
# Opening the Reserves Floodgates: The SARB's new Excess Reserves System and its Impact on the South African Banking System

by

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SUBMITTED TO THE UNIVERSITY OF CAPE TOWN

In partial fulfilment of the requirements for the degree

Master of Commerce specialising in Finance (in the field of Corporate Finance and Valuations)

Faculty of Commerce

UNIVERSITY OF CAPE TOWN

February 2025

Supervised by: Professor Phillip De Jager

## Declaration

This dissertation has been submitted to Turnitin and I confirm that my supervisor has seen my report. Any concerns revealed have been settled in collaboration with my supervisor.

Furthermore, this body of work has not been previously submitted in whole, or in part, for the award of any degree in this or any other university. It is my own work. Each noteworthy contribution to, and quotation in, this dissertation from the work, or works of other people has been attributed, and has been cited and referenced.

The ChatGPT AI was used to assist with parts of the Data and Methods section of the research. Example prompts that demonstrate how the AI was used are:

- Provide me with the Unix code to replicate this formula in Word.
- What is the EViews® process for running a Tsay test for nonlinearity.
- Provide me with the Excel formula to convert a text string to numbers.

Joe Donald Ekstein
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Signed by candidate

_____

6 February 2025

## Acknowledgements

First and foremost, my eternal gratitude goes to my wife for affording me the time and space to pursue this research even though it meant precious time away from her and our kids. Secondly, thank you to my supervisor Professor Phillip De Jager for his support and abundant patience in guiding me through this research.

# Abstract

This research evaluates the impact on the South African banking system of the South African Reserve Bank's (SARB) decision to shift from the traditional shortage reserves system to one that is now based on excess reserves. This shift changes the behaviour of the banking system that could have significant implications for the South African economy, especially for credit extension.

This research focuses on three main questions. First, has there been a significant increase in reserves observed in the South African banking system since the shift to an excess reserves system? Second, has there been any notable changes in the interbank lending market since the shift to an excess reserves system? Third, has there been any notable changes in credit extension to the South African domestic economy since the shift to an excess reserves system? To answer these questions, this research used descriptive statistics to evaluate the significance of the shift to an excess reserves system while a Threshold Autoregressive (TAR) Model was used to evaluate the dynamics between excess reserves, the Jibar-repo spread and credit extension to the domestic economy. The research comprises of monthly time-series data from the period January 2000 up to August 2024. This research finds that there has been a significant increase in the level of excess reserves in the South African banking system and the estimation results show that spreads in the interbank market and credit extension display regime-specific behaviour relative to excess reserves. There is an inverse relationship among the variables in a declining reserves regime and conversely, a direct relationship among the variables in an increasing excess reserves regime. The implications of these findings are important in understanding the role the SARB now plays in the South African banking system as a risk-free borrower that competes with others in the financial system for banks' surplus funds. Given the recency of this shift, this research contributes to the existing body of knowledge in two primary aspects. First, it studies the shift from a shortage reserve system to an excess reserve system in an emerging-market context such as South Africa where most research on this topic focuses on developed markets. Second, the shift of the SARB to an excess reserve system is recent and not yet well understood and this research contributes to that understanding and paves the way for further empirical research as more data becomes available.

# Table of Contents

**Declaration** ..... **ii**
**Acknowledgements** ..... **iii**
**Abstract** ..... **iv**
**Table of Contents** ..... **v**
**List of Tables** ..... **vii**
**List of Figures** ..... **viii**
**Acronyms** ..... **ix**
**1. Introduction** ..... **1**
**2. Literature Review** ..... **4**
2.1 Objectives of central banking ..... 4
2.2 Central bank reserves and the interbank market ..... 8
*2.2.1 Central banking under the shortage reserves system* ..... *9*
*2.2.2 Central banking under the excess reserves system* ..... *13*
2.3 SARB's shift to an excess reserves system ..... 16
**3. Data and Method** ..... **19**
3.1 Verifying shift through descriptive statistics ..... 20
*3.1.1 Excess reserves* ..... *20*
*3.1.2 Repo and Jibar rates* ..... *24*
*3.1.3 Total credit extension* ..... *26*
3.2 TAR model ..... 28
*3.3.1 Test for stationarity* ..... *29*
*3.3.2 Test for nonlinearity* ..... *30*
*3.3.3 Test for lag structure* ..... *30*
**4. Results and Discussion** ..... **31**
4.1 Validity of the estimated model ..... 31
4.2 Key findings per regime ..... 32
*4.2.1 Regime 1: Declining excess reserves* ..... *33*
*4.2.2 Regime 2: Stable excess reserves* ..... *35*
*4.2.3 Regime 3: Increasing excess reserves* ..... *36*
**5. Conclusion** ..... **37**
5.1 Implications ..... 38
5.2 Limitations of the research ..... 39
5.3 Further research ..... 40
**References** ..... **41**
**Annexure A: Augmented Dickey-Fuller test for unit root (stationarity)** ..... **45**
**Annexure B: Augmented Dickey-Fuller test verifying stationarity at *I*(1)** ..... **46**

**Annexure C: Tsay's test for nonlinearity of ordered variables ..... 47**

**Annexure D: TAR Estimation outputs at different lags showing AIC, SC, HQ information criteria ..... 47**

**Annexure E: TAR Estimation model output ..... 48**

**Annexure F: Autocorrelation tests for up to 12 lags ..... 49**

**Annexure G: Breusch-Godfrey Serial Correlation LM test ..... 50**

**Annexure H: Breusch-Pagan-Godfrey test for heteroskedasticity of residuals ..... 50**

**Annexure I: Variance Inflation Factor test for multicollinearity of redundant variables ..... 51**

# List of Tables

Table 1: Summary statistics of the variables of interest ..... 20
Table 2: Summary of excess reserves threshold values across regimes ..... 32
Table 3: Regime 1: Declining excess reserves ..... 34
Table 4: Regime 2: Stable excess reserves ..... 35
Table 5: Regime 3: Increasing excess reserves ..... 36

# List of Figures

Figure 1: Stylised corridor system ..... 11
Figure 2: Stylised floor system ..... 14
Figure 3: Select SARB Liabilities (R millions) ..... 21
Figure 4: Banks - Repo loans from SARB and domestic other (R million) ..... 22
Figure 5:Minimum required reserves versus total deposits with the SARB (R million) ..... 23
Figure 6: Excess reserves (R million) ..... 24
Figure 7: Repo and Jibar rates, and Jibar-Repo spread ..... 25
Figure 8: Total domestic credit extension (R million) ..... 27
Figure 9: Split of total domestic credit extended (January 2023 to June 2024) ..... 28
Figure 10: Variables after applying first difference ..... 30
Figure 11: Jibar-repo spread with Regimes. ..... 33

## Acronyms

| | |
|---|---|
| AIC | Akaike Information Criterion |
| BoE | Bank of England |
| BoJ | Bank of Japan |
| ECB | European Central Bank |
| GFC | Global Financial Crisis |
| HQ | Hannan-Quinn |
| Jibar | Johannesburg Interbank Bank Average Rate |
| JIBSPR | Jibar-Repo Spread |
| MPC | Monetary Policy Committee |
| MPI | Monetary Policy Implementation |
| MPIF | Monetary Policy Implementation Framework |
| MPT | Monetary Policy Transmission |
| NB | Norges Bank |
| NCDs | National Certificates of Deposit |
| OCR | Official Cash Rate |
| RBA | Reserve Bank of Australia |
| RBNZ | Reserve Bank of New Zealand |
| SARB | South African Reserve Bank |
| The Fed | The Federal Reserve of the United States |
| VIF | Variance Inflation Factors |
| ZARONIA | South African Rand Overnight Index Average rate |
| ZLB | Zero Lower Bound |

# 1. Introduction

The South African Reserve Bank (SARB) made the shift from a shortage reserves system to one that now operates under an excess reserves system of monetary policy implementation in June 2022 (Financial Markets Department, 2022). In doing so, the SARB, a central bank of a developing country with an open economy, joins the ranks of the most influential central banks of developed countries globally which uses some variation of an excess reserves system (Hall & Reis, 2016). Central bank reserves are deposits held by the banking system at the central bank. In a shortage reserve system, central banks create a shortage of reserves in the interbank market to encourage banks to borrow from the central bank at an interest rate that aligns with the central bank's monetary policy objective (Borio, 1997). Excess reserves are where banks hold more than what it is needed as minimum reserves and banks are remunerated by central banks for these excess reserves (Baker & Rafter, 2022). This research explores the market for central bank reserves and evaluates the impact on the South African banking system of this shift by the SARB. Although this shift by the SARB is not unique when compared to developed markets, it is worth researching the dynamics and nuances of this implementation in the context of the South African financial market as an emerging market because there is no "one size fits all" when it comes to monetary policy implementation (Financial Markets Department, 2022:4). Furthermore, the significance of this shift as envisioned by the SARB has implications for how this surplus of reserves leads to behaviour shifts of banks when it comes to lending practices and interest rate dynamics. These dynamics will have broader consequences for the South African economy.

In understanding and evaluating the significance of this shift to an excess system it is important to understand how a central bank functions and the different frameworks it uses to implement monetary policy. Central banks execute monetary policy within a monetary policy framework and pursue objectives that involve some variation of price and financial stability by targeting the value of short-term interest rates (Ennis & Keister, 2008; Goodhart, 2010; Van der Merwe, 2014). Monetary policy is transmitted through different channels, and the effectiveness of these transmission channels is an important aspect of this research. Monetary policy transmission is about how monetary policy decisions affect the macroeconomic environment (Boivin, Kiley & Mishkin, 2010). Two closely related channels are the credit or lending channel and the interest rate pass-through channel. The

credit channel refers to how monetary policy affects the ability of banks to extend credit to households and firms (Bernanke & Gertler, 1995). Central banks affect the demand and supply of credit through the availability and price of central bank reserves either through minimum reserves requirements and/or the buying and selling of financial securities in the open market (Bernanke & Blinder, 1988; Kashyap & Stein, 2000). The interest rate pass-through channel is where changes in the central bank's policy rate is transmitted to other short-term money market rates, starting at the rate at which banks are willing to transact with one another in the interbank market; these rates then ultimately determine the price or interest rate of credit in the economy (Aberg et al., 2021; Borio, 1997; Greenwood-Nimmo, Steenkamp & Van Jaarsveld, 2024).

The market for central bank reserves (reserves) is an important one for the transmission of central bank policy and determines the short-term interest rates for lending and deposit rates (Tucker, 2004). The two primary forms of monetary policy implementation are shortage and excess reserves systems that uses different mechanisms such as corridor and floor systems to give effect to its implementation (King & Mancini-Grifolli, 2018). With shortage systems, central banks engineer a deficit in reserves (also referred to as a liquidity deficit) using binding reserves requirements and sales of financial instruments (primarily government securities) that forces banks to borrow from the central bank at the policy rate (Borio, 1997; Guender & Rimer, 2008). For the SARB, the repurchase agreement (repo) rate is the rate at which it will lend reserves to South African banks to meet the banking system's demand for liquidity. This rate puts a price on reserves issued by the SARB for the banking system. With a shortage reserves system, the SARB constantly needed to run a deficit of reserves in the banking system so it could force banks to borrow reserves at the repo rate and thus strongly influence all other interest rates in the South African economy (Van der Merwe, 2014). The SARB provides these repo loans to banks against eligible collateral with government securities typically being the primary form of collateral (Adendorff, 2019).

The shift to an excess reserves system by the SARB means that the South African banking system now has enough reserves to not only meet its daily liquidity needs but also has a sufficient reserve buffer to withstand liquidity shortages during a crisis (Financial Markets Department, 2022). However, the recency of this shift means that the impact of this shift on the different facets of the banking system remains unclear. This research addresses three questions to fill this gap: (1) Has there been a significant increase in reserves observed in

the South African banking system since the shift to an excess reserves system? The answer to this question is critical in first identifying the significance of the shift relative to the level of reserves in the banking system prior to the shift. (2) Have there been any notable changes in the interbank lending market since the shift to an excess reserves system? This research builds on existing literature in demonstrating the importance of the interbank lending market to the transmission of monetary policy. (3) Have there been any notable changes in credit extension to the South African domestic economy since the shift to an excess reserves system? Monetary policy is only effective insofar as it can influence broader economic activity. The lending channel is one of the primary channels of monetary policy implementation.

Using data obtained from the SARB's quarterly bulletin, this research used descriptive statistics and a threshold autoregressive model to address the research questions. The descriptive statistics show that excess reserves increased from an average of R4 billion per month before the shift to an average of R64 billion per month after the shift thus confirming the significance of the shift. The estimation results from the TAR model revealed regime specific behaviours in the relationship between the Jibar-repo spread, credit extension, and excess reserves. In a declining excess reserves regime, reserves and credit extension are substitutes for a bank's use of funds where banks will choose the use of funds that will produce the higher return for a given risk. In an excess reserves regime that pays interest on excess reserves, banks do not have to choose one over the other because there is no opportunity cost to holding these excess reserves (Baker & Rafter, 2022; Bech & Monnet, 2013). Additionally, in a declining reserves regime, the Jibar-repo spread has an inverse relationship to excess reserves but a direct relationship in an increasing reserves regime. These findings imply that the SARB has not only changed how monetary policy is transmitted but also significantly changed the role it plays in the South African banking system where the SARB now actively competes with others in the economy for the use of the banks' excess reserves.

This research builds on existing knowledge in two ways. First, the recency of the change means that the understanding of this shift by the SARB is limited, and with its impact still unfolding, this research paves the way for further empirical research that will assess the full implications of this shift over time as more data becomes available. Second, where most

available research on excess reserves focuses on developed economies, this research shows the impact on a small open economy such as South Africa.

The rest of the research report proceeds with Section 2 covering the related literature on the important aspects of central banking in general and the SARB specifically with particular attention to the rationale behind the shift. Section 3 looks at the data and methods used in verifying the shift through descriptive statistics and covers the estimation of the TAR model used to evaluate the relationship between excess reserves, the Jibar-repo spread and credit extension to the domestic economy. Section 4 provides the results and discussion of the research and Section 5 concludes.

# 2. Literature Review

The literature review explores the objectives of central banks, how central banks operate under a shortage reserves system, and how they work under an excess reserves system, including the payment of interest on those excess reserves. Both shortage and excess reserves systems are explored in the context of the SARB and their specific implementation. Furthermore, the related literature is reviewed in the context of the interbank market for reserves and this market's importance for the setting of overnight lending rates for the transmission of monetary policy.

## 2.1 Objectives of central banking

Central banks all over the world effectively pursue the same objectives, albeit through different mechanisms of both interpretation and application. These objectives are variations of price and financial stability (Goodhart, 2010). Ennis and Keister (2008) went further and asserted that not only have central banks adopted a common approach to monetary policy but also that this approach involves targeting the level of short-term interest rates. Goodhart (2010) provided an opposing perspective and argued that the core function of a central bank is not in managing interest rates, but in managing the central bank's balance sheet. They went further in asserting that the primary management function of a central bank should be about financial stability and liquidity management because the setting of interest rates has

historically and could in future be set by national governments (Goodhart, 2010). Reis (2013) provided a more contemporary perspective and believed that in choosing the goals of a central bank, it must be considered who makes the choices, the macroeconomic variables that will be included along with their associated time horizons, and the consideration of different points of view when making these choices.

Central banks make and execute monetary policy decisions within a monetary policy framework where Van der Merwe (2014) considered several aspects. First, the objective of monetary policy must be clearly stated with numerical targets so that the public can understand these objectives. Second, the framework must specify whether a philosophy of market-oriented instruments will be applied in pursuit of these objectives or if the central bank will use a more direct approach in controlling the creation of money, credit extension, and interest rates. Third, a decision must be made on the operational variable or monetary policy instrument that will be used when conducting monetary policy where these instruments are those that the central bank can manage directly (Van der Merwe, 2014). Central banks mostly implement monetary policy through market-oriented instruments that are designed to influence short-term interest rates closely (Bindseil et al., 2006; Borio, 2000).

It is important for central bank policymakers to understand the mechanisms or channels through which monetary policy affects the macroeconomic environment (Boivin et al., 2010). Central banks transmit its monetary policy stance in pursuit of its policy objectives through a mechanism known as monetary policy transmission (MPT) (Angelis, Aziakpono & Faure, 2005). One of the primary channels of MPT considered in literature is the lending or credit channel where Bernanke and Gertler (1995) argued that the basis of a lending channel is that the existence of frictions hampers the efficiency of financial markets and thus creates an external finance premium. This premium is the difference between the cost of funds raised by banks externally (debt markets) and the opportunity cost of funding from within (bank deposits). With banks being the primary source of intermediated credit in most economies, reducing the supply of bank credit relative to other forms of credit is likely to increase the external finance premium and reduce real economic activity (Bernanke & Gertler, 1995). On the other hand, Gertler and Gilchrist (1993) framed the discussion about the existence of the lending channel as a money versus credit view. The traditional money perspective argues that it is the supply and demand for money that determines short-term

interest rates which influences investment and output. This money view reflects mostly the liabilities side of banks' balance sheets. The credit (lending) view emphasises the asset side of banks' balance sheets in that for borrowers (mostly households and small firms), there are no close substitutes for bank credit because of various barriers these borrowers face when needing to access the credit market. These borrowers rely mostly on banks for their external financing needs and any disruption or shock to this supply may have significant real economic effects.

Kashyap and Stein (2000) followed a similar line of research that looks at the bank lending channel from the liquidity of banks' balance sheets as measured by the banks' ratio of securities to total assets. They evaluate the existence of the bank lending channel of monetary policy transmission where a central bank (such as the Fed) can shift loan supply through the conduct of open market operations. In such a scenario, a restrictive policy stance that reduces bank reserves (increases lending rates) raises the cost of capital for those that are dependent on banks for their borrowing needs. The authors argued that for a bank lending channel to exist it must mean that banks are not able to access non-deposit source of funds to compensate for loss of depository funds (because of reduced reserves) without friction. They concluded that the empirical case for the existence of a bank lending channel is not definitive and part of the reason for that is the identification problem that distinguishes clearly whether transmission happens through the credit channel or the balance sheet channel (Bernanke & Blinder, 1988; Kashyap & Stein, 2000).

Greenwood-Nimmo et al. (2024), investigated the pass-through efficiency of the policy rate through to a selection of lending rates in South Africa. Their use of bank-level data enabled a detailed examination of pass-through of interest rates to home loans, overdrafts, and credit cards for both households and corporations. Their nonlinear autoregressive distributed lag model enabled them to identify how quickly both hikes and cuts in policy rates are transmitted (the efficiency of monetary policy) to lending and deposit rates. They found asymmetry in that loan rate hikes are fully passed through while a pass-through in rate cuts is incomplete (Greenwood-Nimmo et al., 2024). The authors' findings suggested evidence of a credit channel of monetary policy transmission. Although the identification of a credit channel of monetary policy transmission was not the objective of their research in the South African context; it had relevance in this research in assessing how these credit variables

(credit extension to households and firms) respond to the shift in the SARB's new implementation framework.

Summarising from the literature, the existence of a lending channel is not in dispute, what is in doubt is the strength of the lending channel and the ability to identify it empirically. Another issue with the lending channel identified in the research is the direction of flow of the lending channel. Does a positive monetary policy shock (increase in monetary policy rate) lead to banks reducing the lending or supply of loans or, is it that demand for loans just simply dry up because of adverse economic conditions? Yet another view is that smaller firms are more affected by the lending channel as firms are not easily, or sometimes not at all, able to substitute their sources of funds. Lastly, for a lending channel to exist, sources of funding from a bank's perspective are not substitutable (Gertler & Gilchrist, 1993). When there is a shock to deposits (cheap source of funds for a bank, especially in South Africa where banks pay little to zero interest on demand-deposits), banks are not able to substitute this with other sources of funding without friction.

In the South African context, monetary policy is set by the SARB with its primary mandate being "to achieve and maintain price stability in the interest of balanced and sustainable economic growth" with a complementary mandate to "oversee and maintain financial stability" (South African Reserve Bank [SARB], 2024b: iii). The SARB, in consultation with the South African government, had set the target rate of inflation between 3% and 6% since 2000 as its key measure in pursuit of the price stability objective (SARB, 2024a). Monetary policy implementation in South Africa has its roots (like other central banks) in the targeting of money supply. However, this became increasingly difficult once South Africa integrated back into global markets and effectively became a small open economy. This meant that the traditional domestic lines between money supply, market interest rates, and the rate of inflation became blurred as global markets started to have an outsized influence on these measures (Smal & de Jager, 2001). Subsequently, the repo system was introduced in 1998, and South African monetary policy stance became that of inflation targeting in the 2000s. The repo rate became the SARB's primary tool used to manage the rate of inflation in the implementation of its monetary policy objectives (Aron & Muellbauer, 2007).

The SARB uses market-based discretionary measures to pursue its price stability objective as opposed to direct quantitative control measures (Mollentze & Van der Merwe, 2014). A

successful or efficient transmission mechanism of monetary policy depends on whether changes in the policy variable announced by a central bank (the repo rate as an example) have the desired effect on the target variable (the rate of inflation) in the real economy (Adendorff, 2019). This transmission mechanism is comprised of complex relationships that link central bank action to changes in the real economy. A change by the SARB in its main policy interest rate affects short-term money market interest rates directly, which in turns cascades to other rates in the market and ultimately affects spending and the rate of inflation (Adendorff, 2019).

## 2.2 Central bank reserves and the interbank market

Before discussing the functioning of central banks under either a shortage or excess reserves system it is important to begin with an overview of central bank reserves and the dynamics of the interbank market where these reserves are the primary means of transaction and settlement among banks. Central bank reserves are deposits of the banking system that are held at the central bank (Borio, 1997). In conjunction with the currency in circulation within an economy, they represent the most risk-free and liquid asset available in the financial system and serves as the basis for liquidity management and settlement of payments among banks (Aberg et al., 2021). The central bank of a country is a monopoly supplier of these reserves in that they are the only ones that control both the quantity and price of these reserves through mechanisms such as imposing a minimum reserves requirement and/or through the control of the payment settlement systems that banks use to settle transactions with one another in the interbank market (Financial Markets Department, 2022). The implementation of central bank policy and its effectiveness in eventually passing policy rates through to the real economy takes place in this interbank market for reserves (Borio, 2000; King & Mancini-Grifolli, 2018; Nautz & Offermanns, 2007).

Becker, Osborn, and Yildirim (2012) considered interbank money market rates as representative of the marginal cost of funding liabilities faced by banks. Thus, by varying policy rates, central banks exert influence on the retail loan and deposits rates (the lending channel) that banks offer to non-financial firms and individuals. According to the authors, this can be seen as a two-stage transmission process where official monetary policy rate affects the interbank money market rates, which in turn influence retail loan rates (credit extension). This crucial role that the interbank money market plays in determining both the

level and availability of retail loan funds was especially acute during certain periods in the global financial crisis (GFC) (Becker et al., 2012). Bech and Monnet (2013) argued that the study of monetary policy implementation in the context of the quantity and liquidity dynamics in the interbank market is limited. They consider four stylised facts about the price and quantity dynamics in the overnight interbank market during periods of excess reserves. Using Australia as a control group, because their central bank did not adopt the unconventional monetary policy, Bech and Monnet (2013) compared the impact of excess reserves across the major global central banks including the Fed and the ECB. Their findings highlighted several important points of relevance for this research. First, substantial increases in excess reserves push interbank rates towards the rate where central banks pay interest on reserves. In other words, there is a narrowing of the spread between overnight interbank rates and the central bank's policy rate. Second, credit risks push up overnight interbank rates as was observed during the GFC where the spreads between policy rates and interbank rates widened significantly. This widening spread demonstrated deterioration in liquidity and greater credit risk in the interbank market. Lastly, excess reserves have reduced volatility in overnight market rates and reduced interbank market volumes (Bech & Monnet, 2013).

The objectives and the functioning of central banks discussed above are independent of the types of reserves systems used by central banks and will be discussed in the sections that follow.

### *2.2.1 Central banking under the shortage reserves system*

With the shortage reserves system, central banks want to control and adjust the demand for reserves balances so that it equals (clears the market) close to or at the target rate of interest (Borio, 1997). Managing the demand and supply of reserves is done through monetary policy operational procedures that form part of a central bank's implementation framework. To do so, however, requires that a central bank estimate the demand for reserves balances closely and then use its open market operations to meet this demand at the required target rate of interest. Where there are significant shortfalls in these reserves estimates, it will lead to volatility in short-term interest rates and render monetary policy ineffective (Guender & Rimer, 2008).

Creating reserves shortages means draining liquidity from the banking system and central banks do this through the setting of a minimum reserves requirement for banks and/or through open market operations where central banks buy and/or sell financial securities from or to the banking system (Van der Merwe, 2014). A minimum reserves requirement means that banks are required to have a proportion of their liability (mostly bank deposits) as a minimum on deposit at the central bank. Usually, this requirement is regulatory in nature and banks face penalties if found (on average over a specified maintenance period) to have held less than this requirement in reserves (Van der Merwe, 2014). Without a binding reserves requirement, the demand for reserves by banks would only serve as a means of settlement of working balances (overnight deficits) with other banks (Borio, 2000). Banks typically try to keep any excess reserves (above the minimum required) to a minimum as they do not receive any interest under a shortage reserves system and thus incur an opportunity cost (Borio, 2000). This minimum reserves requirement was the primary way in which a central bank conducted monetary policy under a shortage reserves system. Where central banks still have a minimum reserves requirement in place, these minimum reserves are used more for macroprudential and financial stability reasons (Aberg et al., 2021; Ennis & Keister, 2008; Gray, 2011). Central banks conduct open market operations through the outright buying and selling of securities in the secondary market where securities purchases inject reserves into the banking system and securities sales reduces the available reserves for banks (Van der Merwe, 2014).

Monetary policy (whether under a shortage or excess reserves system) is conducted under different implementation frameworks or systems. King and Mancini-Grifolli (2018) discussed four basic designs for interest-rate-based operational frameworks: a mid-corridor system with either a market rate (such as the federal funds rate in the United States) , or a policy rate (such as the repo rate in South Africa) as its objective, a floor system that pays interest on reserves at the policy rate, and finally, (which is now also the SARB's preferred system of implementation), a tiered-floor system that pays interest on reserves at the policy rate but only up to a certain cap or quota. Once this quota is reached, any reserves beyond that point receives a rate lower than the policy rate (King & Mancini-Grifolli, 2018). The most preferred monetary policy implementation system in use by central banks under a shortage reserves system is the corridor system. This system operates with the policy rate at the centre of the corridor with deposit and lending standing facilities available to banks at either side of that centre (Bernhardsen & Kloster, 2010). Whitesell (2006) saw the corridor

system as healthy competition to the traditional reserves system of monetary policy implementation. Although both systems use open market operations to influence a target rate of operation, they differ in institutional structure of how each operates. A corridor system relies on a central bank's standing (deposit and lending) facilities to set both a ceiling and floor that becomes the 'corridor' for overnight rates with the policy rate set in the middle of the corridor (see Figure 1). The interest rate on the central bank's deposit facility is the overnight rate banks get for their reserves with the central bank. This deposit facility provides the floor of the corridor as no bank will lend reserves below this rate, as it would rather leave it at deposit with the central bank. The interest rate on the central bank's lending facility is where banks go when they are unable to borrow enough reserves in the interbank market for their overnight liquidity needs. Similarly, this lending rate becomes the ceiling of the corridor, as no bank will borrow reserves at a rate above this in the interbank market (Baker & Rafter, 2022).

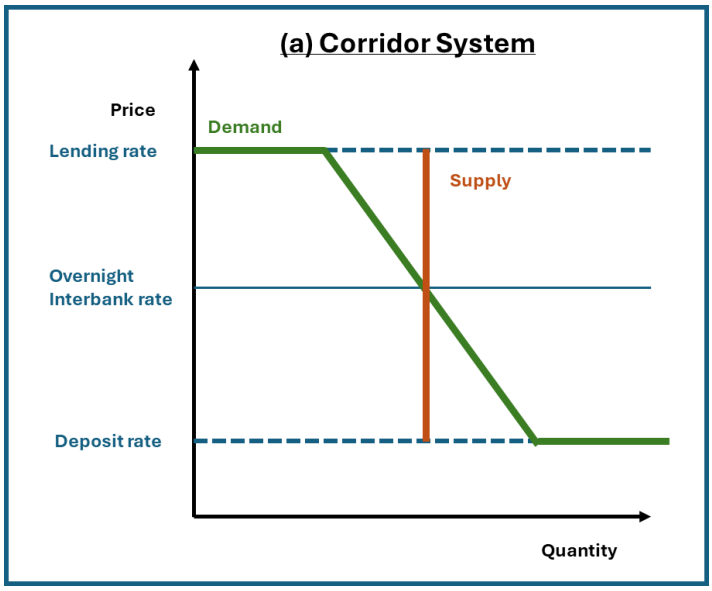



*Figure 1: Stylised corridor system*

Source: Baker & Rafter (2022:52)

With mid-corridor systems that target a market rate, the central bank offers just enough liquidity to the banking system to equal the demand and supply of reserves at the target market rate. The operation of this type of system requires a high degree of accurate liquidity forecasting of the demand for reserves. The middle of the corridor rate is achieved through these forecasts where an excess supply of reserves exerts downward pressure on rates while a shortage of reserves exerts upward pressure on rates. This system is difficult to maintain

as it includes the forecasting of autonomous liquidity shocks such as government deposits held at the central bank and private banks (King & Mancini-Grifolli, 2018). On the positive side, however, this system encourages an active interbank market where banks are incentivised to manage their daily liquidity needs as they do not want to incur penalties for either being too short (deficit reserves) by having to borrow at a penalty rate from the central bank, or too long (surplus reserves) by having reserves earning no interest at the central bank (King & Mancini-Grifolli, 2018).

The key policy variable under a corridor system is the central bank's policy rate. To implement monetary policy, various central banks adopted an approach that involves targeting the value of a key interest rate that best captures a central bank's policy intentions (Borio, 1997). In the case of the Fed, it sets a target range that it wants the federal funds rate to trade at in the market for reserves. The Fed does not have direct control over this rate, however, but uses open market operations to influence this rate toward its target rate (Kahn, 2010). For the Bank of England (BoE) and the SARB the principle is the same, but the mechanism is different. The BoE uses the bank rate, and the SARB uses the repo rate. How these rates differ to that of the Fed is that these are actual policy rates set by the central banks at which they transact with the banking system; central banks do not merely influence the rate, they set the rate explicitly (Borio, 1997). Thus, when there is a shortage of reserves in the system, banks will borrow from the central bank at these policy rates and the central bank's standing facilities will offer rates above or below the policy rate depending on the transaction (depositing or lending) with the central bank. Where it is like the Fed, both the BoE and the SARB wants the other short-term wholesale money market rates to trade close to its policy rates to ensure the efficient pass-through of monetary policy. Like the Fed, these central banks also use open market operations to influence these short-term money market rates (Angelis et al., 2005; Tucker, 2004). These short-term lending interbank rates are market rates and move according to supply and demand but serve as benchmarks against which the central bank measures the efficiency of its monetary policy implementation efforts; the role it plays in the flow of payments in the banking system is crucial (Tempelman, 2009).

Until June 2022, the SARB also operated under a shortage reserves system (Financial Markets Department, 2022). In this shortage reserves system, the key operational variable is the repurchase (repo) rate, which is the short-term interest rate that is determined by the

SARB's monetary policy committee (MPC). Where a shortage system is in operation, the central bank must create a liquidity shortage, where after commercial banks are compelled to refinance these shortages through the central bank (Adendorff, 2019). In the SARB's case, the refinancing system was the main mechanism for implementing its monetary policy objectives where South Africans banks had to borrow funds from the SARB through various accommodation facilities at the repo rate (Adendorff, 2019). This liquidity shortage in the market for reserves was created firstly through the minimum reserves requirements (2.5% in 2024) put in place by the SARB for banks, and secondly using open market operations (by the SARB) to manage the shortage. The refinancing of these shortages by the banking system determines the marginal financing cost of additional asset growth and ties up banks' collateral because this collateral is what is required to conduct repo transactions with the SARB (Adendorff, 2019).

### *2.2.2 Central banking under the excess reserves system*

Excess reserves are the reserves held by the banking system with their central bank that is more than what they require as minimum reserves. The ability of a central bank to manage these reserves is regarded as an important part of the monetary policy transmission process (Bindseil et al., 2006). The preferred system of operation for monetary implementation under an excess reserves system is the floor system. With floor systems (see Figure 2), excess reserves are remunerated at the policy rate where central banks set the policy rate at the floor of the corridor and then supply sufficient reserves to keep policy rates close to that floor (Baker & Rafter, 2022; King & Mancini-Grifolli, 2018). The demand for reserves is downward sloping because banks will hold more reserves at lower deposit rates for precautionary reasons when the opportunity cost for doing so is also lower. The opportunity cost here is the difference between the remuneration of reserves-deposits at the policy rate and the rate at which reserves clear in the interbank market. Where the interbank rate is equal to policy rate, the opportunity cost is zero, which allows the central bank to increase the amount of reserves in the system without having to change the interest rate or cause it to move (Baker & Rafter, 2022; King & Mancini-Grifolli, 2018). As the central bank controls both the price and quantity of reserves, the demand curve is flat where demand meets the floor, and it is at this point where a central bank sets it target supply of reserves. Should the central bank shift its supply of reserves too far to the right of this point there will be little incentive for banks to trade as was seen during the GFC (King & Mancini-Grifolli, 2018).

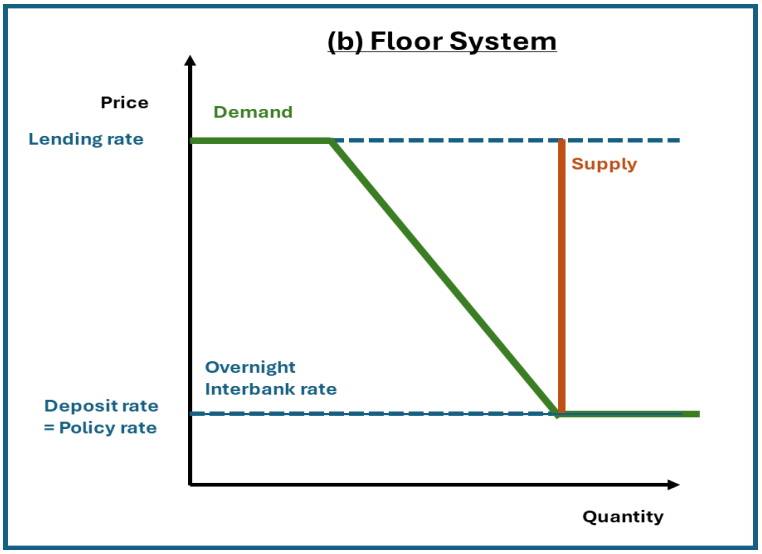



*Figure 2: Stylised floor system*

Source: Baker & Rafter (2022:52)

In their analysis of the liquidity management system option for the Norges Bank (NB), Norway's central bank, Bernhardsen and Kloster (2010) found that several central banks moved from corridor systems to floor systems because of the GFC. They found that a key advantage of the floor system is the ability to increase the supply of reserves beyond the liquidity demand of the banking system without pushing the short-term money market rates below the central bank's policy rate. When comparing corridor and floor systems the authors raised three important implications that are also relevant for this research in the South African context. First, central banks can separate monetary policy from managing the supply of reserves when operating a floor system where the interest rate is set to achieve monetary policy objectives while the supply of liquidity can perform a financial stability function, especially in times of financial crises. Second, the need for fine-tuning liquidity operations is no longer necessary with a floor system. This means that the need for accurate forecasting of liquidity demand in the banking system is obsolete as the system is flooded with sufficient reserves (liquidity) not only for required reserves and daily settlement but also for liquidity shocks. Third, unlike a corridor system (under a shortage system) where there is a strong incentive for banks to trade reserves in the interbank market, a floor system where reserves are abundant, the opportunity cost to trade reserves is low and thus the interbank market is not as active. This aspect of a floor system could be seen as undesirable because an active interbank market provides strong financial stability and monitoring signals to the central bank about the banking system (Bernhardsen & Kloster, 2010).

Another form of the floor system is called the tiered-floor system. This system is in operation in both Norway and New Zealand, with South Africa having adopted it now as its preferred system of liquidity management. As with all floor systems, a tiered-floor system operates on an excess reserves system. The tiered-floor system takes care of central banks' concern about the reduced interbank activity that results when implementing a pure floor system. This is done by remunerating reserves at the policy rate up to a set limit (or quota, as is the case with the SARB); this represents the first floor. Once a bank's reserves exceed this limit, the excess will be remunerated at a rate below the policy rate (100 basis points in both NZ and SA); this represents the second floor. The thinking here is that banks would rather trade reserves in the interbank market and earn a return on excess reserves higher than the second floor (King & Mancini-Grifolli, 2018).

The SARB used the RBNZ system as one of its benchmark systems when considering the shift to an excess reserves system (Financial Markets Department, 2022). The RBNZ, much like all other central banks, also implements monetary policy by setting short-term nominal interest rates by using both standing facilities and open-market operations (Guender & Rimer, 2008). The RBNZ uses the official cash rate (OCR) as its target policy rate and uses its tools to influence all other short-term rates close to that (Guender & Rimer, 2008). Until recently, the RBNZ has run a tiered-floor system and made the shift in 2022 to move to a pure floor system much like the Fed runs today. Furthermore, and before COVID-19, the RBNZ remunerated banks for excess reserves up to a certain quota where reserves above the quota were remunerated at a penalty rate 100 basis points below its OCR (the model the SARB has now adopted) (Silk, 2022). The quota system was to ensure that banks had an incentive to not hold reserves beyond their quota and use these to lend among each other in the interbank market. Interestingly, the RBNZ found that the tiered-floor system was inadequate during the Covid-19 induced financial market dysfunction. Even though it was running an excess reserves system, the RBNZ had to inject significantly more liquidity into the banking system that pushed excess reserves beyond the banks' quotas. This had the impact of pushing banks to be remunerated at a penalty rate below the OCR and meant that the RBNZ had difficulty in controlling short-term rates that moved below the official rate (Silk, 2022). This last point is important for the SARB to consider during times of market dysfunction.

In implementing an excess reserves system, the ability of a central bank to pay interest on reserves is an important monetary policy tool alongside other regular open market operations. A central bank is thus able to influence short-term interest rates by either using open market operations or managing the opportunity cost of holding reserves by varying how much interest it pays on reserves (Goodfriend, 2002). The management of reserves after the GFC marked the point where central banks now maintain elevated levels of reserves in the banking system by setting and paying interest on these reserves close to the policy rate (Hall & Reis, 2016). However, Hall and Reis (2015) considered whether maintaining elevated levels of excess reserves can impact the financial stability of central banks and could run the risk of creating an "exploding reserves" environment (Hall & Reis, 2015:2). Central banks fund the payment of excess reserves with the assets side of its balance sheet which typically hold government bonds and other financial securities. This subjects central banks to various risks such as interest rate risk on its bond holdings where bond yields move inversely to price, default risk from its counterparties in these bond transactions, and exchange rate risk for its foreign currency holdings. These risks put a constraint on how many reserves central banks can issue and compel commercial banks to lend it money (Hall & Reis, 2015). Exploding reserves will risk its independence from government, because these increased risks will compel a government to intervene in the operations of a central bank (Hall & Reis, 2015). Ennis and Wolman (2015) looked at the relationship between reserves holdings and relevant bank balance sheet components such as liquidity, capital, lending capacity, and lending opportunities. They found that massive quantities of excess reserves could make an economy more sensitive to delays when monetary policy is adjusted. One way of considering this is to see banks holding excess reserves as a storage facility for future lending. The banking system or a bank with a higher storage facility can adjust to lending more quickly relative to one where most of the storage has been used to fund existing loans. Holding all else constant, paying higher interest on these reserves incentivises banks to make no loans at the margin where risk-adjusted rates of return are equivalent to the interest being received on excess reserves (Ennis & Wolman, 2015).

## 2.3 SARB's shift to an excess reserves system

Given the recency of the SARB's shift in its implementation framework, empirical research on its impact in South Africa is not widely available. The SARB's rationale for making the shift was first proposed through a consultation paper released in 2021 to the banking industry

and formalised through another release in 2022 (Financial Markets Department, 2022). The SARB provided several reasons for the shift that form the basis for their rationale. First, it had been running a surplus since 2007 and engineering a structural deficit became increasingly difficult (Financial Markets Department, 2022). One plausible reason for this reserves surplus was the increased use of cash reserves by the banking system when managing their liquidity in response to changes in the refinancing facilities offered by the SARB (Leshoro & Van der Merwe, 2014). The factors that create a shortage of reserves compel banks to refinance this shortage through various refinancing options available from the SARB. The SARB in turn requires that banks hold sufficient statutory liquid financial securities which are primarily government securities; the SARB extended the list of eligible financial securities in 2007, and this could explain some of the surplus liquidity in the banking system (Mollentze & Van der Merwe, 2014). However, the SARB believes that the primary reason for the surplus reserves was because of the accumulation of foreign exchange reserves (Financial Markets Department, 2022). As discussed earlier, running a shortage reserves system requires continuous and accurate forecasting of not only the liquidity needed in the banking system, but also executing the necessary open market operations to engineer the shortage, and then finally being ready with the necessary standing facilities to meet the demand for the shortage that was created. This is both administratively and operationally intensive and the SARB argued that an excess reserves system would be simpler and more efficient to manage (Financial Markets Department, 2022). Furthermore, the SARB was concerned with its ability to create the shortages in the market without causing harmful side effects such as liquidity draining (the selling of financial securities) procedures that was already causing price distortions in certain financial markets and incurring excess costs (Financial Markets Department, 2022). Second, the SARB argued that a surplus system provides them with greater balance sheet flexibility, especially in times of market dysfunction as was experienced during the GFC and recently the Covid-19 pandemic. The ability to absorb these shocks is advantageous for financial stability without putting the implementation of monetary policy at risk (Financial Markets Department, 2022). Third, a shortage-reserves system requires an active interbank lending market that can efficiently square off long and short liquidity positions at the end of each day. However, activity in the interbank market started to reduce already before the implementation and according to the SARB this was because of regulatory shifts and other market factors. The SARB believes that an excess reserves system is less reliant on an interbank market but has implemented

quotas to ensure that the interbank market does not become dormant (Financial Markets Department, 2022).

In summary, what the SARB was alluding to is that the banking system has hoarded reserves since the pandemic which has had a significant impact on the shortage needed for monetary policy implementation to be effective. Furthermore, the usual liquidity draining mechanisms were either not viable, not significant enough to be effective, relatively expensive, and no longer relevant in the market of today. Thus, for a system that relies on a liquidity shortage, the SARB could no longer rely on its traditional shortage reserves system of monetary policy implementation. The literature review suggests that when central banks pay interest on these excess reserves, banks' opportunity cost of holding this excess liquidity reduces which in turn has the potential of reducing interbank lending activity thus ultimately affecting credit allocation to the broader economy (Bech & Monnet, 2013). However, these dynamics have not been empirically tested in the South African context and lead to research questions outlined in the introduction and repeated in the next section.

(1) Has there been a significant increase in reserves observed in the South African banking system since the shift to an excess reserves system?
(2) Has there been any notable changes in the interbank lending market since the shift to an excess reserves system?
(3) Has there been any notable changes in credit extension to the South African domestic economy since the shift to an excess reserves system?

# 3. Data and Method

This section uses data collected directly from the SARB's quarterly bulletin publications website (SARB, 2024a) to answer the research questions quantitatively. Using the EViews® work files downloads provided on the SARB's website as well as Microsoft Excel versions of the same dataset, this research will generate descriptive statistics, graph constructions and other quantitative analysis to address each of the research questions. Additionally, the data is used to estimate a threshold autoregressive model using the excess reserves time series as a threshold variable to evaluate the dynamics between excess reserves, the interbank market and credit extension by banks to the domestic sector.

The time series variables of interest used for this research were excess reserves, the spread of Jibar (3-month) over the repo rate, and the total credit extended by the monetary sector to the domestic sector. The excess reserves variable is the primary variable of interest for this research because the main objective of the SARB was to influence the level of excess reserves in the banking system. The Jibar-repo spread variable is important for two reasons. First, the three-month Jibar is the rate at which banks lend to each other in the interbank market while the repo rate is not only the SARB's policy rate for the transmission of monetary policy but also the rate at which it remunerates excess reserves. Second, the spread between the Jibar and repo rate is a key indicator of the dynamics in the interbank market for the lending and borrowing of reserves among banks and this spread also signals the level of liquidity in the interbank market (Bech & Monnet, 2013; Bernhardsen & Kloster, 2010). The credit extension variable emerges from the theory on the bank lending channel to assess whether the change in the excess reserves has any impact on the ability of banks to extend credit.

The time series data for the variables of interest is comprised of monthly data from January 2000 up to August 2024, which provided 296 observations. However, after transformation of data with differences, observations dropped to as low as 292. Summary statistics in Table 1 show the transformations applied and variable names for purposes of analysis. All analyses were performed using the EViews®12 University Edition statistical software package.

*Table 1: Summary statistics of the variables of interest*

| Statistic | Excess Reserves (R millions) | Total Credit Extended (R millions) | Jibar-Repo spread (basis points) |
|---|---|---|---|
| Mean | 8 582 | 2 572 347 | 3 |
| Median | 2 710 | 2 334 369 | 13 |
| Maximum | 93 193 | 5 482 712 | 69 |
| Minimum | -3 408 | 574 652 | -167 |
| Std. Dev. | 18 734 | 1 439 184 | 45 |
| Skewness | 3 | 0 | -2 |
| Kurtosis | 12 | 2 | 8 |
| Observations | 294 | 294 | 296 |
| Data Transformation | First difference | First difference | None |
| Transformed variable name | DEXCESS | DTCREDIT | JIBSPR |

Source: Own construction using EViews® output and SARB Quarterly Bulletin data.

## 3.1 Verifying shift through descriptive statistics

This research considered several data points that demonstrate the significance of the shift towards an excess reserves system. The research objectives will be addressed by first looking at the balance sheets of both the SARB and the banking system to identify the shift and the impact of the shift to an excess reserves system. Second, the Jibar and repo time series is evaluated to identify how the spread between these two series behave before and after the shift. Third, the total credit extension to the domestic economy series is discussed to identify if there has been any meaningful shift in this series before and after the shift.

### *3.1.1 Excess reserves*

Looking at a selection of the SARB's liabilities (Figure 3) its balance sheet has grown overall while some elements have remained stable. Of interest to this research was the item circled in red, which shows the surplus deposits that banks have with the SARB daily after

it has squared off all transactions with each other. The prominence of this balance sheet item, since the start of the shift in June 2022, is striking and warrants observation as more data becomes available.

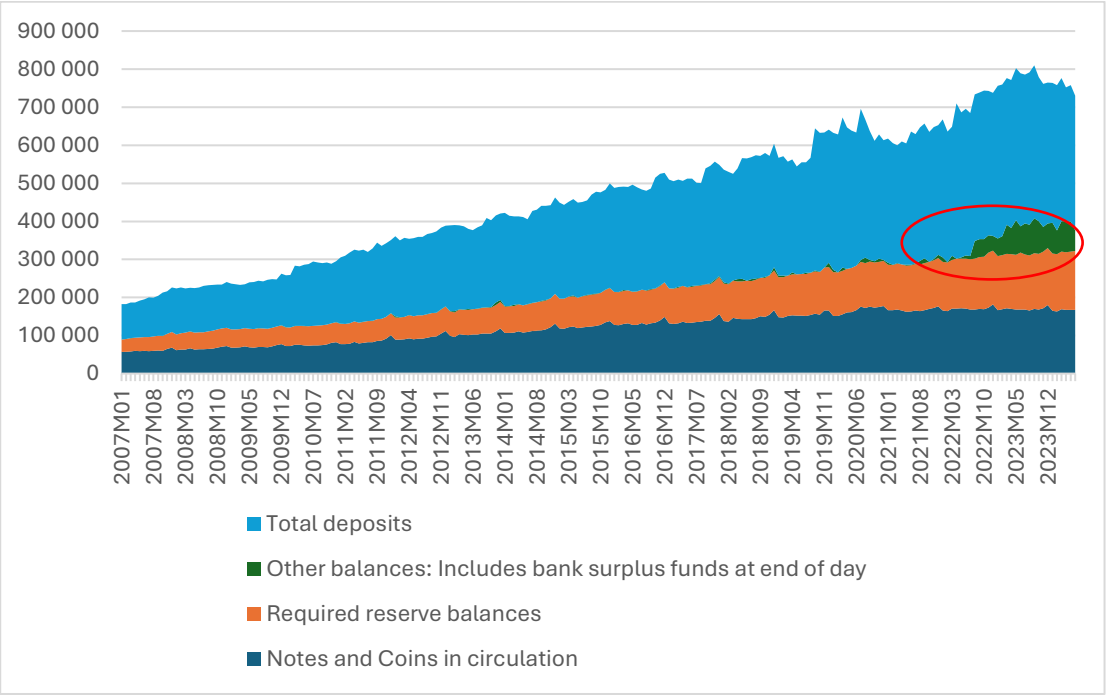



*Figure 3: Select SARB Liabilities (R millions)*

Source: Own construction using SARB Quarterly Bulletin data

Since the shift to the excess system, there has been a marked decline in the demand for the SARB's weekly auctions (see shaded section of Figure 4). This is unsurprising given that the liquidity is now with the banks directly and not with the SARB; exactly what was intended with this shift. Interestingly, repo loans received from other participants in the domestic money market have seen an increase since the shift and perhaps support the SARB's claim that the market for reserves have moved away from an unsecured lending market towards a secured one (Financial Markets Department, 2022).

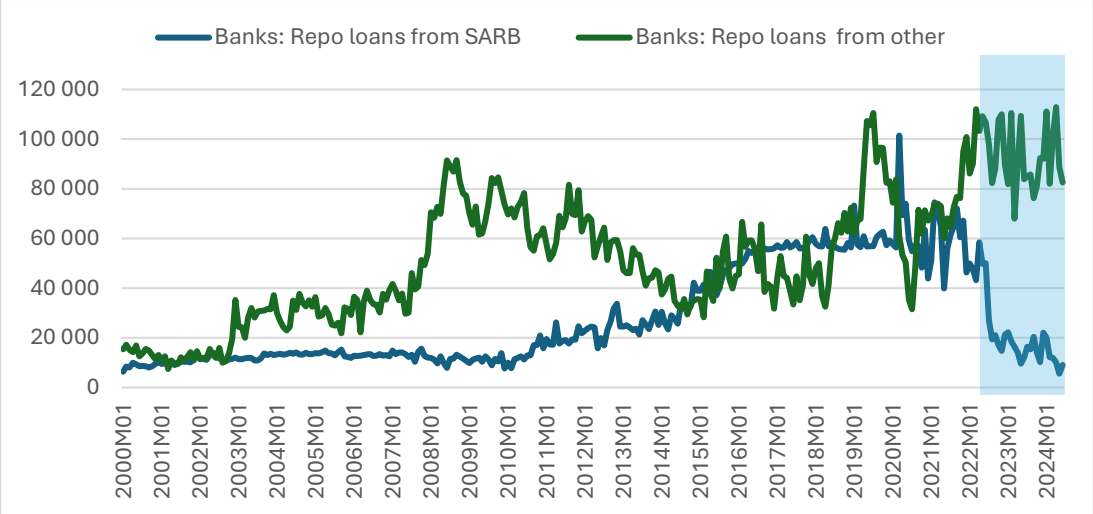



*Figure 4: Banks - Repo loans from SARB and domestic other (R million)*

Source: Own construction using SARB Quarterly Bulletin data

The impact of the shift towards excess reserves has been significant when looking at it from the banks' perspective (Figures 5 and 6). From the start of the period of observation in 2000 up to late 2009, total deposits (reserves) with the SARB tracks minimum required reserves very closely at an average of R560 million monthly and peaking at R5 billion. This is consistent with the research that banks' opportunity cost of holding excess would have been too high given that it was not remunerated for any excess reserves (Baker & Rafter, 2022; King & Mancini-Grifolli, 2018). Furthermore, the SARB's deposit facility paid for overnight reserves at a rate of 100 basis points below its policy rate. Given that overnight rates track policy rates closely, it was more profitable for banks to lend out excess reserves than holding those reserves overnight.

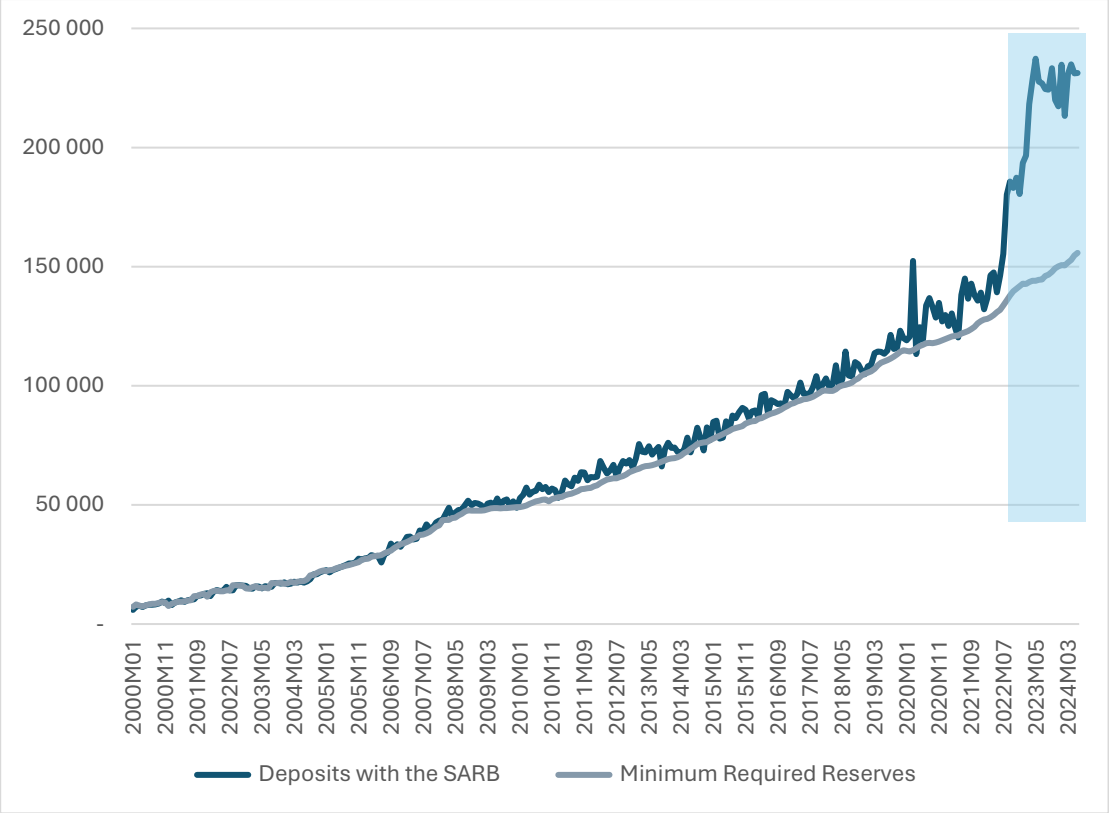



*Figure 5:Minimum required reserves versus total deposits with the SARB (R million)*

Source: Own construction using SARB Quarterly Bulletin data

Excess reserves are obtained when subtracting the minimum reserves required from total reserves (Figure 6) where the significance of the shift becomes even more apparent. From 2010 to 2019, reserves started going into excess with average monthly excess reserves around R4 billion, peaking at close to R14 billion. This is consistent with the SARB's assertion earlier that the banking system has been operating in excess reserves before the formal shift (Financial Markets Department, 2022). The reasons for this behaviour by the banks were alluded to in an earlier section and is a possible area for future research. The period from 2020 to 2021 shows significant volatility mostly because of the Covid-19 pandemic's impact on the economy. The average monthly excess reserves in this period were R11.4 billion, with a peak of R37.5 billion in one month. This period should perhaps be seen as a liquidity injection during a time of economic instability as the SARB needed to stabilise the financial system. The official shift to an excess reserves system was in June of 2022 and is highlighted by the shaded areas in the graphs. Excess reserves jumped to a monthly average of R64 billion, peaking at R93.2 billion in a month during this period. It is worth noting that the average monthly excess reserves of R64 billion post the shift is almost

twice that of the peak needed during the Covid period of R37.5 billion. Therefore, the significance of the shift from a shortage to an excess system of reserves is apparent and verified by the data.

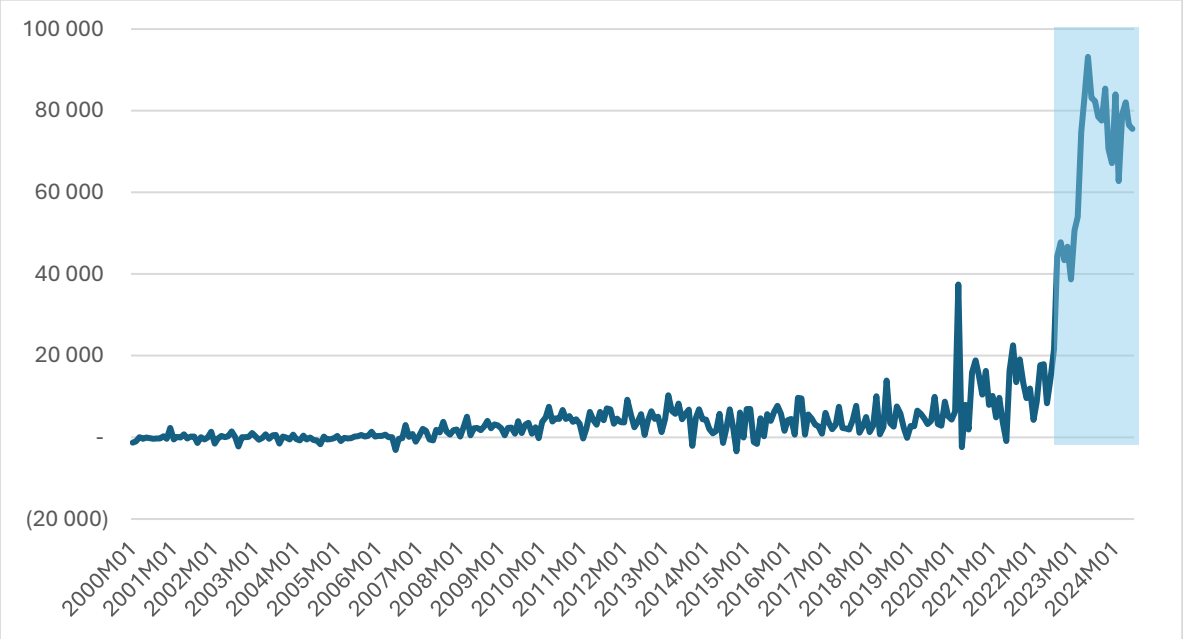



*Figure 6: Excess reserves (R million)*

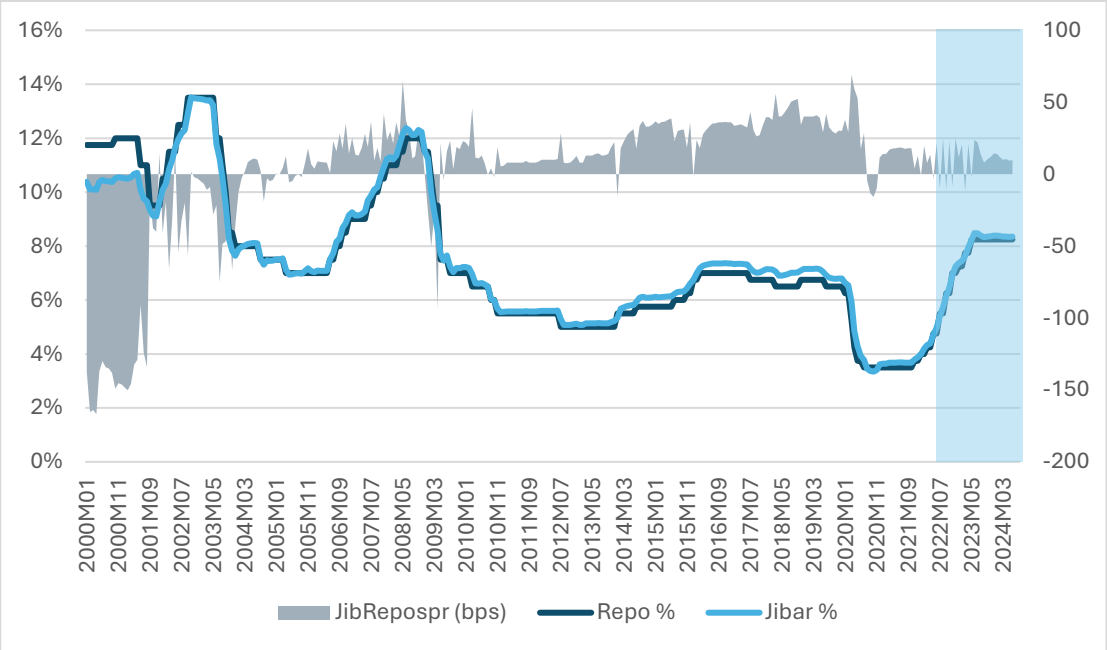
Source: Own construction using SARB Quarterly Bulletin data

### *3.1.2 Repo and Jibar rates*

The repo rate is the short-term interest policy rate set by the SARB and is the most important rate in the South African economy (Financial Markets Department, 2022). The SARB's Monetary Policy Committee (MPC) has the responsibility of setting the repo rate and this is done based on its monetary policy stance. The repo rate governs the price of reserves. During the period of shortage reserves, the repo rate was the price at which banks could borrow from the SARB for seven days on a secured basis. With the excess reserves system, the repo rate is the rate at which banks are remunerated on excess reserves up to a quota. Figure 7 shows the movement of the repo rate over the time with a peak at 13.5% in the early 2000s reaching a low of 3.5% in 2020 during the Covid period.

The Johannesburg Interbank Bank Average Rate (Jibar) (Figure 7) was the key money market benchmark rate up until June 2022 (Financial Markets Department, 2022). As part of the shift towards an excess reserves system the SARB is in the process of discontinuing

Jibar as a reference rate and replacing it with the South African Rand Overnight Index Average rate (ZARONIA); Jibar will be phased out in 2026 (SARB, 2021). However, given the recency of ZARONIA there is not sufficient historical data to evaluate the impact of an excess reserves regime, and this research uses Jibar for purposes of analysis.




**Note**: Repo and Jibar rate as % on left axis; Jibar-Repo spread as basis point on right axis

*Figure 7: Repo and Jibar rates, and Jibar-Repo spread*

Source: Own construction using SARB Quarterly Bulletin data

The three-month Jibar rate is the tenor that is most widely used in South African financial contracts with outstanding contracts valued at over R40 trillion as at 2018 (SARB, 2018). According to the SARB, Jibar is important as both a reference rate and as a channel of monetary policy transmission. The Jibar consists of mostly of National Certificates of Deposit (NCDs) which is partly what banks issue as wholesale deposit funding of their liabilities. Therefore, the Jibar is also indicative of banks' cost of funding. However, it must be noted that part of the reason why the Jibar is being replaced is that NCDs have become a smaller part of what banks use to fund liabilities. Its importance as an overnight interbank reference rate cannot be overstated.

The spread between the Jibar and the repo rate (Figure 7) is the second variable of interest for the purposes of this research. As discussed in the literature, the spread between a central bank's policy rate and the overnight money market interbank lending rate is a valuable tool for monitoring liquidity and stability in the interbank market (Bernhardsen & Kloster, 2010).

Additionally, this spread is an important indicator for the effective pass-through of the policy rate to other short-term money market rates, which begins with the overnight rate. Given how closely the Jibar rate tracks the repo rate, the average spread in absolute value terms is around 30 basis points. Negative spreads should be rare because it would imply an overnight lending rate that is lower than the repo rate (Bernhardsen & Kloster, 2010). Given that the repo rate represents the floor for the overnight lending market, banks would be better off lending to the SARB than to other banks in the interbank market. The Jibar rate came into effect in the late 1990s, so the significant negative spread could be because of adjustments of this rate. The early 2000s also represent the period of the so-called dotcom bubble. The main signal of market liquidity challenges is when the spread is significantly positive. The narrower the spread the better liquidity is in the interbank market (Bech & Monnet, 2013). A wide positive spread signals that banks are only willing to lend at higher Jibar rates. The narrowing of the Jibar-repo spread since the shift is worth noting and could be indicative of a more efficient pass-through of monetary policy. However, there were periods under the shortage reserves system (2010 – 2013) where spreads were comparatively narrow to what it is now under an excess reserve system. Thus, it cannot be conclusively asserted that the shift is the reason for the narrowing of the spread and more observations would be required to verify this conclusively.

### *3.1.3 Total credit extension*

Total domestic credit extension (Figure 8) is the third variable of interest for the purposes of this research. Total credit extended has reached about R5.5 trillion in 2024.

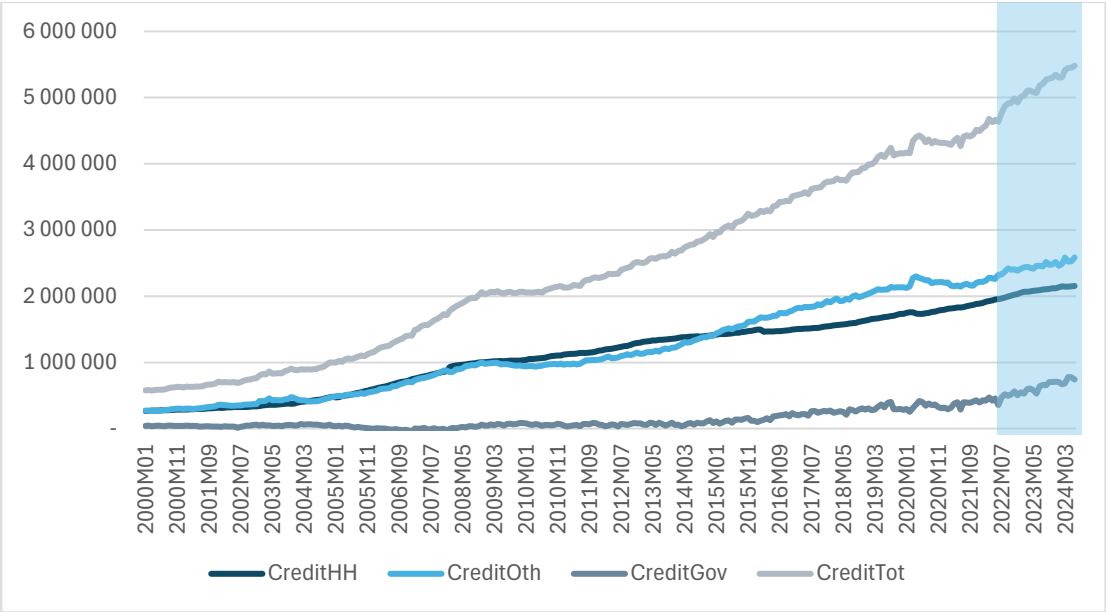



*Figure 8: Total domestic credit extension (R million)*

Source: Own construction using SARB Quarterly Bulletin data

Net credit extended to government is the smallest proportion of credit extended (Figure 9) when looking at the period from January 2023 to June 2024. Credit extension to households represents 40% of total credit with credit to other (total credit extended to private sector minus credit extended to households) being the largest at 47%. When considering the level of credit extension before and after the shift to an excess reserves system, there is no clear indication of an impact to credit extension. One reason for this lack of impact could be that SARB has been operating under a restrictive monetary policy stance since the shift where the repo rate has been increasing and thus makes the cost of credit more expensive and thus not conducive for credit extension by banks. Once monetary policy becomes expansive, and credit conditions improve can an assessment be done of the full impact of the shift to excess reserves on credit extension in the economy.

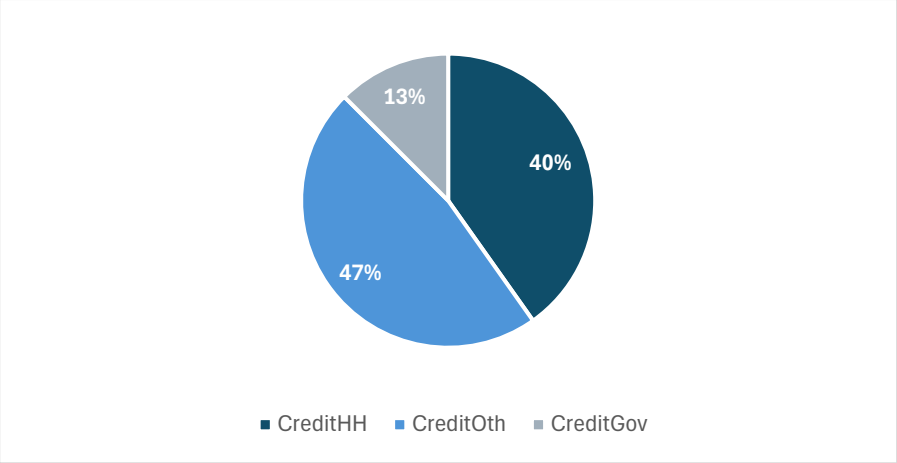



*Figure 9: Split of total domestic credit extended (January 2023 to June 2024)*

Source: Own construction using SARB Quarterly Bulletin data

## 3.2 TAR model

The basic mechanics of a threshold model is making a piecewise series linear by introducing a time series indicator where the threshold variable is used to split a sample into distinct groups that are referred to as classes or regimes (Hansen, 2000; Tong, 2011). Threshold Autoregressive (TAR) models are a class of threshold models that provide a straightforward nonlinear extension of the autoregressive model. TAR models are particularly suited for time series processes that are subject to periodic shifts due to regime changes (Enders, Falk & Siklos, 2007). Threshold models can be expressed in diverse ways based on the context of the research and the specific goals that the model seeks to achieve (Tong, 2011).

This research uses a TAR model as its primary method of verifying the existence of a distinct excess reserves regime because of the shift by the SARB from a shortage reserves system to an excess reserves system. More specifically, using the excess reserves as a threshold variable, the model evaluates the dynamics of the Jibar-repo spread on excess reserves, whether distinct regimes can be identified, and if these dynamics differ across regimes.

The general form TAR model (Enders., et al., 2007) can be formulated as:

$$Y_t = (\alpha_0 + \alpha_1 y_{\{t-1\}})I_t + (\beta_0 + \beta_1 y_{\{t-1\}})(1 - I_t) + \varepsilon_t, t = 1, \dots, T \quad (1)$$

Where:

- $I_t$ is the indicator function defined in terms of the threshold parameter $\tau$ as
- $I = \begin{cases} 1 \; if \; y_{t-\mathrm{d}} > \tau \\ 0 \; if \; y_{t-\mathrm{d}} \leq \tau \end{cases}$
- The $d$ is a delay parameter and the $\varepsilon_t$'s are $i.i.d.\ (0, \sigma^2)$ random variables.

The specific form for this TAR model is given as:

$$DEXCESS_t = \begin{cases} \alpha_1 + \beta_{11} DEXCESS_{t-1} + \beta_{12} JIBSPR_t + \beta_{13}\, DTCREDIT_t + \varepsilon_t, if\ DEXCESS_t < \tau_1 \\ \alpha_2 + \beta_{21} DEXCESS_{t-1} + \beta_{22} JIBSPR_t + \beta_{23} DTCREDIT_t + \varepsilon_t, if\ \tau_1 \leq DEXCESS_t < \tau_2 \\ \alpha_3 + \beta_{31} DEXCESS_{t-1} + \beta_{32} JIBSPR_t + \beta_{33} DTCREDIT_t + \varepsilon_t, if\ DEXCESS_t \geq \tau_2 \end{cases} \quad (2)$$

Where:

- $\mathrm{D}EXCESS_{\mathrm{t}}$: is the first difference of excess reserves at time $t$ and represents the threshold variable
- $\tau_1, \tau_2$: Threshold values that divide the series into specific regimes
- $\alpha_1, \alpha_2, \alpha_3$: Non-varying threshold series and constant across regimes to provide stability to the model
- $\beta_{ij}$: regime-specific coefficients that represent the relationship between the dependent variable $(DEXCESS_t)$ and the $j$-th independent variable within the $i$ -th regime
- $\varepsilon_t$: error term $(\varepsilon_t \sim N\ (0, \sigma^2)$

### *3.3.1 Test for stationarity*

Stationarity forms the basis for time series analysis (Tsay, 2005). A stationary time series must have a time-invariant mean and variance without time trends (Lütkepohl, 2004). A unit root test for stationarity using the Augmented Dicky-Fuller test was performed on each variable to determine the presence of a unit root. The results of the unit root test (Annexure A) show that the Jibar-Repo spread (JIBSPR) variable is the only one found to be stationary $I(0)$ at level. Therefore, TCredit and ExcessReserves must be transformed to be integrated at $I(1)$ to be stationary.

Figure 10 shows the Excess Reserves (DEXCESS) and Total Credit (DTCREDIT) variables after applying first difference to both series, and Annexure B shows the Augmented Dicky-Fuller test verifying that series is stationary at $I(1)$.

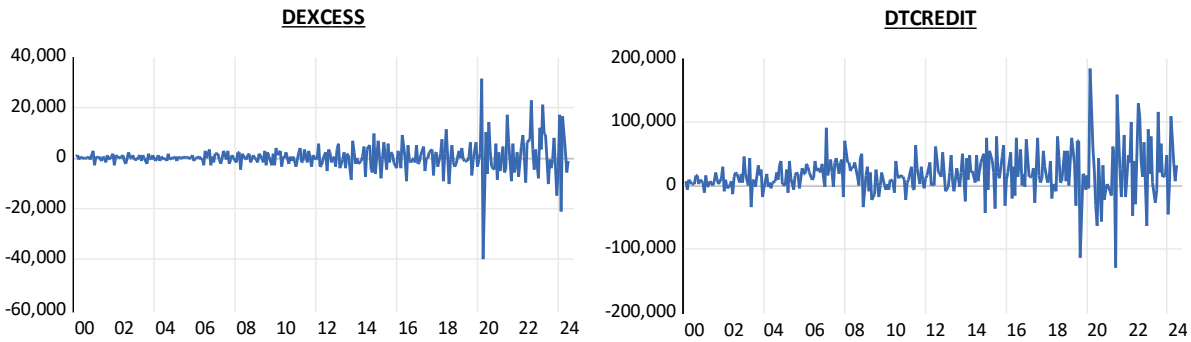



*Figure 10: Variables after applying first difference*

Source: EViews® output

### *3.3.2 Test for nonlinearity*

To verify the suitability of performing a TAR model estimation, a test for nonlinearity of the threshold variable must be conducted. Using Tsay's (1989) test for nonlinearity requires several steps. First, an autoregressive (AR) test of order two AR (2) using DEXCESS as the dependent variable was performed. Second, residuals from the AR (2) estimation were retrieved and saved as a series. Third, the DEXCESS variable was arranged in ascending order. Fourth, the AR (2) residuals series was used as the dependent variable and an ordinary least squares regression was performed using the ordered DEXCESS (ORDEREDDEXCESS) series as the independent variable. The results can be seen in Annexure C with both the coefficient and the F-stat being statistically significant at the 1% level. Thus, the null hypothesis of linearity is rejected and the threshold variable confirmed as nonlinear.

### *3.3.3 Test for lag structure*

To choose the appropriate lag structure the TAR model was estimated at different lags of the DEXCESS threshold variable starting from the first and adding these sequentially. For each estimation the values for the Akaike Information Criterion (AIC), Schwarz criterion and Hannan-Quinn (HQ) criterion respectively were recorded with the results in Annexure D. Suitability of the lag structure is achieved by minimising the information of the different criteria. In the second lag, both the AIC and HQ criteria improves but the Schwarz criterion worsens. Estimating the TAR model with a lag structure of two did not significantly improve the coefficient estimates or the overall fit of the model so a lag structure of one was used for efficiency of the model.

# 4. Results and Discussion

The full model estimation output can be found in Annexure E. The model evaluated the dynamics of the excess reserves in the banking system since the official shift to an excess reserves regime that pays interest on those excess reserves. This dynamic was evaluated specifically in the context of the interbank lending market using the Jibar-repo spread as a proxy for interbank lending behaviour and its influence on banks' holding of excess reserves. Total credit extension is added to the model to assess its influence on excess reserves. The model captures three distinct regime-dependant behaviours of excess reserves ($DEXCESS$) in response to its lagged ($DEXCESS_{t-1}$) value, the spread between Jibar and the repo rate ($JIBPSPR$) and the total credit extended to the domestic sector ($DTCREDIT$).

## 4.1 Validity of the estimated model

The overall goodness of fit statistics (see Annexure A) showed an $R^2$ of 0.65 and an adjusted $R^2$ of 0.63. The AIC, SC, and HQ criteria were discussed earlier, and values represented the appropriate lag structure. The Durbin-Watson statistic of 2.247 inferred the possibility of negative autocorrelation at the first lag; however, this was addressed in the setup of the model.

Using the Q-statistic to test for autocorrelation up to lag 12, the results are displayed in Annexure F. Although the test indicated significant (5% significance level) autocorrelation at lag 1, this autocorrelation was accounted for in the TAR model's lag structure by including a first order lag. Therefore, the model adequately addresses the identified autocorrelation.

The Breusch-Godfrey test for serial correlation is displayed in Annexure G. The null hypothesis of no serial correlation up to 12 lags could not be rejected based on $F-statistic$ and $Obs * R^2$ results at a p-value of 0.238 and 0.212 respectively and thus it could be inferred that there was no serial correlation among the variables in the model

Using the Breusch-Pagan-Godfrey test for heteroskedasticity the null hypothesis failed rejection based on the F-statistic as displayed in Annexure H and thus homoscedasticity of the residuals could be inferred.

Multicollinearity in variables can be detected by variance inflation factors (VIF) where the auxiliary regressions were estimated for each independent variable. Using the $R^2$ from each regression the VIF was calculated as $VIF = \frac{1}{1-R_k^2}$ where a rule of thumb is that VIFs of a variable above 10 indicates that a variable may be redundant in the model (O'Brien, 2007; Zeltzer, n.d.). The results of the VIF are displayed in Annexure I.

## 4.2 Key findings per regime

Before delving into the regime specific observations a few overarching observations are worth noting. Table 2 shows the threshold value (in first difference) of the excess reserves across the different regimes. Regime-2 has the most observations and covers the range from declining reserves to increasing reserves. Regime-1 represent the observations that signify declining excess reserves, while Regime-3 covers observations in the period where excess reserves are declining. See Annexure A for complete output.

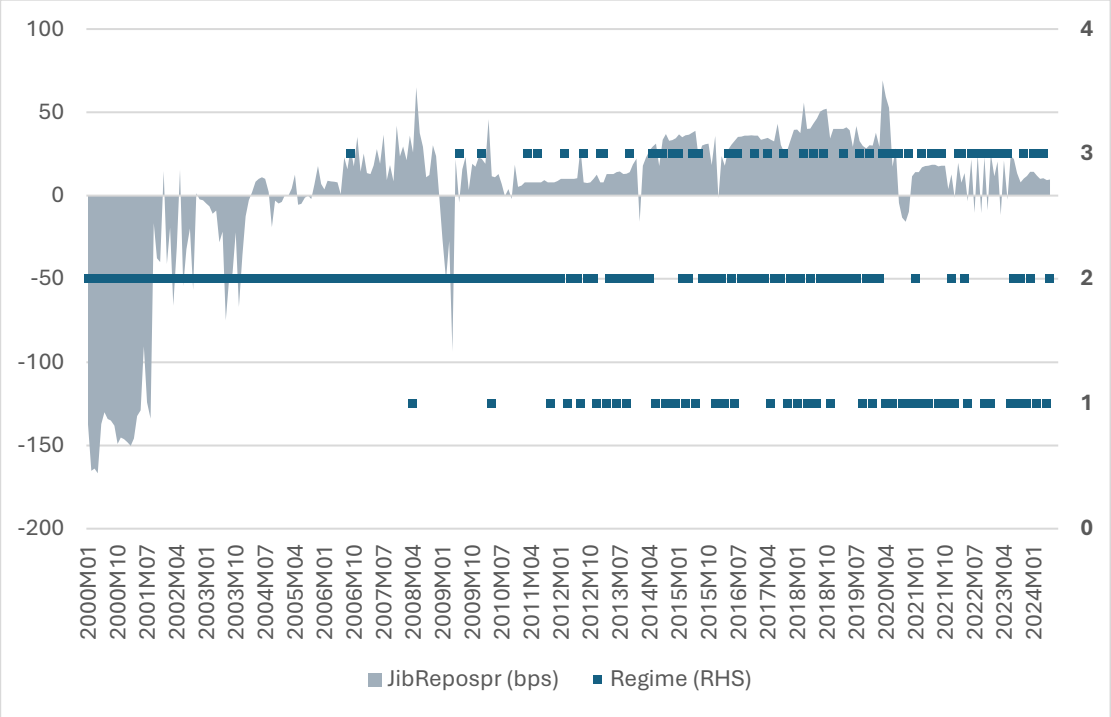
*Table 2: Summary of excess reserves threshold values across regimes*

| Regime | Threshold Value | Observations | % of observations after shift |
|---|---|---|---|
| Regime 1 | DEXCESS < -3554.285 | 46 | 15% |
| Regime 2 | -3554.285 <= DEXCESS < 2907.396 | 193 | 2% |
| Regime 3 | 2907.396 <= DEXCESS | 53 | 25% |

Source: Own construction using EViews® output

When overlaying the Jibar-repo spread with the different regimes (Figure 11) identified in the TAR model it is notable how Regime-2 stretches the entire sample period with most of its observations clustered in the period from the early 2000s up to early 2014 followed by a second cluster from 2015 until early 2020. Regime-1 and Regime-3 on the other hand have no dominant cluster of observations but do cover the periods mostly from 2011 onwards. When looking at the Jibar-repo spread alongside the regimes the period January 2014 up to February 2020 marks the highest spreads peaking at 69 basis points and with all three regimes running across this period. The higher Jibar-repo spreads signal liquidity challenges

in the interbank market that result in higher funding cost for banks (Beau et al., 2014). This period also marks a time of significant challenges in South Africa because of state capture during the Jacob Zuma presidency (Madonsela, 2018).




**Note**: Jibar-Repo spread as basis point on left axis, Regimes as number on left axis;
Broken lines signify heavy overlap between regimes but never occupy same period

*Figure 11: Jibar-repo spread with Regimes.*

.Source: Own construction using SARB data and EViews® output

Since its peak in early 2020, the Jibar-repo spread seemed settled into its historical range and shows a decline towards the end of the period. Interestingly, this period of narrower spreads covers both Regimes 1 and 3 that are periods of declining and increasing excess reserves respectively. A more comprehensive analysis of this behaviour is covered under the specific regimes below.

### *4.2.1 Regime 1: Declining excess reserves*

Table 3 shows Regime 1, which captured the periods where excess reserves were declining. See Annexure A for complete output.

*Table 3: Regime 1: Declining excess reserves*

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| DEXCESS < -3554.285 -- 46 observations | | | | |
| DEXCESS (-1) | -0.833655 | 0.091167 | -9.144261 | 0.0000 |
| JIBSPR | -118.2503 | 26.84953 | -4.404187 | 0.0000 |
| DTCREDIT | -0.043180 | 0.012931 | -3.339359 | 0.0010 |

Source: Own construction from EViews® output

The variable DEXCESS is presented in first difference and thus the threshold value of < -3 554.285 suggested that excess reserves were declining on average in this regime. The lagged coefficient of excess reserves was negative and statistically significant. This variable captured the effect of the excess reserves on itself from the period (month) before. The sign and significance (-0.83) of this coefficient makes sense in that it had a dampening effect on changes in excess reserves. That is, an increase in excess reserves in the prior period leads to a decrease in excess reserves in the current period and vice versa. However, this impact reduces (becomes smaller on average) over time because the coefficient is less than one. Additionally, during the shortage reserves system, the SARB actively managed liquidity (discussed in the previous section) and thus a decline in reserves would be offset by an injection of liquidity through either weekly repo auctions or the SARB's standing facilities.

The Jibar-repo spread variable also had a highly significant and negative relationship in this regime of declining excess reserves. This indicates that the changes in the Jibar-repo spread had a strong impact on excess reserves dynamics. The interpretation of this coefficient needs to be carefully considered. This regime had seen significant increases in spreads (Figure 11) but also reduced towards end of the period. Thus, it cannot be inferred from the sign of the coefficient that spreads were widening or narrowing, only that the movement of the spread in either direction is likely to have an inverse relationship in this declining excess reserves regime. A widening spread implies tighter liquidity conditions in the interbank market and higher borrowing costs for banks (Beau et al., 2014; Bech & Monnet, 2013). These conditions would prompt banks to draw down on any excess reserves they have with the SARB rather than borrowing in the interbank market. Unsurprisingly, this will see further

declines in excess reserves. Conversely, a narrowing of spreads implies better interbank liquidity and favourable borrowing costs for banks. Although this is a declining excess reserves regime, narrower spreads would slow down the rate of decline as banks reduce the need to draw down on reserves and would rather meet their daily liquidity needs in the interbank market.

Total credit extended to the domestic sector had a slightly negative albeit statistically significant coefficient in this regime. An increase in credit extension leads to a decline in reserves in this regime suggesting that banks prefer to extend credit rather than hold reserves in a shortage regime. This finding is consistent with the literature where holding reserves under a shortage system where no interest is paid on excess reserves represents an opportunity cost for banks. In other words, these use of funds (assets) for banks are substitutes where banks would rather extend credit to the economy to earn a return rather than hold on to excess reserves that pays no interest.

### *4.2.2 Regime 2: Stable excess reserves*

Table 4 shows Regime 2 which covers most of the observations and extends throughout the period. See Annexure A for complete output.

*Table 4: Regime 2: Stable excess reserves*

| Variable | Coefficient | Std. Error | t-Statistic | Prob*. |
|---|---|---|---|---|
| -3554.285 <= DEXCESS < 2907.396 -- 193 observations | | | | |
| DEXCESS (-1) | -0.077776 | 0.082755 | -0.939837 | 0.3481 |
| JIBSPR | 1.962410 | 5.053670 | 0.388314 | 0.6981 |
| DTCREDIT | -0.011499 | 0.010438 | -1.101592 | 0.2716 |

*Coefficients statistically insignificant and cannot be interpreted

Source: Own construction using EViews® output

This regime could be categorised as a regime of stable excess reserves that has no significant shifts of reserves in either direction. Most of the observations (189) captured by this regime ran in the period before the shift to excess reserves. The model estimated no statistically significant relationships between the variables and excess reserves.

### *4.2.3 Regime 3: Increasing excess reserves*

Table 5, captures the periods where excess reserves are increasing. See Annexure A for complete output.

*Table 5: Regime 3: Increasing excess reserves*

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| 2907.396 <= DEXCESS -- 53 observations | | | | |
| DEXCESS (-1) | -0.011041 | 0.050357 | -0.219250 | 0.8266* |
| JIBSPR | 193.5220 | 20.70106 | 9.348409 | 0.0000 |
| DTCREDIT | 0.042578 | 0.008670 | 4.911092 | 0.0000 |

*Coefficient statistically insignificant and cannot be interpreted

Source: Own construction using EViews® output

With 53 observations, this regime effectively began in October 2011 and carried on until the end of the period in May of 2024. The threshold value (first difference) of +2 907 suggests that the change in excess reserves increased on average more than they declined in this regime. It is important to note that despite it being a regime of increasing excess reserves, most of the observations in this regime were found in the period where the SARB was still operating in a shortage reserves system. More specifically, of the 53 observations characterised by this regime, 39 observations took place during the shortage reserves system while only 14 occurred during the excess reserves system of monetary policy implementation. However, given the significance of the shift from shortage to excess reserves, it is important to look at the monetary value of excess reserves for the 14 observations relative to the 39 observations. Furthermore, given that the threshold value is defined by the changes in excess reserves, the absolute value of reserves provides important context. The total average of excess reserves per observation (monthly) was R9.7 billion during the shortage reserves system and increased significantly after the shift to excess reserves with a total average per observation of R61.6 billion. This signifies an increase in monthly excess of reserves of almost six times because of the shift to an excess reserves system of monetary policy implementation.

The Jibar-repo spread coefficient was statistically significant and positive in this regime. The positive sign of the coefficient suggested that the impact of the spread would be in the

same direction as the excess reserves. Given that a significant feature of the new excess reserves era for banks is that excess reserves are remunerated at the repo rate, the opportunity cost of holding excess reserves is minimal (Beau et al., 2014; Bech & Monnet, 2013). This would have a particularly significant impact on the interbank market and by extension, the Jibar-repo spread. In this increasing excess reserves regime, the widening Jibar-repo spread still represents a lack of liquidity in the interbank market, however, in contrast to Regime-1, in this regime banks have sufficient reserves to meet their daily liquidity needs plus a buffer. Thus, surplus banks do not have as big an incentive to lend and/or borrow in the interbank market and this pushes up the price of interbank lending for deficit banks. In fact, by design, surplus banks will only lend once they have reached their quota, which will leave deficit banks as price takers in the interbank market. On the other hand, Figure 11 suggests that spreads are in fact narrowing which points to a more liquid interbank market. A liquid interbank market in an excess reserves regime could imply that the quota system is providing an active interbank market that is forcing surplus banks to lend to deficit banks. Given that reserves in excess of a bank's quota is remunerated at 100 basis points below the repo rate, this represents banks' opportunity cost of accumulating excess reserves and means that lending in the interbank market at Jibar would be more profitable.

The total credit extension coefficient in this regime was positive and statistically significant. This is the opposite finding to that of Regime 1. In this regime, an increase in credit extension implies an increase in excess reserves. Given that both credit extension and excess reserves are assets for banks (use of funds), an increase in both implies that one is not a substitute for the other on the banks' balance sheet in this regime. This finding is also supported in the literature where the opportunity cost of holding reserves is minimised through the remuneration of excess reserves (Baker & Rafter, 2022; King & Mancini-Grifolli, 2018).

# 5. Conclusion

The SARB moved from a shortage reserves system to an excess reserves system in June 2022. This research evaluated the impact of these excess reserves on the South African banking system. Using excess reserves as a threshold and dependent variable, a TAR model

was estimated to evaluate the dynamics between excess reserves, the interbank lending market, and credit extension to the economy.

The descriptive statistics verified the significance and impact of this shift when looking at the SARB's and banking system's balance sheets in response to the first research question. Excess reserves averaged R4 billion per month from 2010 to 2019, increased to an average of R11.4 billion per month for 2020 and 2021 with the most significant increase to an average of R64 billion per month post the shift in June 2022.

The second research question evaluated the changes in the interbank market post the shift to an excess reserves system. By using the spread between Jibar and the repo rate as a proxy for the dynamics of the interbank market this research found a narrowing of this spread which could be indicative of a more efficient pass-through of monetary policy as identified in the literature. This finding is inconclusive for two reasons. First, there were periods identified during the shortage reserve system where the Jibar-repo spread was at similar levels. Second, there are not sufficient data observations post the shift to an excess reserves regime to draw meaningful conclusions about the Jibar-repo spread. This last point becomes moot as the Jibar is being phased out as the interbank market rate.

In response to the third research question, there was no notable increase or decrease in the level of credit extension to the South African economy before and after the shift to excess reserves. However, this finding must be interpreted with caution because South Africa has been in a restrictive monetary policy environment with repo rates at levels where lending in the economy would be naturally constrained. Attributing the lack of credit extension post the shift to either an excess reserves regime or a constrained economic environment is difficult.

## 5.1 Implications

The TAR model verified three distinct regimes of excess reserves that cover periods of declining excess reserves, stable excess reserves, and increasing excess reserves. The implications of the findings come down to several considerations. The SARB is likely now to operate firmly in Regime-3 and must be aware of the dynamics of the interplay of the

interbank market, excess reserves and credit extension. In this regime, banks can hold excess reserves without incurring any opportunity cost in doing so and do not need to actively pursue other uses for funds in the interbank market or through credit extension in the economy. This could have unintended consequences for how monetary policy is transmitted through the bank lending channel. Furthermore, policy makers will need to monitor the spread of repo to their now preferred overnight benchmark rate (ZARONIA) actively to evaluate the effectiveness of monetary policy transmission under and excess reserves regime and the impact to the interbank market. Given that the tendency in this regime would be for banks to hoard reserves, the quota system becomes a critical mechanism of ensuring continued interbank activity albeit at lower levels relative to the shortage reserves system. Another implication of the excess reserves regime is that the SARB has now made reserves a risk-free asset. Banks do not have to take on higher risks by extending credit to the firms and households when it can keep excess reserves on deposit with and is effectively lending to the SARB at no risk. This behaviour could have significant implications for domestic credit extension where access to bank credit is a significant and important part of the South African economy.

## 5.2 Limitations of the research

The primary limitation of this research is that the shift by the SARB happened in June of 2022 and thus provides only two years' worth of observations. Any inferences and conclusions must be seen in this context. Therefore, the excess reserves dynamic as it pertains to the Jibar-repo spread in the excess reserves regime needs more time to be developed and observed. Related to this is the discontinuation of the Jibar as an overnight interbank lending rate and the ZARONIA being onboarded instead. More observations would be required to evaluate the spread between ZARONIA and the repo rate empirically and compare against the historical Jibar-repo spread to measure the pass-through efficiency of the SARB's policy rate under the excess reserves regime effectively.

Given that the SARB has been operating under a restrictive monetary policy (see Figure 6) since November 2021 with the repo rate peaking at 8.25% in August 2024, it is difficult to assess whether credit extension to the economy has been affected by the excess reserves regime or by a constrained economic environment. An important reason for the SARB making the shift to excess reserves was the need for the banking system to absorb liquidity

shocks better during times of crises. This outcome could not be assessed on an ex-ante basis, however the RBNZ found that the excess reserves system was not sufficient to absorb the liquidity crisis during the Covid-19 pandemic (Silk, 2022).

Finally, data in terms of volume and value of the interbank market is not freely available and this research could only use the Jibar-repo spread as a proxy for this market.

## 5.3 Further research

Although the recency of this shift in the South African context is a limiting factor, it does open possibilities for future research as more data becomes available. With the SARB remunerating excess reserves at repo, it is effectively competing with other actors in the financial system for banks' use of funds. Could this dynamic result in a crowding out effect by the SARB for other borrowers in the financial system? Related to this is the impact of excess reserves on credit extension to the South African economy where future research could use the repo rate as a threshold variable and assess at the level of interest on reserves that banks would be willing to lend to other actors in the economy instead of to the SARB.

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# Annexure A: Augmented Dickey-Fuller test for unit root (stationarity)

| Null Hypothesis: EXCESSRESERVES has a unit root | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | 0.783287 | 0.9937 |
| Test critical values: | 1% level | -3.452674 | |
| | 5% level | -2.871263 | |
| | 10% level | -2.572023 | |
| Null Hypothesis: JIBSPR has a unit root | | t-Statistic | Prob.* |
| Augmented Dickey-Fuller test statistic | | -3.794593 | 0.0033 |
| Test critical values: | 1% level | -3.452442 | |
| | 5% level | -2.871161 | |
| | 10% level | -2.571968 | |
| Null Hypothesis: TCredit has a unit root | | t-Statistic | Prob.* |
| Augmented Dickey-Fuller test statistic | | 3.186740 | 1.0000 |
| Test critical values: | 1% level | -3.452596 | |
| | 5% level | -2.871229 | |
| | 10% level | -2.572004 | |

Note: *MacKinnon (1996) one-sided p-values

Source: Own construction using EViews® output and SARB Quarterly Bulletin data

# Annexure B: Augmented Dickey-Fuller test verifying stationarity at *I*(1)

| Test | % level | t-Statistic | Prob.* |
|---|---|---|---|
| Null Hypothesis: DEXCESS has a unit root | | | |
| Augmented Dickey-Fuller test statistic | | -16.42729 | 0.0000 |
| Test critical values: | 1% level | -3.452674 | |
| | 5% level | -2.871263 | |
| | 10% level | -2.572023 | |
| Null Hypothesis: DTCREDIT has a unit root | | | |
| Augmented Dickey-Fuller test statistic | | -20.47505 | 0.0000 |
| Test critical values: | 1% level | -3.452596 | |
| | 5% level | -2.871229 | |
| | 10% level | -2.572004 | |

Note: *MacKinnon (1996) one-sided p-values; .Null hypothesis of unit root rejected and variables shown to be stationary

Source: Own construction using EViews® output and SARB Quarterly Bulletin data

## Annexure C: Tsay's test for nonlinearity of ordered variables

| | |
|---|---|
| Method: | Least squares |
| Dependent Variable: | DEXCESS AR (2) Residuals |

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | -221.1784 | 117.4785 | -1.882714 | 0.0607 |
| ORDEREDDEXCESS | 0.845330 | 0.021154 | 39.96086 | 0.0000 |
| R-squared | 0.845858 | | | |
| Adjusted R-squared | 0.845328 | | | |
| F-statistic | 1596.870 | | | |
| Prob(F-statistic) | 0.000000 | | | |

Source: Own construction using EViews® output

## Annexure D: TAR Estimation outputs at different lags showing AIC, SC, HQ information criteria

| Lags | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Akaike info criterion | 19.12741 | 19.10756 | 19.12068 | 19.12861 |
| Schwarz criterion | 19.25333 | 19.27166 | 19.32316 | 19.36965 |
| Hannan-Quinn criterion | 19.17785 | 19.17330 | 19.20180 | 19.22519 |

Source: Own construction using EViews® output

# Annexure E: TAR Estimation model output

| | |
|---|---|
| Method: | Discrete Threshold Regression |
| Dependent Variable: | DEXCESS |
| Sample (adjusted): | 2000M03 2024M06 |
| Included observations: | 292 after adjustments |
| Selection: | Trimming 0.15, Max. thresholds 5, Sig. level 0.05 |
| Threshold variable: | DEXCESS |

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| DEXCESS < -3554.285 -- 46 obs | | | | |
| DEXCESS (-1) | -0.833655 | 0.091167 | -9.144261 | 0.0000 |
| JIBSPR | -118.2503 | 26.84953 | -4.404187 | 0.0000 |
| DTCREDIT | -0.043180 | 0.012931 | -3.339359 | 0.0010 |
| -3554.285 <= DEXCESS < 2907.396 -- 193 obs | | | | |
| DEXCESS (-1) | -0.077776 | 0.082755 | -0.939837 | 0.3481 |
| JIBSPR | 1.962410 | 5.053670 | 0.388314 | 0.6981 |
| DTCREDIT | -0.011499 | 0.010438 | -1.101592 | 0.2716 |
| 2907.396 <= DEXCESS -- 53 obs | | | | |
| DEXCESS (-1) | -0.011041 | 0.050357 | -0.219250 | 0.8266 |
| JIBSPR | 193.5220 | 20.70106 | 9.348409 | 0.0000 |
| DTCREDIT | 0.042578 | 0.008670 | 4.911092 | 0.0000 |

| Non-Threshold Variables | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 436.6282 | 264.4227 | 1.651250 | 0.0998 |

| | | | |
|---|---|---|---|
| R-squared | 0.641028 | Mean dependent var | 261.9111 |
| Adjusted R-squared | 0.629571 | S.D. dependent var | 5566.337 |
| S.E. of regression | 3387.831 | Akaike info criterion | 19.12741 |
| Sum squared resid | 3.24E+09 | Schwarz criterion | 19.25333 |
| Log likelihood | -2782.602 | Hannan-Quinn criter. | 19.17785 |
| F-statistic | 55.95297 | Durbin-Watson stat | 2.247286 |
| Prob(F-statistic) | 0.000000 | | |

## Annexure F: Autocorrelation tests for up to 12 lags

| Q-statistic probabilities adjusted for 3 dynamic regressors | | | | |
|---|---|---|---|---|
| Lags | Autocorrelation | Partial Correlation | Q-Stat | Prob* |
| 1 | -0.124 | -0.124 | 4.5433 | 0.033 |
| 2 | 0.039 | 0.024 | 4.9943 | 0.082 |
| 3 | -0.002 | 0.006 | 4.9956 | 0.172 |
| 4 | -0.042 | -0.044 | 5.5336 | 0.237 |
| 5 | 0.039 | 0.029 | 5.9874 | 0.307 |
| 6 | 0.057 | 0.069 | 6.9719 | 0.323 |
| 7 | 0.083 | 0.098 | 9.0447 | 0.249 |
| 8 | -0.000 | 0.017 | 9.0447 | 0.339 |
| 9 | 0.013 | 0.013 | 9.0968 | 0.428 |
| 10 | 0.022 | 0.030 | 9.2463 | 0.509 |
| 11 | -0.001 | 0.008 | 9.2464 | 0.599 |
| 12 | 0.058 | 0.048 | 10.261 | 0.593 |

Source: Own constructions using EViews® output

## Annexure G: Breusch-Godfrey Serial Correlation LM test

| Null hypothesis: No serial correlation at up to 12 lags | | | |
|---|---|---|---|
| F-statistic | 1.266627 | Prob. F (12,270) | 0.2383 |
| Obs*R-squared | 15.56195 | Prob. Chi-Square (12) | 0.2121 |

Source: Own constructions using EViews® output

## Annexure H: Breusch-Pagan-Godfrey test for heteroskedasticity of residuals

| Null hypothesis: Homoskedasticity | | | |
|---|---|---|---|
| F-statistic | 1.349120 | Prob. F (9,282) | 0.2114 |
| Obs*R-squared | 12.05365 | Prob. Chi-Square (9) | 0.2103 |
| Scaled explained SS | 62.69503 | Prob. Chi-Square (9) | 0.0000 |

Source: Own constructions using EViews® output

## Annexure I: Variance Inflation Factor test for multicollinearity of redundant variables

| Variable | Coefficient Variance | Uncentred VIF |
|---|---|---|
| DEXCESS < -3554.285 -- 46 obs | | |
| DEXCESS (-1) | 0.008311 | 1.697862 |
| JIBREPOSPR | 7208973. | 1.939630 |
| DTCREDIT | 0.000167 | 1.064479 |
| -3554.285 <= DEXCESS < 2907.396 -- 193 obs | | |
| DEXCESS (-1) | 0.006848 | 1.040357 |
| JIBREPOSPR | 255395.9 | 1.066846 |
| DTCREDIT | 0.000109 | 1.449665 |
| 2907.396 <= DEXCESS -- 53 obs | | |
| DEXCESS (-1) | 0.002536 | 1.093087 |
| JIBREPOSPR | 4285340. | 1.431032 |
| DTCREDIT | 7.52E-05 | 1.219768 |

| Non-Threshold Variables | Coefficient Variance | Uncentred VIF |
|---|---|---|
| C | 69919.38 | 1.778840 |

Source: Own constructions using EViews® output