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Order flow and rand/dollar exchange rate dynamics[*]

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December 8, 2017

Abstract

This paper uses the microstructure approach for the South African foreign exchange market to determine the impact of order flow on the rand/US dollar exchange rate over the short and long term. A hybrid model which combines microeconomic and macroeconomic fundamental determinants of the exchange rate has been adopted. The analysis uses monthly series from January 2004 to December 2016. We find that order flow explains movements in the exchange rate, both in the short and in the long term. The speed of adjustment from short-term deviations is relatively slow. The results based on the rolling-window estimation of the long-run model provide evidence of a changing relationship between order flow and the exchange rate. Consistent with the literature, the results show that the rand/dollar exchange rate reacts to fundamental variables only in the long term. Unlike Meese and Rogoff (1983), who postulate that the best way to estimate the exchange rate over the short term is with a random walk model, the current study shows that the microstructure approach can be exploited to explain short-term dynamics in the exchange rate. The results suggest that transaction flows at the micro level contain important information in explaining rand/dollar exchange rate movements.

JEL Classification Numbers: F31, F33, G14, G21.
Keywords: Order Flow, Exchange Rate, Microstructure Approach, Error Correction Model.

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1 Introduction

Since the seminal paper of Meese and Rogoff (1983), there has been a rising interest in the factors explaining the movements in the exchange rate over the short and long term. Long-term models mostly include fundamental factors such as the interest rate differential, money supply differential and measures of risk. These authors show that traditional macroeconomic models do not sufficiently explain changes in exchange rates in the short term, though they are more successful in the long term. Subsequently, Evans and Lyons (2002) address the macro-puzzles using microeconomic reasoning based on asset pricing theory. This microstructure approach addresses the exchange rate puzzles such as excess volatility, the forward bias and the determination puzzle.[1] It is worth mentioning that transaction flows convey information at micro level that is necessary for the estimation of the exchange rate movement which is not captured by macroeconomic fundamentals. Instead of using either the microstructure approach or models based on macroeconomic fundamentals, it is appropriate to use the hybrid model which combines the two approaches into a single model. Ever since, there has been an increasing use of the microstructure model or hybrid model in modelling exchange rates for both advanced economies (AEs) and emerging market economies (EMEs).

However, only Mokoena, Gupta and Van Eyden (2009) attempt to use the hybrid model of Evans and Lyons (2002) for South Africa. They use the autoregressive distributed lag (ARDL) model of Pesaran, Shin and Smith (2001) which includes the short-term interest rate differential between South Africa and the United States (US), commodity prices and a measure of risk for EMEs. But they use the dollar-denominated net average turnover on the South African foreign exchange market as a proxy for order flow. Instead, this paper uses order flow data submitted by Authorised Dealers (B12 forms) to the South African Reserve Bank (SARB), which consist of spot, forward and swap transactions. It is worth noting that swap transactions are excluded since currency swaps are the equivalent of securitised funding; therefore there are no order flow consequences.

Order flow refers to signed foreign exchange transactions, meaning that the signs reflect the buying (positive) and selling (negative) of foreign exchange in the domestic foreign exchange market. The short- and long-term models are specified separately,

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[1]Excess volatility refers to exchange rate volatility which cannot be explained by macroeconomic fundamentals. The forward bias refers to instances where returns to speculating in foreign exchange are predictable. Finally, the determination puzzle is when exchange rate movements are unrelated to macroeconomic fundamentals.

and a combination of the two in an error correction model (ECM). The short-term model includes the order flow at level and the change in the exchange rate, whereas the long term representation follows closely Evans and Lyons (2002) and Cheung and Rime (2014) in that it contains the cumulative order flow and the exchange rate at level. Macroeconomic variables such as the interest rate differential between South Africa and the US as well as a measure of EME risk are used. It has been discovered that order flow explains dynamics in the rand/dollar exchange rate both in the short and in the long term. Even though the explanatory power of the short-run estimation is weak, the order flow depicts an impact that is statistically significant, whereas the macroeconomic fundamentals are statistically insignificant. However, in the long run, all variables have strong effects on the exchange rate, with a high explanatory power. The results based on the rolling-window estimation indicate a time-varying coefficient of order flow. In other words, there are therefore periods when other fundamentals have a larger impact on the exchange rate.

The rest of the paper is organised as follows. Section 2 briefly discusses literature on the impact of order flow on exchange rates based on the microstructure approach. Section 3 explains microstructure models using order flow as core to price determination, while Section 4 introduces the hybrid model used to estimate the exchange rate model for South Africa. Data and their transformations are described in Section 5 and the results are discussed in Section 6. Section 7 concludes the paper.

2 Literature review

In a macro-micro contrast of exchange rate determination, homogenous macroeconomic information determines prices in the former, while in the micro-approach prices are determined on the premise of heterogeneity, according to Sarno and Taylor (2001). The macro or fundamental approach is based on the efficient market hypothesis (EMH). Frankel and Rose (1995) concur with Meese and Rogoff's (1983) findings that macro factors better explain the exchange rate dynamics in the long run and that micro factors are important in the short term. In addition, they find that some traditional models depict incorrect signs and that in some cases coefficients are statistically insignificant. In the years subsequent to the initial studies of the 1980s and early 1990s, and especially since Meese and Rogoff's (1983) criticism, economists began exploring alternatives in explaining the theoretical and empirical movements in exchange rates in the short term.

The failure of macroeconomic models to explain exchange rate movements in the short term led many economists to explore price changes in the short term, using the microstructure approach to the exchange rate. It is along those lines that Flood and

Taylor (1996) find that some factors, besides those included on the list of macro fundamentals significantly affect the behaviour of exchange rates in the short term. These findings provide avenues for new research focusing on the determinants of exchange rate movements over the short term. This has paved the way for a promising field of research centered on the microstructure foundation of the foreign exchange market.

According to Gereben, Gyomai and Kiss M (2005), the microstructure approach had already been used extensively for a long time in the analysis of equity markets, while it has gained prominence in exchange rate literature after the seminal work of Evans and Lyons (2002). Moreover, Osler and Wang (2013) contest that the foreign exchange market differs from equity and bond markets. In the context of foreign exchange rates, microstructure refers to the pertinent role played by the trading environment as a transmission mechanism of information, which is in turn reflected in the spot rate of a currency. The key variable featuring in the microstructure approach in empirical studies is order flow data. It is positively correlated with the exchange rate, as reflected in Figure 3. An increase in order flow is indicative of buying pressure in foreign exchange, resulting in an appreciation in the case of the US dollar, which is accompanied by the depreciation in the local currency, that is, the rand. However, the fact that this relationship exists does not necessarily mean that order flow alone drives the exchange rate. In fact, Rime, Sarno and Sojli (2010) state that neither of the two approaches to exchange rate determination seems to be plausible in isolation; instead, they propose a hybrid approach to exchange rate determination. This is consistent with the earlier work by Lyons (2002). Hence, the poor explanatory power of macroeconomic variables and the need to understand short-term exchange rate fluctuations have channeled research towards investigating the concept of 'order flow', yet mostly in AEs.

Evans and Lyons's (2002) hybrid model explains over 60% of the variation in the Deutsche mark/US dollar. In addition, they find that order flow explains about 40% of the variation in the Japanese yen/US dollar. Rime (2000) suggests that customer order flow strongly explains the Norwegian krone. Marsh and O'Rourke (2005) are of the view that using data over a two-year period for the sterling, US dollar, yen and the euro (sourced from the Royal Bank of Scotland) show evidence of a relationship between these exchange rates and order flow. Similarly, Berger, Charboud and Hjalmarsson (2009) find correlations of 65%, 42% and 49% based on the daily order flow data of the euro/US dollar, the sterling/US dollar and the US dollar/yen respectively. Danielsson, Luo and Payne (2012) go further to demonstrate much stronger co-movement with high-frequency data such as five-minute intervals. Besides its application in explaining exchange rate dynamics, Rime et al. (2011) find that a multi-currency trading strategy based solely on customer order flow outperforms the carry trade strategy, especially after the most

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recent Global Financial Crisis.

Figure 1 depicts a microstructure framework, proposed by Lyons (2002), in which order flow is core in the transmission mechanism of an exchange rate. The diagram consists of two stages of information processing. In the first stage, non-dealers observe and analyse publicly available macroeconomic fundamentals, and in addition conduct in-house research and analyses. Furthermore, non-dealers who are privy to private information may utilise this information, which in turn is reflected in their price and volume orders. Private information is defined as information which is not publicly known, and which produces a better price forecast than public information alone. Such information includes market makers who are aware of central bank transactions, large trade flows, and mergers and acquisitions, even before publically published. Private information also includes expectations on future payoff, risk premia and on inventory/supply imbalances in the foreign exchange market which could have a price effect. Non-dealers include mutual funds, hedge funds and individuals with special information. In the second stage, dealers set prices based on their understanding of the information received from the non-dealers in the first stage. Hence, information which once was private becomes public through price setting and is reflected in the foreign exchange rate. This implies that order flow is a mechanism through which the exchange rate puzzle is solved. Several empirical studies, such as the one by Menkhoff et al. (2012), refer to this framework as the 'information processing hypothesis'. These authors find customer order flow to be informative about excess future currency returns, both in an in-sample and in an out-of-sample setting, based on order flow portfolios. These findings remain consistent regardless of the specification of the model.

Figure 1: Stages of information processing
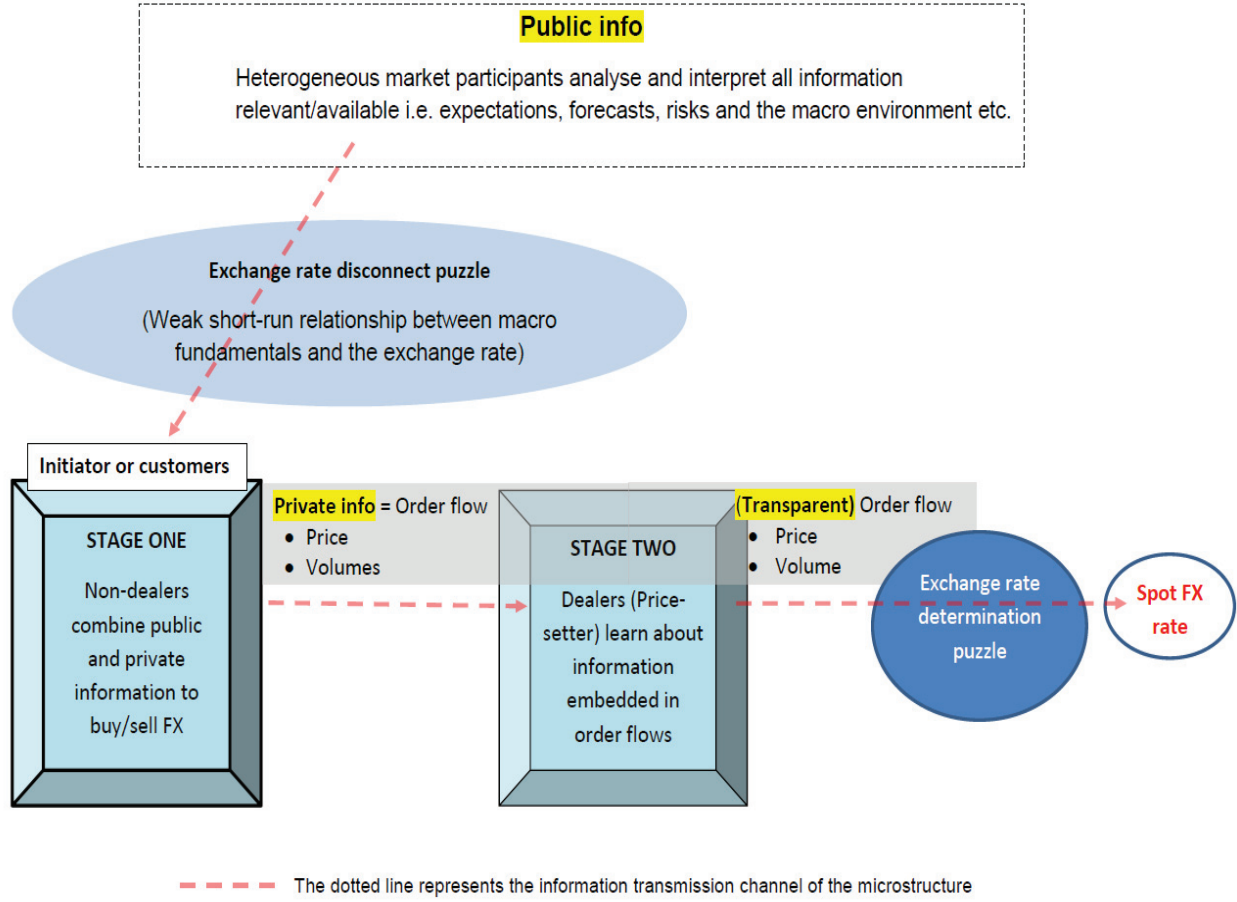
It is worth mentioning that turnover is sometimes used as a proxy of order flow. The main difference between the two concepts is that order flow ascribes a sign to transactions, depending on whether it is a purchase or a sale of foreign exchange, while turnover does not. Table 1 portrays this difference. When compiling order flow data, identifying the initiator of the transaction is vital to allocating the correct sign. For example, in transaction 1, customer 1 is the initiating party, placing an order to sell R5 million to market maker A. In this regard, a negative sign is assigned to the R5 million, reflecting the initiator's decision to sell currency, while turnover is regarded as volume and no sign is therefore ascribed to it. Hence, the cumulative order flow after five transactions is evaluated at -R16 million (negative/selling) compared with R18 million recorded as turnover.

Table 1: The difference between order flow and turnover

Transaction	Initiating Party	Passive Party	Order Flow	Cum Order Flow	Turnover
1	Customer 1	Market maker A	-5	-5	5
2	Market maker A	Market maker B	+1	-4	6
3	Customer 2	Market maker C	-4	-8	10
4	Customer 3	Market maker D	-4	-12	14
5	Market maker D	Market maker E	-4	-16	18

Order flow is ultimately the net balance of buyer-initiated and seller-initiated foreign exchange transactions. Hence, in this paper, the approach proposed by Gereben, Gyomai and Kiss M (2005) who define the positive values of order flow as an indicator of buying pressure and the negative values as selling pressure on a given currency is followed.

This paper is one of the few studies which examine the effects of order flow on the exchange rates of EMEs. Data constraints are the key reason explaining limited research on EMEs. Further, most of these countries are characterised by prolonged periods of fixed exchange rate regimes. Nevertheless, the consensus supports evidence of a significant impact of order flow on exchange rates, but the explanatory power seems very low. For example, in their study on China, Zhang, Chau and Zhang (2013) find that about 9% of variation in the renminbi/US dollar exchange rate is explained by order flow. The explanatory power is considerably low in comparison to studies on AEs, such as by Evans and Lyons (2002). A plausible explanation for this is the exposure of most EMEs to intervention in the foreign exchange market. In addition, Cheung and Rime (2014) establish a relationship between offshore and onshore renminbi based on order flow. They show a significant effect of order flow on offshore renminbi, which in turn has an increasing impact on the onshore rate. Hence, order flow has an indirect impact on the onshore rate through the offshore rate. Gereben, Gyomai and Kiss M (2005) find a relatively strong relationship between order flow and the exchange rate for Hungary, with the explanatory power of 30%. These findings are confirmed by Scalia (2008) on the Czech koruna.

Duffour, Marsh and Phylaktis (2011) used order flow data to examine short-term exchange rate dynamics in Ghana. They find evidence of strong explanatory power and confirm the contemporaneous relationship between order flow and exchange rates, as suggested in the literature. In addition, their research finds a lagged interaction between order flow and exchange rates, which could be due to the delays in the price transmission, which in turn are associated with market inefficiencies.

De Roure, Furniagiev and Reitz (2015) conducted an empirical study on Brazil using the microstructure approach to explicitly analyse the effectiveness of exchange rate policies, wherein the efficacy of policies was judged by their ability to influence (a desired

subset of) market participants. This supports the microstructure approach, that is, the processes driving currency prices begin on the individual microstructure level. They analysed the effectiveness of the capital controls introduced to counter the appreciation of the Brazilian real and also to evaluate macroprudential policies.

Using the microstructure approach, the Brazilian Central Bank (BCB) finds that, firstly, the central bank's intervention affected the behaviour of financial customers (those trading in financial assets) and secondly, the microstructure approach allows for a richer evaluation of macroprudential policies. The research also showed that the BCB's benchmark model explains 39% of the variation in the exchange rate. In a comparable study, Kohlscheen (2012) specifically investigates the effectiveness of sterilised interventions by the BCB. The regressions suggest that a 1% appreciation of the Brazilian real would require the sale of US$2 billion by final customers on days in which the central bank refrained from intervening. This compares to the required sale of US$5.5 billion on days in which the central bank was present in the market.

In the most recent research, Collussi and Pereira (2015) applied an out-of-sample model to the established microstructure approach. They compare three different models (the pure microstructure, macro-financial and hybrid models) to a random walk, and find that in most cases and in various frequencies (daily, weekly and monthly) these models render better results compared to the random walk. This result demonstrates that private information (order flow) is valuable for explaining fluctuations in exchange rates at high frequencies.

Gereben, Gyomai and Kiss M (2005) examine the role of customer order flow in the Hungarian foreign exchange (EUR/HUF) market. Not only do they test whether customer order flow contributes to explaining the exchange rate, but they also identify the roles played by the different customer types for which they have data (domestic non-market-making banks, domestic non-banks, the central bank, foreign banks and foreign non-banks). They estimate a generic model at a daily frequency where all the different order flow variables are included. The results indicate that the estimated coefficients of the foreign banks', foreign non-banks' and central bank's order flow are positive and significant, implying that purchases of the domestic currency by these customers cause an appreciation in the Hungarian currency relative to the euro, while the coefficients of the domestic banks and non-banks are not significant. A subsequent study was conducted in Hungary in a more floating exchange rate regime, and Lovcha and Perez Laborda (2013) find that the price impact and information transmission varies in different market conditions, i.e. the price impact is higher in times of volatility.

Onur (2008) uses order flow data which separate financial and non-financial flows, and finds that order flow from financial customers has a larger impact on the currency.

The empirical analysis indicates that a US$1.0 million purchase by financial investors induces an increase of 0.06% in the Israeli sheqel/US dollar exchange rate over a one month period.

In summary, while existing research indicates that the impact of order flow on exchange rates may be low due to foreign exchange intervention in EMEs, the relationship nevertheless exists. Over time, with the movement towards flexible exchange rate regimes, additional studies in EMEs have slowly emerged. The literature review also indicates that certain EMEs use the microstructure approach to determine the effectiveness of exchange rate policies. However, such a policy analysis is beyond the scope of this paper.

3 Microstructure models

In order to fully understand the fundamental role of the microstructure approach, it is important to outline the key distinction between microstructure and macrostructure models. Microstructure models reflect that trading is the transmission mechanism through which information pertaining to the pricing of foreign exchange is captured in the spot rate. In contrast, traditional macroeconomic exchange rate models ignore the impact of 'trading' on the exchange rate.

Two main models appear in most of the literature: the Kyle model and the Evans-Lyons model. The Kyle model has limited applicability in the real world due to the assumption of batch auctions where individual orders cannot be independently analysed. Because all orders are executed in batches, there is no bid-ask spread generation and the model does not have any features that can produce inventory price effects, a key feature in microstructure theory.

However, even though the Kyle model is considered to be impractical in the real world, it is nevertheless a key departure point due to its simplicity. According to the Kyle model, there are three participants in the market: the informed trader (with full information at disposal), the liquidity or passive trader (making a purchase due to being forced) and the single market maker. The basic premise of the model is that the market maker exchanges the desired quantity at the desired price at equilibrium. Gereben, Gyomai and Kiss M (2005) describe the Kyle model as a three-phased process. They confirm the process to be: all else being equal, that during the first stage the informed trader makes a decision to buy/sell. At the same time the liquidity trader experiences a need to buy/sell for various reasons. In the second stage the market maker is aware of the net buy/sell orders for the entire market based on the decisions of the informed trader and the liquidity trader. Barring the decision of the liquidity trader, the market

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maker can conclude that the informed trader has a trading request based on additional private information that he/she has at his/her disposal. Therefore, the higher (lower) order flow observed by the market maker results in the setting of the price at the desired quantity. If the market maker is convinced that no additional information is priced in the asset, he/she will offer to the market at the same price. If not, he/she will adjust the given price. In the final stage, the 'actual true price' of the asset becomes known.

In stark contrast to the Kyle model, in which only one participant has information, the Evans-Lyons model explicitly states that the market consists of heterogeneous participants. However, similar to the Kyle model, the trading occurs through a three-stage process and the market consists of a variety of market makers and customers. The literature describes this three-stage process in the Evans-Lyons model as follows: In the first stage the decision to trade is based on the observation of interest rate differentials resulting in the change in the supply of, and demand for, currencies based on different portfolio requirements. In this stage, all the participants have formulated an opinion based on public information. In the second stage the market makers commence trading with each other. The market maker learns about the net order flow during this stage since every transaction is publicly known. Finally, market makers trade again with customers in the third stage. Given their knowledge of order flow, market makers set exchange rates which, as summarised by Gereben, Gyomai and Kiss M (2005), induce their customers to mop up the open positions accumulated during the earlier stages of trading.

To summarise global studies, even though the literature depicts a positive correlation between order flow and exchange rates, the relationship is two-fold. It confirms a positive correlation between order flow and spot exchange-rate movements in the inter dealer market, as confirmed by research carried out by Evans and Lyons (2002). In subsequent research, this relationship between spot exchange-rate movements expanded to broader customer order flow (Fan and Lyons, 2003). The three possible explanations for this positive relationship have been explained using the Evans-Lyons model, that is, the informational aspect (informed trader), the liquidity aspect (liquidity trader) and the market maker-driven trades (inventory).

As stated earlier, the previous study on South Africa uses a proxy for order flow data, namely the average daily net turnover in the South African domestic foreign exchange market, due to the lack of order flow data available in the public domain. To the best of our knowledge, the study mentioned above is the only paper from a South African perspective. They find evidence that a long-term relationship exists between the rand/dollar exchange rate, the interest rate differential and the net average daily turnover in US dollar terms at 10% level of significance. This paper therefore contributes to the

existing literature in the following ways. Firstly, the research presented by Mokoena, Gupta and Van Eyden (2009) make use of the net average daily turnover as a proxy for order flow. The disadvantage of using turnover data is that it ignores the sign of transactions, whether it is a purchase or sale of foreign currency. Signed transactions are key to the microstructure concept as it is indicative of the buying/selling pressure of a currency. This paper improves on the data by using actual order flow data collected by the SARB. Secondly, turnover data consist largely of swap transactions, that is, approximately 70% of total turnover. The literature confirms that swap transactions have no order flow consequences and should therefore not be included in the empirical analysis using the microstructure approach. For the purpose of our empirical analysis, swap transactions have been excluded from the order flow data. Finally, this paper covers the period before and after the Global Financial Crisis. Compared to other EMEs, the data coverage of this paper is also much longer than existing domestic and international research.

4 The hybrid model

This paper uses the hybrid model of the exchange rate where order flow combined with macroeconomic variables explains the dynamics in the exchange rate. In the short term, we have:

$$\Delta s_t = \alpha + \beta OF_t + \Gamma' \Delta x_t + \Delta \varepsilon_t \tag{1}$$

where s_t is the natural logarithm of the rand/dollar exchange rate; OF_t is the order flow; x_t is a vector of macroeconomic variables such as the interest rate differential and a measure of risk; α, β and Γ are parameters of the model; ε_t is the stochastic error term which is independent and identically distributed with zero mean and constant variance $(\varepsilon_t \tilde{} N(0, \sigma_\varepsilon^2))$; and Δ represents the first difference of variables, such that $\Delta s_t = s_t - s_{t-1}$. The long-run representation of equation (1) follows closely Evans and Lyons (2002) and Cheung and Rime (2014), and it represented as follows:

$$s_t = \gamma + \delta CUMOF_t + \Psi' x_t + \varepsilon_t \tag{2}$$

where $CUMOF_t$ is the cumulated order flow while γ, δ and Ψ are parameters of the long-run model. Note that equation (2) assumes the existence of a long-term or co-integrating relationship. Hence, we can reconcile the short-term deviations of the exchange rate in (1) to its long-run equilibrium in (2) by an error correction model of the form:

$$\Delta s_t = \alpha + \rho \Delta s_{t-1} + \Sigma_{i=0}^{p} \beta_i OF_{t-i} + \Gamma' \Delta x_t - \lambda(s_{t-1} - \gamma - \delta CUMOF_{t-1} - \Psi' x_{t-1}) + \Delta \varepsilon_t \quad (3)$$

where the vector Δx_t contains lagged and contemporaneous macroeconomic variables. λ represents the speed of adjustment from short-term deviations back to the long-run equilibrium relationship.

5 Data and data transformation

Definitions and sources of the variables are listed in Table 2. All data are obtained from the SARB and Bloomberg, and they are available publicly, except for order flow data which are confidential.

Table 2: Definitions and sources of variables

Names	Variables	Description	Source
OF	Order flow*	Net purchase/sale orders	SARB
$i - i^*$	Interest rate differential	SA and US Treasury bills	SARB and Bloomberg
$EMBI$	Bond spread	SA sovereign EMBI+ bond spread	Bloomberg
s	Rand/dollar exchange rate	Nominal dollar/rand exchange rate	Bloomberg

All variables are expressed in natural log with the exception of order flows and interest rate differentials.

* Data is confidential and remains unpublished.

The rand/dollar exchange rate is obtained from Bloomberg. Monthly spot rand/dollar exchange rates, where the exchange rate is defined as the rand (per dollar) price of a unit of the foreign currency are used so that an increase in the exchange rate implies a depreciation of the local currency. The rand/dollar exchange rate is used for comparative purposes as other EME-specific studies will follow subsequent to this paper.

The selection of the control macroeconomic variables is informed by the literature on hybrid characterisation of the microstructure model.[2] The independent variables reflect the distinct methodology of this study, which is, firstly, to combine the macro- and micro-structure approaches where the interest rate differentials replicate the macro fundamental drivers according to exchange rate economic theories. These variables signify the 'macro-link' to financial markets and more specifically to exchange rates and fixed-income assets. In addition to the combined macro/micro approach, the second distinction of this model is to incorporate a more market-related approach, specifically

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[2]See Table A.1 on existing literature of macroeconomic variables included in exchange rate models for South Africa.

related to short- and medium-term drivers, and also to incorporate risk - and/or senti-ment - related indicators. Also, there is empirical evidence of the effects of risk factors from EMEs on domestic currencies.

Although order flow data are available on a daily basis, monthly series covering the period from January 2004 to December 2016 are used. The historical trend in turnover is reflected in Figure 2, from which the order flow data are calculated.

Figure 2: Turnover in the domestic foreign exchange market
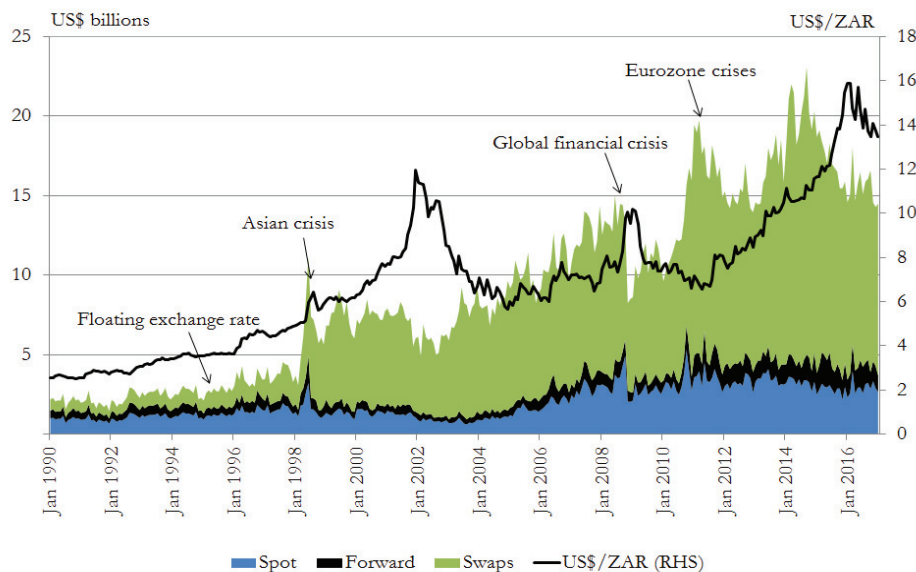
Order flow data are submitted by Authorised Dealers to the SARB. This data cap-tures the daily over-the-counter (OTC) transactions conducted by Authorised Dealers with counter parties, which are described as residents, non-residents, the SARB as well as transactions between Authorised Dealers. Order flow reflects the buying/selling pres-sure for foreign currency, which is initiated by the counter parties (or the market) of the Authorised Dealers. In the event of a purchase/sale order, Authorised Dealers assign a positive/negative sign to transactions to indicate the direction of trade as initiated by the counter party. Order flow data can be transformed in one time series consisting of different transactions (spot, forward and swaps), as reflected in Figure 3. For the purposes of this paper, only spot and forward transactions are used, given that swaps have no order flow consequences, as stated in the literature by Lyons (2002). Interest-ingly, Figure 3 depicts a strong co-movement between the cumulative order flow and the rand/dollar exchange rate, though the relationship seems weak at the beginning of the sample and then strengthens gradually, especially from 2010 onward.

Three distinct patterns of the exchange rate can be identified from Figure 3. Before the Global Financial Crisis, the rand mostly appreciated against the US dollar, recovering

from the currency crisis of 2001. The trend in order flow during that period reflects the expected negative sign as suggested by microstructure theory. During the crisis period, however, the relationship moderated somewhat but still generally exhibited the expected trend, especially at the height of the Global Financial Crisis in 2008/09. In the aftermath of the crisis, the two series portray the strongest trend, which coincides with the selling of the domestic currency. This period includes various global events such as the euro-zone crisis (2010–2012), the 'taper tantrum' of the US Federal Reserve (Fed) in 2013, economic growth concerns and policy uncertainties in China, political and economic instability in various EMEs, uncertainty regarding the future interest rates in the US, and the departure of the United Kingdom from the European Union (Brexit). As a result of these events most EME currencies depreciated. And, although the currencies in EMEs as a group were negatively affected by these developments, the rand was among the worst performers, depreciating by more than 50% against the US dollar between April 2011 and December 2016. The rand was particularly influenced by domestic issues in 2015 and 2016, reflecting the sharp upward trend in order flow, in other words the selling of the rand.

Figure 3: Historical trend in aggregate cumulative order flow data
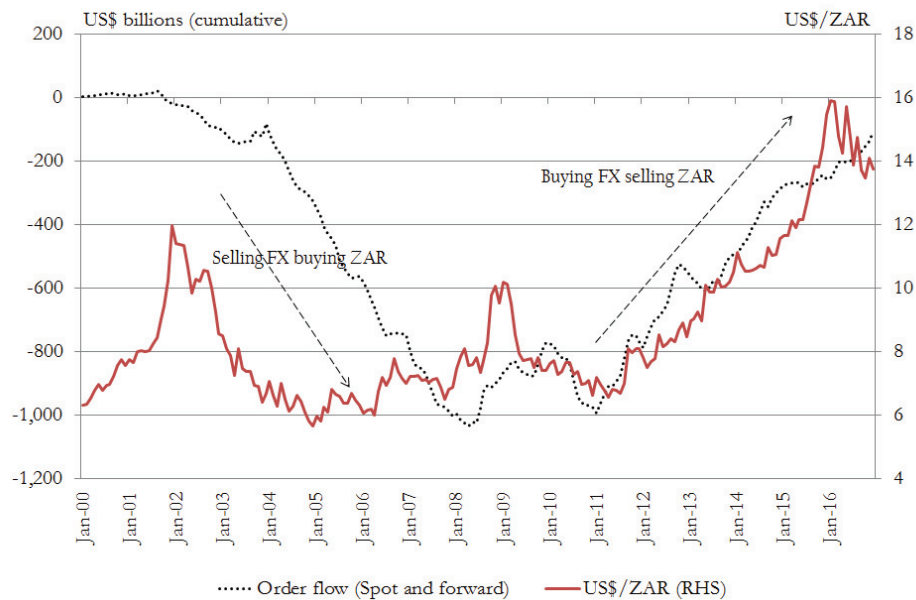
The use of the interest rate differential is based on the uncovered interest rate parity (UIP) which postulates that movement in the domestic currency adjusts in line with changes in the interest rate differential between the domestic and foreign rates. For the interest rate differential, the difference between the South African nominal 3-month Treasury bill rates and the US 3-month Treasury bill rates are used.

To control for EME risk, the South African sovereign JP Morgan Emerging-market Bond Index (EMBI+) spread which represents the risk aversion of investors towards the country is used. Note that many empirical studies – such as those by Berganza, Chang and Herrero (2004) – use the EMBI+ bond spread as the proxy of a country's risk premium. Risk also emerges from the portfolio approach, which includes financial assets such as bonds. Changes in these asset prices in turn affect the exchange rate.

Natural logarithm for all variables is used, except for the interest rate differential and order flow. The results of the unit root tests shown in Table A.2 of the Appendix, reveal that all variables but the order flow are integrated of order 1. The Johansen co-integration test, including an intercept and a trend, indicates one co-integrating relationship.

Figure 4: Short-term: order llow, rand/dollar, bid-offer spreads
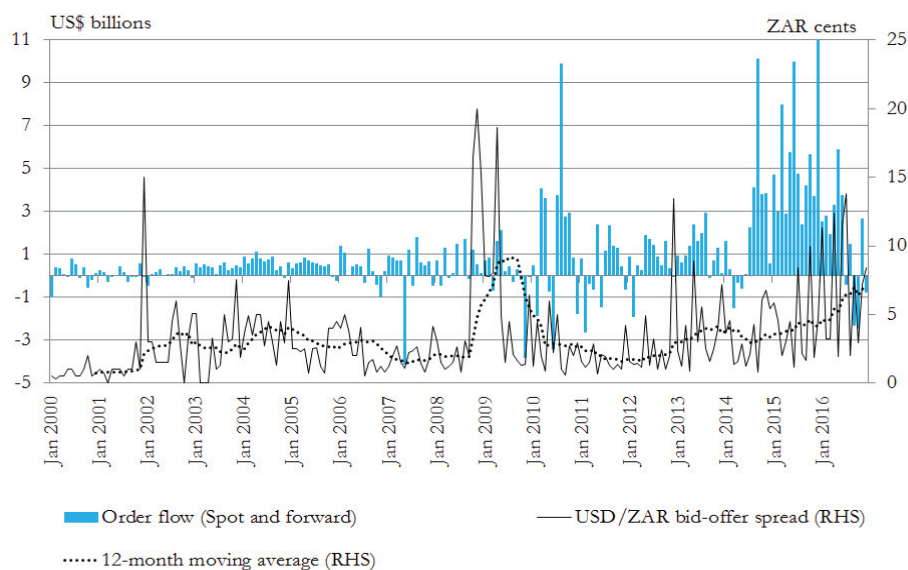
From a short-term perspective, the informational dynamics of order flow are also visible in bid-offer spreads of the rand exchange rate. As reflected in Figure 4, bid-offer spreads are generally wider during times of positive order flow (rand selling) compared to periods when investors are buying the rand. This implies, similar to the microstructure theory, that the information embedded in order flow is also reflected in another 'price/risk measure' of the foreign exchange market. The trend in this relationship coincides with the periods of strong correlations between the exchange rate and order flow.[3]

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[3] As reflected by Figures 3 and 4.

6 Empirical results

The empirical section is divided into three subsections, namely the long-term model, followed by the short-term exchange rate model as well as the estimation of an ECM equation to reconcile the long-term dynamics to the short-term disequilibrium.

6.1 The long-term model

Table 3 depicts the results of the long-term model, as represented by equation (2), with cumulative order flow, $(CUMOF)$, the interest rate differential, $(i-i^*)$, and the EMBI+ bond spread, $(EMBI)$. Like Evans and Lyons (2002) and Cheung and Rime (2014) we cumulate order flow in the long-term model. It is evident from estimation (3) that order flow alone explains 84% of the movement in the exchange rate, which is a very high explanatory power. The explanatory power of the regression increases slightly when we control for the interest rate differential in estimation (2), to 87%. The small increment in the explanatory power is mainly the result of the insignificance of the control variable. Moreover, the sign of the interest rate differential is incorrect. Column 1 depicts an even higher adjusted R^2, at 90%, when we control for both the interest rate differential and the risk indicator. Note that cumulative order flow is statistically significant at 1% in all three regressions. In addition, the coefficient of order flow is relatively the same throughout all the estimations. In column 1, all the variables are statistically significant and exhibit expected signs. An increase in the interest rate differential, meaning that the domestic rate is higher than the foreign rate, boosts capital inflows to South Africa, which in turn is translated into an appreciation of the rand. A higher risk leads to a depreciation of the rand, which is a positive relationship between the risk indicator and the exchange rate.

Table 3: Long-term model

	(1)	(2)	(3)
$CUMOF_t$	0.0038***	0.0045***	0.0046***
	(0.0002)	(0.0003)	(0.0003)
$(i - i^*)_t$	-0.0162*	0.0245	
	(0.0089)	(0.0008)	
$EMBI_t$	0.2193***		
	(0.0468)		
N	155	155	156
$Adj.R^2$	0.90	0.87	0.84

*,**,*** denote significant at 10%, 5%, and 1% respectively

Values in parentheses are standard errors

6.2 The short-term model

Table 4 presents the results of the short-term model. Consistent with the literature, such as Meese and Rogoff (1983), the results show that macroeconomic variables poorly explain the dynamics in the exchange rate in the short term. In line with microstructure literature, results from the short-term equation reinforce the notion that order flow is positively correlated with the movement of the exchange rate. The short-term estimation of the model shows that order flow is the only variable that is statistically significant across different specifications. It accounts for 5% of the movement in the exchange rate in regression (4). These results are interesting in that, according to Meese and Rogoff (1983), it is difficult to outperform the random walk model in the short-term specification of the exchange rate. Subsequent research shows that the microstructure approach is capable of explaining the dynamics in the exchange rate even in the short term. But the extremely low explanatory power of the short-term model indicates that order flow alone is unable to capture all the movements in the exchange rate over the short-time horizon. This is consistent with the findings by Zhang, Chau and Zhang (2013) who provide evidence of low explanatory power of the exchange model over the short run for developing countries and EMEs as compared with Evans and Lyons (2002) who find higher explanatory power even in the short term for a panel of AEs. Similarly, the results of this study are comparable to those of Cheung and Rime (2014) who find low explanatory power for both onshore and offshore exchange rate representation for China. De Medeiros (2004) also finds low explanatory power in his estimation of the short-term hybrid model for Brazil.

Table 4: The short-term model

	(1)	(2)	(3)	(4)
OF_t	0.0041***	0.0041***	0.0041***	0.0041***
	(0.0009)	(0.0009)	(0.0009)	(0.0009)
$\Delta(i - i^*)_{t-1}$	0.0173	0.0166	0.00154	
	(0.0120)	(0.0119)	(0.0121)	
Δs_{t-1}	-0.0319	-0.0566		
	(0.0791)	(0.0787)		
$\Delta EMBI_{t-1}$	-0.0140			
	(0.0309)			
N	154	154	154	154
$Adj.\ R^2$	0.066	0.064	0.061	0.049

*,**,*** denote significant at 10%, 5%, and 1% respectively. Values in parentheses are standard errors.

6.3 The error correctional model

The ECM estimation combines the long-run dynamics of the exchange rate and the short-term deviations. It is clear from Table 5 that the error term (EC_{t-1}) and order flow (OF_t) have their expected signs and are statistically significant at 1%. The estimated error term (EC_{t-1}) indicates that the pace of adjustment is rather slow. The results of this study are in stark contrast to those of Mokoena, Gupta and Van Eyden (2009) who show that, in the short term, the correcting factor of -0.741 suggests a rapid adjustment back to equilibrium. In their case, half of the deviations are recovered in less than a month. In this case, the half-life ranges between 6.36 and 6.86, implying that half of the deviations are recovered between six and seven months. The slow speed of adjustment is in line with the recent work of Zhang, Chau and Zhang (2013) and Cheung and Rime (2014) for China. The slow pace of adjustment is also in line with a key overarching theme of the microstructure theory, that is, when order flow conveys information, the effect on prices should be long-lived. In fact, Lyons (2002) stresses that the effects of order flow convey information which has long lasting effects on price. Evans and Lyons (2002), Payne (1999), and Rime (2000) support these findings and provide evidence of persistent effects of the order flow on exchange rates, which is similar to this study's findings based on the long-run model.

Table 5: The error correction model

	(1)	(2)	(3)	(4)
EC_{t-1}	-0.1099***	-0.1030***	-0.1056***	-0.1012***
	(0.0403)	(0.0383)	(0.0358)	(0.0377)
OF_t	0.0046***	0.0047***	0.0047***	0.0047***
	(0.0011)	(0.0011)	(0.0011)	(0.0011)
$\Delta(i - i^*)_{t-1}$	0.0188	0.0060	0.0017	
	(0.0110)	(0.0046)	(0.0110)	
Δs_{t-1}	-0.0234	-0.0238		
	(0.0850)	(0.0846)		
$\Delta EMBI_{t-1}$	-0.0250			
	(0.0317)			
N	154	154	154	154
$Adj.\ R^2$	0.067	0.093	0.075	0.066

*,**,*** denote significant at 10%, 5%, and 1% respectively. Values in parentheses are standard errors.

Figure 5: Time-varying order flow coefficient
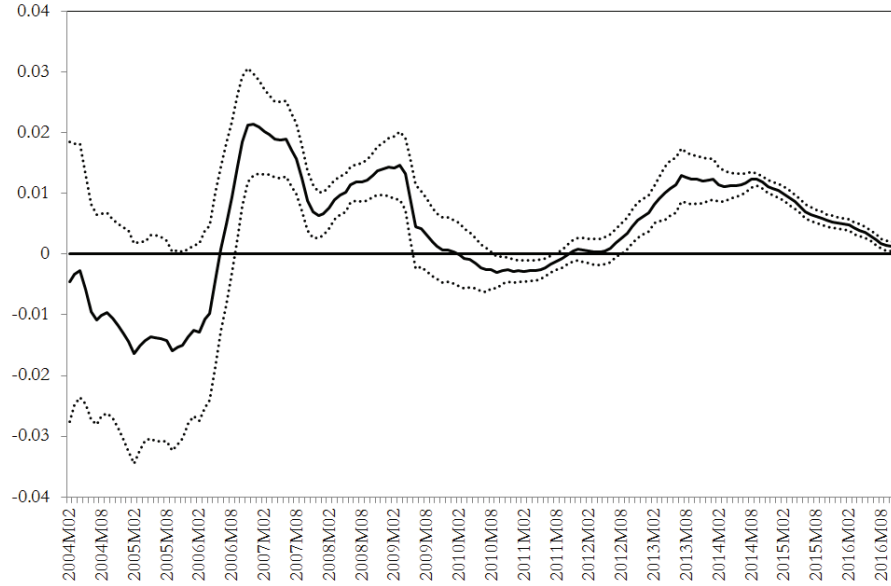
Dotted lines are 95% confidence intervals.

To account for the possibility of a changing relationship between order flow and the rand/dollar exchange rate, we estimate a fifty-month rolling-window regression based on equation (2). Figure 5 represents the time-varying coefficient of order flow together with the confidence interval. It is clear that the relationship between order flow and the exchange rate is not constant over time. The relationship between the two series is weak

at the beginning of the sample and then it strengthens and reaches the maximum impact of 0.021 in the latter part of 2006. This period coincides with the substantial decline in interest rate differentials as a result of the aggressive monetary policy tightening both in the US and in South Africa. This implies that market makers in South Africa considered order flow as highly informative during the period and set prices accordingly, instead of macro fundamentals driving the rand. The coefficient of order flow plummets in the aftermath of the Global Financial Crisis and remains relatively constant until 2012, owing mainly to the unconventional monetary policy pursued by the US through large-scale asset purchases which flooded financial markets with liquidity. Most EMEs witnessed massive capital inflows which in turn translated into an appreciation of the domestic currency. This trend of the coefficient is consistent with the picture portrayed in figures 3 and 5. Then the coefficient increases again, reaching the maximum of 0.013 in July 2013, primarily because of persistent instability in Europe and China, which in turn exerted pressure on EME currencies. Uncertainty reached its peak with the 'taper tantrum' when the Fed announced its intention to reduce large-scale asset purchases. Finally, the relationship reverts to the lower value of 0.0013 and is statistically significant at the end of 2016. Idiosyncratic factors contribute substantially to the recent depreciation in the South African rand.

Lyons (2002) argues that order flow is a vehicle for conveying information. Understanding the information intensity of different trade types brings us close to the market's underlying information structure. At composite level, as reflected in this study, order flow comprises diverse counter parties with miscellaneous strategies. A study of disaggregate measures of order flow will improve the understanding of factors underlying the movement of composite order flow. For example, Wu (2012) and Onur (2008), in their study respectively for Brazil and Israel, find that financial customers' order flow have a larger impact compared to non-financial customers. These findings point to heterogeneity of the value of information arising from various market participants, especially between financial and non-financial transactions/counter parties. Similarly, Gereben, Gyomai and Kiss M (2005) in their analysis of Hungary find that foreign participants have a strong positive impact on the exchange rate, while domestic customers seem to play the role of liquidity providers. Hence, the next step of this research, based on our finding that order flow explains exchange rate movements in South Africa, is to uncover the factors driving order flow. Therefore, a study based on disaggregate measures of order flow is warranted.

7 Conclusion

This paper uses an alternate dimension for the determination of exchange rate movements in South Africa. The microstructure approach, which is common in the literature, explains the weak link between macro variables and the exchange rate over the short term. This is done by exploiting order flow data, the variable within the microstructure that is both theoretically and empirically the driver of price. Consistent with the literature, the results indicate that macro fundamental models benefit from the inclusion of order flow in the estimation of the exchange rate model in the short term. Order flow reflects the trading environment and role of market expectations in the foreign exchange market. In addition, it is possible to explain the long-term dynamics in the rand/dollar exchange rate by cumulating this information over time. More precisely, the paper estimates an error correction model (ECM) which combines the short-term dynamics of the exchange rate with its long-term relationship. This confirms the overarching theme of the microstructure approach that the impact from order flow on the exchange rate is persistent. These results establish the foundation for using the order flows as an important driver for the rand exchange rate, though still relatively uncharted territory in South Africa. In this regard, disaggregating order flow data could even provide further insight of an evolving domestic foreign exchange market. That said, recent challenges facing policymakers since the Global Financial Crisis compel financial stability authorities to closely monitor the microstructure of financial markets.

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Appendix A

Table A.1: Summary of existing macro-models

Author(s)	Period	Exchange rate measure	Method	Variables*	BEER Misalignment
Aron et.al (1997)	1970-1995	REER	Single Equation ECM	TOT, OPEN, COMM, NFA, GOVT, CAP	No
Balcilar et.al (2014)	1981-2013	REER	TP-VAR	INT, INFL, GDP	No
DeJager (2012)	1982-2011	REER	VECM	PROD, INT, COMM, OPEN, CAPT, GOV	Yes
Du Plessis (2005)	1970-2002	REER	VECM	INT, PROD, COMM, OPEN, NFA, GOV	No
Fattouh et.al (2008)	1975-2007	REER	MS-VECM	GOLD, INT, INFL	No
Frankel (2007)	1984-2007	Bilateral USD/ZAR RER	OLS	TOT, INT, COMM, CAP, RISK	No
Macdonald and Ricci (2004)	1970-2002	REER	VECM	INT, PROD, COMM, OPEN, NFA, GOV	Yes
Lacerda et.al (2010)	1972-2007	Nominal USD/ZAR	MS-VECM	INT, INFL, GOLD, OIL	No
Saayman (2007)	1978-2005	Bilateral USD/ZAR RER	VECM	PROD, INT, GOLD, OPEN, GOVT, RES,	No
Saayman (2010)	1999-2008	Bilateral RERs	Panel DOLS & FMOLS	PROD, OPEN, CAP, GOLD, RES	No

*INT (real interest rate differential), TOT (terms of trade), PROD (productivity differential), OPEN (external openness), COMM (commodity prices), NFA (net foreign assets), GOV (government expenditure), INFL (relative inflation), RES (foreign exchange reserves), CAPT (capital flows), M2 (money supply), GOLD (gold price), RISK (country risk indicator), GDP (relative GDP).

Source: Aziakpono and Khomo

Table A.2: Unit root tests

Variables	Level		First difference	
	PP	KPSS	PP	KPSS
OF	1.000***	0.089		
$i - i^*$	0.359	0.168***	0.000***	0.098
s	0.939	1.140***	0.000***	0.178
$EMBI$	0.078*	0.635**	0.000***	0.035

*, **, *** denote significance at 10%,5% and 1% respectively

PP (P-values) and KPSS (LM statistic)