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# Monetary policy and herding behaviour in the ZAR market

Xolani Sibande*

**Abstract**

This paper investigates the presence of herding and its interactions with monetary policy in the ZAR market. We use both the standard herding tests and Sim and Zhou's (2015) quantile-on-quantile regressions. Similar to previous results in other markets, we found that extreme market events mainly drove herding behaviour in the ZAR market. This result is significant in the presence of monetary policy announcements. However, herding in the ZAR markets was not related to market fads. It therefore was, in the main, a rational response to public information, indicating central bank credibility. This credibility gives scope to the central bank to improve communication in periods of market crisis to dampen potential volatility. Further studies on the herding of specific ZAR market participants can be invaluable.

**Key words**

Monetary policy, herding behaviour, exchange rate, time-varying regression

**JEL codes**

G15, G40

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## 1. Introduction

In recent years little work has been done to understand the relationship between investor behaviour and monetary policy (Krokida, Makrychoriti and Spyrou 2020), even though the importance of investor behaviour to financial stability is well established. For example, Khan (2018) stresses that financial regulators and central banks are yet to realise the full potential of behavioural elements and advocates for a behavioural approach to financial regulation and central banking. The European Securities and Markets Authority, under the Markets in Financial Instruments Directive II,[1] advocates for a response to investor behaviour biases that lead to sub-optimal outcomes such as increased volatility (European Securities and Markets Authority 2017). Within this context, it is important to understand the relationship between monetary policy and herding behaviour.

Since the 2008 financial crisis, the importance of behavioural elements in investment decisions has grown. For example, Shiller (2013) attributes herding behaviour – defined as correlated trading patterns across individual investors (Devenow and Welch 1996) – as one of the key contributors to the financial crisis. An important element of this behaviour is its coordinating mechanism or a signal which precedes it (Devenow and Welch 1996). This mechanism can take a variety of forms, such as price movements, observations of other investors' decisions or reactions to public information.

Herding behaviour can reflect a rational response to a common market event. On the other hand, it can reveal weaknesses in investor psychology, resulting in the substitution of rational analysis with that of other investors. This behaviour can have financial stability implications if, for example, it can lead to asset price bubbles. Herding behaviour is, therefore, a key consideration for market supervisors, regulators and policymakers, including central banks.

Furthermore, monetary policy announcements can be considered a herding coordinating mechanism through the expectations channel (Krokida, Makrychoriti and

[1] A European Union legislative framework to regulate financial markets and improve investor protections in the bloc.

Spyrou 2020). The expectations channel illustrates the importance of central bank credibility in maintaining price stability (European Central Bank 2011). Central bank credibility, which includes the ability of the central bank to communicate its stance, is essential to the formation of investor expectations. Monetary policy announcements, therefore, can impact investor sentiment, which includes herding behaviour (for example, Lutz 2015). It is possible for shortcomings in central bank communication to increase uncertainty in the market, which may be amplified by herding behaviour (see Amador and Weill 2010).

Notwithstanding the successes of the South African financial system in implementing financial stability measures before and after the global financial crisis, it remains important to understand potential risks to financial stability. In South Africa, studies were conducted linking market events to monetary policy announcements (for example, see May, Farrell and Rossouw 2018). However, these studies primarily focus on the reaction of investors to monetary policy announcements. They primarily focus on the overreaction hypothesis[2] while excluding other investor behaviour. Furthermore, existing herding behaviour studies (Gilmour and Smit 2002, among others; see Cakan et al. 2019) have not linked this behaviour to monetary policy.

To address this gap, we focus on the ZAR currency market. In general, herding behaviour studies focusing on the currency market are limited. Furthermore, no existing studies link herding in the ZAR currency market to monetary policy announcements. Most ZAR currency market studies focus on exchange rate pass-through and the response of monetary policy (see Soobyah and Steenkamp 2019), or the response of the ZAR to inflation surprises (for example, Farrell, Hassan and Viegi 2012). However, given the regime-switching behaviour[3] of the ZAR (Tsuchiya and Kato 2015), other factors, such as herding behaviour, may be contributing to the eventual pass-through. That is, the clustering of investor sentiments (or herding) may explain the regime-switching behaviour or this clustering may cause a regime to persist longer than necessary, contributing to the size of the eventual pass-through.

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2 According to De Bondt and Thaler (1985), investors can overreact or underreact to market events, leading to price volatility and bubbles.

3 Regime-switching behaviour is the ability of a currency to respond differently depending on the state of the economy.

We explore herding in the ZAR spot market to understand its prevalence. Based on Gong and Dai (2017), we investigate the relationship between ZAR currency market herding behaviour and monetary policy announcements, which contributes to the literature on the impact of monetary policy on financial markets. We extend the methodology from Gong and Dai (2017) to test the rationality of the herding behaviour in the ZAR market using Sim and Zhou's (2015) quantile-on-quantile regression. To this end, we start with a literature review of herding behaviour in South Africa. A descriptive analysis of the global and South African currency markets is provided, followed by the data and methodology discussion sections. We then present the results and draw some conclusions. Our results show herding on days when the central bank made policy rate announcements. In line with other markets, ZAR market investors tended to herd around monetary policy announcements, but only during market crises.

## 2. Literature review

### 2.1 Herding behaviour

Although it has been apparent since the 1960s that markets did not conform to the efficient market hypothesis (see Fama 1965), it was only as recent as the 1990s that herding behaviour was identified as a driver of financial market dynamics (Scharfstein and Stein 1990). Herding is defined as correlated trading patterns across individual investors (Devenow and Welch 1996). Herding studies are part of a larger literature on market anomalies and behavioural economics, which shows that other factors such as human behaviour can impact markets and contribute to market volatility.

In general, the relationship between individual returns and the market return can be thought of as linear or linearly correlated. When individual investors perform better or worse, the market return will correspondingly improve or worsen (Black 1972). This is a fundamental aspect of asset pricing theory which underpins how investors allocate funds across different securities. Investors aim to allocate resources in their portfolios to target an overall return, and investors can offset risk from non-performing securities if the overall market performs well. However, the presence of herding means that investors cannot diversify portfolio risk by targeting the overall market return as it no longer reflects only market fundamentals.

Herding can be fundamental (or non-intentional) and non-fundamental (or intentional) (Bikhchandani and Sharma 2000). Fundamental herding occurs when investors face similar circumstances and respond similarly. This type of herding enhances market efficiency as investors respond to common market-wide information such as an interest rate announcement. This common response reduces market volatility and is efficient. Non-fundamental herding is a clear intent to follow other investors, even if their responses are not aligned with market fundaments. This leads to market inefficiency.

The causes of herding are varied. The economic literature presents a few main explanations. First, pay-offs from the actions of others can incentivise herding behaviour, resulting in externalities such as asset price bubbles (Hirshleifer, Subrahmanyam and Titman 1994). Second, herding can occur when fund managers mimic market behaviour to preserve their reputations (Rajan 1994). Lastly, investors can substitute private information for those of "more informed" investors to avoid, for example, individual information attainment costs (Calvo and Mendoza 2000). This can result in information cascades[4] which lead to herding behaviour.

### 2.2 Herding behaviour and monetary policy

Monetary policy action (anticipated or not) can impact stock prices through the discount rate and, therefore, future dividends. Several studies have shown the impact of monetary policy changes on financial markets. For example, Bernanke and Kuttner (2005) used an event study to understand the impact of monetary policy changes on stock prices and found that a 25 basis point cut in the federal funds rate led to a 1% increase in stock prices. In addition, Thorbecke (1997) investigated how shocks in the federal funds rate impacted stock returns and found significant short-term impact.

Herding behaviour can be one of the factors that explain financial market volatility resulting from monetary policy action. Su and Fleisher (1998) argued that volatility was associated with exogenous government action in the Shanghai and Shenzen stock markets during those periods associated with government action in the early 1990s. Furthermore, Demirer and Kutan (2006) found a link between the Chinese stock

[4] The phenomena where investors substitute private information with inferences about the prior actions of other investors are referred to as information cascades (see Calvo and Madoza 2000).

market herding and central bank action in the same markets. Following the Asian financial crisis in 1995, the Chinese central bank placed ceilings on municipal bonds, transferring many of these funds to the stock market. Demirer and Kutan (2006) found evidence of herding in how market participants discounted these bonds. However, without fully understanding the central bank's intentions, it is difficult to conclude whether this herding behaviour was rational. More relevant to this study is Gong and Dai (2017), who found that interest rate increases induced herding behaviour only in bear markets. Furthermore, Gong and Dai (2017) found that contractionary monetary policy changes led to herding behaviour and concluded that improved monetary policy communication was important in these circumstances.

### 2.3 Herding behaviour in the ZAR market

Herding behaviour in financial markets is not without precedent in South Africa. Several herding studies were conducted in South Africa. For example, Seetharam (2013) found evidence of herding behaviour on the JSE All Share Index, which showed that herding behaviour fluctuated with market cycles, with herding being more pronounced before market contractions. In the housing market, Cakan et al. (2019) found evidence of a non-linear link between herding behaviour and economic uncertainty, with the relationship becoming stronger at higher levels of uncertainty.

There are limited studies of herding in the ZAR market. Tsuchiya and Kato (2015) conducted the most relevant study. Between 2001 and 2012, the authors found no evidence of herding or anti-herding[5] among ZAR forecasters, which means that these forecasters were likely to produce their forecasts in an unbiased way. Tsuchiya and Kato (2015) used a non-parametric herding test introduced by Bernhardt, Campello and Kutsoati (2006). This tests for biases in the expectations of forecasters (or their posterior distribution) compared to the median or mean of the exchange rate over the same period. This method is however not relevant to our study as we are testing for actual herding, and not herding in expectations. As such, our analysis is limited to the spot market. Beyond Tsuchiya and Kato (2015), we found no other significant work on currency market herding in South Africa. This study can help close this gap.

[5] See Section 4.2.1 for more detail.

The value of the rand is determined by a range of short- and long-term factors. These include labour strikes, the activities of currency speculators and the impact of adverse weather conditions on agricultural exports (Bhundia and Ricci 2005). Herding is another factor. Herding in the foreign exchange rate market can increase the rand's volatility, which is damaging for exporters and importers and affects the country's trade and macroeconomic policy (Le Roux 2015; Frankel 2007). Oseifuah and Korkpoe (2018) refer to rapid shifts between periods of appreciation and depreciation as 'regime switching'. This behaviour reflects changes in economic and financial fundamentals but can be amplified by herding behaviour in the exchange rate market. Policymakers need to identify what type of herding is driving market dynamics and decide whether to intervene.

### 2.4 Herding behaviour and market liquidity

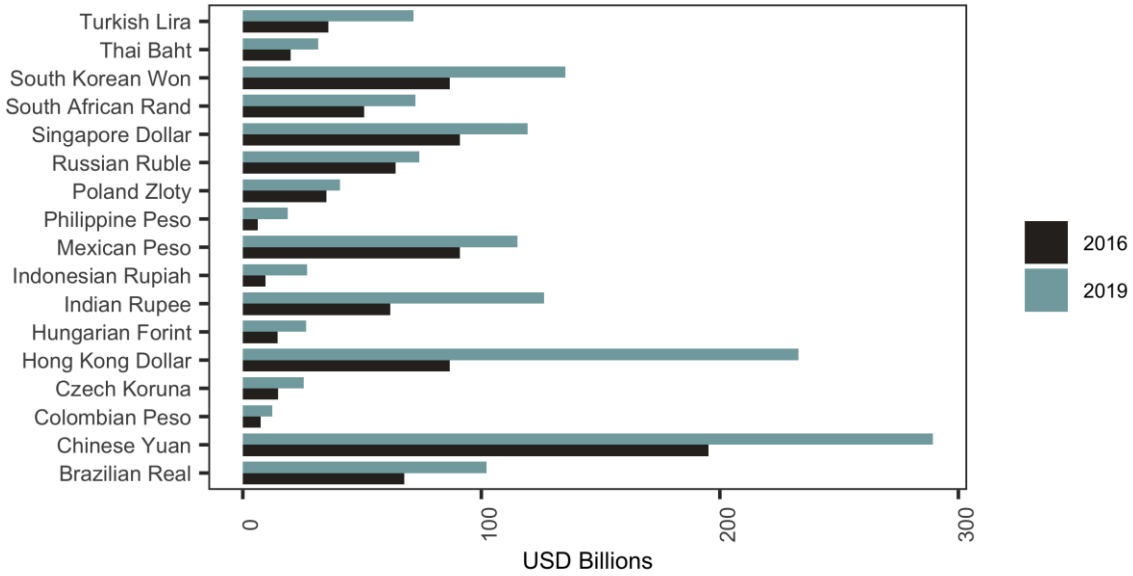
In general, liquidity can predict equity prices through its link to transaction costs. For example, liquidity in a market can be improved by the addition of a new stock to an index, leading to lower transaction costs and therefore higher stock prices (see Amihud and Mendelson 1986; Kong, Zhu and Azencott 2021). However, the link between market liquidity and herding behaviour is not as direct as that of liquidity to stock prices. Market liquidity can be related to herding mainly through transaction costs and information flows. Firstly, one of the features of an illiquid market is the limited number of stocks to purchase, which results in high transaction costs (Tan et al. 2008). In an effort to minimise these costs, investors can herd around perceived low-cost stocks, disregarding other relevant information such as the expected return on that stock. Secondly, in illiquid markets it is difficult for investors to know the true value of securities without sufficient turnover of stocks. This lack of information can lead to herding as investors seek to avoid missing out on, for example, good value stocks. Herding behaviour is thus generally more prevalent in illiquid markets (Tan et al. 2008).

## 3. The ZAR market in a global context

In this section we highlight the importance of the ZAR market in a global context. Foreign exchange (FX) turnover in the ZAR comprises domestic and offshore markets. In 2019, ZAR turnover was USD72 billion, and most of it was offshore (see Figure 1).

This made the rand the 18th most traded currency in the world that year.[6]

**Figure 1: Emerging market FX turnover in 2019**




Source: BIS (2019)

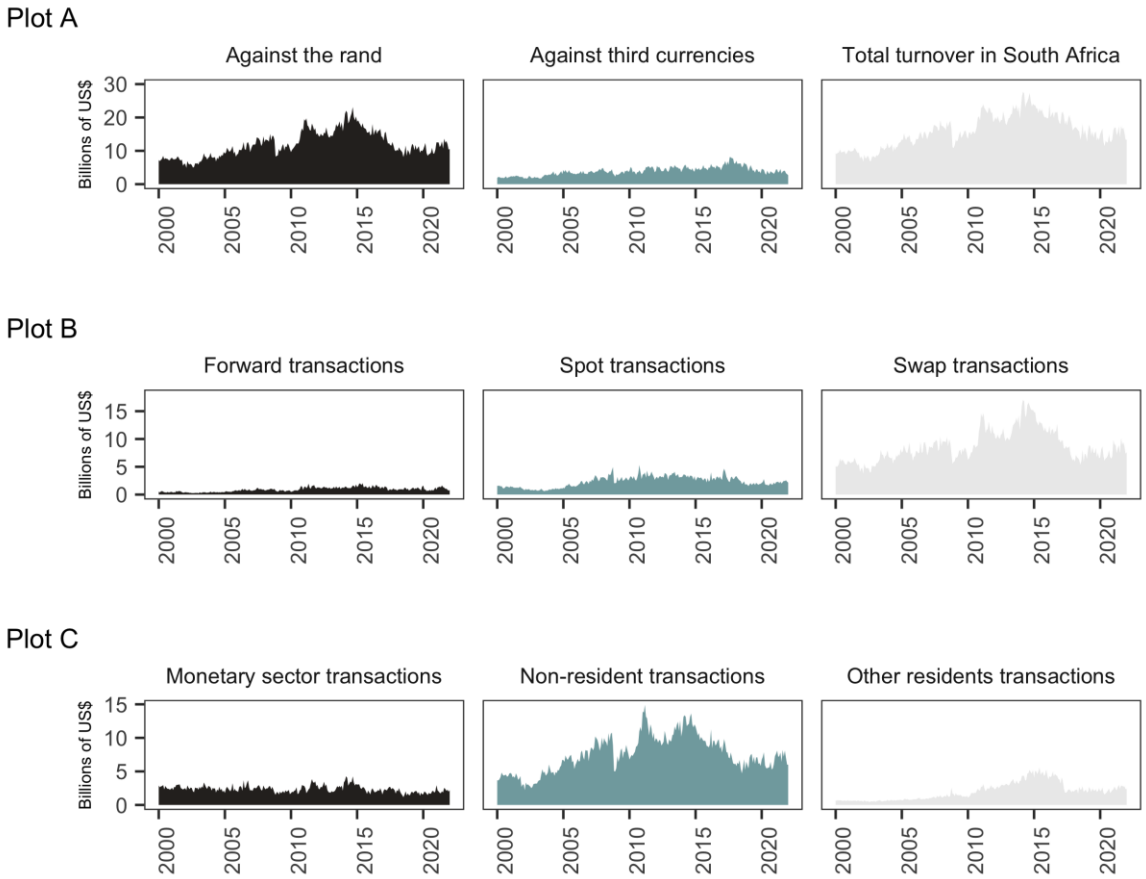
In 2022, domestic ZAR market turnover averaged USD13.2 billion, largely unchanged from 2019 (USD13.8 billion).[7] This reflected that while economic growth was strong in 2022, the level of market activity was largely the same as in 2019. Domestic ZAR market transactions were predominantly rand-based (as opposed to other currencies). However, some third-currency transactions are evident.[8] Transactions by non-residents (rather than monetary institutions and other residents) were the most common, showing the global nature of FX markets in which investors seek to diversify portfolios even in emerging markets (see Figure 2).

6 According to the Bank for International Settlements (2019). This data is released once every three years.

7 According to the SARB daily FX market survey (2019).

8 'Against third currencies' refers to transactions between two foreign currencies in the domestic ZAR market.

**Figure 2: Rand market activity**




Source: SARB (2022)

Note: Plot A is the average daily market activity, Plot B is the average daily market activity against the rand by transaction type, and Plot C is the average daily market activity against the rand by counter-party.

## 4. Data and methodology

### 4.1 Data

Daily currency data was sourced from Bloomberg as it provides a comprehensive dataset on the South African currency market.[9] The daily currency market data ranges from 2000-01-03 to 2022-03-03, which is 5 459 observations (see Figures A.1 and A.2). We focus on South Africa's trading partners using the Bank for International Settlements' (BIS's) trade weights.[10] These partners constitute the ZAR currency

9 Data was extracted from the Bloomberg terminal.

10 https://www.bis.org/statistics/eer.htm

market and are summarised in Table 1. The BIS data are available in three-year frequencies and were converted to daily observations by assuming that the trade weights do not change much within each three-year period (see Figure A.4).[11] Figure A.3 shows data on the repo rate from the South African Reserve Bank (SARB).

**Table 1: ZAR currency market**

| Trading partners | Currencies | Ticker |
|---|---|---|
| Brazil | Brazilian Real | BRL |
| United States | Dollar | USD |
| Great Britain | Pound | GBP |
| Thailand | Baht | THB |
| Switzerland | Franc | CHF |
| Sweden | Krona | SEK |
| South Korea | Won | KRW |
| Japan | Yen | JPY |
| India | Rupee | INR |
| European Union | Euro | EUR |
| China | Yuan | CNY |

In our analysis we need to weigh the returns from the different currency markets to calculate cross-sectional deviations. Unlike most studies, we use the BIS trade weights as a proxy for selecting currency returns.[12] This implies that certain markets are weighted less than others in calculating the cross-sectional deviations. This is a departure from Chang, Cheng and Khorana (2000), who weight all markets equally. Most studies of herding behaviour continue to weigh markets equally. However, Xie, Xu and Zhang (2015) highlight the limitation of equal weighting given the dominance of some currency pairs. It is reasonable to assume that not all markets have the same

11 The conversion of trade weights to a daily frequency preserves the sample size while considering the effect of the weights.

12 The BIS trade weights are similar to the national trade weights used to calculate the effective exchange rate by the SARB. However, we use the BIS trade weights as, unlike the South Africa trade weights, they are reported in both directions of trade. That is, they are reported as trade from South Africa with the rest of the world and the rest of the world with South Africa. This is relevant in the calculation of cross-sectional deviations in Section 4.2.1

level of activity. In the context of herding behaviour, the trade weights are a gauge for external shocks (BIS 2006).[13]

We construct our liquidity measure (the bid-ask spread as explained in Section 4.2.3) using USD/ZAR intraday transactional data from Refintiv, which is the only provider of long historical FX data. As the USD is most traded, it is appropriate to use the USD/ZAR as a proxy for overall ZAR market liquidity. The data provides over a million transactions on a sub-hour basis. We aggregated this data using the median observation so that it is in line with the frequency of the daily returns data used in the herding analysis. However, data on the volume of transactions was not available, limiting our analysis to measures of liquidity that do not use volumes. We included the open and close prices (first price of an intra-day price snapshot based quoted rates and last quoted price) and bid/ask prices. We used these to calculate the percentage bid-ask spread (as shown in section 4.2), which we use as a liquidity measure.

## 4.2 Methodology

### 4.2.1 Herding behaviour

Empirically, herding is defined in line with Chang, Cheng and Khorana (2000). Herding is measured by first calculating returns:

$$R_t = \left(\frac{E_t}{E_{t-1}} - 1\right) \times 100,$$

where $R_t$ is a return at time $t$, $E_t$ and $E_{t-1}$ is index value at time $t$ and $t-1$. Returns form the foundation of the analysis as they contain all information incorporated by the market, including shocks and investor sentiment.

Following Christie and Huang (1995) and Chang, Cheng and Khorana (2000), we calculate two dispersion metrics, the cross-sectional standards deviation ($CSSD_t$) and the cross-sectional absolute standard deviations ($CSAD_t$). These measure dispersion

[13] The weights are derived from trade flows and capture both direct bilateral trade and third-party competition. Any real shock can therefore be transmitted in these flows and indirectly to the currency or the effective exchange rate.

in currency returns with a higher dispersion indicative of the diverging behaviour of traders compared to the aggregate market. The overall currency market is a composite of sub-markets reflected by various exchange rates. However, instead of assuming equal weighting of the sub-markets, we use the respective trade weight of each sub-market with South Africa (see Xie, Xu and Zhang 2015; Sibande et al. 2021). Trade weights reflect the importance of a specific sub-market to the overall currency market. The dispersion measures are calculated for all markets as follows:

$$CSSD_t = \sqrt{\sum_{i=1}^{N} w_{i,t} \left(R_{i,t} - R_{m,t}\right)^2},$$

and

$$CSAD_t = \sum_{i=1}^{N} w_{i,t} \left|R_{i,t} - R_{m,t}\right|,$$

where $R_{i,t}$ represents the observed currency returns from market $i$ at time $t$, $R_{m,t}$ is a trade weighted average of the $R_{i,t}$ or the market return, $w_{i,t}$ is the respective trade weight of each market over time with the South Africa, and the $\sum_i w_{i,t} = 1$. The return dispersion measures capture the directional similarity across currency returns at a given point in time with respect to the aggregate market. Herding tests, in turn, are based on the pattern of return dispersions during periods of large price movements. Usually, the return dispersion metrics tend to be positively associated with market returns in the absence of herding.[14] Typically in the literature the $CSAD_t$ is preferred to the $CSSD_t$, as the $CSSD_t$ can be biased by extreme data points (see Gong and Dai 2017). However, given the limited literature on the South Africa currency market it is more prudent to use both measures to independently determine any significant differences.

Next, the pattern of return dispersions during periods of large price movements is examined. The rationale behind the testing methodology is that, if herding is present,

[14] That is, the higher the risk or dispersion, the higher the return. However, in the presence of herding this may not be the case, suggesting that the information on which investors relied on does not reflect market fundamentals or the true market risk.

the correlated trades by investors will lead to greater directional similarity in currency returns, thus leading to lower dispersion in returns. This can be measured by the sign of the coefficients of the relationship between the return dispersion and $R_{m,t}$ and $R_{m,t}^2$ (or market return measures) in these equations for the general market herding:

$$CSSD_t = \alpha_0 + \alpha_1 \left| R_{m,t} \right| + \alpha_2 R_{m,t}^2 + \epsilon_t,$$

and

$$CSAD_t = \alpha_0 + \alpha_1 \left| R_{m,t} \right| + \alpha_2 R_{m,t}^2 + \epsilon_t,$$

where $\alpha_2$ is the herding coefficient. The expectation is that $\alpha_1 > 0$ and $\alpha_2 = 0$ indicates the absence of herding. However, herding would be implied by $\alpha_2 < 0$, which indicates that return dispersions are significantly lower during market stress due to correlated trading behaviour, leading to greater directional similarity in returns. Likewise, $\alpha_2 > 0$ would indicate anti-herding, indicating that traders go against the market consensus (Babalos and Stavroyiannis 2015). The purpose of the $CSSD_t$ and the $CSAD_t$ regressions is not to determine the best fit but to test the directional similarity of returns. This is possible because returns data are typically highly correlated and stationary. To ensure that the results are not spurious, all the $CSSD_t$ and the $CSAD_t$ regressions in this study use heteroskedasticity and autocorrelation consistent (HAC) standard errors as defined by Zeileis (2004).

Given that herding is most prevalent in extreme market conditions, three sets of the $CSSD_t$ and the $CSAD_t$ are run:

- one set using the full sample;
- another set with the top 5% of market returns ($R_{m,t}$); and
- the last set with the bottom 5% of market returns.

This extreme market segmentation is a standard practice in the literature (for example, Demirer and Kutan 2006). The full sample specification is defined above. For the top market, the equations are defined as follows:

$$CSSD_t^{Top} = \alpha_0 + \alpha_1^{Top} \left| R_{m,t}^{Top} \right| + \alpha_2^{Top} \left( R_{m,t}^{Top} \right)^2 + \epsilon_t,$$

and

$$CSAD_t^{Top} = \alpha_0 + \alpha_1^{Top}\left|R_{m,t}^{Top}\right| + \alpha_2^{Top}\left(R_{m,t}^{Top}\right)^2 + \epsilon_t.$$

For the bottom market, they are:

$$CSSD_t^{Bottom} = \alpha_0 + \alpha_1^{Bottom}\left|R_{m,t}^{Bottom}\right| + \alpha_2^{Bottom}\left(R_{m,t}^{Bottom}\right)^2 + \epsilon_t,$$

and

$$CSAD_t^{Bottom} = \alpha_0 + \alpha_1^{Bottom}\left|R_{m,t}^{Bottom}\right| + \alpha_2^{Bottom}\left(R_{m,t}^{Bottom}\right)^2 + \epsilon_t,$$

where the definitions of the $(.)^{Top}$ and $(.)^{Bottom}$ variables and parameters estimates are equivalent to their full sample counterparts above, with the same herding (anti-herding) test.

### 4.2.2 Herding behaviour and monetary policy

The central issue of this paper is to test if changes in the policy rate induce herding behaviour in the currency market. In South Africa, changes to the repo rate or policy rate only occur with the announcement by the Monetary Policy Committee.[15] Empirically, this is equivalent to testing if the interaction of the herding term ($R_{m,t}^2$) and variations in the policy rate is significant ($Dum_0$) in the following equations:

$$CSSD_t = \alpha_0 + \alpha_1\left|R_{m,t}\right| + \alpha_2 R_{m,t}^2 + \omega Dum_0 R_{m,t}^2 + \epsilon_t,$$

and

$$CSAD_t = \alpha_0 + \alpha_1\left|R_{m,t}\right| + \alpha_2 R_{m,t}^2 + \omega Dum_0 R_{m,t}^2 + \epsilon_t,$$

where $Dum_0$ takes a value of one a day after a change in the policy rate and zero otherwise. To further understand the effect of monetary policy announcements on herding in the ZAR market, we outline the effect of upward policy rate announcements from negative policy announcements in the following manner:

$$CSSD_t = \alpha_0 + \alpha_1\left|R_{m,t}\right| + \alpha_2 R_{m,t}^2 + \omega_1 Dum_1 R_{m,t}^2 + \omega_2 Dum_2 R_{m,t}^2 + \epsilon_t,$$

[15] Market participants herd around information and not necessarily the actual event. That is, market participants are likely to herd around a monetary policy announcement rather than the actual change in the policy rate.

and

$$CSAD_t = \alpha_0 + \alpha_1 \left| R_{m,t} \right| + \alpha_2 R_{m,t}^2 + \omega_1 Dum_1 R_{m,t}^2 + \omega_2 Dum_2 R_{m,t}^2 + \epsilon_t,$$

where $Dum_1$ takes a value of 1 a day after an upward policy rate announcement and zero otherwise. $Dum_2$ takes a value of one a day after a downward policy rate announcement and zero otherwise.

### 4.2.3 Herding behaviour and market liquidity

There are numerous approaches to calculating liquidity in any market. These can be broadly divided into volume-based measures which emphasise market breadth, market impact measures which focus on the impact of liquidity on market prices, and transaction-based measures such as the bid-ask spread which are a measure of transaction costs.[16]

Fundamentally in FX markets, dealers drive liquidity by quoting bid and ask prices, and by taking positions. As a result, we use the bid-ask spread as a measure of liquidity in the ZAR market. Others such as Olds, Steenkamp and van Jaarsveld (2021) used the same measure in the ZAR market. However, the choice of the measure is also informed by the availability of data.

The percentage bid-ask spread ($\%spread_t$) is defined as follows:

$$\%spread_t = \frac{(ask\ price_t - bid\ price_t)}{\left(\frac{ask\ price_t + bid\ price_t}{2}\right)} * 100,$$

and calculated as the difference between the ask price and the bid price of a currency, as a percentage of the midpoint between the two prices.

A high $\%spread_t$ indicates high transaction costs,[17] which, among other factors, is a

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16 Amihud's (2002) illiquidity measure is the most commonly used in studies. However, due to limitations in the volume data it was not possible to use this measure.

17 Execution costs and not explicit transaction costs such as order processing costs and taxes

potential limitation on the number of market participants (Sarr and Lybek 2002). Furthermore, high transaction costs can lead to a fragmented market in which trades tend to reflect changes in the $\%spread_t$ and not the equilibrium price. This departure from the equilibrium price is a potential link between market liquidity and herding. In other words, market illiquidity can be one of the drivers of herding behaviour in the ZAR market.[18]

We test this link between herding and liquidity in the ZAR market in the following manner:

$$CSSD_t = \beta_0 + \beta_1\left|R_{m,t}\right| + \beta_2 R_{m,t}^2 + \beta_3 D_1 R_{m,t}^2 + \beta_4 D_2 R_{m,t}^2 + \epsilon_t,$$

and

$$CSAD_t = \beta_0 + \beta_1\left|R_{m,t}\right| + \beta_2 R_{m,t}^2 + \beta_3 D_1 R_{m,t}^2 + \beta_4 D_2 R_{m,t}^2 + \epsilon_t,$$

where $D_1$ takes a value of 1 when liquidity lies in the upper 25% and 0 otherwise. Similarly, $D_2$ takes a value of 1 when liquidity lies in the lower 25% and 0 otherwise. $D_1$ and $D_2$ allow for the estimation of herding in periods of high and low liquidity, with $\beta_2$ capturing periods of normal liquidity. Significant $\beta_3$ and $\beta_4$ estimates suggest that herding behaviour in the ZAR market interacts with liquidity.

## 5. Results

### 5.1 Descriptive results

Our descriptive analysis justifies the subsequent use of non-linear estimations. The descriptive statistics are summarised in Tables A.1 to A.5 in the annexure. Typical of financial data, the currency returns in our sample are highly correlated and normally distributed. For example, in Table A.2, the correlation between the returns from THB/ZAR and CNY/ZAR is 0.92. These high correlations justify the concept of a 'market' return in detecting herding. Furthermore, our data is leptokurtic[19] and is right-

[18] We test using the 'liquidity' data which represents both liquidity when it is high and illiquidity when it is low. But herding is generally associated with illiquidity. Put differently, liquidity improves the functioning of markets and therefore reduces herding behaviour. See Section 2.4 for further details about the link between market liquidity and herding behaviour.

[19] Kurtosis measures the 'tailedness' of the data. For example, leptokurtic refers to high positive excess kurtosis.

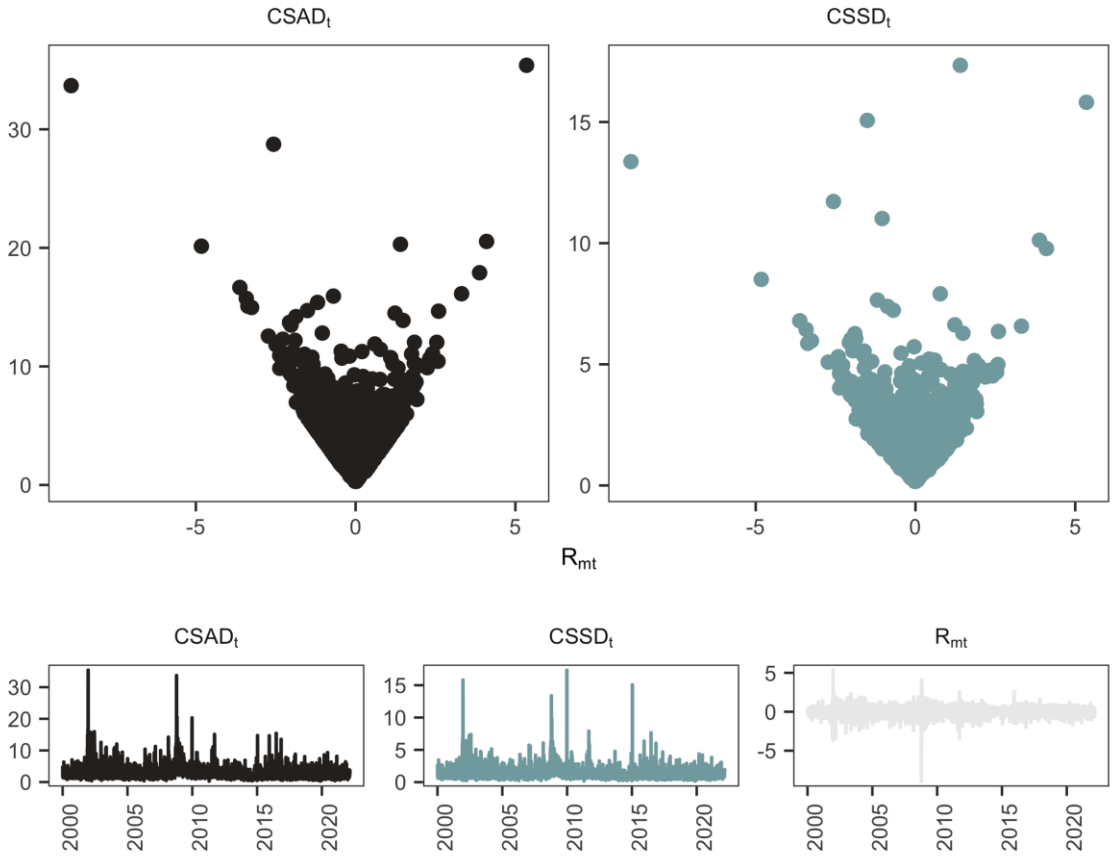
and left-skewed (see Table A.1). Along with most of the data being heteroskedastic and autocorrelated, as shown in Tables A.4 and A.5, the data justify the use of the quadratic herding model from the previous section.

## 5.2 Main herding results

The presence of herding means that the currency return dispersion tends to the market return, contradicting traditional asset-pricing models (Chang, Cheng and Khorana 2000). Under these conditions, investors cannot effectively offset risk from non-performing securities as all returns are too closely correlated to the market return because of herding (that is, market fads and other factors). The relationship between the market return and dispersion becomes non-linear ($R_{m,t}^2$),[20] indicating the presence of herding (negative relationship) and anti-herding (positive relationship). No relationship (or a zero) confirms rational asset pricing theory. We show this quadratic relationship between $CSSD_t/CSAD_t$ and $R_{m,t}$ in Figure 3.

[20] Non-linear means that the market return does not always increase with portfolio returns. This makes risk diversification difficult, leading to market volatility and bubbles.

**Figure 3: Relationship between return dispersions and the market return**




Note: $CSSD_t$ refers to the cross-sectional standard deviation, $CSAD_t$ refers to the cross-sectional absolute deviation and $R_{mt}$ refers to the weighted average market return.

The full sample herding test indicates that, generally, herding is not present in the ZAR market (Table 2). Both dispersion measures show no significant relationship to the quadratic term ($\alpha_2$). This result is unsurprising given the heterogeneous nature of ZAR investors with varying preferences and geographical locations, which are biased toward the offshore market. It is not unprecedented given that the ZAR is liquid and well traded relative to the emerging market status of South Africa. Lastly, in line with Chang, Cheng and Khorana (2000) and others, we extend the test to the top and bottom 5% of the market return or bull and bear markets, respectively. The bull market results indicate the presence of anti-herding.

**Table 2: General herding**

| Estimate | Full sample | | Top 5% | | Bottom 5% | |
|---|---|---|---|---|---|---|
| | CSSD | CSAD | CSSD | CSAD | CSSD | CSAD |
| $\alpha_0$ | 2.49*** | 18.17*** | 5.50*** | 47.66** | 1.02 | 3.64 |
| | (0.06) | (0.49) | (1.50) | (14.86) | (1.00) | (8.93) |
| $\alpha_1$ | 5.79*** | 49.28*** | 1.29 | 6.89 | 7.55*** | 66.25*** |
| | (0.25) | (1.94) | (1.90) | (18.76) | (0.99) | (8.65) |
| $\alpha_2$ | 0.04 | 0.58 | 1.41** | 12.52* | -0.28** | -2.23* |
| | (0.16) | (1.38) | (0.49) | (4.97) | (0.10) | (0.89) |
| $N$ | 5692 | 5692 | 284 | 284 | 284 | 284 |
| $R^2$ | 0.581 | 0.609 | 0.631 | 0.608 | 0.457 | 0.538 |

Note: The results flow from the $CSSD_t = \alpha_0 + \alpha_1 \mid R_{m,t} \mid + \alpha_2 R_{m,t}^2 + \epsilon_t$ and $CSAD_t = \alpha_0 + \alpha_1 \mid R_{m,t} \mid + \alpha_2 R_{m,t}^2 + \epsilon_t$ equations as defined above. In all the results tables $R_{m,t}$ is the market return and $R_{m,t}^2$ is the herding or anti-herding term. Furthermore $N$ is the sample size and $R^2$ is the goodness of fit measure. The regressions are implemented on the full sample, top 5% market return sample, and bottom 5% market return sample.

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

Table 3 is an extension of the initial herding tests and adds the effect of monetary policy announcements ($\omega$). $\omega$ is a dummy estimate which takes a value of 1 when there is an increase or decrease in the repo rate. The estimates indicate that even in the presence of the monetary policy effects, there is anti-herding in the bull market and herding in the bear market (see Table 1). In addition, $\omega$ was only significant and negative in the bear market. This reconfirms that herding in the ZAR market is associated with 'bad' news.

**Table 3: Herding and monetary policy announcements**

| Estimate | Announcement: full sample | | Announcement: top 5% | | Announcement: bottom 5% | |
|---|---|---|---|---|---|---|
| | CSSD | CSAD | CSSD | CSAD | CSSD | CSAD |
| $\alpha_0$ | 2.49*** | 18.15*** | 5.96*** | 49.21** | 0.93 | 2.86 |
| | (0.06) | (0.51) | (1.53) | (15.97) | (1.21) | (11.82) |
| $\alpha_1$ | 5.77*** | 49.20*** | 0.70 | 5.09 | 7.69*** | 67.26*** |
| | (0.25) | (1.98) | (2.02) | (21.13) | (1.17) | (11.23) |
| $\alpha_2$ | 0.04 | 0.60 | 1.52** | 12.85* | -0.30* | -2.34* |
| | (0.16) | (1.38) | (0.58) | (6.13) | (0.12) | (1.12) |
| $\omega$ | -0.10 | 1.45 | 0.29 | 5.39 | -1.74*** | -10.51* |
| | (0.24) | (2.20) | (0.33) | (4.05) | (0.47) | (4.85) |
| $N$ | 5458 | 5458 | 271 | 271 | 271 | 271 |
| $R^2$ | 0.584 | 0.610 | 0.672 | 0.614 | 0.454 | 0.535 |

Note: The results flow from the $CSSD_t = \alpha_0 + \alpha_1 \mid R_{m,t} \mid + \alpha_2 R_{m,t}^2 + \omega Dum_0 R_{m,t}^2 + \epsilon_t$ and $CSAD_t = \alpha_0 + \alpha_1 \mid R_{m,t} \mid + \alpha_2 R_{m,t}^2 + \omega Dum_0 R_{m,t}^2 + \epsilon_t$ equations as defined above. $Dum_0$ takes a value of one a day after a change in the policy rate and zero otherwise. The regressions are implemented on the full sample, top 5% market return sample and bottom 5% market return sample.

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

To further understand this effect, in Table 4 we delineated $\omega$ to upward announcements ($\omega_1$) and downward announcements ($\omega_2$). The results show marginal evidence of anti-herding in the general and bull markets ($\omega_1$) but large herding behaviour in the bear market (Table 5). Herding behaviour was driven by downward announcements or a reduction in the policy rate ($\omega_2$).

**Table 4: Herding and monetary policy upward and downward announcements**

| Estimate | Full sample | | | | Top 5% | | | | Bottom 5% | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Upward announcement | | Downward announcement | | Upward announcement | | Downward announcement | | Upward announcement | | Downward announcement | |
| | CSSD | CSAD | CSSD | CSAD | CSSD | CSAD | CSSD | CSAD | CSSD | CSAD | CSSD | CSAD |
| $\alpha_0$ | 2.49*** | 18.15*** | 2.49*** | 18.15*** | 5.97*** | 49.32** | 5.96*** | 49.21** | 0.90 | 2.68 | 0.93 | 2.86 |
| | (0.06) | (0.51) | (0.06) | (0.51) | (1.53) | (15.97) | (1.53) | (15.98) | (1.20) | (11.81) | (1.21) | (11.82) |
| $\alpha_1$ | 5.77*** | 49.23*** | 5.76*** | 49.20*** | 0.69 | 4.99 | 0.71 | 5.19 | 7.70*** | 67.32*** | 7.69*** | 67.26*** |
| | (0.25) | (1.97) | (0.25) | (1.97) | (2.02) | (21.13) | (2.02) | (21.15) | (1.17) | (11.22) | (1.17) | (11.23) |
| $\alpha_2$ | 0.04 | 0.59 | 0.04 | 0.60 | 1.53** | 12.87* | 1.52** | 12.83* | -0.30* | -2.34* | -0.30* | -2.34* |
| | (0.16) | (1.38) | (0.16) | (1.39) | (0.58) | (6.13) | (0.58) | (6.14) | (0.12) | (1.12) | (0.12) | (1.12) |
| $\omega_1$ | -0.27 | 0.42 | | | 0.83*** | 11.62*** | | | | | | |
| | (0.21) | (2.10) | | | (0.15) | (1.44) | | | | | | |
| $\omega_2$ | | | 0.18 | 3.04 | | | -0.16 | 0.18 | | | -1.74*** | -10.51* |
| | | | (0.37) | (3.62) | | | (0.15) | (3.88) | | | (0.47) | (4.85) |
| $N$ | 5458 | 5458 | 5458 | 5458 | 271 | 271 | 271 | 271 | 271 | 271 | 271 | 271 |
| $R^2$ | 0.584 | 0.610 | 0.584 | 0.610 | 0.672 | 0.615 | 0.672 | 0.614 | 0.453 | 0.534 | 0.454 | 0.535 |

Note: The results flow from the $CSSD_t = \alpha_0 + \alpha_1 \mid R_{m,t} \mid + \alpha_2 R_{m,t}^2 + \omega_1 Dum_1 R_{m,t}^2 + \omega_2 Dum_2 R_{m,t}^2 + \epsilon_t$ and $CSAD_t = \alpha_0 + \alpha_1 \mid R_{m,t} \mid + \alpha_2 R_{m,t}^2 + \omega_1 Dum_1 R_{m,t}^2 + \omega_2 Dum_2 R_{m,t}^2 + \epsilon_t$ equations as defined above. $Dum_1$ takes a value of one a day after an upward policy rate announcement, and $Dum_2$ takes a value of one a day after a downward policy rate announcement. The regressions are implemented on the full sample, top 5% market return sample and bottom 5% market return sample.

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

Lastly, we focus on whether market liquidity is a predictor of market prices and therefore herding behaviour. Figure 4 shows that in recent years the percentage change in the bid-ask spread has remained relatively low, indicating improved liquidity. As shown by Olds, Steenkamp and van Jaarsveld (2021), this trend is similar to global FX market trends. However, there are periods of crisis, such as the period after the financial crisis of 2008, where there was some liquidity tightening due to increased volatility. Olds, Steenkamp and van Jaarsveld (2021) also highlight a brief period of an increased bid-ask spread during the recent COVID crisis. Like Galariotis, Krokida and Spyrou (2016), Figure 4 suggests there is no clear linear relationship between the $\%spread$ and herding measures ($CSSD$ and $CSAD$). This is not surprising as we have shown that the $CSSD$ and $CSAD$ have non-linear features.[22]

The regression results in Table 5 indicate that in general there is no evidence of an impact of liquidity on herding.[23] Even in the presence of liquidity interactions, the herding results were still significant in the bottom market ($\beta_2$). This is a clear indication that liquidity does not impact on herding behaviour in the ZAR market. However, some evidence of anti-herding behaviour was found in the bull market ($\beta_3$ and $\beta_4$).

[22] For reasons explained in Section 5.1 above.

[23] It is important to note that the period covered in this study excludes the change Monetary Policy Implementation Framework to a floor system. Under the new system this finding may no longer hold.

**Figure 4: Relationship between herding measures and ZAR market bid-ask percentage spread**

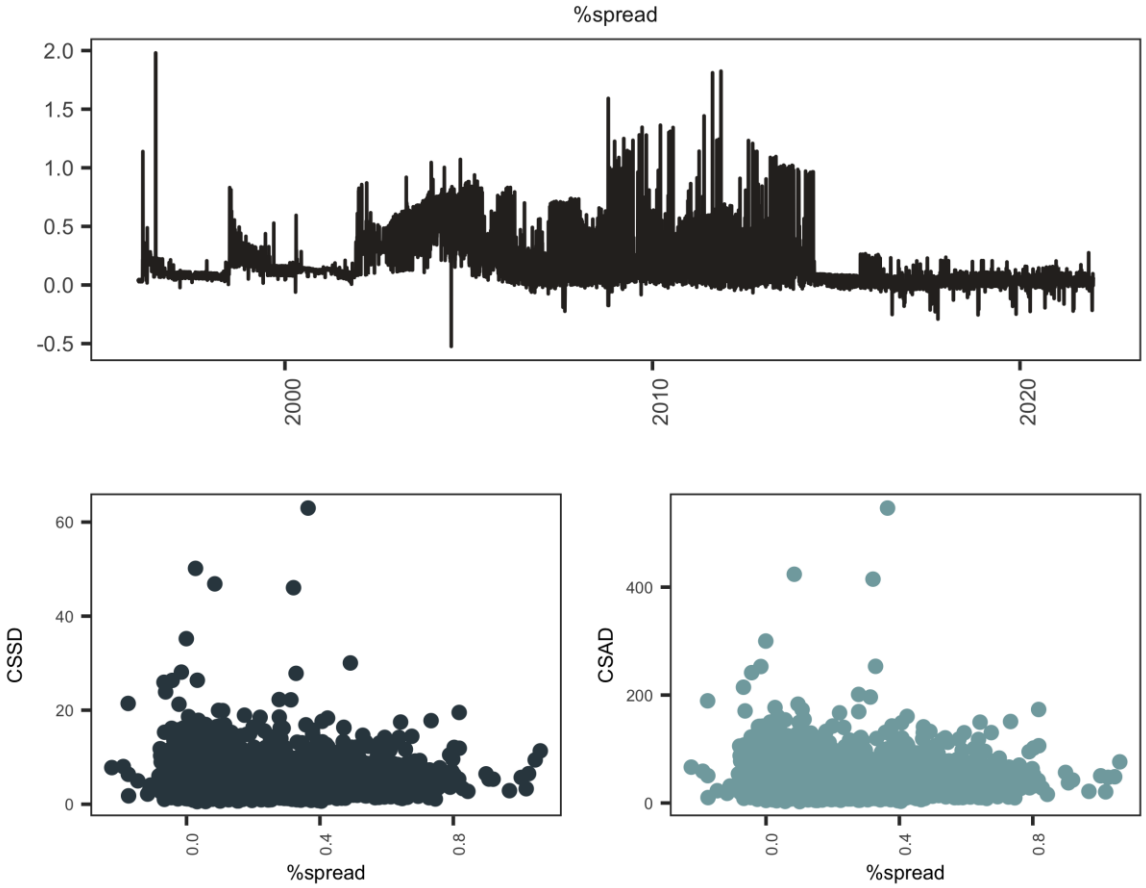


**Table 5: Herding and ZAR market liquidity**

| Estimate | Full sample | | Top 5% | | Bottom 5% | |
|---|---|---|---|---|---|---|
| | CSSD | CSAD | CSSD | CSAD | CSSD | CSAD |
| $\beta_0$ | 2.62*** | 19.23*** | 4.05*** | 34.07*** | 1.69* | 10.76 |
| | (0.06) | (0.45) | (0.72) | (6.06) | (0.82) | (7.25) |
| $\beta_1$ | 5.23*** | 44.75*** | 3.42*** | 26.33*** | 6.76*** | 57.94*** |
| | (0.26) | (2.15) | (0.93) | (7.42) | (0.83) | (6.98) |
| $\beta_2$ | -0.04 | -0.03 | 0.15 | 1.77 | -0.21* | -1.44+ |
| | (0.04) | (0.33) | (0.31) | (2.44) | (0.09) | (0.73) |
| $\beta_3$ | 0.69* | 6.16* | 1.09*** | 9.45*** | 0.16 | 2.37 |
| | (0.30) | (2.56) | (0.20) | (1.84) | (0.22) | (1.91) |
| $\beta_4$ | 0.50 | 3.18 | 0.54* | 3.52 | 0.26 | 1.25 |
| | (0.35) | (3.10) | (0.26) | (2.41) | (0.34) | (2.52) |
| $N$ | 5652 | 5652 | 284 | 284 | 284 | 284 |
| $R^2$ | 0.596 | 0.624 | 0.670 | 0.659 | 0.461 | 0.542 |

Note: The results flow from the $CSSD_t = \beta_0 + \beta_1 \mid R_{m,t} \mid + \beta_2 R_{m,t}^2 + \beta_3 D_1 R_{m,t}^2 + \beta_4 D_2 R_{m,t}^2 + \epsilon_t$ and $CSAD_t = \beta_0 + \beta_1 \mid R_{m,t} \mid + \beta_2 R_{m,t}^2 + \beta_3 D_1 R_{m,t}^2 + \beta_4 D_2 R_{m,t}^2 + \epsilon_t$ equations as defined above. The regressions are implemented on the full sample, top 5% market return sample and bottom 5% market return sample.

It is well established that herding is related to extreme market events where investors are more likely to disregard private information for public information to avoid reputation damage. In good times (bull markets), ZAR market investors show enough confidence in private information for formulating investment decisions. It is typical in the literature, including in highly traded currencies such as the USD and CNY (see Gong and Dai 2017), that investors respond more intensely to bad news than to good news.

Periods of extreme market uncertainty can partly explain ZAR volatility even if they do not reflect South Africa-specific macroeconomic or political factors. For example, changes in fundamentals such as commodity prices (Frankel 2007) can spill over from other markets (Oseifuah and Korkpoe 2018). The presence of herding in extreme

markets can amplify these spill-overs and therefore ZAR volatility. One of the factors that can contribute to herding is investor reaction to monetary policy.

In terms of the link between herding behaviour and monetary policy announcements, we find similar results to Gong and Dai (2017) in the ZAR market. As discussed in Section 6, these results may point to episodes of intentional herding, which indicate investors' similar and rational responses to monetary policy announcements. However, finding a significant result in bear markets on the days of monetary policy announcements suggests that investors pay more attention to these announcements in crisis periods than usual. It also suggests that markets look to the SARB for guidance on the direction of the economic environment in general.

## 6. Robustness

To test for the robustness of the results, we add the effect of two periods of extreme volatility in the ZAR market to the analysis.[24] The first period started in December 2015, when the Minister of Finance, Nhlanhla Nene, suddenly resigned, leading to extreme volatility in the broader South African financial markets. The ZAR market alone saw a 5% decline in the ZAR/USD exchange rate in a single day. Subsequently, the market capitalisation of the JSE declined by over R100 billion. This episode is an example of how uncertainty or government action can cause extreme volatility in financial markets, which could be amplified by herding behaviour. The second period of extreme volatility was caused by exogenous factors, beginning in March 2020 with the COVID-19 crisis.

Using the models developed by Christie and Huang (1995) and Chang, Cheng and Khorana (2000), we extend the results to look at extreme markets. However, specific periods of volatility in the ZAR market can bias the results and falsely confirm herding. Isolating these periods can, therefore, give a clear indication of the robustness of the results. We therefore extend the analysis to include the effects of two volatility periods in the following manner:

[24] The robustness test is to determine whether the results are due to a specific event or general conditions.

$$CSSD_t = \alpha_0 + \alpha_1 \left| R_{m,t} \right| + \alpha_2 R_{m,t}^2 + \omega Dum_0 R_{m,t}^2 + \lambda_i Dum_i + \epsilon_t,$$

$$CSAD_t = \alpha_0 + \alpha_1 \left| R_{m,t} \right| + \alpha_2 R_{m,t}^2 + \omega Dum_0 R_{m,t}^2 + \lambda_i Dum_i + \epsilon_t \quad (i = 1,2),$$

where $Dum_0$ takes a value of 1 a day after a change in the policy rate and zero otherwise. $Dum_i$ is a set of dummies representing three periods of volatility in the ZAR market. $Dum_1$ took a value of 1 during December 2015 when volatility resulted from the resignation of former Minister of Finance Nhlanhla Nene. Finally, $Dum_2$ is a COVID volatility dummy between March 2020 and the end of our sample in July 2020.

Table 6 reveals that almost all the market sample estimates for the two crisis periods were significant ($\lambda_1$ and $\lambda_2$), indicating a strong positive relationship in those periods to the dispersion measures ($CSSD_t$ and $CSAD_t$). Taking into account the effect of these specific crisis periods, our initial results still hold. Herding in the ZAR market is mainly an extreme market phenomenon and monetary policy announcements induce herding only in the bear market.

**Table 6: Robustness analysis**

| Estimate | Full sample | | Top 5% | | Bottom 5% | |
|---|---|---|---|---|---|---|
| | CSSD | CSAD | CSSD | CSAD | CSSD | CSAD |
| $\alpha_0$ | 2.47*** | 17.91*** | 6.11*** | 51.55*** | 0.77 | 1.46 |
| | (0.06) | (0.51) | (1.49) | (15.34) | (1.19) | (11.65) |
| $\alpha_1$ | 5.75*** | 49.02*** | 0.41 | 1.43 | 7.66*** | 66.93*** |
| | (0.25) | (1.94) | (2.00) | (20.66) | (1.17) | (11.14) |
| $\alpha_2$ | 0.04 | 0.63 | 1.56** | 13.35* | -0.29* | -2.27* |
| | (0.16) | (1.39) | (0.58) | (6.16) | (0.12) | (1.11) |
| $\omega$ | -0.09 | 1.49 | 0.38 | 6.29 | -1.62*** | -9.34+ |
| | (0.24) | (2.18) | (0.33) | (4.04) | (0.48) | (5.01) |
| $\lambda_1$ | 1.69+ | 15.27+ | 8.61*** | 96.22*** | 4.24*** | 43.95*** |
| | (0.90) | (8.51) | (0.94) | (10.00) | (0.37) | (3.84) |
| $\lambda_2$ | 1.52*** | 13.13*** | 4.96*** | 44.02*** | 4.94*** | 45.42*** |
| | (0.36) | (2.91) | (1.07) | (4.76) | (0.61) | (3.84) |
| $N$ | 5458 | 5458 | 271 | 271 | 271 | 271 |
| $R^2$ | 0.589 | 0.616 | 0.703 | 0.653 | 0.479 | 0.567 |

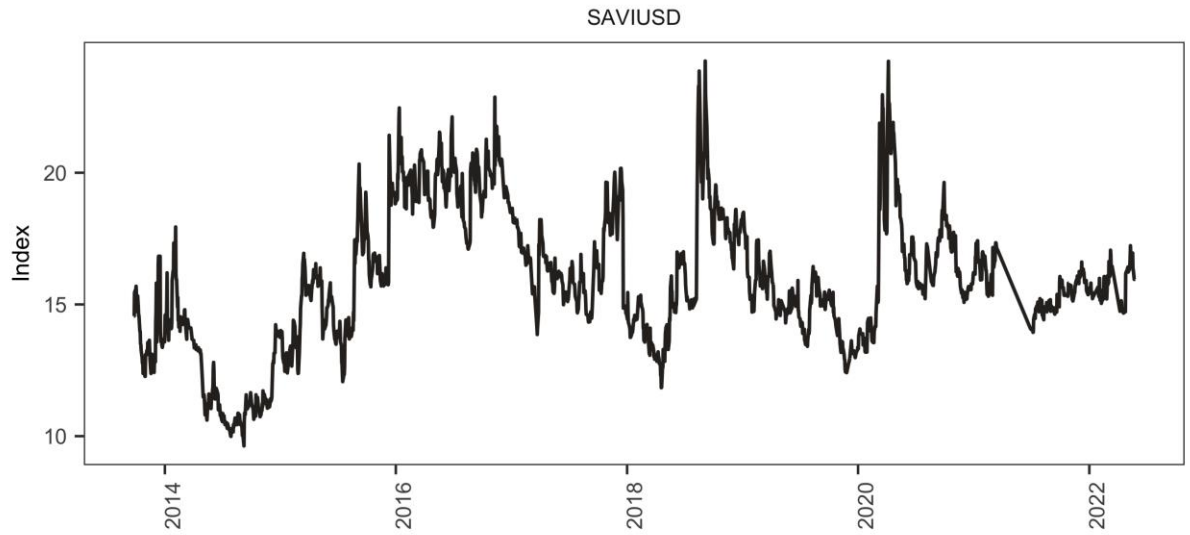
Note: The results flow from the $CSSD_t = \alpha_0 + \alpha_1 \mid R_{m,t} \mid + \alpha_2 R_{m,t}^2 + \omega Dum_0 R_{m,t}^2 + \lambda_i Dum_i + \epsilon_t$ and $CSAD_t = \alpha_0 + \alpha_1 \mid R_{m,t} \mid + \alpha_2 R_{m,t}^2 + \omega Dum_0 R_{m,t}^2 + \lambda_i Dum_i + \epsilon_t$ $(i = 1,2)$. $Dum_0$ takes a value of one a day after a change in the policy rate and zero otherwise. $Dum_i$ is a set of dummies representing two specific ZAR market events used to test for robustness of the results. These events are discussed in this section The regressions are implemented on the full sample, top 5% market return sample and bottom 5% market return sample.

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

## 7. Fundamental herding behaviour in ZAR market

A key question is whether the herding in the ZAR currency market is fundamental or non-fundamental, as described by Bikhchandani and Sharma (2000). Following Sibande et al. (2021), a time-varying approach is best suited to determine the nature of herding in the ZAR market as it involves measures of investor sentiment which evolve with time. No universal measure of investor sentiment in the ZAR market exists, and therefore we use the South African Volatility Dollar Index (SAVIUSD) as a proxy (see Figure 5). The SAVIUSD is a measure of 90-day implied volatility of the rand against the dollar, which is indicative of 'fear' or market sentiment[24] in the ZAR market (JSE 2022).

**Figure 5: SAVI Dollar Index (SAVIUSD)**



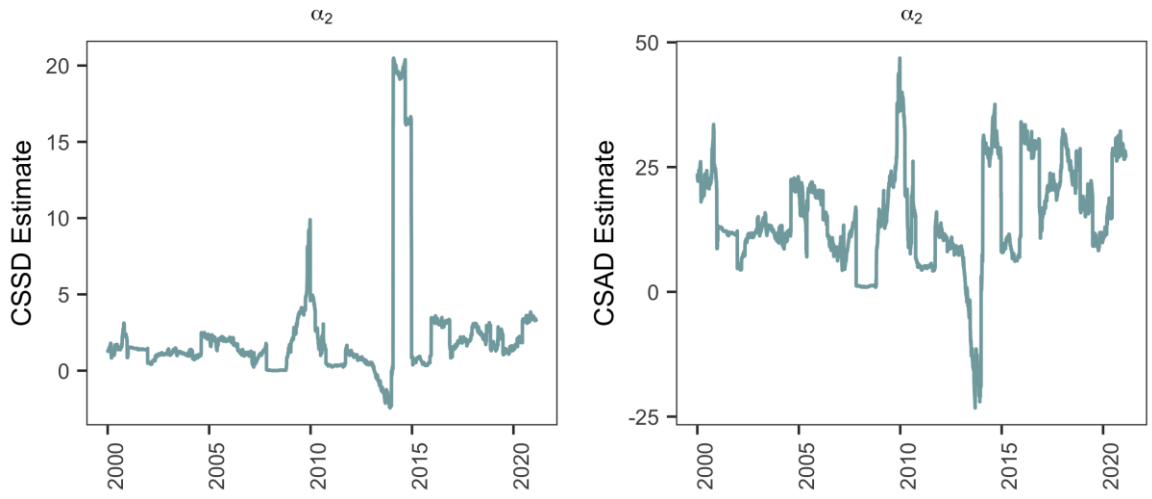

Source: Bloomberg

We estimate a time-varying measure of herding using rolling regressions. The measures are presented in Figures 6 and 7. The 250 window regressions indicate anti-herding (correlates to the positive but insignificant $\alpha_2$ in Table 2) with episodes of herding. The hypothesis is that a significant relationship between the SAVIUSD and time-varying herding indicates non-fundamental herding behaviour, and vice versa. As

[24] A higher value is indicative of a higher volatility in daily returns in the ZAR market, and therefore a higher level of 'fear' and a higher level of expected risk.

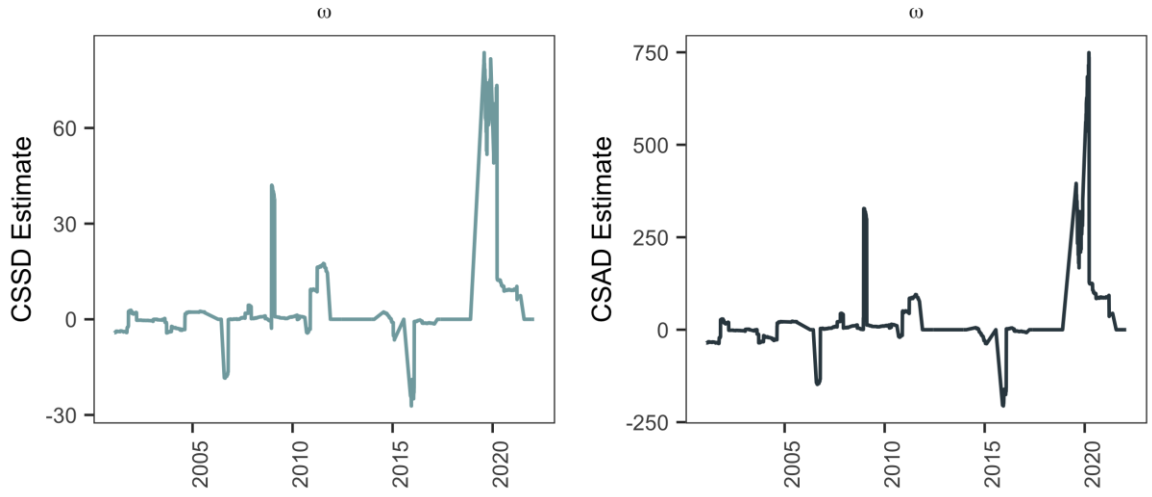
the SAVIUSD measures market fads, its correlation to herding indicates that investors are not responding collectively to public information but are following market fads which can lead to market volatility and bubbles.

**Figure 6: Rolling regressions without announcements**




Note: Rolling regressions, using a 250 day window of $CSSD_t = \alpha_0 + \alpha_1|R_{m,t}| + \alpha_2 R_{m,t}^2 + \epsilon_t$ and $CSAD_t = \alpha_0 + \alpha_1|R_{m,t}| + \alpha_2 R_{m,t}^2 + \epsilon_t$ as defined above.

**Figure 7: Rolling regressions with announcements**




Note: Rolling regressions , using a 250 day window, of $CSSD_t = \alpha_0 + \alpha_1|R_{m,t}| + \alpha_2 R_{m,t}^2 + \omega Dum_0 R_{m,t}^2 + \epsilon_t$ and $CSAD_t = \alpha_0 + \alpha_1|R_{m,t}| + \alpha_2 R_{m,t}^2 + \omega Dum_0 R_{m,t}^2 + \epsilon_t$ as defined above.

The relationship between herding and the SAVIUSD is estimated with and without the effect of monetary policy announcements. Again, we assess whether there are differences across different regimes and we use Sim and Zhou's (2015) quantile-on-quantile regression (QQR). The QQR addresses some of the limitations of the quantile regression (Koenker and Bassett 1978) such as its inability to capture the entirety of the dependency structure[25] between two variables (see Gupta et al. 2018). For this reason, the QQR is now commonly used in the finance literature (for example, Mishra et al. 2019 and Chang et al. 2020). The quantiles capture any regime-switching or estimates which depend on the extreme ZAR market states.

In the estimations, we find no significant relationship between herding behaviour and the SAVIUSD index, suggesting that herding is not a major driver of market volatility. The estimates are all close to zero, as shown in the colour gauge in Figure 8.[26] No regime-switching is evident except on the lower SAVIUSD quantiles. That is, the level of herding is not related to the SAVIUSD across most quantiles. We see a similar picture in Figure 9, which includes the effect of monetary policy announcements. In general, no relationship to the SAVIUSD was detected, particularly on the median or at the 50th quantile. However, some episodic increases and decreases in anti-herding ($\omega$) as a result of the SAVIUSD movements are evident in Figure 9, which are concentrated on the top quantiles of herding. These results are in line with recent literature on the ZAR market. Soobyah and Steenkamp (2019) found that, in the main, ZAR market volatility resulted from macroeconomic fundamentals rather than market fads.

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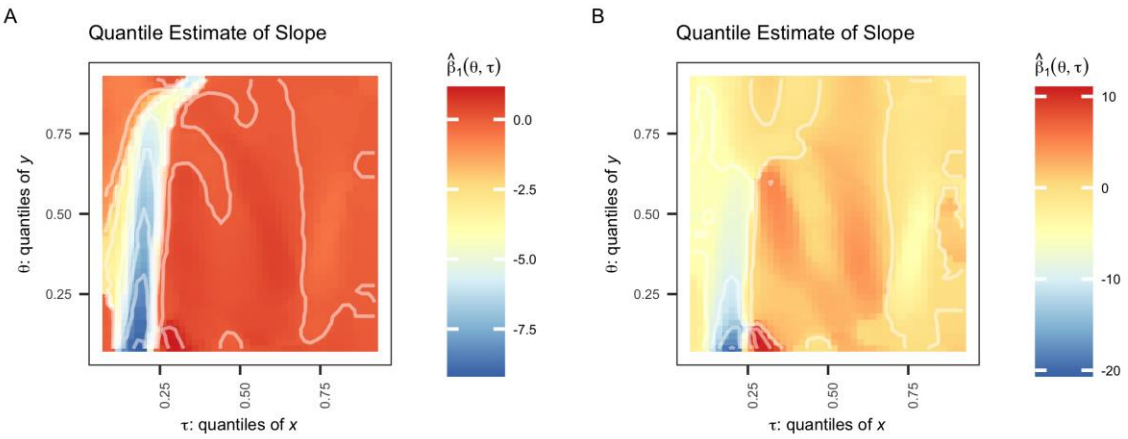
25 That is, although quantile regressions capture the relationship between two variables at various points of the conditional distribution, it restricts the possibility that the nature of the independent variable can also influence how the independent variable is calculated

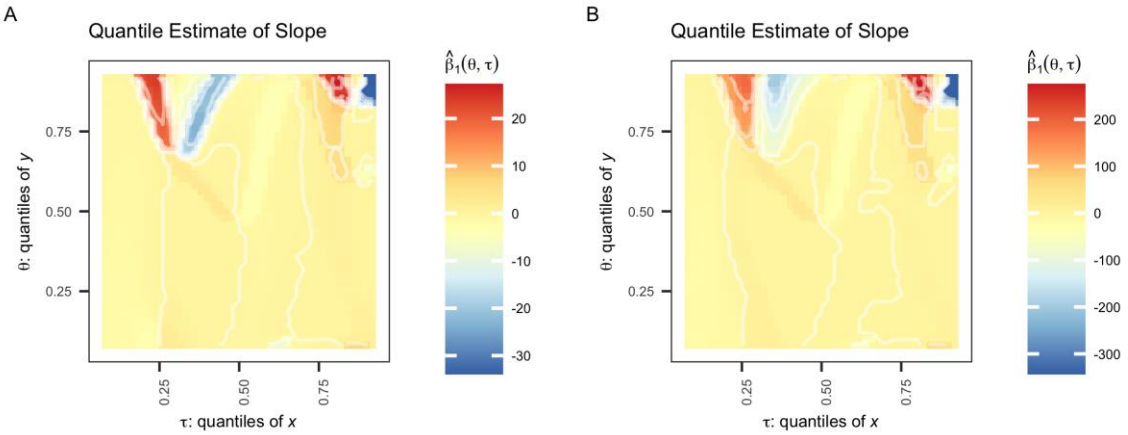
26 A similar conclusion can be drawn from Figure 8 but with the yellow colour. The QQR plot shows the relationship between the SAVIUSD quantiles and the herding quantiles according to the scale shown in the gauge. This has the advantage of detecting relationships which can occur in extremes, that is, regime-switching behaviour. For example, it can detect significance which only occurs in bull or bear markets.

**Figure 8: Fear index and herding**




Note: Panel A is a QQ regression between SAVIUSD and the $CSSD_t$ $\alpha_2$ estimate as shown in Figure 6. Similarly, Panel B is a QQ regression between SAVIUSD and the $CSAD_t$ $\alpha_2$ estimate as shown in Figure 6.

**Figure 9: Fear index and herding with policy rate variations**




Note: Panel A is a QQ regression between SAVIUSD and $CSSD_t$ $\omega$ estimate as shown in Figure 7

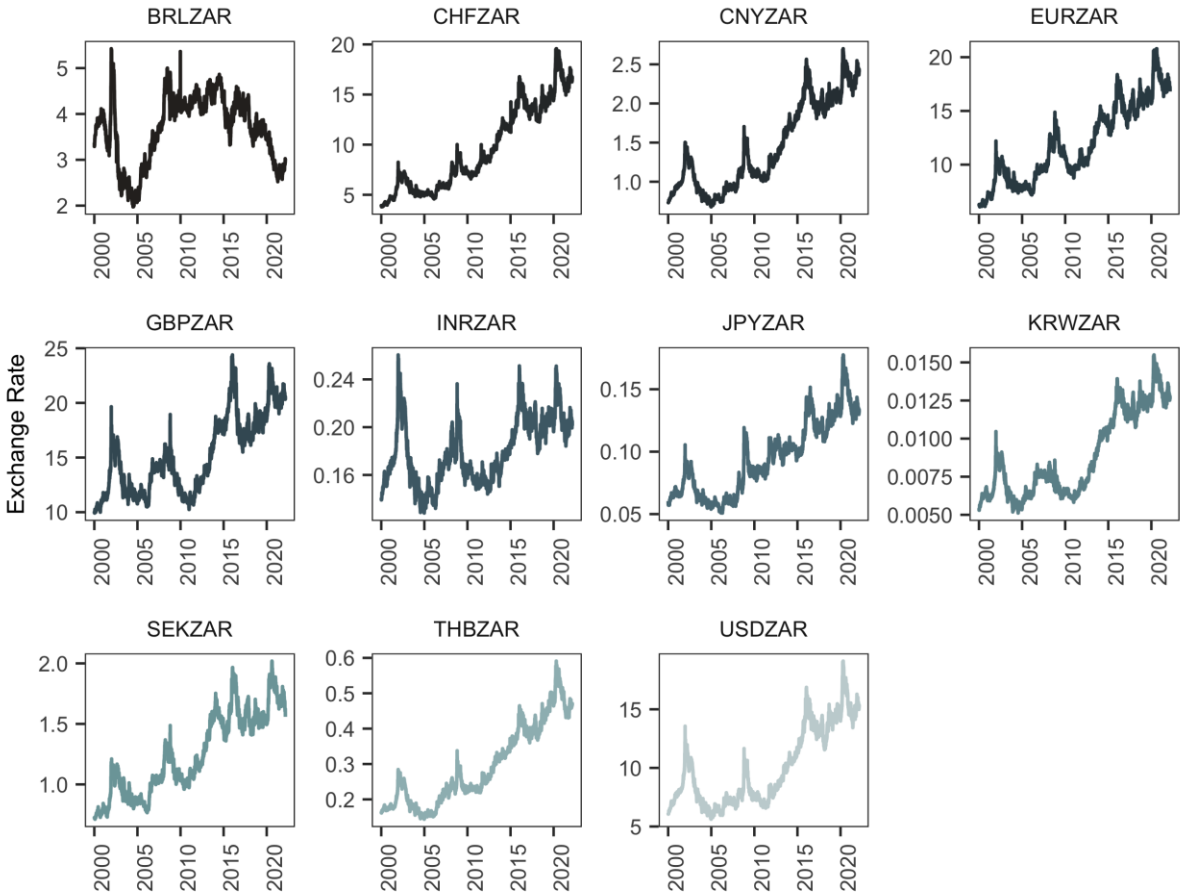
## 8. Conclusion

This paper investigated the presence of herding in the ZAR market and found that herding was present only in extreme markets. The results showed that monetary policy announcements induced herding behaviour only in the bear market. Generally, herding responses are rational and do not contribute to higher market volatility. This result is in line with the literature, which shows that the SARB's monetary policy communication and credibility has improved. As in any economic analysis, there is always scope for improvement. Future analysis could distinguish between expected and unexpected monetary policy shocks and could use alternative weights to calculate currency returns.

# Annexure

## 1. Data

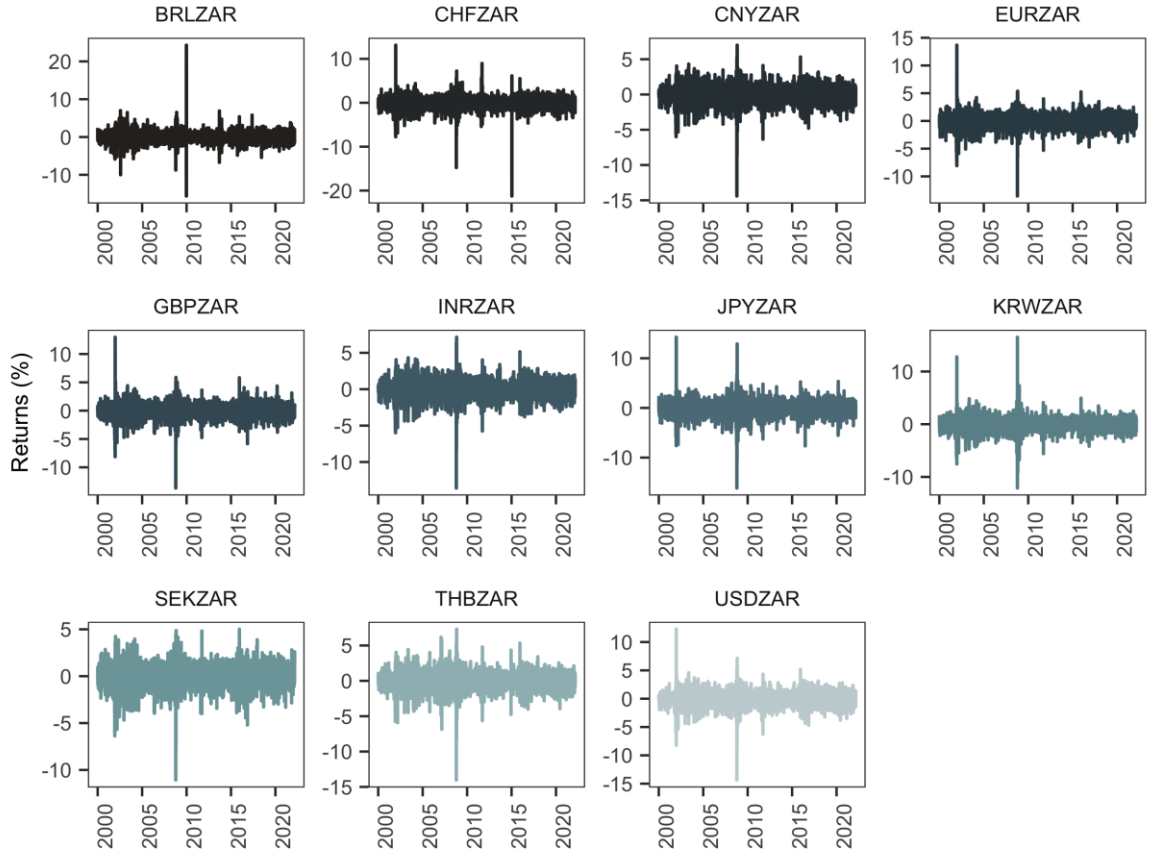
**Figure A.1: Exchange rates**




Source: Bloomberg.

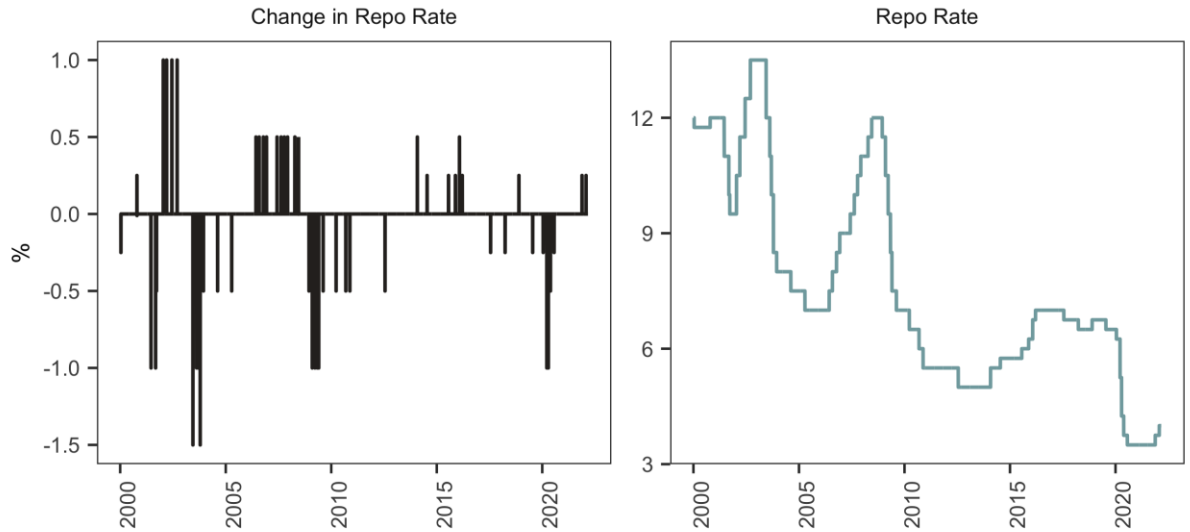
Note: See descriptions of exchange rates in Table 1

**Figure A.2: Returns**




Note: See descriptions of exchange rates in Table 1

**Figure A.3: Daily repo rate**




Source: South African Reserve Bank (2022)

## 2. Descriptive statistics

### Table A.1: Descriptive statistics

| Exchange rates | Observations | Mean | Standard deviation | Median | Min | Max | Skewness | Kurtosis |
|---|---|---|---|---|---|---|---|---|
| BRL/ZAR | 5,692 | 0.01 | 1.22 | 0.00 | -15.61 | 24.29 | 0.95 | 35.74 |
| USD/ZAR | 5,692 | -0.01 | 1.10 | 0.01 | -14.35 | 12.27 | -0.46 | 10.80 |
| GBP/ZAR | 5,692 | -0.01 | 1.05 | 0.00 | -13.65 | 12.97 | -0.27 | 12.12 |
| THB/ZAR | 5,692 | -0.01 | 1.07 | 0.02 | -14.03 | 7.30 | -0.58 | 8.52 |
| CHF/ZAR | 5,692 | -0.02 | 1.15 | 0.00 | -21.24 | 13.11 | -1.36 | 30.68 |
| SEK/ZAR | 5,692 | -0.01 | 1.00 | 0.00 | -11.07 | 5.01 | -0.54 | 5.57 |
| KRW/ZAR | 5,692 | -0.01 | 1.09 | 0.01 | -12.10 | 16.51 | 0.40 | 20.16 |
| JPY/ZAR | 5,692 | -0.01 | 1.25 | 0.04 | -16.12 | 14.24 | -0.39 | 12.91 |
| INR/ZAR | 5,692 | -0.00 | 1.03 | 0.01 | -13.57 | 7.14 | -0.59 | 8.41 |
| EUR/ZAR | 5,692 | -0.01 | 1.03 | 0.00 | -13.54 | 13.66 | -0.40 | 13.62 |
| CNY/ZAR | 5,692 | -0.01 | 1.06 | 0.00 | -14.39 | 6.99 | -0.70 | 8.59 |

Note: See descriptions of exchange rates in Table 1

### Table A.2: Returns correlations

| BRL/ZAR | USD/ZAR | GBP/ZAR | THB/ZAR | CHF/ZAR | SEK/ZAR | KRW/ZAR | JPY/ZAR | INR/ZAR | EUR/ZAR | CNY/ZAR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.00 | 0.51 | 0.47 | 0.50 | 0.42 | 0.44 | 0.49 | 0.43 | 0.52 | 0.46 | 0.52 |
| 0.51 | 1.00 | 0.85 | 0.90 | 0.80 | 0.73 | 0.81 | 0.87 | 0.90 | 0.83 | 0.97 |
| 0.47 | 0.85 | 1.00 | 0.79 | 0.81 | 0.79 | 0.75 | 0.78 | 0.79 | 0.87 | 0.83 |
| 0.50 | 0.90 | 0.79 | 1.00 | 0.75 | 0.72 | 0.77 | 0.82 | 0.86 | 0.78 | 0.92 |
| 0.42 | 0.80 | 0.81 | 0.75 | 1.00 | 0.79 | 0.68 | 0.81 | 0.73 | 0.89 | 0.78 |
| 0.44 | 0.73 | 0.79 | 0.72 | 0.79 | 1.00 | 0.67 | 0.70 | 0.71 | 0.88 | 0.74 |
| 0.49 | 0.81 | 0.75 | 0.77 | 0.68 | 0.67 | 1.00 | 0.70 | 0.79 | 0.73 | 0.80 |
| 0.43 | 0.87 | 0.78 | 0.82 | 0.81 | 0.70 | 0.70 | 1.00 | 0.78 | 0.81 | 0.85 |
| 0.52 | 0.90 | 0.79 | 0.86 | 0.73 | 0.71 | 0.79 | 0.78 | 1.00 | 0.77 | 0.91 |
| 0.46 | 0.83 | 0.87 | 0.78 | 0.89 | 0.88 | 0.73 | 0.81 | 0.77 | 1.00 | 0.81 |
| 0.52 | 0.97 | 0.83 | 0.92 | 0.78 | 0.74 | 0.80 | 0.85 | 0.91 | 0.81 | 1.00 |

Note: Lighter colours indicate higher correlation. See descriptions of exchange rates in Table 1

## 3. Statistical tests

**Table A.3: Jarque-Bera test for normality**

| Variable | Statistic | P value |
|---|---|---|
| BRL/ZAR | 304 001.86 | 0.00 |
| USD/ZAR | 27 899.52 | 0.00 |
| GBP/ZAR | 34 963.12 | 0.00 |
| THB/ZAR | 17 562.95 | 0.00 |
| CHF/ZAR | 225 115.07 | 0.00 |
| SEK/ZAR | 7 651.44 | 0.00 |
| KRW/ZAR | 96 606.07 | 0.00 |
| JPY/ZAR | 39 726.75 | 0.00 |
| INR/ZAR | 17 103.03 | 0.00 |
| EUR/ZAR | 44 155.34 | 0.00 |
| CNY/ZAR | 17 969.51 | 0.00 |

Note: Shaded cells indicate significance. See descriptions of exchange rates in Table 1

**Table A.4: Arch test for residual heteroscedasticity**

| Variable | Statistic | P value |
|---|---|---|
| BRL/ZAR | 702.97 | 0.00 |
| USD/ZAR | 657.01 | 0.00 |
| GBP/ZAR | 447.13 | 0.00 |
| THB/ZAR | 610.00 | 0.00 |
| CHF/ZAR | 140.09 | 0.00 |
| SEK/ZAR | 462.59 | 0.00 |
| KRW/ZAR | 1 048.98 | 0.00 |
| JPY/ZAR | 729.31 | 0.00 |
| INR/ZAR | 721.14 | 0.00 |
| EUR/ZAR | 495.98 | 0.00 |
| CNY/ZAR | 619.01 | 0.00 |

Note: Shaded cells indicate significance. See descriptions of exchange rates in Table 1

**Table A.5: Ljungbox test for residual independence**

| Variable | Statistic | P value |
|---|---|---|
| BRL/ZAR | 31.37 | 0.00 |
| USD/ZAR | 11.64 | 0.04 |
| GBP/ZAR | 17.66 | 0.00 |
| THB/ZAR | 22.26 | 0.00 |
| CHF/ZAR | 30.84 | 0.00 |
| SEK/ZAR | 17.51 | 0.00 |
| KRW/ZAR | 108.62 | 0.00 |
| JPY/ZAR | 19.10 | 0.00 |
| INR/ZAR | 17.08 | 0.00 |
| EUR/ZAR | 16.04 | 0.01 |
| CNY/ZAR | 8.56 | 0.13 |

Note: Shaded cells indicate significance. See descriptions of exchange rates in Table 1

## 4. Trade weights

**Figure A.4: Daily other country trade weights**

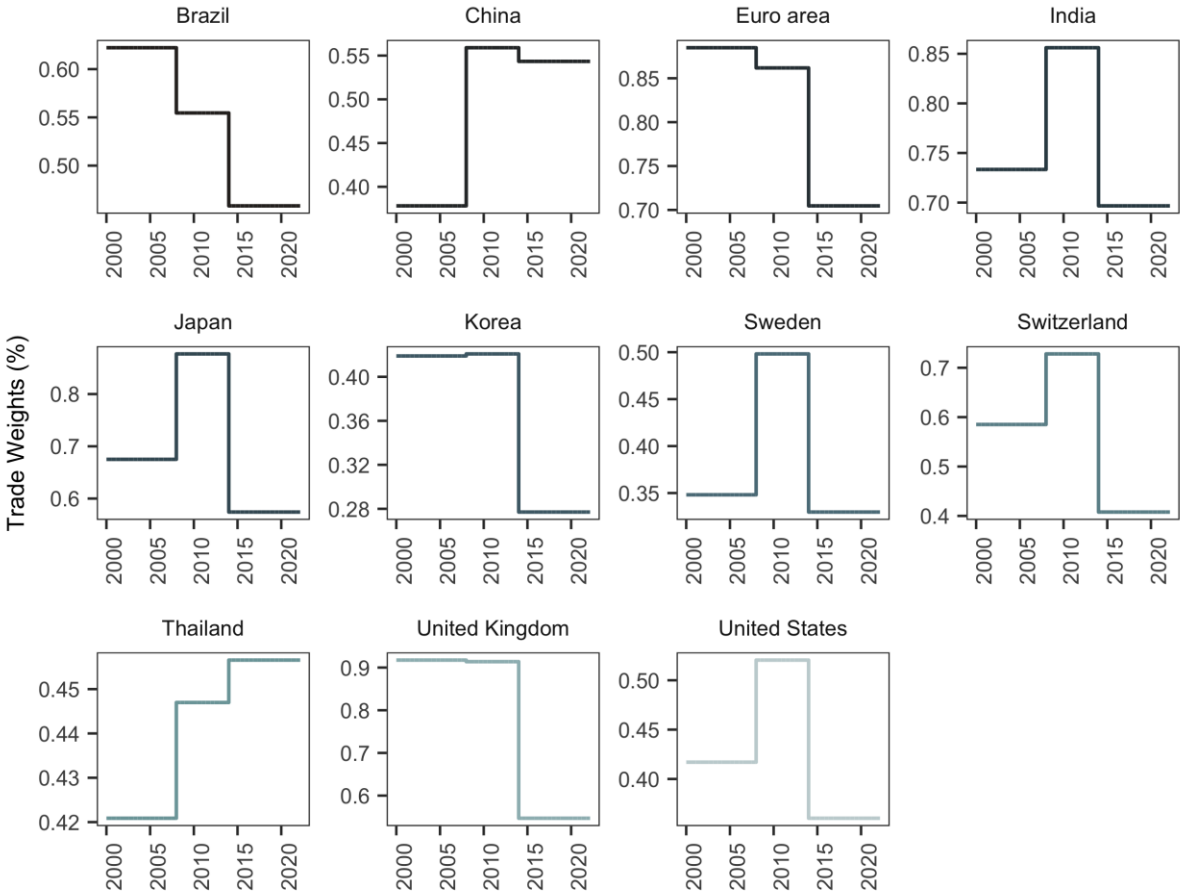
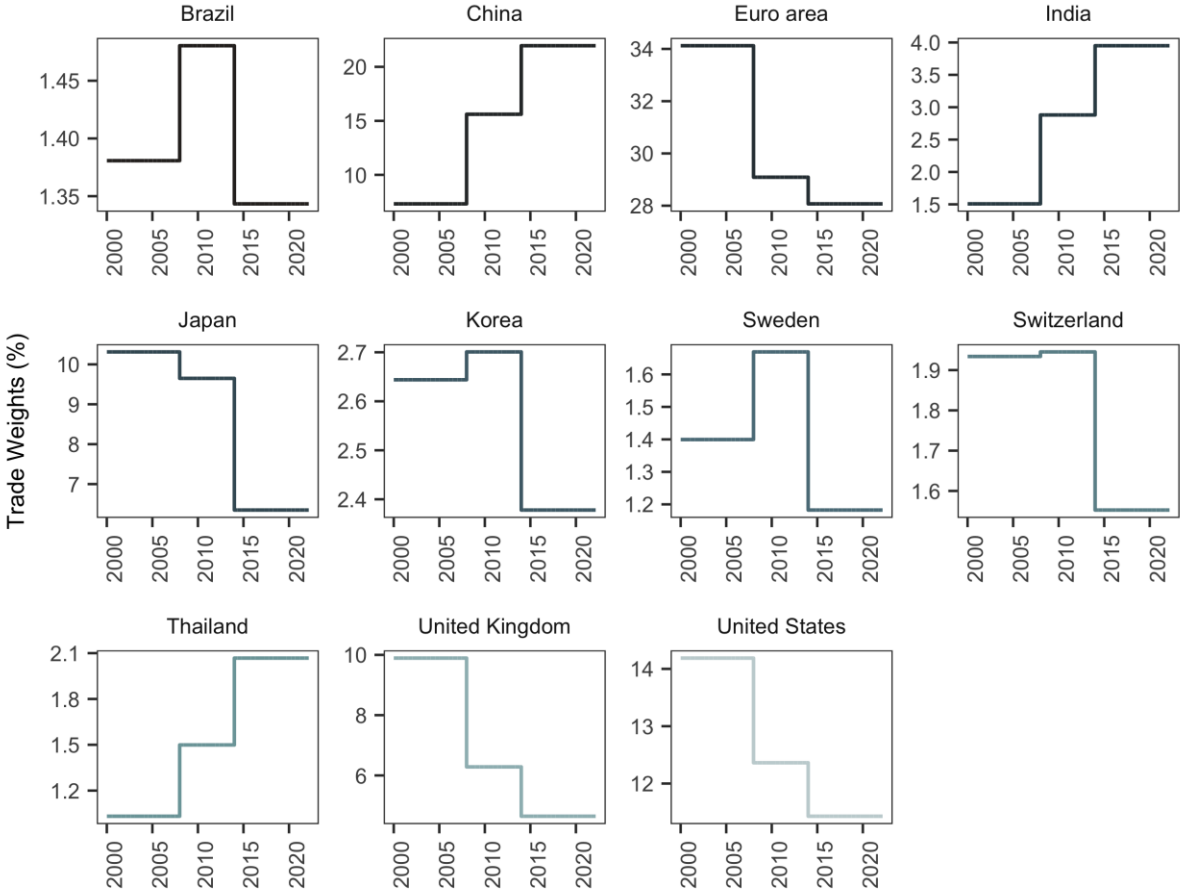


**Figure A.5: Daily South Africa trade weights**



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