cedi is only traded onshore. [8] The US dollar is the most traded foreign currency in Ghana and subsequently plays the role of a vehicle currency in cross currency transactions.

Only licensed banks and foreign exchange bureaus are allowed to perform FX intermediation. In Ghana, all banks (both domestic and foreign-owned) are permitted to deal in FX. The licensing of intermediaries makes it easier for the central bank to enforce its regulations concerning the use and exchange of foreign currency. For example, a customer will have to provide the proper documentation relating to the underlying economic transaction that is generating the demand for foreign currency. However, it is regulations like these that make the parallel market a suitable alternative for some participants, as discussed below.

[8] Central bank regulations prohibit the operation of offshore trading of the Cedi.

Currently, there are 17 active dealer banks in the foreign exchange market. However, the top five banks account for approximately 82% of total volume of transactions on the FX market[9] and are thus the main market makers and play a vital role in the determination of the exchange rate. The Ghanaian FX market is a pure dealer market. Dealers usually provide liquidity to the market by absorbing order flow imbalances. This is achieved through a mixture of exchange rate adjustment and inventory management. Specifically dealers set two-way exchange rates at which customers can buy and sell FX, they absorb any excess demand or supply and adjust exchange rates to manage their net open FX positions. Apart from providing liquidity, net open positions allow dealers to speculate against the cedi by building positions before expected currency depreciation takes place.

Unlike many other emerging FX markets, limits are not imposed by the central bank on net open positions. Rather the central bank has opted for monitoring the foreign exchange positions, thus increasing the scope for market making. In Ghana, banks are required to report each foreign exchange transaction at their respective exchange rates. As discussed below, these are the order flow data used in this study.

In communicating and trading with each other, dealers agree to trades in telephone conversation which are later confirmed by fax or telex. There are no electronic trading platforms that allow for bilateral conversations and dealing. Interbank activity is relatively low.

The heavy involvement of the central bank in the FX market limits the scope for price discovery. This is because the central bank has an information advantage over the other banks due to its ability to obtain private information from the main market makers. From 2002 to present there is evidence of large-scale central bank activity in the FX market. The central bank absorbs innovations in the order flow at existing exchange rates, usually with the aim of reducing exchange rate volatility.[10] The exchange rate is still determined by market forces but with the central bank absorbing part of the excess demand or supply. This issue is explored by Duffuor, Marsh and Phylaktis (2009).

The high degree of concentration already mentioned above could also lead to higher transparency. Each of the dealers from the top 5 banks observe a significant proportion of the market and may have a rough idea of the trading flow that they are not involved

[9] See June-September 2007 Quarterly Bank of Ghana Report
[10] The central bank refers to these actions as 'balance of payment support'.

with. In general, however, the central bank does not disclose information obtained from banks' reporting requirements because of the proprietary nature.

The black market for foreign exchange in Ghana came into existence for a number of reasons. In early 1980s the black market was thriving due to smuggling and illegal FX operations.[11] In 1981 the FX operations had become so widespread that the black market rate was 9.6 times higher than the official rate. Around this period, transactions in the black economy accounted for about a third of Ghana's GDP. [12] In 1986, however, the government introduced a system where the exchange rate was determined by periodic currency auctions, which were under the influence of market forces and consisted of a two-tier exchange rate system, one rate for essentials and another for non-essentials. By 1987, the two auctions were merged. Most of the foreign exchange inflows were allocated through the auctions. In an attempt to eradicate black market operations, the government allowed private foreign-exchange bureaus (hereafter FX bureaus) to trade in foreign currency. In July 1989, there were 148 FX bureaus operating all over Ghana. Eventually the huge gap between the auction rate and FX bureau rate narrowed drastically.[13] In 1992, the auction system was abandoned. FX bureaus and other purchasers of foreign currency were referred to the central bank, which used the market-determined exchange rate. Gradually Ghana moved towards a market-determined exchange rate and lowered tariffs in order to attract more trade. In this study we use the FX bureaus rate as a proxy for the black market rate.

There are numerous FX bureaus that compete with the banks but they account for a small portion of the foreign exchange market. On a typical day, the daily turnover of FX bureau operators situated in the main city centres ranges from $10-$20k. However, this depends on seasonal factors with peak flows being observed during the last quarter of the year, when retailers (importers) prepare for Christmas shopping. Peak flows are also associated with the annual Hajj trip to Saudi Arabia. Presently, the bureaus' main source of FX is the general public. The central bank ceased the supply of FX to the bureaus around 2000/2001. This move seriously affected the profitability of the bureaus because Central Bank flows represented a cheap source of funding and fierce competition has developed between bureaus.

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[11] Black markets come into existence, when access to the official foreign exchange market is limited and there are various foreign exchange restrictions on international transactions of goods, services and assets. An excess demand develops for foreign currency at the official rate, which encourages some of the supply of foreign currency to be sold illegally, at a market price higher than the official rate." (see Phylaktis 1997).

[12] It should be noted that often a substantial black economy feeds the black foreign exchange market.

[13] Specifically, the gap narrowed from 29% in 1988 to about 6% in 1991.

FX bureaus engage in FX transactions with banks. Their relationship can be described as a typical bank-customer relationship where bureaus operate FX deposit account with banks. Nevertheless they share a special relationship where bureaus use bank rates as a guide and banks call bureaus on a daily basis to check their rates. On average bureaus quote higher rates than the banks. The difference between bank rate and bureau rates is mainly due to the relative flexibility of the bureaus. Bureaus adjust their rates 3-4 times each day in response to market signals. On the other hand, banks' rates rarely change during the day.

FX bureaus are regulated by the central bank, which obliges them to submit monthly returns and financial accounts, and makes random spot checks where for example officials check whether cash tally with receipts. Nevertheless, a sizeable portion of them still engage in illegal activities. These illegal activities mainly consist of non-issuance of receipts for FX transactions and illegal remittances.[14] Ghanaian bureaus have representative/agents in London who receive remittances on their behalf. Consequently the bureaus in Ghana search for scarce FX on the market to pay the recipients. This is contrary to the normal procedure where it is rather the cedi-equivalent of the remittance that is paid to recipients.

Aside from the banks, the FX bureaus and the financial services companies for remittances constituting the regulated forex market, there is the usual unofficial parallel forex market made up of illegal dealers who operate from unauthorized locations. According to the central bank, their operations constitute less than 5 percent of the forex market turnover. They are not considered further in this paper.

Thus, certain characteristics of the microstructure of the Ghanaian foreign exchange market will have an impact on the role of order flow as a transmission mechanism for private information. The low level of interdealer market and the lack of electronic trading platforms might slow down the aggregation of private information. On the other hand, the small number of players in the market might increase the aggregation process because there is greater transparency as each player observes a greater proportion of the market. Furthermore, the involvement of the Central Bank in the foreign exchange market limits the scope for price discovery. Finally, the existence of FX bureaus might contribute to the aggregation of private information as another market player closely in touch with customers.

[14] The central bank regulation prohibits bureaus from providing money remittances service, yet some bureaus are reported to engage in illegal money remittances.

At the same time, the Central Bank in setting the exchange rate each day could be observing the FX bureau rate as it is freely determined. Thus, there is simultaneously another dynamic relationship between the official rate and the FX bureau rate, which is linking the two rates together in the long-run and which has to be taken into account in modelling the relationship between order flow and the exchange rate.

In the next section, we present the data employed and the models we estimate.

4. DATA AND METHODOLOGY

4.1 Exchange Rate and Interest Rate Data

The Central Bank of Ghana is the main source of data for the spot foreign exchange market. The data set includes both the daily official and the FX Bureau rate, which is a proxy for the parallel (black market) cedi/dollar rates over the period 3rd January 2000 to 29th December 2007. With the exception of the parallel market, foreign exchange trading takes place during normal banking hours (9am to 4/5pm). FX bureau data is collected by the central bank daily and is the average of the individual bureau rates. It should be noted that the FX bureaus do not observe any customer order flow on the official FX market. The banks' transaction quotes represent the midrate between the bid and ask quotes at the close of each day. The transaction rate charged by a particular bank will depend on the availability of FX at that point in time.

For an emerging market like Ghana, it would be unwise to disregard the thriving black market for exchange rates. The Ghanaian Central bank acknowledges this fact and therefore incorporates black market exchange rates (FX Bureau rates) in its analysis and decision making. The official (transaction rate) is a weighted average of the rates charged of the various bank transaction rates, with the volumes used as weights, and the FX Bureau rate.

The interest rate differential is the difference between the Ghana daily three-month Treasury bill rate and the US daily three-month Treasury bill rate, expressed on an annual basis. The Ghanaian rates were collected from the Central Bank of Ghana while the US data were obtained from the Federal Reserve website.

The data sample is diverse in the sense that it contains a period of relative stability and a period of turbulence (see Figure 1). Therefore, the sample period is divided into two sub-periods and our analysis will confirm that the exchange rate behaves differently during these two sub-periods.

The first sub-period represents the crisis period spanning the whole of 2000. The crisis period was characterised by spiralling inflation of more than 40% p.a. and rapid deprecation of the cedi. During 2000, the cedi depreciated by about 50% against the US dollar. This situation could be attributed to falling prices of Ghana's major exports commodities (main foreign exchange earners), namely cocoa, gold and timber. To further exacerbate this situation, the price of imported crude oil which previously hovered around $10 per barrel, soared to $34 by mid 2000. Furthermore, the official donor inflows, which hitherto had been supporting the economy, were withheld in 2000. Against all these challenges, Ghana had to pay about $200 million every month towards foreign debt obligation by drawing on the already depleting foreign exchange reserves. This created an acute shortage of foreign currency as demand for dollars far outstripped supply. In light of the fact that the nation is heavily dependent on imports, the scarcity of FX fuelled inflationary pressures. Low business confidence and political uncertainty over the outcome of the December 2000 presidential elections led to massive capital outflows around the middle of 2000. At this point, the relative scarcity of FX allowed the black market agents to demand large premiums.[15] This contributed to the spike in the premium during July 2000 (see Figure 2b).

The second sub period represents the relatively stable period spanning 2002-2007.[16] By 2002 the prices of Ghana's main exports, cocoa and gold, had recovered slightly and the authorities were able to stabilise the main macroeconomic indicators. Equally important in 2002 was the resumption of intervention activity on the FX market by the central bank, which stabilised the official exchange rate.

By the end of 2001 CPI inflation stood at 21% and the Cedi depreciated by only 3.5%. This was the result of tight monetary and fiscal policies. These developments contributed to the restoration of business confidence in Ghana. At the start of 2004, there is another big hike in the premium due to political uncertainty over the outcome of the December 2004 elections.

The descriptive statistics (see Panel A, Table 1) demonstrate the heterogeneity of volatility across the regimes. In order to give an idea of scale, we compare exchange rate movements in the cedi to those of the larger and more liquid market euro-dollar market. In comparison to the cedi/USD movements, the EUR/USD has enjoyed

[15] The black market premium is defined as the spread between the black market rate and the official rate divided by the official rate and multiplied by 100.

[16] It should be noted that the transitional period between the crisis period and the relatively stable period, Jan 2001 to Jan 2002, was left out. Data during that period was noisy and could over-shadow the actual results of the analysis.

extreme stability. The relative stability experienced by the Ghanaian cedi in what we call the stable period would be a currency crisis for the Euro.

With the exception of black market rate changes during the crisis period, exchange rate changes are generally serially correlated (Panel B, Table 1). All the autocorrelations (and unreported partial autocorrelation coefficients) are statistically significant out to several lags. This could be evidence of inefficiencies in an under-developed and illiquid market. This issue will be addressed when considering our modelling strategy.

4.2 Order Flow Data

The source of order flow data is the Daily Foreign Exchange Report of the Bank of Ghana (the Central Bank of Ghana), which contains all foreign exchange transactions of significant size carried out by commercial banks resident in Ghana. This data allows us to calculate daily order flow measures between domestic market-making banks and their different customer groups. Most banks consider their customer trades to be highly confidential and are usually reluctant to release such data to the public. In Ghana, it is a regulatory requirement for all market making banks (both Ghanaian and foreign) to report all their daily foreign exchange transactions to the central bank. The five banks in order of share of deposits are Barclays Bank (BBG), Standard Chartered (SCB), Social Security Bank (SSB), Agricultural Development Bank (ADB) and Ghana Commercial Bank (GCB).[17] These commercial banks register every single foreign exchange trade (purchase and sale) with their customers at respective transaction rates.

This data set provides us with a relatively complete picture of the cedi/dollar market. This is similar to the datasets of Rime (2001) and Bjønnes, Rime and Solheim (2005) which account for about 90% of the Norwegian and Swedish markets respectively. The trades are aggregated over each day for each bank and for the total of the five banks.[18]

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[17] SCB and BBG were the first banks to be set up in Ghana at the beginning of the 20th century. Their main line of business was trade finance and they mainly served the expatriate community. This trend has continued with a majority of their customers being multinationals and large and medium-scaled enterprises. GCB was the first indigenous bank to be set up in 1953. Its main objective was to extend credit to the local population. GCB owns about 50% of all branches in Ghana. Its customer base is well diversified with customers ranging from state enterprises to private individuals. It is the largest bank in Ghana in terms of deposits and assets. ADB was a development bank established in 1965 to cater for the needs of the agricultural sector. It has a vital role since the agricultural sector is still the largest contributor to the GDP. Until 2005 it was the sole agent for Western Union money transfer. As a result remittances account for about 90% of its foreign flows. Its customer base consists of mainly small to medium scaled enterprises and private individuals. SSB is the smallest bank in the 1st quartile. It was set up by the social security and national insurance trust in 1977. Societe Generale, the French Bank, acquired controlling interest in the bank in March 2003.

[18] We have performed similar analyses based on flows seen by individual banks. However, these results are more noisy and statistically less reliable.

Order flow is calculated by taking the difference between the value of buyer initiated trades and the value of seller initiated trades, measured in dollars. A positive order flow denotes net dollar purchases. In order to determine the sign of the trades we make the widely used assumption that trades between banks and customers are initiated by the customer. This assumption is based on the fact that trading between banks and their customers is likely to occur when customers demand this service and therefore become initiators. Banks act as the middlemen between the interbank market and the customers. Customers place orders with their banks and then the banks trade with each other on the interbank market. The resulting order flow is what aggregates information into prices. Unfortunately, this data set does not allow us to distinguish between the various customer groups as has been possible in some earlier studies. We use data aggregated to a weekly frequency in our analysis, as explained below, and so we plot weekly order flow in Figure 2.

4.3 Methodology

We start our analysis with the static framework proposed by Evans and Lyons (2002a) to be consistent with previous literature. Nevertheless, it is unlikely that this static model will be successful at capturing the dynamics of a largely inefficient, under-developed and illiquid FX market. Furthermore, it ignores the relationship between official and black markets. We subsequently explain the modifications to the model to take into account the characteristics of foreign exchange markets in emerging economies.

The generic order flow model proposed by Evans and Lyons (2002a) can be represented by an equation of the form:

$$\Delta S_t = \alpha + \beta X_t + \gamma \Delta r_t + \varepsilon_t \qquad (1)$$

where ΔS_t is the log change in official exchange rate, X_t is the total net customer order flow from the top five Ghanaian commercial banks, Δr_t is the change in the interest differential defined as the nominal Ghanaian three-month treasury bill rate minus the nominal US three-month t-bill rate.[19] Customer order flow is measured in millions of US dollars. When β, the coefficient of order flow, is positive and significant we say that the purchase of dollars by customers results in a depreciation of the cedi (an increase in the exchange rate versus the dollar). This refers to the null hypothesis of the

[19] A similar equation is estimated using the black market exchange rate rather than the official rate.

order flow concept which states that information from order flow causes exchange rate changes.

Subsequently, in light of the discussions above regarding the particular characteristics of the Ghanaian FX market, we modify the generic model in the following ways. First, as indicated by the presence of autocorrelation in exchange rates, there are inefficiencies in the Ghanaian foreign exchange market (see Tables 4-7). We capture the dynamics in the market by including lags of both the explanatory and dependent variables. We thus take into account the fact that changes in order flow and interest rate differentials may not affect the exchange rate immediately but rather with a lag over several time periods. When customer trades are executed, there may be some delay in the time it takes for the information conveyed by trades to be embedded in exchange rate.

Second, we include the black market premium to take into account the long-run relationship between the black and official exchange rates. We explore the long-run relationship between the official and black exchange rates by testing whether the black market premium is stationary using the augmented Dickey-Fuller (ADF) test. The null hypothesis of a unit root is rejected in favour of the stationarity alternative for both periods, suggesting that the official and black market rates move in tandem in the long-run. [20]

Third, we explore whether the explanatory power of order flow comes from its expected component, the unexpected component, or both. In the Evans and Lyons (2002a) model, all order flow is deemed to be unexpected (and statistically this assumption appears to be borne out by the unpredictability of most major market order flow series at daily horizons). However, in the case of Ghana we will demonstrate that order flow is to some extent predictable and it is possible that explanatory power comes from both the expected and unexpected components. In this case, whilst a significant role for unexpected order flow would indicate price discovery in the FX market, a significant impact from expected flow on the exchange rate would be an indication of inefficiencies in the FX market.

Our modified model is based on an enriched version of the VAR in Love and Payne (2008). We say 'enriched' in the sense that, though we drop the news variable from their equation, we include lagged changes in the black and official market rates, lagged

[20] Results not shown but can be provided by the authors. Similar results were found in Phylaktis and Moore (2000) for other emerging markets. For a theoretical explanation of the long-run relationship between the official and the black market rates see Phylaktis (1992)

changes in the interest differential and lagged black market premium. We decompose order flow into expected (EF) and unexpected (UF) components and determine which component accounts for movements in the official and black exchange rates.

The decomposition of the contemporaneous order flow X_t into its expected and unexpected components is done using a two stage procedure. Order flow is first regressed on changes in the interest rate differential, the lagged black market premium, lagged values of order flow and lagged exchange rate changes (both official and black market).

$$X_t = \alpha_2 + \sum_{i=1}^{n} \beta_i X_{t-i} + \sum_{i=1}^{n} \gamma_i \Delta S_{t-i} + \sum_{i=1}^{n} \delta_i \Delta B_{t-i} + \sum_{i=1}^{n} \sigma_i \Delta r_{t-i} + \kappa P_{t-i} + \mu_t \qquad (2)$$

where in addition to terms already defined, ΔB_t is the log change in the black market rate and P_t is the black market premium. We store the fitted values as expected flows and the residuals as unexpected flows. We then substitute the expected and unexpected flow variables in the exchange rate equation and run the regression. This is done for both the official and black market exchange rates. Specifically one equation has changes in the official exchange rate as the dependent variable, whilst the other has changes in the black market rate as the dependent variable. The equation for the official exchange rate is given below:

$$\Delta S_t = \alpha_1 + \sum_{i=0}^{n} \beta_i EF_{t-i} + \sum_{i=0}^{n} \tau_i UF_{t-i} + \sum_{i=1}^{n} \sigma_i \Delta r_{t-i} + \sum_{i=1}^{n} \delta_i \Delta B_{t-i} + \sum_{i=1}^{n} \gamma_i \Delta S_{t-i} + \kappa P_{t-1} + \mu_t \qquad (3)$$

We estimate equations for the exchange rate and the order flow individually using OLS. Since these equations have many regressors we adopt the general to specific modelling approach. Specifically we start with an extremely general model, which is over-parameterised, and reduce it to the most parsimonious model by sequentially excluding insignificant terms. We also apply the Newey-West procedure which results in standard errors that are consistent in the presence of both heteroscedasticity and serial correlation. Finally, it should be noted that we estimate the regressions for the two sub-periods separately.

5. Empirical Evidence

5.1 Main Results

The first two columns of Table 2 report estimates of the static model (equation (1)) using the full data period. Although the original data is at a daily frequency, preliminary regressions indicated that daily data is too noisy. Consequently, we aggregate the data to a weekly frequency in an attempt to solve the problem. Customer order flows are significant in this generic static model but have a negative sign, contrary to what is expected, for both official and black market exchange rate changes. Over the full sample period, then, net purchases of the dollar by customers are associated with an appreciation of the cedi.

These negative results could emanate from the heterogeneity of our data sample, the static nature of our model, and the inefficiencies likely in this FX market. As already discussed we tackle sample heterogeneity by dividing the sample into sub-periods. The first sub-period represents the crisis period spanning January 2000 to December 2000 when the exchange rate depreciated by almost 50%. The second sub-period corresponds to the relatively stable period spanning March 2002 (when the central bank resumed intervention) to December 2007.

Splitting our data sample improves our estimates in one dimension. For the crisis period, the order flow variable is now positively signed and significant in explaining movements in the official exchange rate (columns 3 and 4 of Table 2). This means that a net purchase of dollars by customers is associated with a depreciation of the cedi. When the dependent variable is the change in the black market rate, order flow is not significant. In other words, flows have no explanatory power in the black market during the crisis period. The interest differential is however highly significant and correctly signed in both markets.

During the stable period, however, order flow remains highly significant but negatively signed with the official exchange rate as the dependent variable. For the black market rate, order flow is only weakly significant but is still negatively signed. The interest differential is now insignificant. The adjusted goodness of fit measures are low in both markets, suggesting that contemporaneous order flows and changes in interest rates do little to explain exchange rate changes.

In general, the results of the static model are unconvincing even when we split the sample. Given the peculiarities of the Ghanaian FX market we proceed to estimate the modified enriched model as represented by equations (2) and (3). Detailed results for the order flow regressions are presented in Table 3, while those for the exchange rate are given in Table 4.

Looking first at the results for order flow we observe positive momentum in flows during the stable period and negative momentum during the crisis period. Lagged official exchange rate changes are also important in explaining order flow in both periods. The coefficient signs are such that appreciations of the dollar induce subsequent selling of the dollar – negative feedback trading. Black market rates and changes in the interest differential are important during the crisis period but not during the stable regime. The lagged black market premium is never significant. The goodness of fit statistics suggest that we can explain a reasonable proportion of the variation in order flows using simple lagged information. This is in contrast to studies on advanced markets where order flow is more or less unpredictable.

Recall that the estimated values of the equations now form the expected component of order flow and the residuals the unexpected component. These two order flow terms are introduced separately into a regression with the change in the exchange rate as dependent variable.[21]

Once order flow is split in two, the expected and unexpected components (current and/or lagged) are significant in explaining movements in both official and black market exchange rates.

During the crisis period expected and unexpected flows have an instantaneous and lagged effect on the official exchange rate, while both have only lagged effects on the black market exchange rate. The coefficients on order flow components are mainly positive (exclusively so for the unexpected flow) suggesting that buying pressure on the dollar – expected or unexpected – is associated with an appreciation of the dollar.

There is also positive momentum in official and black market exchange rate changes during the crisis period. Another important observation is that the lagged black market premium is statistically significant only in the black market exchange rate equation. The negative coefficient estimate implies that, in the long-run, the black market rate eventually adjusts to the official rate. The interest rate differential is positive as expected and statistically significant only in the official market indicating that different factors might affect the black market rate.

Moving to the stable period, lagged unexpected order flows are significantly positively associated with changes in the official exchange rate. Expected flows bear mixed signs

[21] In addition to the decomposition used in the paper, we also decompose flows based on fundamentals. Our results carry through.

at different lag lengths. Exchange rate momentum patterns are also more complex during the stable period.

A clearer picture emerges about the impact of order flow on the exchange rate when we add up the coefficients of the lags of the order flow components in the specific model (see Table 5). In the official market, unexpected order flow has a larger impact on exchange rates relative to expected order flow and is correctly (positively) signed for both crisis and stable periods. Results for the black market are mixed. Unexpected order flow has a relatively smaller impact for both periods but is negatively signed during the stable period.

We also observe that the coefficients during the crisis are generally much larger in magnitude compared to those in the stable period. In other words the dollar impact of flows on exchange rates is much larger in the crisis period. The estimates suggest, for example, that during the crisis period an unexpected net customer purchase of $1bn over the previous four weeks would result in 37% depreciation in the official exchange rate of the cedi this week. A similar flow in the stable period would cause a 3.3% depreciation. This is consistent with findings by Marsh and O'Rourke (2005) who find that there is an inverse relationship between the magnitude of coefficients and the liquidity of the FX market.[22] Of course, the coefficients always suggest a flow of a given dollar value has a much larger impact in the Ghanaian market than in more liquid advanced markets.

In most cases, other variables such as the lagged changes in exchanges rates (official and black) are very significant. As discussed previously this is consistent with the inefficiencies and under-development in the Ghanaian FX market. As a result, agents' speculation about future exchange rate movements is based on immediate past values of the exchange rate itself.

5.2 Temporary or Permanent effects of order Flow?

It is critical to order flow literature to ascertain whether impacts are temporary or permanent. If the effects of unexpected flows are permanent then that means information is being conveyed by flows. On the other hand, the temporary effect of unexpected flows could be as a result of a variety of liquidity effects, most likely due to

[22] Supporting evidence of the reduced liquidity during the crisis period is provided by the much higher bid/ask spread for both the official and black markets. The spread in the official (black) market was 0.250 (0.418) during the crisis period, compared to 0.120 (0.237) during the stable period.

inventory management by the market-makers. To find out whether effects of flows are purely temporary, we test for the significance of an aggregate effect using a Wald coefficient restriction test on the flow variables. This consists of an F-test with a null hypothesis that the sum of the coefficients is zero. In other words the null hypothesis states that the aggregate effect of flows is temporary, while the alternative is that the effect is long-lasting.[23] The Wald tests were conducted on the specific models, i.e. once the insignificant coefficients have been eliminated through sequential removal of insignificant terms in the regression, and p-values of these tests are reported in brackets below the aggregated order flow impacts in Table 4.

Unexpected order flow has a positive and long-lived effect on the official exchange rate in both periods. This can be interpreted to mean that unexpected order flow conveys incremental information which causes permanent (or at least very long-lasting) changes in the exchange rate, in line with the basic microstructural approach exchange rates. The price-impact of unexpected order flow is much lower during the stable period than during the crisis. As previously discussed, this could be related to the level of liquidity during both periods.

Lagged unexpected flows into the dollar are positively correlated with future appreciations of the dollar. This forecasting power is consistent with the findings of Evans and Lyons (2005b) and Rime, Sarno and Sojli (2010) who demonstrate short-term forecasting ability based on order flows in major FX markets. It is important to note that our results are not necessarily indicative of a failure of market efficiency. No one private sector institution knows the market-wide flow used in our analysis, and so cannot infer the unexpected component necessary to forecast exchange rate changes as we have.

Results for expected flows are more mixed. In the stable period they have a long-lasting negative impact on exchange rates, but a long-lived positive effect during the crisis. We interpret the latter result as possibly indicating the long-lived nature of liquidity impacts during the crisis. The negative impact during stable times is more difficult to explain since it would suggest that expected flows into the dollar permanently lower the price of the dollar. However, we note from Table 10 that this result is largely driven by the highly negative contemporaneous correlation between official exchange rate changes and expected flows. The conventional explanation for a

[23] Strictly speaking, we are not testing for a permanent impact. The cedi exchange rate does not follow a pure random walk, and so our approach tests for an impact from flows on the exchange rate that, in sum, is non-zero.

contemporaneous negative correlation is that corporates follow negative feedback trading rules, taking advantage of short-term exchange rate movements to exchange money for non-speculative reasons such as repatriation of funds and import of raw materials. That is, the causation of the key contemporaneous relationship runs from exchange rates to (expected) flows and not vice versa.[24] It is interesting to note that in the crisis period (when negative feedback trading would incur serious losses) the contemporaneous correlation between expected flows and official exchange rate changes is positive. Thus we hypothesis that the long-lasting negative effect of expected flows on the exchange rate is spurious, and is driven instead by a long-lasting negative effect of the exchange rate on expected flows.

Expected and unexpected order flows have only temporary effects on the black market rate during stable market conditions. This absence of price discovery reflects the nature of transactions on the black market. The official FX market is relatively stable and it costs less (and is more convenient) for customers (individuals and institutions) to obtain FX from the banks. As a result a majority of flows that reflect information are seen by commercial banks and priced in the official market. These results further confirm previous findings that it is the black market rate that adjusts to the official spot rate.

6. Discussion and Conclusion

This paper examines whether customer order flows influence exchange rates using data from an emerging market. We use a standard model from the FX market microstructure literature, but in considering an emerging market like Ghana, we recognise the need to incorporate some distinct features of the market. In particular, we must recognise potential inefficiencies in the market place and allow for the existence of a parallel black market for foreign exchange. Further, we find it necessary to split our data into periods coinciding with economic crisis and more stable times.

Once modified to take into account market inefficiencies, the (long-run) relationship between the black and official rates, and decomposing flows into expected and unexpected components we find more positive results from the application of Evans and Lyons' (2002a) model.

Our key finding is that unexpected order flow has a permanent effect in the official market during both crisis and more stable periods. This is consistent with the previous

[24] The presence of negative feedback trading in our application is also confirmed by the highly significant and negatively signed lagged exchange rate variables in the order flow VAR (see Table 3).

literature, based mainly on analysis of advanced markets, that unexpected order flows convey incremental private information that affects exchange rates. Our results confirm this premise in an emerging market, once its idiosyncrasies are incorporated into the empirical model.

We observe that when the market is almost illiquid during the crisis period, order flow has a relatively larger impact on exchange rates than in the more liquid stable period. This confirms findings by Marsh and O'Rourke (2005) who find that there is a connection between the price impact of the order flow and the (cross-sectional) degree of liquidity in the FX market.

We observe lagged interactions in both directions between order flow and exchange rates. The lagged effects of flows on exchange rates are due to the delays in the price transmission which are in turn associated with inefficiencies in the FX market. The effect of lagged exchange rate changes on flows is indicative of feedback trading.

We find no evidence of price discovery in the black market. We argue that this could be because the majority of the FX transactions now occur in the official market, while transactions on the black market are significantly lower in terms of volume and value. Not surprisingly most of these transactions are conducted by individuals and petty traders. We also observe that the lagged black market premium (which is highly significant) is negatively correlated with changes in the black market rate. This suggests that the black market rate adjusts to the official rate to maintain equilibrium between exchange rates in these two markets.

Our results give us a deeper insight into the relationship between order flow and the exchange rate in emerging markets. Specifically, there is strong evidence of information aggregation and price discovery based on the unexpected component of order flow during both regimes. Nonetheless, expected order flow too seems to have an impact on order flow and we argue that this is due to a combination of inefficiencies in the FX market and negative feedback trading by corporates.

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Table 1: Descriptive statistics for weekly changes in log exchange rates

	Full		Crisis			Stable		
	Spot	Black	Spot	Black	Euro-dollar	Spot	Black	Euro-dollar
Panel A:								
Mean	0.243	0.247	1.313	1.263	0.000	0.085	0.085	0.000
Median	0.064	0.063	1.095	0.622	0.000	0.041	0.064	0.000
Maximum	4.373	6.206	4.373	6.206	0.042	0.973	1.697	0.025
Minimum	-0.896	-1.738	-0.885	-1.738	-0.023	-0.742	-1.398	-0.021
Std. Dev.	0.623	0.798	1.243	1.759	0.009	0.189	0.330	0.006
Panel B:								
AC(1)			-0.299	-0.035		-0.448	0.105	
AC(4)			-0.128	0.103		-0.063	0.080	
Observations	412	412	51	51	51	300	300	300

Full period statistics are calculated over the period January 2000 to December 2007, the crisis period is January 2000 to December 2000, and the stable period is March 2002 to December 2007.

Table 2: Generic Order Flow Model

Regression of weekly change in log exchange rates (both official spot and black market) on total order flow and change in interest differential over the full sample period and two sub-periods: $\Delta S_t = \alpha + \beta X_t + \gamma \Delta r_t + \varepsilon_t$

	Full		Crisis		Stable	
	Spot	Black	Spot	Black	Spot	Black
X_t	-1.548	-1.727	1.259	0.494	-3.965	-3.471
	(-3.085)	(-3.354)	(2.456)	0.741	(-2.364)	(-1.506)
Δr_t	0.249	0.308	0.538	0.900	-0.004	0.001
	(1.576)	(1.244)	(4.325)	(3.000)	(-2.364)	(0.013)
Adjusted R^2	0.076	0.061	0.146	0.138	0.003	-0.001
Serial correlation	0.000	0.000	0.010	0.149	0.062	0.000
Heteroscedasticity	0.001	0.000	0.902	0.789	0.298	0.162

All equations are estimated using OLS. We multiply the order flow coefficients by 10. Robust t-statistics are given in parentheses below coefficient estimates. The final two rows give p-values for tests for first order serial correlation and heteroscedasticity, respectively. Full period statistics are calculated over the period January 2000 to December 2007, the crisis period is January 2000 to December 2000, and the stable period is March 2002 to December 2007.

Table 3: Order flow regression from augmented VAR for crisis and stable periods.

Order flow is regressed on its own lags, lagged spot exchange rate changes, lagged black exchange rate changes and lagged interest differential

$$X_t = \alpha_2 + \sum_{i-1}^{4} \beta_i X_{t-i} + \sum_{i=1}^{4} \gamma_i \Delta S_{t-i} + \sum_{i=1}^{4} \delta_i \Delta B_{t-i} + \sum_{i=1}^{4} \sigma_i \Delta r_{t-i} + \kappa P_{t-i} + \mu_t$$

	Crisis	Stable
X_{t-1}	-3.885	1.361
	(-3.180)	(2.243)
X_{t-2}	-2.801	1.824
	(-3.233)	(2.878)
X_{t-3}		1.521
		(2.605)
X_{t-4}		1.706
		(2.627)
ΔS_{t-1}	-0.593	-0.501
	(-02.011)	(-1.942)
ΔS_{t-2}		-0.396
		(-2.086)
ΔB_{t-2}	0.681	
	(2.207)	
ΔB_{t-3}	-0.159	
	(2.262)	
Δr_{t-1}	-0.860	
	(-3.451)	
Δr_{t-4}	-0.477	
	(-3.478)	
Adjusted R^2	0.376	0.290
Serial correlation	0.861	0.102
Heteroscedasticity	0.024	0.074

All equations are estimated using OLS. We multiply the order flow coefficients by 10. Robust t-statistics are given in parentheses below coefficient estimates. The final two rows give p-values for tests for first order serial correlation and heteroscedasticity, respectively. Full period statistics are calculated over the period January 2000 to December 2007, the crisis period is January 2000 to December 2000, and the stable period is March 2002 to December 2007.

Table 4: Exchange rate regression from augmented VAR for crisis and stable periods.

Changes in the official spot exchange and black market rates are regressed on its own lags, current and lagged expected and unexpected order flows, lagged black exchange rate changes, lagged interest differentials and lagged black market premium.

$$\Delta S_t = \alpha_1 + \sum_{i=0}^{4}\beta_i EF_{t-i} + \sum_{i=0}^{4}\tau_i UF_{t-i} + \sum_{i=1}^{4}\sigma_i \Delta r_{t-i} + \sum_{i=1}^{4}\delta_i \Delta B_{t-i} + \sum_{i=1}^{4}\gamma_i \Delta S_{t-i} + \kappa P_{t-1} + \mu_t$$

	Crisis		Stable	
	Spot	Black	Spot	Black
EF_t	2.854		-10.650	
	(4.121)		(-9.289)	
EF_{t-1}			5.134	
			(5.985)	
EF_{t-2}		1.793	4.914	1.828
		(2.149)	(5.418)	(1.700)
EF_{t-3}	-1.748	2.537	-1.411	-2.513
	(-3.641)	(1.849)	(-2.874)	(-2.361)
UF_t	2.367			
	(4.059)			
UF_{t-1}			1.480	0.453
			(7.158)	(2.006)
UF_{t-2}	1.379	1.779	1.458	
	(1.836)	(1.958)	(7.938)	
UF_{t-3}			0.358	-0.591
			(2.264)	(-2.119)
ΔS_{t-1}	0.202	0.331	-0.369	
	(2.693)	(2.535)	(-4.755)	
ΔS_{t-2}	0.363		0.397	
	(3.252)		(9.188)	
ΔS_{t-3}			0.266	
			(4.201)	
ΔB_{t-1}		0.426		0.471
		(3.305)		(6.142)
ΔB_{t-2}	-0.201		-0.048	-0.099
	(-2.587)		(2.924)	(-1.709)
ΔB_{t-3}	0.354			
	(4.319)			
Δr_{t-1}	0.838			
	(4.424)			
Δr_{t-2}			0.036	
			(3.034)	
Δr_{t-3}	-0.469		-0.033	
	(-4.001)		(-3.121)	
ΔP_{t-1}		-0.300		-0.059
		(-3.282)		(-3.119)
Adjusted R^2	0.542	0.303	0.697	0.240
Serial correlation	0.277	0.979	0.000	0.386
Heteroscedasticity	0.997	0.059	0.000	0.029

All equations are estimated using OLS. We multiply the order flow coefficients by 10. Robust t-statistics are given in parentheses below coefficient estimates. The final two rows give p-values for tests for first order serial correlation and heteroscedasticity, respectively. Full period statistics are calculated over the period January 2000 to December 2007, the crisis period is January 2000 to December 2000, and the stable period is March 2002 to December 2007.

Table 5: Aggregate impact of order flows

	Crisis		Stable	
	Spot	Black	Spot	Black
UF	0.3748 [0.0001]	0.1780 [0.0574]	0.0330 [0.0000]	-0.0014 [0.6620]
EF	0.1105 [0.0728]	0.4330 [0.0491]	-0.0202 [0.0000]	-0.0070 [0.0953]

Robust p-values are in brackets.

Figure 1: Weekly spot exchange rates for the full sample period

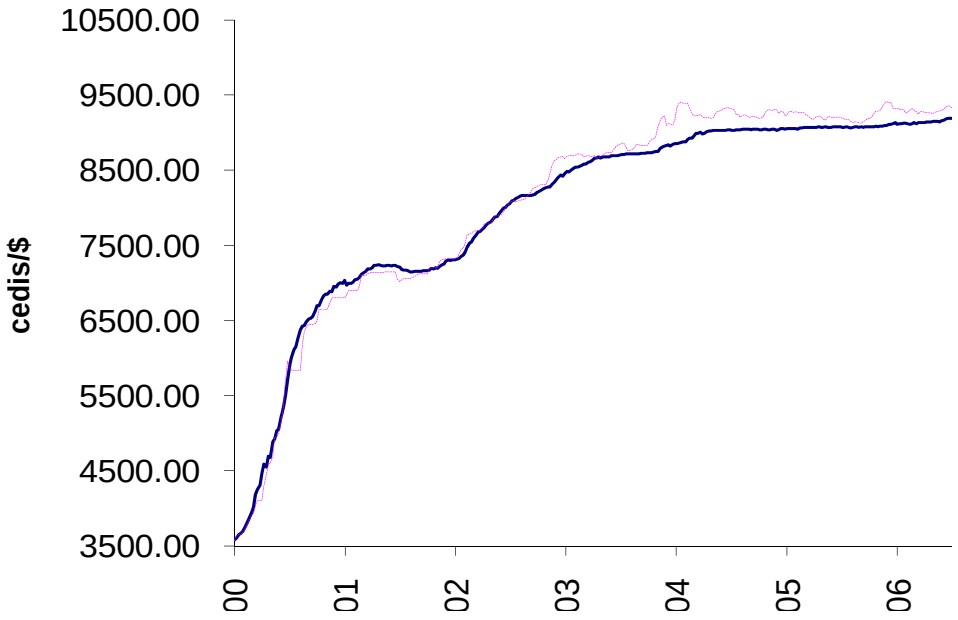
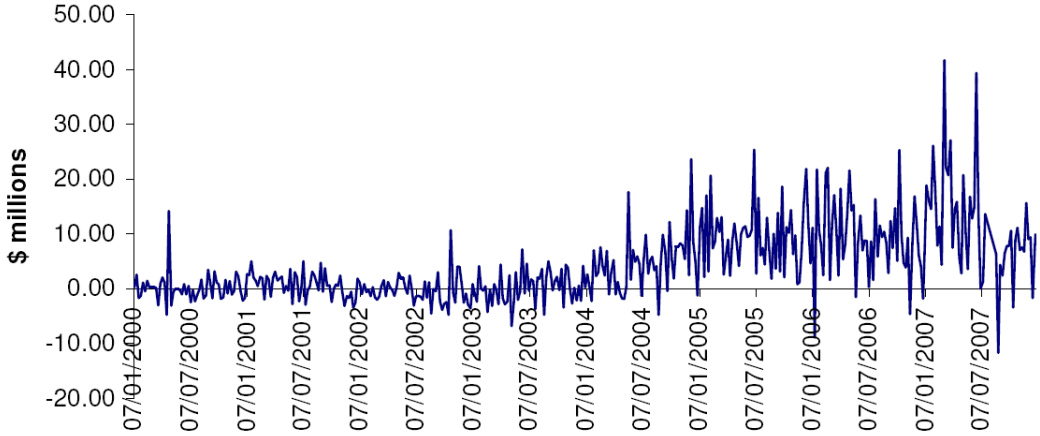
Figure 2 Weekly net order flow