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A bank-level analysis of interest rate pass-through in South Africa

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April 2022

Abstract

We study how changes in the South African Reserve Bank's policy rate are passed through to a range of household and corporate lending and deposit interest rates over the period January 2009 to December 2020. We use a suite of asymmetric error correction models that allow for sign asymmetry while controlling for a range of confounding factors, including bank funding spreads, liquidity and credit premia. Our results indicate that interest rate hikes are passed through to mortgage interest rates more strongly than rate cuts in long-run equilibrium but that pass-through to other lending rates is generally complete and symmetric. While pass-through to call deposit interest rates is found to be complete and symmetric, cheque account interest rates are very sticky. A notable implication of our results is that the stimulatory effect of a policy rate cut is blunted, both in terms of the degree to which it reduces debt servicing costs and the degree to which it disincentivises saving. A counterfactual analysis reveals that household mortgage interest rates have fallen by approximately 300 basis points during the COVID-19 pandemic relative to a business-as-usual scenario. This indicates that the South African Reserve Bank's accommodatory policy has remained effective over the COVID-19 period, despite offsetting increases in risk and liquidity premia that have weakened the transmission of policy easing to the real economy.

JEL classification: E43, E52, G21

Keywords: Interest rate pass-through, monetary policy transmission mechanism, bank funding costs, sign asymmetry.

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1 Introduction[1]

In South Africa, the primary implement of monetary policy is the repo rate - the interest rate at which the South African Reserve Bank (SARB) will enter into overnight repurchase agreements with South African commercial banks. Consequently, the repo rate acts as the reference price for overnight borrowing in the banking sector. SARB sets the repo rate to achieve its constitutional mandate 'to achieve and maintain price stability in the interest of balanced and sustainable economic growth'. A key channel by which changes in the repo rate affect the wider economy is through their impact on the spectrum of interest rates offered by commercial banks. Changes in bank interest rates impact the cost of external financing faced by households and firms and the opportunity cost of holding liquid funds. In a stylised economic model, one may expect repo rate changes to be passed through to bank rates rapidly and completely, but this may not occur in practice. Knowledge of the degree to which changes in the repo rate are actually passed through to bank lending and deposit rates is central to the conduct of monetary policy. Our goal in this paper is to estimate the strength of interest rate pass-through to a range of bank rates at both the sector-wide aggregate level and the disaggregate level, using de-identified data for the five largest banks in South Africa.

In their extensive survey of the literature on interest rate pass-through, Aziakpono and Wilson (2013) note that there is a relative scarcity of work on South Africa. Their own analysis focuses on pass-through from the official rate to six benchmark interest rates, including the bank rate, the prime lending rate and the deposit rate, and finds near-complete long-run pass-through to lending, deposit and money market rates. Kabundi and Ngwenya (2011) and Kabundi and Rapapali (2019) focus primarily on the transmission of monetary policy shocks to the aggregate economy. Our paper contributes to this line of research as it is the first to analyse not only aggregate but also bank-level pass-through to a range of lending and deposit interest rates while controlling for a range of common and bank-specific confounding factors.

The extent to which banks have adjusted their deposit and lending rates in response to changes in monetary policy has become an increasingly pressing issue in the period since the global financial vrisis (GFC) in 2009, not just in South Africa but around the world (e.g. Hristov et al. 2014 and Gambacorta et al. 2015). While policy rates have fallen meaningfully in the post-GFC period in many countries, new prudential requirements on banks and higher liquidity and credit premia have seen bank funding costs increase relative to policy rates over the same period. In South Africa, the spreads between many lending rates and the repo rate have widened in the post-GFC period, while some deposit spreads against the repo rate have narrowed. These trends in lending and deposit spreads are not sufficient on their own to conclude that interest rate pass-through has been incomplete and/or asymmetric with respect to the sign of repo rate changes, owing to the influence of the aforementioned confounding factors. Nonetheless, these trends do provide strong motivation for the development and estimation of econometric

[1] We are grateful to Tim Olds for assistance with data and to Lisa de Beer, Myrtle van Jaarsveld, Danie Meyer, Wessel Mostert and Susana Paulse for helpful comments. A NARDL Toolbox written for R to accompany this paper is available at https://github.com/Rossouwvj/NARDL-toolbox.

models that can be used to characterise the extent and pattern of interest rate pass-through.

We use the Nonlinear Autoregressive Distributed Lag (NARDL) model advanced by Shin et al. (2014, henceforth SYG) to study pass-through from the repo rate to a selection of lending and deposit interest rates at both the aggregate level and the level of individual financial institutions over the period January 2009 to December 2020. The NARDL model is an asymmetric generalisation of the linear Autoregressive Distributed Lag (ARDL) framework developed by Pesaran and Shin (1998) and Pesaran et al. (2001). It has several desirable characteristics that make it well suited to the analysis of interest rate pass-through, including its capacity to address issues of autocorrelation, weak endogeneity and mixed orders of integration. In addition, it provides a straightforward method to test for both the completeness and symmetry of interest rate pass-through.

Our NARDL models include a more comprehensive set of controls to explain the evolution of bank lending rates than have been used in the literature to date, including sophisticated liability-side measures of the weighted average cost of bank funding sourced from Olds and Steenkamp (2021). This sets our paper apart from existing studies of interest rate pass-through that are either subject to aggregation bias by virtue of their reliance on aggregate data (e.g. Borio and Fritz 1995, Deuker 2000, Sellon 2002, Kleimeier and Sander 2006, Gropp et al. 2007 and Gambacorta 2008) or have avoided aggregation bias by using bank-level data but that either do not control for bank funding costs or use less complete measures of bank funding costs than ours (e.g. Hannan and Berger 1991, Neumark and Sharpe 1992, Hofmann and Mizen 2004, Fuertes et al. 2010 and Banerjee et al. 2013).

We present five principal findings. First, we show that pass-through into household flexible mortgage interest rates at the bank level is typically complete in the case of rate hikes, but is often incomplete in the case of rate cuts. This asymmetry is considerably less prevalent in the case of corporate mortgages. We also find that banks tend to smooth corporate overdraft interest rates relative to household overdraft rates. We interpret these findings in terms of the switching costs and information frictions faced by different classes of borrowers. Households will typically experience larger switching, monitoring and information processing costs than corporate borrowers per rand borrowed. This difference may be particularly pronounced during SARB cutting cycles, where cyclical downturns may reduce household income and equity to the point that many households may be unable to discharge the exit costs associated with refinancing loans. Interestingly, we do not find any systematic difference between pass-through to household and corporate credit card interest rates, although corporate credit card balances account for just 0.3% of total loans to corporate customers, so there may be little competition among banks in this market segment.

Second, we find that pass-through into both household and corporate cheque account interest rates is typically incomplete, while pass-through into call deposit interest rates is generally complete. This is an interesting finding, because South Africans hold large deposit balances despite the low interest rates on offer, and South African banks rely heavily on household and corporate deposits as a source of cheap local currency funds that satisfy the high-quality liquid asset requirements of the Basel 3 regulations. Cheque accounts and call deposits differ in two primary respects - cheque accounts are used for transaction purposes, while call deposits are not, and cheque account balances are remunerated at a lower rate than call deposits. Both receive the same regulatory treatment under Basel 3, so the observed difference in pass-through cannot be attributed to regulation. A partial explanation is likely to be rooted in the higher unit cost faced by banks in providing cheque account services than call deposit services, including the costs of operating branch and ATM networks and providing transaction services. In addition, because households and firms use cheque accounts for transaction purposes, they may face high switching costs due to the necessity to update standing payment facilities, invoicing details, thereby reducing the incentive for banks to compete for cheque deposits on price. The prevalence of incomplete pass-through into cheque account interest rates has at least two important implications. First, it is likely to have distributional consequences, as poorer individuals may hold proportionately larger balances in cheque accounts than wealthier individuals. Second, it means that the opportunity cost of holding cheque deposit balances does not adjust to fully reflect monetary policy actions.

Third, we use our models to construct a counterfactual scenario for flexible household mortgage interest rates from March to December 2020 corresponding to the hypothetical case in which the COVID-19 pandemic does not occur. This exercise reveals that household mortgage interest rates were approximately 300 basis points (bps) lower as of December 2020 than under the no-COVID-19 scenario, which approximately matches the observed reduction in the repo rate over this period. This suggests that SARB's monetary easing has been passed through strongly to household mortgage servicing costs.

Fourth, we show that pass-through estimates obtained using aggregate data often differ substantially from bank-level estimates, which indicates that aggregation bias may be a significant problem. Consequently, we caution against the use of aggregate pass-through estimates to inform the conduct of monetary policy.

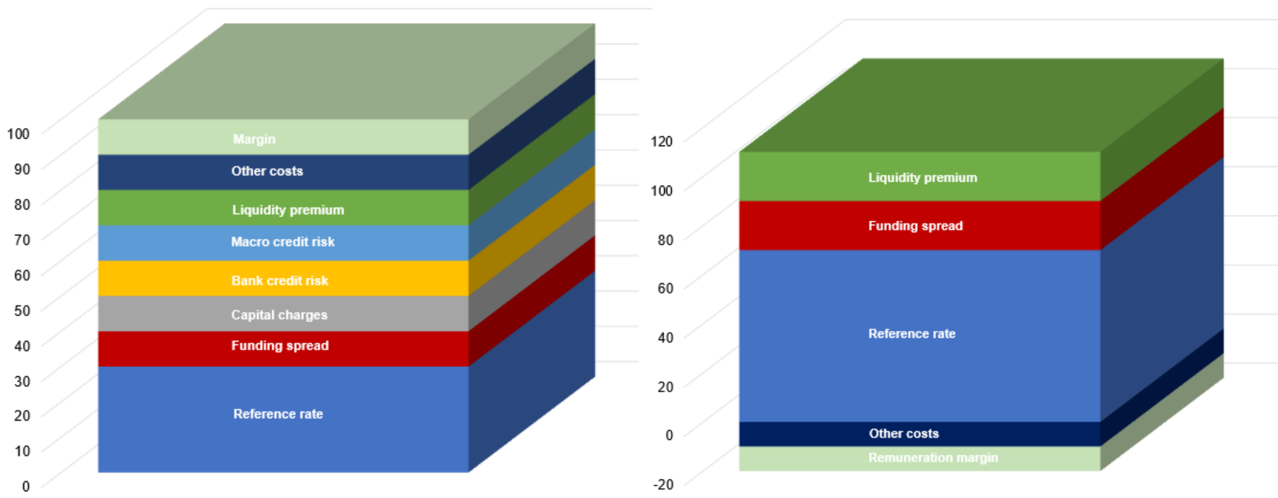
Finally, we show that the failure to control for bank funding costs significantly compromises the fit, diagnostic performance and even the interpretation of our NARDL models. In some cases, it is not possible to identify a stable equilibrium relationship when bank funding costs are excluded from the model. This highlights the value of controlling for funding costs and provides motivation for central banks to continue to invest resources in the development of sophisticated funding cost proxies. By analogy to the case of aggregation bias discussed above, it also suggests that pass-through estimates obtained from models that do not include adequate funding cost measures should be treated with caution.

This paper proceeds as follows. In section 2, we introduce our dataset, paying particular attention to the suite of control variables that distinguish our analysis from the prior literature. In section 3, we introduce the NARDL model before we present and discuss our results in section 4. Results of our counterfactual analysis of the COVID-19 period are reported in Section 5, while the results of sensitivity analysis are summarised in Section 6. We conclude in section 7. Additional details relating to the construction of our dataset are contained in an appendix.

2 Data

In order to assess the pass-through of policy rate changes into bank lending and deposit rates, it is necessary to identify and control for a range of confounding factors that also affect bank interest rates. To this end, Figure 1 provides a stylised representation of the factors that contribute to the determination of lending and deposit rates by a typical bank in South Africa. Figure 1(a) shows that policy rate changes have both direct and indirect effects on lending rates. The direct effect arises because the policy rate anchors short-term money market rates (represented by 'reference rate' in the figure), which directly affect banks' funding costs (i.e. the cost of raising new funding for new loans). Indirect effects arise via the influence of monetary policy on the macroeconomic trajectory, including the outlook for output growth and inflation. While loan rates are typically marked up relative to the cost of raising funds, Figure 1(b) shows that the pricing of deposit rates typically includes offsetting remuneration, reflecting the value of deposits as a source of funding for banks. Raising retail deposits also creates operating costs for banks (such as operating branch and ATM networks), while originating term deposits may require banks to pay a premium for long-term funds. In South Africa, deposit funding is relatively stable and cheap relative to interbank money market funding, with deposit rates historically below the monetary policy rate or the three-month Johannesburg Interbank Average Rate (JIBAR).

Figure 1: Illustrative decomposition of bank lending and deposit rates



(a) Lending rates (b) Deposit rates

NOTE: The figure provides a stylised representation of the percentage contribution of each item to the lending/deposit interest rate.

In the remainder of this section, we introduce the interest rate data that we study, as well as a selection of controls motivated by the stylised decompositions in Figure 1. Information on data sources and series identifiers may be found in Appendix Table A1.

2.1 Policy interest rate

We use the repo rate to represent the stance of monetary policy. SARB reviews the repo rate every two months on a pre-announced schedule. Over our period, SARB was on a tightening cycle until November 2008, a loosening cycle until December 2013, a tightening cycle until June 2017, a loosening cycle until October 2018, then a brief tightening cycle until June 2019, followed by a further loosening cycle extending to the end of the sample in December 2020.[2] We conduct sensitivity analysis with respect to the use of alternative short-term market interest rates instead of the repo rate in section 6.

2.2 Household and corporate lending and deposit interest rates

We study the pass-through of policy rate changes to a range of lending and deposit interest rates. Specifically, we work with interest rate data for the following three categories of loans: flexible mortgages, overdrafts and credit cards. In addition, we analyse interest rates for two different types of bank deposits: cheque accounts and call deposits.[3] For each of these five lending/deposit interest rates, we analyse the pass-through of policy rate changes to the interest rates charged/payable to the household and corporate sectors separately.

In each case, we analyse interest rate pass-through in two ways. First, we consider pass-through into sector-wide weighted average aggregate interest rates as marginal rate data are not available in South Africa. This provides a high-level overview of the interaction between policy rates and retail bank interest rates but it is potentially subject to aggregation bias, as the aggregate interest rate is not a rate that is available to households and firms and it may not behave like the rates quoted by any individual bank. Therefore, the second way in which we study pass-through is on a bank-by-bank basis for each of the five largest banks in South Africa by market share (ABSA, Investec, FirstRand, Nedbank and Standard Bank).[4] Owing to the confidentiality and commercial sensitivity of bank-level interest rate data, the data are de-identified; we simply refer to Banks 'A'–'E' henceforth, where the banks are randomly assigned a letter. By repeating our analysis using disaggregate data, we can avoid aggregation bias and shed light on the degree of heterogeneity of interest rate pass-through among the biggest banks in South Africa. It also allows us to compare aggregate interest rate pass-through against bank-level pass-through and thereby to gain insight into the implications of aggregation bias for the estimation of pass-through effects. This is an important issue, because bank-

[2] Nkuna et al. (2020) demonstrate that the 'effective repo rate' briefly declined relative to the official repo rate set by the MPC during the initial market stress induced by the COVID-19 crisis. However, they show that immediate monetary policy easing and refinancing operations during the onset of the COVID-19 crisis passed through effectively to the front-end of the South African yield curve.

[3] For reporting purposes, cheque accounts include cheque/current and transmission deposits. Call deposits are flexible short-term investment instruments that cannot be used to make third-party payments and do not support direct debit or stop orders. Call accounts typically offer a higher interest rate than cheque accounts.

[4] Over our sample period, these five banks have consistently accounted for more than 90% of total loans and advances in South Africa. The banking sector in South Africa is concentrated with limited product differentiation, which implies that banks compete in an oligopolistic manner, which provides scope for strategic behaviours, such as price leadership.

level data are often unavailable to researchers, meaning that one is often obliged to rely on aggregate estimates and to assume that relationships observed at the aggregate level continue to hold at the bank level.

Our aggregate and bank-level interest rate series are sourced from Olds and Steenkamp (2021), who extract information from the BA-930 survey forms that South African banks are required to file on a confidential basis under the Banks Act (94/1990). Banks calculate their own weighted average rates on each type of account, where the weights are based on outstanding balances on each account type at month-end.[5] Olds and Steenkamp use the BA-930 survey data to create aggregations of mortgage rates, overdraft rates, credit card rates, cheque and call deposit rates at the bank level, as well as banking sector aggregates using weights based on the outstanding balances (per category) of each of bank at the end of the month.

In Figure 2, we provide time series plots of the aggregate household and corporate flexible mortgage interest rates in comparison to the repo rate. We refrain from providing descriptive statistics or time series plots of bank-level interest rates or control variables to ensure that it is not possible to identify individual banks in our analysis. In South Africa, flexible mortgage rates are linked to a variable base rate, such as the 'prime' rate, which has been at a fixed 350 bps spread over the repo rate since September 2001. Lending rates can be set above or below the prime rate, depending on client risk profiles and market conditions. Despite the fixed prime rate spread with respect to the repo rate, bank average mortgage lending margins to the policy rate do not necessarily adjust one-for-one with the repo rate, as the composition of the loan book changes over time and the terms on which new loans are extended may differ from the terms on existing loans. In practice, the spread of average mortgage rates over the repo rate has been steadily rising since 2008 (see Figure 1 in Rapapali and Steenkamp (2020) or Meyer and Morope (2021) for a discussion). Some lending rates are also linked to the JIBAR or fixed at rates based on considerations such as loan duration and credit risk. Flexible rate mortgages account for the large majority of household and corporate mortgage lending in South Africa. Pass-through would be expected to be complete for existing mortgage loans set at a positive or negative spread to the prime rate, unless the terms of such loans are renegotiated. Fixed rate loans are typically considerably more expensive than flexible rate products and are generally only offered for short durations.[6] Hence, we do not consider interest rate pass-through to fixed mortgage interest rates in this paper.

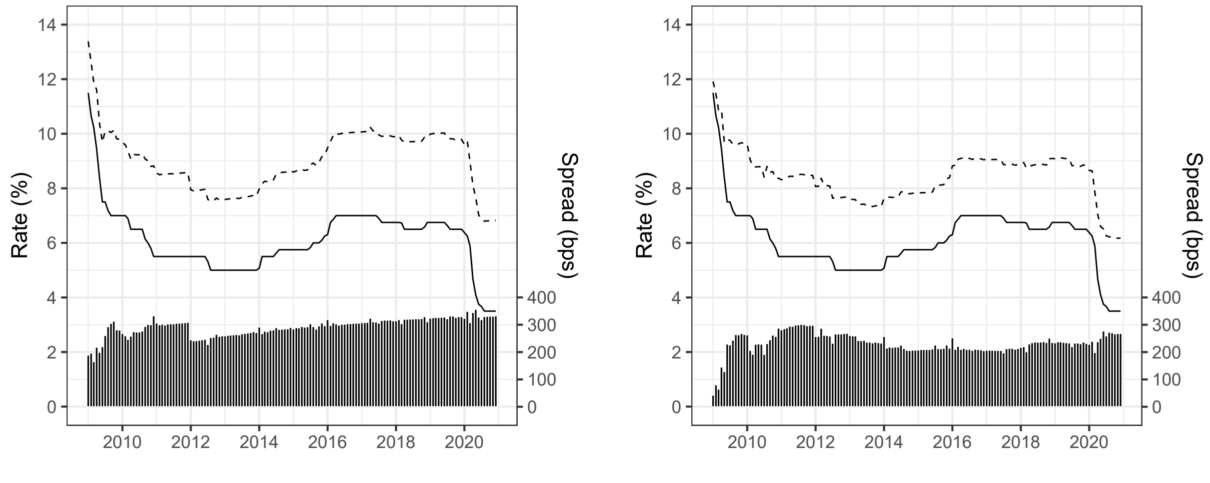
Both household and corporate mortgage rates have tracked repo movements closely and, in both cases, the spread to the repo rate is positive and widened materially in the period immediately after the GFC. This widening has continued gradually for household loans but stabilised for corporate loans. The widening spread between household mortgage rates and the repo rate is a source of concern for policy makers, as it suggests that the historically low

[5] The reported rates are set in the ordinary course of arms-length business. Special, concessionary or outlying interest rates are excluded from these calculations. The maturities are defined as original maturity.

[6] Figure A1 provides estimates of the weighted duration across loan categories for household and corporate loans (combined) for 2020. In South Africa, the average duration of aggregate mortgage loans is relatively stable over time relative to other loan categories.

repo rate at the time of writing may be translating into higher mortgage rates on new loans than would have been the case before the GFC.

Figure 2: Aggregate household and corporate flexible mortgage interest rates (dashed lines) vs. the repo rate (solid line)

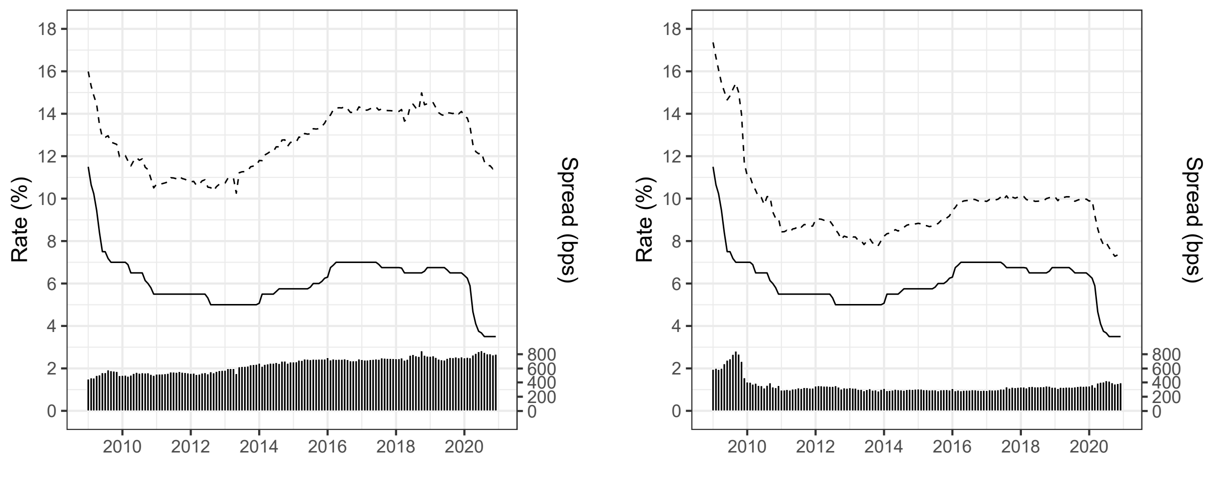


(a) Household flexible mortgages

(b) Corporate flexible mortgages

Figures 3 and 4 show that the interest rates on household and corporate overdraft facilities and credit cards exhibit spreads of several hundred basis points to the repo rate. The spreads associated with household lending are wider but less volatile than the corresponding spreads on corporate loans, which may reflect the relatively low magnitude of these types of corporate loans (e.g. credit card debt accounts for approximately 0.3% of total loans for corporate customers) and the degree of surety that corporate borrowers can offer, even if only due to their size and the diversification of their income streams compared to a representative household.

Figure 3: Aggregate household and corporate overdraft interest rates (dashed lines) vs. the repo rate (solid line)

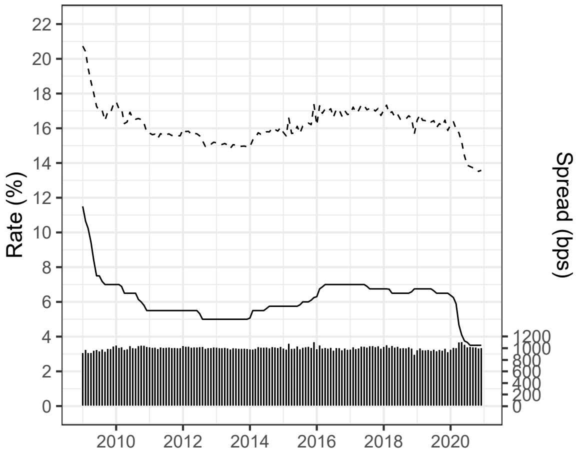


(a) Household overdrafts

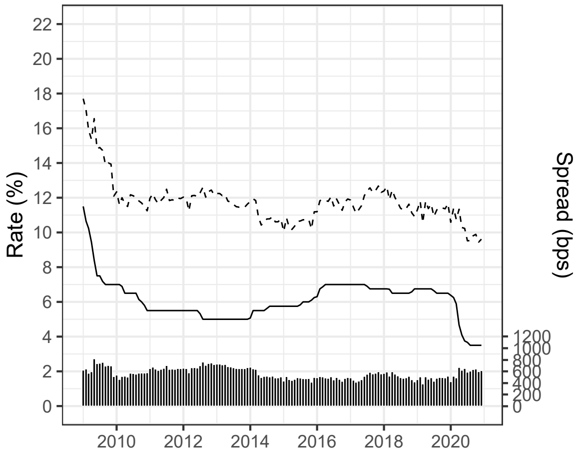
(b) Corporate overdrafts

Figure 5(a) reveals that the interest rates on both household and corporate cheque accounts exhibit considerable stickiness over our sample period, coupled with a substantial negative

Figure 4: Aggregate household and corporate credit card interest rates (dashed lines) vs. the repo rate (solid line)



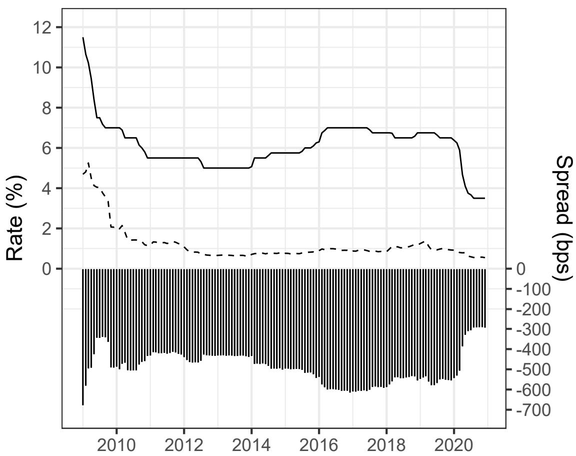
(a) Household credit cards



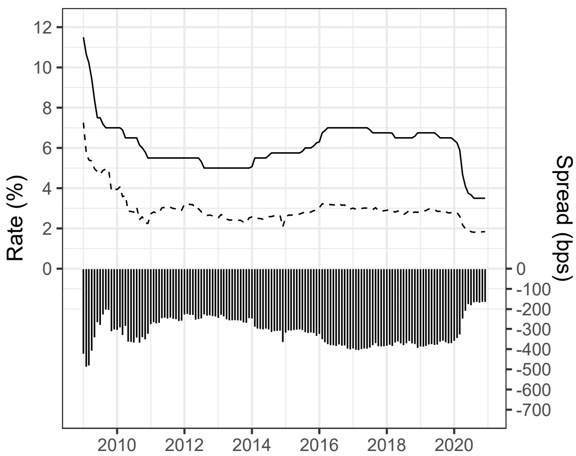
(b) Corporate credit cards

spread relative to the repo rate. In the most recent policy easing phase, this spread narrowed appreciably, as banks were unable to reduce the rates offered on cheque accounts in line with the repo rate without quoting negative interest rates to depositors, as customers were already experiencing near-zero nominal interest rates from mid-2012. In practice, the real interest rates payable on cheque account deposits have been low or negative for much of the post-GFC period. The rate payable on household cheque deposits is considerably lower than the rate on corporate deposits, owing to the fact that corporate deposits often attract a premium related to their large size relative to typical household deposits, and banks incur a range of additional costs to service household customers, including costs related to branch and ATM networks.

Figure 5: Aggregate household and corporate cheque account interest rates (dashed lines) vs. the repo rate (solid line)



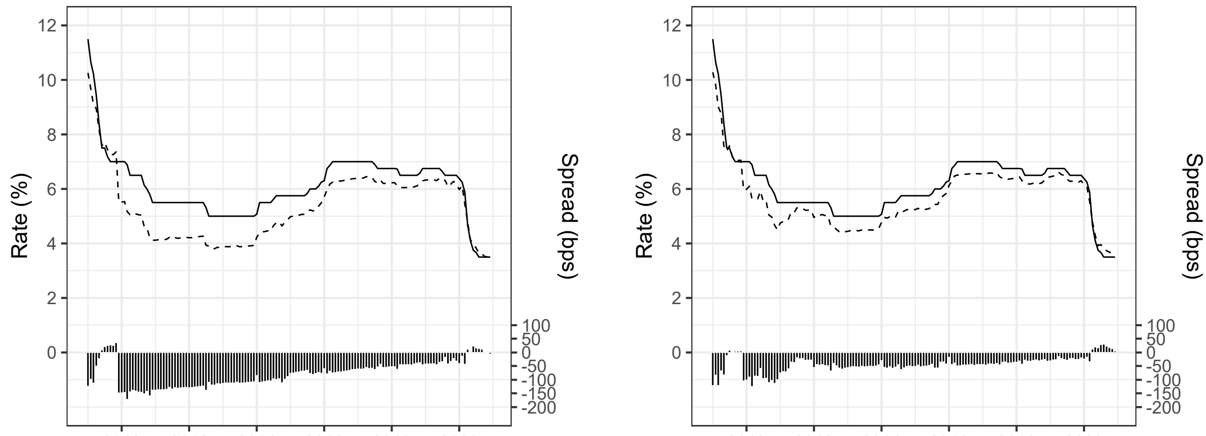
(a) Household cheque accounts



(b) Corporate cheque accounts

Figure 6 shows that call deposit rates for both household and corporate clients have, by contrast, converged toward the repo rate from below over the past decade, exhibiting a modest positive spread during the most recent monetary policy easing. Much of this convergence on the repo rate is likely to have been driven by increased competition for term deposits - over our sample period, the share of deposits held by the five largest banks has dropped from almost 98% to around 90%. Nevertheless, the real rate of return on call deposits is still low. Yet despite the low returns on offer, South African households and corporates hold significant cheque and call deposit balances, reflecting a strong demand for local currency liquidity. As a consequence, and as we will discuss below, household and corporate deposits represent a significant source of cheap local currency funding for South African banks - household deposits alone account for approximately 26% of banking sector liabilities as of the end of our sample, up from 22% a decade earlier. Low deposit interest rates therefore represent a substantial net transfer from depositors to banks.

Figure 6: Aggregate household and corporate call deposit interest rates (dashed lines) vs. the repo rate (solid line)



(a) Household call deposits

(b) Corporate call deposits

2.3 Controls

As shown in Figure 1, the interest rates available to the household and corporate sectors depend on a range of factors aside from the policy interest rate. To account for these confounding factors, we use a sophisticated set of control variables, several of which are unique to the South African context, as discussed below.

2.3.1 Bank funding costs

Variations in bank funding costs are known to affect the interest rates that banks offer to their customers. Illes et al. (2019) show that the apparent post-GFC breakdown in the relationship between policy interest rates and bank interest rates can be attributed to a divergence between policy rates and a liability side measure of bank funding costs - while funding costs tracked policy rates to a reasonable degree prior to the GFC, this relationship broke down with the introduction of historically low policy rates during the GFC, and the spread between funding costs and reference rates has exhibited notable time-variation over our sample period (e.g. Rapapali and Steenkamp, 2020). Several factors may impact funding cost spreads, including the rise of liquidity and counterparty risk during and after the GFC, as well as subsequent regulatory changes that impact on bank funding costs, such as the Basel 3 regulations (see Hollander and Havemann 2021 and Diesel et al. 2022, forthcoming).

Our goal in this paper is not to measure the pass-through of funding costs into bank interest rates, because funding costs cannot be directly manipulated to achieve policy goals. Rather, our interest is in measuring the extent to which policy rate changes are passed through to bank rates, controlling for variations in funding cost spreads relative to reference rates. To this end, we use estimates of funding cost spreads constructed by Olds and Steenkamp (2021), which are derived from the cost of raising bank liabilities. Unlike the weighted average cost of liabilities of Illes et al. (2019), which is based on just five forms of bank liabilities and only vis-à-vis the euro area, the weighted average funding cost measures that we use are comprehensive in the sense that they cover all of the liabilities of the South African banking sector except bank equity.[7]

Rapapali and Steenkamp (2020) and Olds and Steenkamp (2021) construct a weighted average funding cost measure using balance sheet data to evaluate both the volume and cost of the different components of bank funding on a bank-by-bank basis, in addition to a marginal funding cost proxy based on actual deposit rates and debt issuance data. This approach confers several benefits relative to Illes et al. (2019), whose funding cost estimates are predicated on the assumption that banks use the cheapest available funding and are based on new business rates for each form of liability: interbank money market rates for deposits, the sum of interest rate swaps and credit default swap rates for the cost of debt securities, yields to maturity for covered bonds and the euro main refinancing rate for central bank operations.

The aggregate weighted average cost of bank funding that we use, denoted $WACF$, is based on the weighted average of all of the components of the outstanding liabilities from the total banking sector from the BA form balance sheet data, which are published monthly by the SARB.[8] It is calculated as follows:

$$WACF_t = WACF_t^{\text{Deposits}} + WACF_t^{\text{WSD}}, \tag{1}$$

where t indexes time periods in months and the two major components of funding are monthly aggregations of deposits and wholesale debt funding (WSD). Deposits are obtained from three

[7] Shareholder equity represents less than 10% of total bank liabilities in South Africa and is not a regular source of bank funding for loans in practice. Illes et al. (2019) also exclude equity from their weighted average cost of liabilities measure, which is based on deposits, short-term debt securities (under one year maturity), covered bonds and funding from central bank operations. Their ‘flow’ measure is based on new deposits and changes in the volumes of debt securities and covered bond issuance data.

[8] Anomalies and missing entries in the BA survey data are addressed by applying a simple average of the values for the periods before and after an anomaly, while, for missing entries, the data point is ignored for the purposes of the calculation of funding cost estimates.

sectors: household, corporate and foreign. That is:

$$WACF_t^{\text{Deposits}} = WACF_t^{\text{Household deposits}} + WACF_t^{\text{Corporate deposits}} + WACF_t^{\text{Foreign deposits}}. \quad (2)$$

Likewise, there are three components of WSD: short term (deposit components with original maturity of up to one month), medium-term (up to six months) and long term (longer than six months).[9] Therefore:

$$WACF_t^{\text{WSD}} = WACF_t^{\text{short term WSD}} + WACF_t^{\text{medium term WSD}} + WACF_t^{\text{long term WSD}}. \quad (3)$$

Wholesale debt is defined as all liabilities accrued other than deposits. Over 200 components of bank funding are aggregated and weighted across all 36 registered banks as a share of total banking sector liabilities ($L_t^{\text{Total banks}}$):

$$L_t^{\text{Total banks}} = \sum_{i,d} L_{i,d,t} + \sum_{i,w} L_{i,w,t}, \quad (4)$$

where $L_{i,d,t}$ represents the total outstanding balance of bank i for deposit component d at time t, and $L_{i,w,t}$ is similarly defined as the outstanding balance for each wholesale debt funding component (denoted w). The weight for deposit component d for the ith bank is the sum of the relevant sub-components, d_s:

$$WACF_{i,d,t} = \sum_{d_s} \frac{L_{i,d_s,t}}{L_t^{\text{Total banks}}} \times \text{weighted rate}_{i,d_s,t}. \quad (5)$$

The weighted cost of funding for the components of the deposit categories, weighted rate$_{i,d_s,t}$, is constructed as the weighted rate of each sub-component, d_s, for each bank i at time t, based on data from the BA-930 survey, which requires banks to self-report weighted rates for each deposit category. The weights for each component of wholesale deposits is similarly calculated as the sum of the weighted contribution of the sub-components of bank i, or w_s:

$$WACF_{i,w,t} = \sum_{w_s} \frac{L_{i,w_s,t}}{L_t^{\text{Total banks}}} \times \text{rate}_{w,t}. \quad (6)$$

where rate$_{w,t}$ is based on market rate data from Bloomberg. The market rate data include monthly negotiable certificate of deposit (NCD) rates, NCD spreads to reference rates, as well as the three-month JIBAR. NCD rates are not available historically for each bank, so Rapapali and Steenkamp (2020) and Olds and Steenkamp (2021) use average NCD rates and spreads for all banks for the wholesale debt funding components based on a simple average of the rates available for the five largest banks for each month. Rates are standardised across all

9 The maturity breakdown employed here is constrained by the maturity structure of wholesale liabilities in the BA surveys.

banks and all sub-components of the same time period as follows:[10]

$$\text{rate}_{w,t} = \begin{cases} NCD_t^{1m}; & w = \text{short term}, \\ NCD_t^{6m}; & w = \text{medium term}, \\ \frac{1}{4}\left(NCD_t^{12m} + NCD_t^{24m} + NCD_t^{36m} + NCD_t^{60m}\right) + JIBAR_t^{3m}; & w = \text{long term}. \end{cases} \tag{7}$$

For ease of interpretation, we express weighted average funding costs as spreads relative to the three-month JIBAR, as follows:

$$WACF_{i,d,t}^{\text{spread}} = \sum_{d_s} \frac{L_{i,d_s,t}}{L_t^{\text{Total banks}}} \times \text{spread}_{i,d_s,t}, \tag{8}$$

where:

$$\text{spread}_{i,d_s,t} = \text{weighted rate}_{i,d_s,t} - JIBAR_t^{3m}, \tag{9}$$

and:

$$WACF_{i,w,t}^{\text{spread}} = \sum_{w_s} \frac{L_{i,w_s,t}}{L_t^{\text{Total banks}}} \times \text{spread}_{w,t}, \tag{10}$$

where:

$$\text{spread}_{w,t} = \text{rate}_{w,t} - JIBAR_t^{3m}. \tag{11}$$

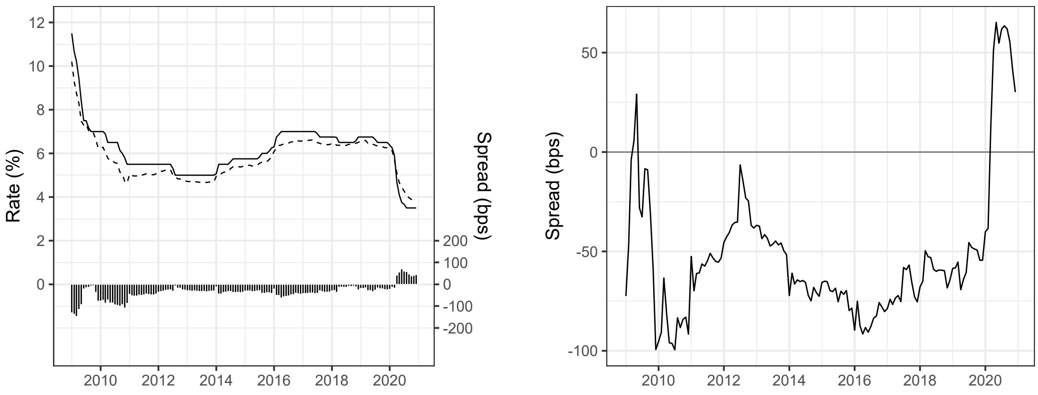
$WACF_{i,d,t}^{\text{spread}}$ and $WACF_{i,w,t}^{\text{spread}}$ are weighted together using their respective shares in total bank-level liabilities to obtain an aggregate $WACF_{i,t}^{\text{spread}}$ measure. To create an aggregate banking sector $WACF_t^{\text{spread}}$ measure, the $WACF_{i,t}^{\text{spread}}$ measures from all 36 banks in the system are aggregated based on their shares in total liabilities.

Even though we use the WACF spread in our analysis, we plot both the WACF level and spread in Figure 7 to facilitate comparisons against other interest rates. Figure 7(a) shows that the level of the aggregate WACF for the banking sector typically tracks the repo rate from below, with a significant narrowing of the spread during previous monetary easings. The current easing cycle stands apart from previous easing cycles due to the emergence of a positive spread of approximately 50 bps, reflecting reduced funding liquidity driven by the COVID-19 crisis and a proportionate increase in the cost of household and corporate deposit funding over this period, as seen in Figures 5 and 6. These same features characterise the WACF spread in Figure 7(b), because the reference rates used to compute the WACF spread share similar

[10] The long-term NCD rates (for 12-, 24-, 36-, and 60-month tenors) are expressed as spreads to the JIBAR, hence the addition of $JIBAR_t^{3m}$ in (7). As market NCD rates are only available from March 2011, Rapapali and Steenkamp (2020) backdate these rates using the two-month NCD rate as a proxy for the one-month NCD rate, while the six-month and long-term rates are backdated using a weighted average of rate for three of the largest five banks for which historical data are available.

dynamics to the repo rate.

Figure 7: WACF and WACF Spread



(a) WACF level vs. repo rate

(b) WACF spread

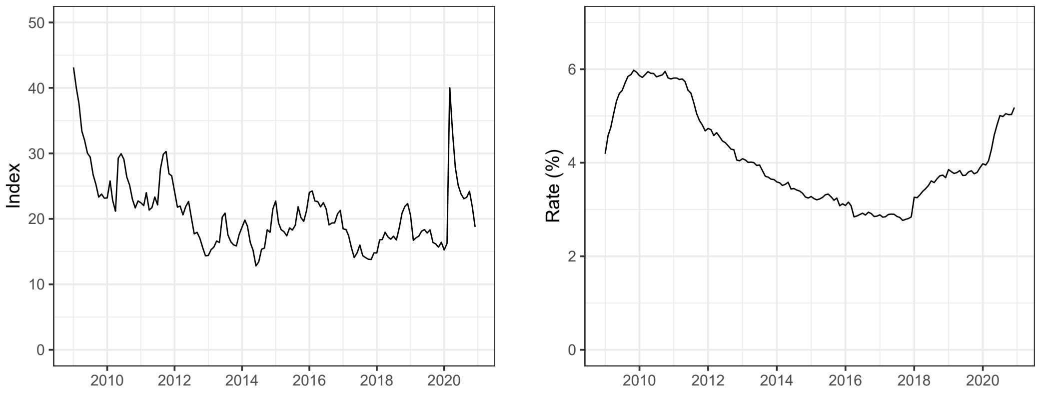
2.3.2 Risk measures

As shown in Figure 1, both aggregate risk perceptions in the South African financial markets and perceptions of bank credit risk are also expected to affect bank interest rates. We capture the former using the South African Volatility Index (SAVI) Top 40 option-implied equity volatility index for South Africa. To capture the latter, in the absence of a liquid market for South African single-name credit default swaps, we approximate banking sector and bank-specific credit risk using the non-performing loans (NPL) ratio, calculated as the ratio of impaired advances to gross loans and advances based on data from the BA survey.

The SAVI Top 40 index is plotted in Figure 8(a). It measures market expectations of the three-month implied market volatility of the FTSE/JSE Top 40 index and acts as a gauge of investor sentiment, as it incorporates the premium for protection against equity market volatility risk. The SAVI Top 40 tends to take values above its well-known counterpart for the S&P 500 index-the VIX -because market risk is generally higher in South Africa than in the US and the VIX measures implied volatility at the one-month horizon, as opposed to the three-month horizon. For much of our sample, equity volatility in South Africa was unusually low, as it was in many other global equity markets. The dramatic spike in the SAVI Top 40 index during the COVID-19 crisis is consistent with a significant increase in investor fear at that time, at levels similar to those last seen during the GFC.

The sector-wide NPL ratio is plotted as a percentage in Figure 8(b). Because loans are only classified as non-performing after a period of delinquency, the NPL ratio evolves relatively gradually. It reaches a peak in 2009 as a result of the GFC before trending downward on a sustained basis until 2018. The increase in the NPL ratio at this time in part reflects the impact of the implementation of IFRS 9, which requires earlier recognition of impairment losses based on a forward-looking view of macroeconomic developments (see South African Reserve Bank 2018a for further detail). The subsequent slowdown in the economy is also naturally reflected in an increase in loan impairments.

Figure 8: Risk Measures



(a) SAVI Top 40 volatility index

(b) Non-performing loans

2.3.3 Liquidity measures

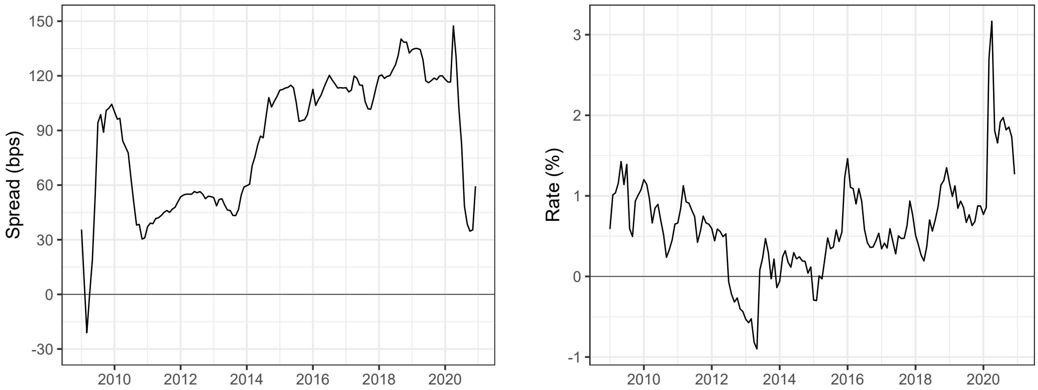
Liquidity premia affect bank interest rates directly, as shown in Figure 1. We control for variations in liquidity affecting South African banks in two ways. First, we construct a liquidity spread proxy as the sum of the spread between the three-month JIBAR and the repo rate, the 12-month NCD spread over an equivalent swap rate and a volume adjustment that accounts for an immediacy premium applying to large trades. The liquidity spread is plotted in Figure 9(a). The plot reveals that liquidity pressures in the South African money market have been steadily rising over most of our sample period. Despite lower short-term interest rates in the latter part of our sample, market liquidity premia rose in response to a combination of credit considerations, particularly related to a worsening fiscal position and increased competition for liquid assets and stable funding among commercial banks as a result of the Basel 3 liquidity regulations. A notable spike occurs at the start of the COVID-19 crisis, but it is rapidly tamed by a combination of expansionary policies in South Africa and around the world.

Second, to control for variations in the term premia embedded in South African government bond yields, we include an estimate of the five-year term premium obtained following the approach of Adrian et al. (2013).[11] The role of the term premium in our analysis is twofold. On the one hand, the term premium conveys information on liquidity and duration risk in a manner that complements the liquidity premium described above. Second, it embeds macroeconomic and sovereign credit risk premia, as well as an inflation risk premium. This allows us to control for the effect of the gradual worsening of the perceived creditworthiness of the South African sovereign over the last decade. Figure 9(b) shows that the term premium briefly became negative in 2013 owing to an inversion of the yield curve rooted in expectations of rising short-term

[11] More details of the estimation approach and data used for our estimates can be found in Soobyah and Steenkamp 2020. Our decision to focus on a five-year maturity is motivated by its approximate consistency with the average maturity of long-term wholesale funding and weighted average lending duration over the sample.

rates and that it has been on an upward trend since, with spikes around episodes of heightened South Africa-specific risk, such as the dismissal of Finance Minister Nene in late 2015.

Figure 9: Liquidity measures



(a) Liquidity spread

(b) Five-year Treasury term premium

2.3.4 Bank interest margins

To account for the observation that the margins between key bank interest rates and the policy rate changed in the period after the GFC (notably lending margins typically increased), we include a measure of bank interest margins computed as the ratio of net interest income to total assets using data from the BA100 survey.[12] Figure 10 shows that our bank interest margin proxy rose steadily after the GFC. This is consistent with banks allowing margins to rise over this time to cushion against higher expected loan losses and/or higher funding costs. The subsequent compression of bank interest margins during the COVID-19 period reflects several phenomena, including the introduction of the Basel 3 requirements requiring increased holdings of government bonds and T-bills, the easing in the policy rate and a higher rate of impairments over the latter part of our sample.

Table 1 provides a range of summary statistics for the aggregate dataset in both level and first difference form, while Table 2 provides a similar summary for the bank-level interest rate series.[13] The table reveals that, in the aggregate, households typically face higher lending rates and receive lower deposit rates than corporations. Unit root testing indicates that the large majority of interest rates are first difference stationary, which is consistent with a large literature that explores cointegration relations among interest rates of different types or different maturities. Several of the control variables are stationary in levels, but it is important to realise that the resulting mix of integration orders is not a problem in our analysis because we make use of a bounds-testing framework that is designed to accommodate combinations of persistent and stationary variables, as discussed in the next section. The bank-level data exhibit much the

[12] Note that, in the BA100 definition, gross loans and advances include bills (such as acceptances, commercial paper, similar acknowledgments of debt) but exclude investments, while credit impairments are not deducted. These data definitions are generally in line with the IFRS financial reporting standard.

[13] Additional summary statistics for the bank-level control variables are available from the authors on request.

same behaviour as the aggregate data, so we do not discuss them separately.

Figure 10: Bank interest margin proxy

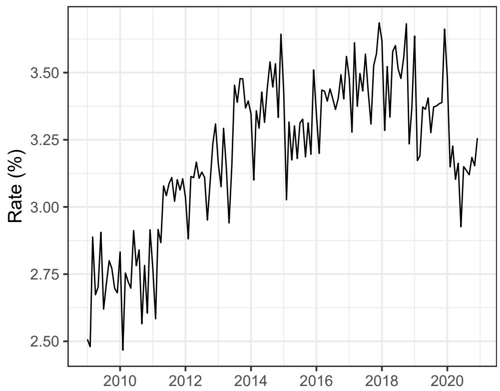


Table 1: Summary statistics for the aggregate dataset

	Levels						First differences					
	Mean	Med	SD	ADF	KPSS	AR(1)	Mean	Med	SD	ADF	KPSS	AR(1)
(a) Household lending and deposit interest rates												
Flexible mortgages	9.041	9.076	1.130	0.128	0.100	0.956	-0.046	0.005	0.218	< 0.01	0.100	0.483
Overdrafts	12.687	12.669	1.424	0.207	< 0.01	0.855	-0.031	0.005	0.253	< 0.01	< 0.01	0.138
Credit cards	16.188	16.201	1.084	0.027	0.100	-0.915	-0.050	-0.024	0.361	< 0.01	0.100	-0.234
Cheque accounts	1.191	0.915	0.899	< 0.01	< 0.01	0.882	-0.029	-0.007	0.153	< 0.01	< 0.01	0.142
Call deposits	5.341	5.142	1.301	0.017	0.091	0.906	-0.048	0.006	0.230	< 0.01	0.091	0.238
(b) Corporate lending and deposit interest rates												
Flexible mortgages	8.437	8.508	0.940	0.036	0.070	0.856	-0.040	-0.001	0.196	< 0.01	0.070	0.163
Overdrafts	9.660	9.291	1.882	0.044	0.023	0.965	-0.069	0.006	0.292	< 0.01	0.023	0.508
Credit cards	11.778	11.733	1.294	0.020	< 0.01	-0.949	-0.057	-0.004	0.478	< 0.01	< 0.01	-0.351
Cheque accounts	2.961	2.845	0.771	< 0.01	< 0.01	0.629	-0.038	-0.008	0.217	< 0.01	< 0.01	0.002
Call deposits	5.684	5.553	1.107	0.020	0.100	0.913	-0.047	0.004	0.215	< 0.01	0.100	0.287
(c) Policy interest rate and control variables												
Repo rate	6.116	6.120	1.187	0.105	0.100	0.979	-0.056	0.000	0.214	< 0.01	0.100	0.677
WACF spread	-51.980	-59.404	35.265	0.168	0.082	0.816	0.717	-0.124	12.681	< 0.01	0.082	0.114
SAVI Top 40 volatility index	20.896	20.000	5.501	0.100	< 0.01	-0.736	-0.170	-0.290	2.781	< 0.01	< 0.01	-0.011
Non-performing loans	4.114	3.819	1.013	0.960	< 0.01	0.950	0.007	-0.001	0.105	< 0.01	< 0.01	0.469
Liquidity spread	85.508	97.983	35.639	0.454	< 0.01	0.982	0.166	0.409	9.344	< 0.01	< 0.01	0.486
Five-year term spread	0.626	0.585	0.602	0.037	0.013	0.807	0.005	-0.005	0.295	< 0.01	0.013	0.049
Bank interest margin proxy	0.320	0.325	0.029	0.739	< 0.01	-0.955	0.001	-0.000	0.017	< 0.01	< 0.01	-0.464

NOTE: 'Mean', 'Med' and 'SD' denote the sample mean, sample median and sample standard deviation. 'ADF' is the p-value of the Augmented Dickey-Fuller test statistic, where the null hypothesis of unit root non-stationarity is tested against the alternative hypothesis of stationarity. 'KPSS' is the stationarity test of Kwiatkowski et al. (1992), in which the null hypothesis is stationarity. 'AR(1)' is the first autocorrelation of the series.

Table 2: Summary statistics for bank-specific interest rates

	ADF	KPSS	AR(1)	ADF	KPPS	AR(1)
(a) Household flexible mortgages						
Bank A	0.090	0.038	0.785	< 0.01	0.100	0.080
Bank B	0.105	0.084	0.932	< 0.01	0.063	0.312
Bank C	0.062	0.100	0.869	< 0.01	0.093	0.205
Bank D	0.040	0.083	0.890	< 0.01	0.069	0.201
Bank E	0.107	0.049	0.920	< 0.01	0.088	0.309
(b) Corporate flexible mortgages						
Bank A	–	–	–	–	–	–
Bank B	0.070	0.100	0.902	< 0.01	0.087	0.266
Bank C	0.059	0.100	0.873	< 0.01	0.100	0.208
Bank D	0.028	0.082	0.775	< 0.01	0.100	0.073
Bank E	0.024	0.094	0.257	< 0.01	0.080	-0.013
(c) Household call deposits						
Bank A	0.155	< 0.01	0.846	< 0.01	0.021	0.184
Bank B	0.109	< 0.01	0.952	< 0.01	0.048	0.510
Bank C	0.084	0.021	-0.582	< 0.01	0.083	-0.066
Bank D	0.021	0.041	0.985	< 0.01	0.100	0.037
Bank E	0.028	0.1	0.890	< 0.01	0.064	0.233
(d) Corporate call deposits						
Bank A	0.048	0.100	-0.933	< 0.01	0.073	-0.322
Bank B	0.085	0.100	0.984	< 0.01	0.100	0.276
Bank C	0.045	0.100	-0.865	< 0.01	0.100	-0.144
Bank D	0.075	0.100	0.617	< 0.01	0.100	0.038
Bank E	0.073	0.100	0.965	< 0.01	0.081	0.561
(e) Household cheque accounts						
Bank A	< 0.01	0.069	0.000	< 0.01	0.1	0.00
Bank B	< 0.01	< 0.01	0.000	< 0.01	< 0.01	0.00
Bank C	–	–	–	–	–	–
Bank D	< 0.01	0.013	0.00	< 0.01	0.1	0.00
Bank E	< 0.01	< 0.01	0.00	< 0.01	0.1	0.00
(f) Corporate cheque accounts						
Bank A	0.593	0.051	-0.946	< 0.01	0.100	-0.310
Bank B	0.175	< 0.01	0.924	< 0.01	0.100	0.223
Bank C	–	–	–	–	–	–
Bank D	0.051	< 0.01	-0.977	< 0.01	0.100	-0.201
Bank E	0.761	0.1	-0.821	< 0.01	0.100	-0.063
(g) Household overdrafts						
Bank A	0.156	0.081	0.000	< 0.01	0.056	0.247
Bank B	0.485	< 0.01	0.000	< 0.01	0.082	0.109
Bank C	0.042	0.065	0.000	< 0.01	0.012	-0.280
Bank D	0.044	0.012	0.000	< 0.01	0.100	-0.018
Bank E	0.344	< 0.01	0.000	< 0.01	0.083	0.248
(h) Corporate overdrafts						
Bank A	0.066	0.012	0.985	< 0.01	0.038	0.055
Bank B	0.099	0.015	-0.825	< 0.01	0.100	-0.142
Bank C	0.151	< 0.01	-0.949	< 0.01	0.100	-0.460
Bank D	0.023	0.018	-0.124	< 0.01	0.100	-0.003
Bank E	0.042	0.059	0.797	< 0.01	0.072	0.068
(i) Household credit cards						
Bank A	0.039	0.047	0.915	< 0.01	0.079	0.254
Bank B	0.308	0.100	-0.964	< 0.01	0.100	-0.459
Bank C	0.069	0.088	0.884	< 0.01	0.072	0.230
Bank D	0.939	0.100	0.698	< 0.01	0.100	0.064
Bank E	0.104	0.100	-0.951	< 0.01	0.100	-0.507
(j) Corporate credit cards						
Bank A	0.696	< 0.01	0.941	< 0.01	0.100	0.409
Bank B	–	–	–	–	–	–
Bank C	0.599	< 0.01	0.893	< 0.01	0.076	0.212
Bank D	0.563	< 0.01	-0.955	< 0.01	0.100	-0.442
Bank E	0.431	0.022	-0.968	< 0.01	0.100	-0.448

NOTE: See the notes to Table 1. Omitted values reflect data issues detailed in section 4.

3 Empirical framework

We begin by specifying the following equilibrium relationship between the policy interest rate, r_t^p, a given bank interest rate (e.g. the household flexible mortgage interest rate for the ith bank), r_{it}^m, and a set of controls:

$$r_{it}^m = \varphi_i + \beta_{ip} r_t^p + \boldsymbol{\beta}_{im}' \boldsymbol{m}_t + \boldsymbol{\beta}_{if}' \boldsymbol{f}_{it} + u_{it}, \tag{12}$$

where time periods are indexed by $t = 1, 2, \ldots, T$; banks are indexed by $i = \{0, A, B, C, D, E\}$ with $i = 0$ denoting the aggregate banking sector and letters 'A'-'E' denoting banks A-E; Greek letters denote unknown parameters to be estimated; and $u_{it} \sim \left(0, \varsigma_i^2\right)$ is a disturbance term with zero mean and variance ς_i^2. The vector $\boldsymbol{m}_t$ contains three variables that are common to all banks and that control for key aspects of the macroeconomic environment: the SAVI Top 40 volatility index, the liquidity spread and the five-year Treasury term premium. Meanwhile, the vector $\boldsymbol{f}_{it}$ contains three bank-specific controls: the WACF spread, the NPL ratio and our proxy for bank interest margins. Of particular interest is the parameter β_{ip}, which measures the degree of pass-through from the policy interest rate to the market interest rate for bank i in long-run equilibrium, controlling for confounding factors. Long-run interest rate pass-through is complete if $\beta_{ip} \geq 1$ and incomplete if $\beta_{ip} < 1$.

In line with much of the existing literature, the equilibrium relationship (12) is linear and symmetric by assumption. In practice, as noted by Cho et al. (2021), this represents a restriction, as it precludes the possibility of asymmetric or nonlinear behaviour. While the assumption of long-run linearity may be innocuous in many practical settings, it may not offer an appropriate description of interest rate pass-through in South Africa over our sample period. To illustrate the point, consider the widening spread between the aggregate household flexible mortgage interest rate and the repo rate shown in Figure 2. This behaviour is potentially consistent with sign asymmetry, in which rate hikes are passed through to household mortgage interest rates more strongly than rate cuts, although this possibility cannot be evaluated formally without controlling appropriately for confounding factors. Therefore, linearity should not be asserted but should be treated as a testable hypothesis against the alternative of sign asymmetry.

Sign asymmetry can be modelled by introducing a threshold mechanism into (12), whereby positive and negative changes in the policy rate, r_t^p, are allowed to exert a differential impact on the bank interest rate, r_{it}^m. This is simply a momentum threshold mechanism in which the threshold is known *a priori* to take a value of $\Delta r_t^p = 0$. This is the approach adopted in the NARDL model of SYG. The NARDL model is considerably simpler than many alternative regime-switching error correction models. The simplicity of the NARDL model derives from the use of a single known threshold. As a consequence, the NARDL model does not suffer from the Davies identification problem, which can arise in models with estimated thresholds.

Following SYG, we generalise (12) as follows:

$$r_{it}^{m} = \varphi_i + \beta_{ip}^{+} r_t^{p+} + \beta_{ip}^{-} r_t^{p-} + \boldsymbol{\beta}'_{im} \boldsymbol{m}_t + \boldsymbol{\beta}'_{if} \boldsymbol{f}_{it} + v_{it}, \tag{13}$$

where r_t^p is decomposed into $r_t^p = r_0^p + r_t^{p+} + r_t^{p-}$, such that:

$$r_t^{p+} = \sum_{j=1}^{t} \left(\Delta r_j^p \mathbb{I}_{\{\Delta r_j^p > 0\}} \right) \quad \text{and} \quad r_t^{p-} = \sum_{j=1}^{t} \left(\Delta r_j^p \mathbb{I}_{\{\Delta r_j^p \leq 0\}} \right),$$

where $\mathbb{I}_{\{\bullet\}}$ is a Heaviside function taking a value of unity if the condition specified within the braces is satisfied and zero otherwise and where $v_{it} \sim \left(0, \sigma_i^2\right)$ is a mean-zero disturbance term. As in SYG, we assume the initial condition $r_0^p = 0$ without loss of generality. Note that (13) collapses to (12) under the testable hypothesis that $\beta_{ip}^{+} = \beta_{ip}^{-}$.

Following SYG, the asymmetric long-run relationship (13) can be embedded within an asymmetric error correction model as follows:

$$\begin{aligned} \Delta r_{it}^{m} = {} & \phi_i + \rho_i r_{i,t-1}^{m} + \theta_{ip}^{+} r_{i,t-1}^{p+} + \theta_{ip}^{-} r_{i,t-1}^{p-} + \boldsymbol{\theta}'_{if} \boldsymbol{f}_{i,t-1} + \boldsymbol{\theta}'_{im} \boldsymbol{m}_{t-1} \\ & + \sum_{j=1}^{p-1} \gamma_{ij} \Delta r_{i,t-j}^{m} + \sum_{j=0}^{q-1} \left(\pi_{ipj}^{+} \Delta r_{t-j}^{p+} + \pi_{ipj}^{-} \Delta r_{t-j}^{p-} + \boldsymbol{\pi}'_{ifj} \Delta \boldsymbol{f}_{i,t-j} + \boldsymbol{\pi}'_{imj} \Delta \boldsymbol{m}_{t-j} \right) + e_{it}, \end{aligned} \tag{14}$$

from which the long-run parameters of (13) can be recovered as $\beta_{ip}^{+} = -\left(\theta_{ip}^{+}/\rho_i\right)$, $\beta_{ip}^{-} = -\left(\theta_{ip}^{-}/\rho_i\right)$, $\boldsymbol{\beta}_{if} = -\left(\boldsymbol{\theta}_{if}/\rho_i\right)$ and $\boldsymbol{\beta}_{im} = -\left(\boldsymbol{\theta}_{im}/\rho_i\right)$. This is the NARDL($p$,$q$) model. To determine the lag orders, p and q, we follow the general-to-specific approach outlined by Hendry and Nielsen (2007) and Hendry and Krolzig (2001, 2005). The procedure starts with a general model with a maximum lag order of $p = q = 4$. The algorithm starts by eliminating the least-significant variable given a critical value, c_α. The path of successive elimination of least-significant variables is then explored until no variable can be eliminated or a diagnostic test rejects.[14] The last nested model in this process is stored as a terminal equation. This process is then repeated by starting with the next least-significant variable and continues on until all feasible paths are explored. Selection between all possible terminal nodes is then determined by the Akaike information criterion.

The existence of a stable long-run levels relationship can be evaluated using either of the two bounds tests proposed by Pesaran et al. (2001, hereafter PSS). The F_{PSS} test is a non-standard F-test of the joint restriction that all lagged levels terms are jointly insignificant, under which the NARDL model (14) reduces to a model in first differences and there is no long-run relationship. PSS tabulate critical intervals of the F_{PSS} statistic, $[c_0, c_1]$, where the lower bound, c_0, applies if all variables are stationary in levels and the upper bound, c_1, applies if all variables are unit-root non-stationary. Inference can be drawn even if the variables entering the model are of mixed integration orders, provided that $F_{PSS} \notin [c_0, c_1]$.[15] In the same vein,

[14] Our procedure employs the Jarque-Bera, Breusch-Godfrey and Breusch-Pagan-Godfrey diagnostic tests.

[15] In practice, as shown in Tables 1 and 2, the variables entering (13) comprise a mixture of stationary and unit

PSS develop a bounds-testing generalisation of t_{BDM}-test procedure proposed by Banerjee et al. (1998, hereafter BDM), in which the null and alternative hypotheses are $H_0: \rho = 0$ and $H_1: \rho < 0$, where a long-run relationship exists only under the alternative.[16]

SYG show that the long-run symmetry restrictions can be evaluated by testing the null hypothesis $\text{H}_{LR,0}$: $\beta^{+}_{ip} - \beta^{-}_{ip} = 0$ against the two-sided alternative hypothesis $\text{H}_{LR,1}$: $\beta^{+}_{ip} - \beta^{-}_{ip} \neq 0$ using a standard Wald test that follows an asymptotic χ^2_1 distribution. Under $\text{H}_{LR,1}$, pass-through is asymmetric in the long-run and it is straightforward to distinguish between positive ($\beta^{+}_{ip} - \beta^{-}_{ip} > 0$) and negative ($\beta^{+}_{ip} - \beta^{-}_{ip} < 0$) long-run asymmetry. Similarly, additive short-run symmetry can be tested using a standard Wald test with the hypothesis system $\text{H}_{SR,0}$: $\sum_{j=0}^{p-1}\left(\pi^{p+}_{ipj} - \pi^{p-}_{ipj}\right) = 0$ and $\text{H}_{SR,1}$: $\sum_{j=0}^{p-1}\left(\pi^{p+}_{ipj} - \pi^{p-}_{ipj}\right) \neq 0$.

SYG also show that the cumulative dynamic multiplier effects associated with unit changes in r^{p+}_t and r^{p-}_t on r^m_{it} can be obtained recursively from the parameters of the NARDL model. For notational convenience, let the cumulative dynamic multipliers evaluated over the h-period horizon be denoted $D^{+}_{ih} = \sum_{j=0}^{h} \partial r^m_{i,t+j} / \partial r^{p+}_t$ and $D^{-}_{ih} = \sum_{j=0}^{h} \partial r^m_{i,t+j} / \partial r^{p-}_t$. Plots of the cumulative dynamic multiplier effects provide an elegant visualisation of the traverse from the initial equilibrium position to the new equilibrium position following a rate hike or a rate cut.

4 Estimation results

4.1 Pass-through into lending interest rates

4.1.1 Flexible mortgage interest rates

We begin by analysing the pass-through of repo rate hikes and cuts into flexible mortgage interest rates. Table 3 provides a summary of the estimated long-run pass-through relationships at the aggregate level and the bank level for both the household and corporate sectors. The corresponding cumulative dynamic multipliers are plotted in Figures 11 and 12.

First, consider household mortgages. Based on the sector-wide data, all else equal, we find that the aggregate household mortgage interest rate increases by 1.249% in the long run following a 1% rate hike, and falls by 0.819% in the long run following a 1% rate cut. The difference between these two estimates is statistically significant at the 1% level and suggests that long-run pass-through to aggregate household mortgage interest rates is asymmetric, with rate cuts being passed through incompletely, while there is some excess sensitivity to rate hikes. This pattern is clearly visible in Figure 11(a), which also reveals that the adjustment process is relatively rapid with respect to both rate hikes and rate cuts, albeit subject to a volatile adjustment path in the case of rate cuts.

root non-stationary processes. Pesaran and Shin (1998) and PSS stress that there is no reason that equilibrium relationships cannot exist among balanced combinations of persistent and stationary time series.

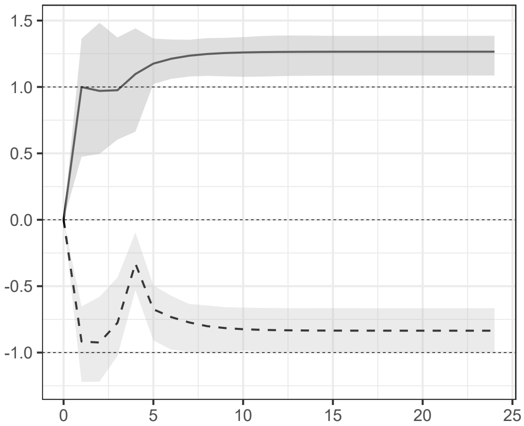
[16] SYG recommend selecting the critical values for both the F_{PSS} and t_{BDM} tests on the basis of the number of included explanatory variables *prior* to their decomposition into partial sums (i.e. counting r^{p+}_{t-1} and r^{p-}_{t-1} as a single explanatory variable).

Table 3: Long-run repo rate pass-through into flexible mortgage interest rates

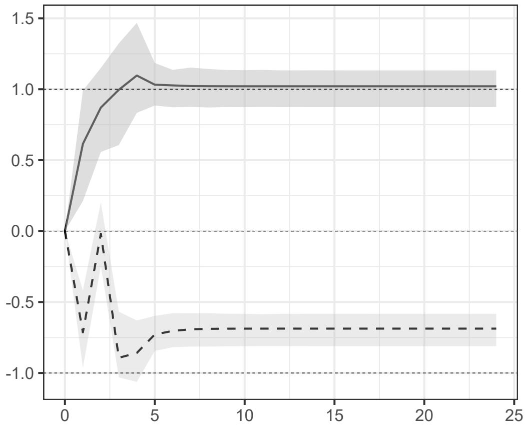
	Long-run pass-through		Complete pass-through		Symmetric	Long-run relationship		Fit	
	Hike	Cut	Hike	Cut	pass-through	PSS	BDM	$\overline{R}^2$	AIC
(a) Aggregate									
Household	1.249***	0.819***	0.999	0.000***	0.000***	6.865***	-7.145***	0.718	-149.709
Corporate	1.235***	0.861***	0.932	0.007**	0.010**	6.580***	-7.225***	0.655	-195.880
(b) Bank A									
Household	1.011**	0.681***	0.575	0.000***	0.000***	18.628***	-10.018***	0.825	-150.680
Corporate	–	–	–	–	–	–	–	–	–
(c) Bank B									
Household	1.086***	1.045***	0.889	0.905	0.586	5.729***	-6.620***	0.595	-97.777
Corporate	1.020***	0.965***	0.918	0.894	0.183	10.640***	-7.089***	0.810	-181.400
(d) Bank C									
Household	0.988***	0.864***	0.448	0.005***	0.254	2.026	-4.159***	0.863	-249.191
Corporate	0.977***	0.892***	0.312	0.004***	0.163	9.322***	-4.866***	0.888	-276.824
(e) Bank D									
Household	1.167***	0.826***	0.901	0.007***	0.029**	6.161***	-5.521***	0.470	97.301
Corporate	1.420***	1.338***	0.643	0.731	0.939	3.520*	-3.024*	0.558	-94.064
(f) Bank E									
Household	1.227***	0.782**	1.000	0.000***	0.000***	11.987***	-7.502***	0.792	-194.767
Corporate	1.164***	1.047***	0.951	0.769	0.144	11.464***	-6.955***	0.602	-44.829

NOTE: Estimates of the long-run pass-through parameters with respect to rate hikes and rate cuts are reported under the heading 'long-run pass-through'. The column headed 'complete pass-through' reports the p-value associated with a test of the hypothesis of complete long-run pass-through (i.e. pass-through coefficient greater than or equal to one) versus the one-tailed alternative hypothesis of incomplete pass-through. The column headed 'symmetric pass-through' reports the p-value associated with a test of the null hypothesis that the long-run pass-through coefficients for rate hikes and rate cuts are equal versus the two-tailed alternative that they are unequal. The values of the PSS F-statistic and the BDM t-statistic are reported in the columns headed 'PSS' and 'BDM', while the adjusted R^2 and the Akaike information criterion are reported in the two rightmost columns. Asterisks denote statistical significance at the 1% (***), 5% (**) and 10% (*) significance levels.

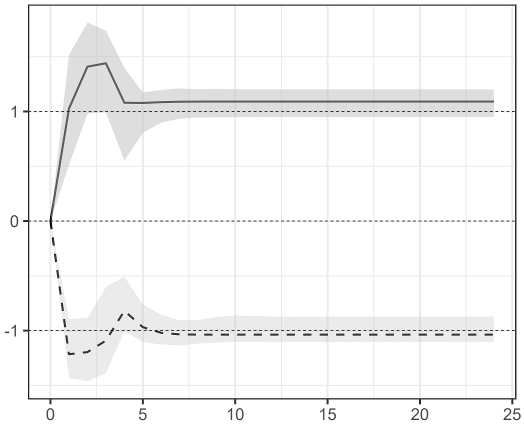
Figure 11: Cumulative dynamic multipliers showing pass-through of a 1% repo rate hike/cut into household flexible mortgage interest rates



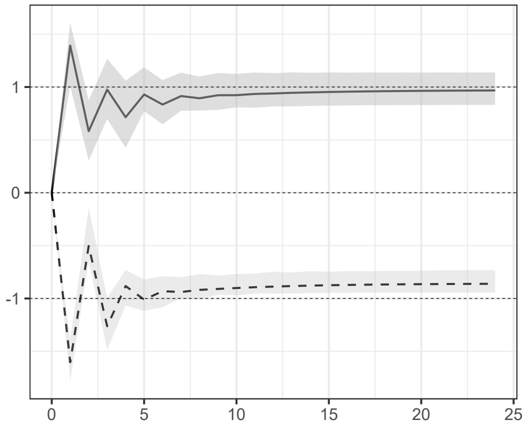
(a) Aggregate



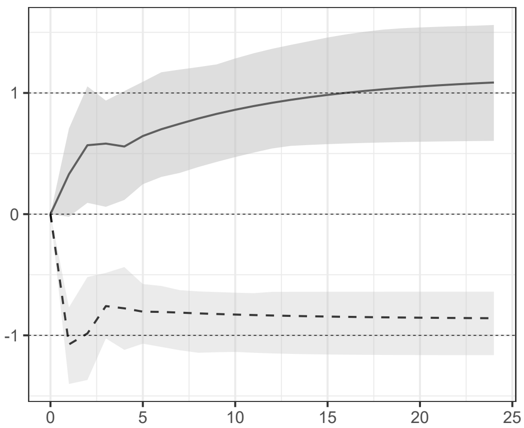
(b) Bank A



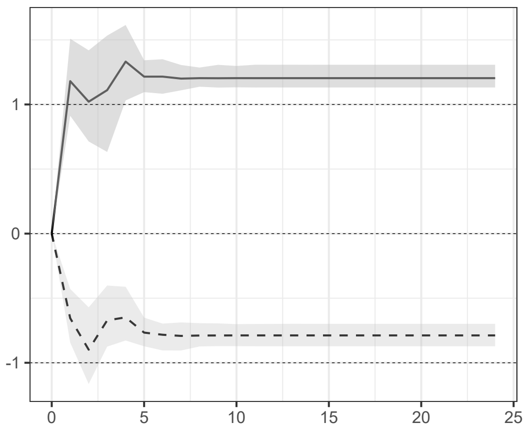
(c) Bank B



(d) Bank C



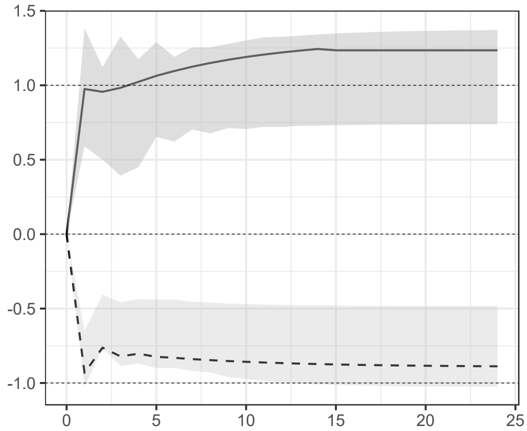
(e) Bank D



(f) Bank E

NOTE: The horizontal axis indicates the time horizon in months, with the period immediately prior to the shock being denoted period zero. The vertical axis reports the cumulative change in the specified market interest rate following a 1% repo rate hike (solid line) or cut (dashed line). The unit of measurement is percent. 95% bootstrap confidence intervals are reported in each panel.

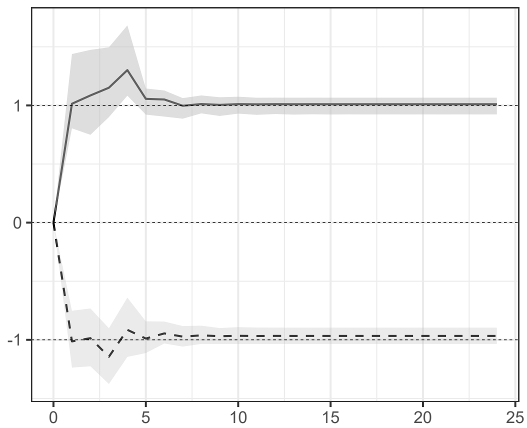
Figure 12: Cumulative dynamic multipliers showing pass-through of a 1% repo rate hike/vut into corporate flexible mortgage interest rates



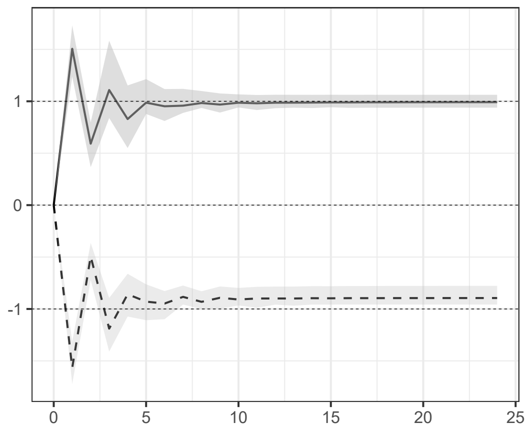
(a) Aggregate

EXCLUDED: DATA DISCONTINUITY

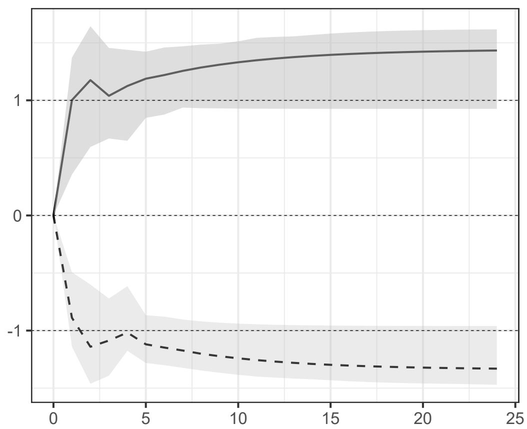
(b) Bank A



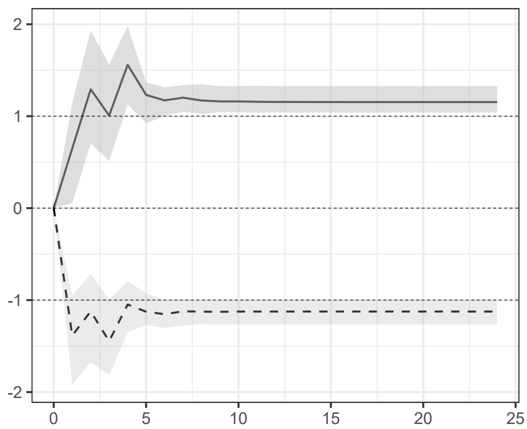
(c) Bank B



(d) Bank C



(e) Bank D



(f) Bank E

NOTE: See the notes to Figure 11.

It is well known that interest rate pass-through estimates based on aggregate data are susceptible to the criticism that aggregation over dissimilar banks may obscure relevant detail, including bank-level heterogeneities in the speed, pattern and extent of interest rate pass-through (see Banerjee et al. 2013 for a similar discussion). Consequently, before attempting to interpret the aggregate findings discussed above, it is interesting to consider the bank-level estimates of pass-through into household flexible mortgage interest rates reported in Table 3 and Figure 11(b)-(f). While it is clear that there is some heterogeneity across banks, the general pattern observed using aggregate data appears to hold at the disaggregate level. For all five banks in our sample, rate hikes are passed through completely and rapidly. However, the bootstrap intervals reported in Figure 11 reveal that only Banks D and E exhibit statistically significant excess long-run pass-through with respect to rate hikes. In the case of rate cuts, all banks except Bank B pass through repo rate cuts incompletely in a manner that is statistically significant at at least the 5% level. Figure 11(b)-(f) reveals that, for several banks, the adjustment process following a rate cut exhibits a similar volatile/overshooting pattern as observed in the aggregate case, which may reflect uncertainty among banks regarding the expected duration of monetary policy easing cycles. There are several possible explanations for our finding of a volatile adjustment of household flexible mortgage rates in the first few months after a repo rate cut. While most existing loans will be repriced immediately because of their direct link to the prime rate, there will be gradual compositional changes to loan books and pricing of new loans.[17] A small proportion of mortgage loans are also linked to JIBAR and may reset only monthly or quarterly. These changes will be affected by banking sector competition and risk appetite and changes in the credit spreads of bank assets and liabilities. Over the recent cutting cycle, for example, it may be that banks gradually added to the risk premia built into loan pricing.

While the bank-level results are generally similar to the aggregate results, this exercise highlights the value of bank-level analysis, because it indicates that excess sensitivity to rate hikes is not a widespread phenomenon (two out of the five largest banks), in contrast to the results based on aggregate data. While one would not expect to observe excess pass-through of rate hikes in the banking sector at large, an individual bank may engage in such behaviour for a variety of reasons, including revisions to the composition of its loan book, for instance (e.g. a change in the average duration of its loans or a strategic decision to re-weight its mortgage portfolio toward riskier market segments). By contrast, our bank-level results indicate that a majority of top banks have passed repo rate cuts through to household mortgage rates incompletely over our sample period. This finding is consistent with the widening spread between flexible mortgage interest rates and the repo rate over our sample period documented in Figure 2. Recall that our models control for a range of confounding factors, so our findings suggest that banks have engaged in asymmetric pass-through even after controlling for factors such as the increase in bank funding spreads and liquidity spreads observed over our sample period. This suggests that banks may be extracting a rent from households during cutting cycles,

[17] For example, some banks provide staff loans (comprising a small proportion of their total loan book) that reprice with a slight delay to repo rate changes.

when the interest elasticity of loan demand among bank-dependent borrowers is depressed.[18]

Next, we consider pass-through into corporate flexible mortgage interest rates. The estimation results based on aggregate data are very similar to those obtained for household mortgages using aggregate data, although there is greater uncertainty in estimation, as reflected in the wider confidence intervals around the cumulative dynamic multipliers in Figure 12(a). This is somewhat surprising, as corporate mortgages differ from household mortgages in several respects; notably, the magnitude of corporate loan facilities is often larger, and this affords corporate borrowers greater negotiating power, corporate clients have access to competing funding sources not available to households (e.g. the market for corporate paper) and corporate borrowers are likely to be better informed than household borrowers and may face lower information processing and switching costs, especially on a per-rand-borrowed basis. Consequently, if weak competition and non-trivial switching costs contribute to the asymmetric pass-through observed for household mortgages, then we would expect to see less evidence of asymmetry in the case of corporate mortgages. This is exactly what we see in the bank-level models in Table 3 and Figure 12. Aside from Bank A, which is excluded owing to a data discontinuity, pass-through is symmetric in all cases and complete for all banks other than Bank C, where completeness is rejected in the case of rate cuts. The comparison between the aggregate and bank-level results in this case indicates that aggregation bias is a significant problem, as reliance on aggregate data would lead one to draw an inappropriate conclusion regarding the nature of pass-through into corporate mortgage interest rates at the bank level. This once again highlights the value of working with bank-level data whenever possible.

Before we move on to other classes of loans, it is interesting to consider whether our results would change materially if we were unable to control for bank funding costs. This is an important exercise, because it is widely believed that funding costs no longer follow policy rates to the degree that they once did (e.g. Illes et al., 2019) and many existing studies either omit bank funding costs altogether or use proxies that suffer from a range of shortcomings. In Table 4, we replicate the analysis from Table 3, having excluded all bank funding cost variables from the NARDL models (i.e. both the one-period-lagged WACF spread and the first-differenced WACF spread terms). This exerts a marked effect both on the estimation results themselves and also on their interpretation. Not only does it compromise the fit of the model, often severely, but it also weakens evidence of cointegration. The likelihood ratio test for the adequacy of the model without funding cost variables indicates that the larger model is preferred for the aggregate data for both household and corporate mortgages and also for the bank-level data in eight out of nine cases at at least the 5% level of significance. The omission of funding spread data weakens the evidence of incomplete pass-through of rate cuts, as well as the evidence of asymmetric long-run pass-through. Not only does this exercise highlight the importance of controlling for funding spreads in our models but it also suggests that the results of other

[18] Another potential explanation for asymmetry in pass-through could be the initial treatment of home loans subject to payment holidays during the 2019/2020 monetary easing cycle as non-performing loans by some banks, leading to lower implied yields on those loans (without a commensurate decrease in interest income as interest may not have been suspended on these accounts).

studies that do not adequately control for bank funding costs should be treated with caution.

Table 4: Long-run repo rate pass-through into flexible mortgage interest rates, excluding controls for bank funding costs

	Long-run pass-through		Complete pass-through		Symmetric	Long-run relationship		Fit		
	Hike	Cut	Hike	Cut	pass-through	PSS	BDM	$\overline{R}^2$	AIC	LR
(a) Aggregate										
Household	1.364**	1.041*	1.000	0.858	0.002***	5.155**	-3.933***	0.643	-118.872	41.832***
Corporate	1.091*	0.950	0.727	0.267	0.343	2.446	-3.823***	0.556	-163.829	54.811***
(b) Bank A										
Household	1.217***	0.864**	1.000	0.000***	0.000***	14.929***	-8.021***	0.808	-139.321	18.298
Corporate	–	–	–	–	–	–	–	–	–	–
(c) Bank B										
Household	1.086**	0.997***	0.905	0.448	0.183	8.721***	-5.047***	0.532	-84.846	31.046***
Corporate	1.016*	0.976***	0.611	0.155	0.492	10.334***	-4.968***	0.753	-150.868	26.566**
(d) Bank C										
Household	1.04***	0.915***	0.636	0.0632*	0.391	1.292	-2.053	0.842	-234.305	28.504***
Corporate	1.001**	0.949***	0.522	0.021**	0.227	3.055	-3.406**	0.869	-260.328	32.789***
(e) Bank D										
Household	1.441***	1.422***	0.735	0.841	0.976	1.936	-3.174*	0.087	103.994	23.393**
Corporate	1.358***	1.68***	0.747	0.979	0.522	2.302*	-0.916	0.490	-76.347	31.872***
(f) Bank E										
Household	1.329**	0.880***	1.000	0.000***	0.000***	4.900*	-4.396	0.769	-183.477	22.946**
Corporate	0.919*	0.952**	0.130	0.146	0.654	14.278***	-4.353	0.533	-27.280	27.341**

NOTE: The table reports a replication of Table 3 with all bank funding cost variables excluded from the NARDL specification. The column headed 'LR' reports a likelihood ratio test statistic evaluating the adequacy of the model without funding cost variables relative to the larger model including funding cost variables. See the notes to Table 3 for additional details.

4.1.2 Overdraft interest rates

Table 5 presents long-run pass-through estimates for household and corporate overdraft interest rates.[19] For households, at the sector-wide level, we find that repo rate hikes are passed through completely, while rate cuts are passed through incompletely at the 5% significance level, with the long-run pass-through coefficients with respect to a 1% change in the repo rate taking values of 0.891% and 0.589%. Owing to the uncertainty in estimation, the long-run symmetry restriction cannot be rejected. Turning to the bank-level data, the evidence favours complete and symmetric long-run pass-through, with completeness only rejected once in the case of rate cuts for Bank B.[20]

[19] To conserve space, we do not plot cumulative dynamic multiplier effects for any case other flexible mortgage interest rates-they are available from the authors on request.

[20] The large pass-through coefficient associated with rate hikes for Bank E may be driven by a period between 2018 and 20199, during which the household overdraft interest rates reported by Bank E display markedly different dynamics than the other four banks in our sample, rising appreciably in 2018 and then plateauing, while the rates provided by other banks are either stable or falling at this time.

Table 5: Long-run repo rate pass-through into overdraft interest rates

	Long-run pass-through		Complete pass-through		Symmetric	Long-run relationship		Fit		
	Hike	Cut	Hike	Cut	pass-through	PSS	BDM	$\overline{R}^2$	AIC	LR
(a) Aggregate										
Household	0.891***	0.589***	0.328	0.005***	0.034**	4.316**	-4.703***	0.530	-81.621	22.112**
Corporate	1.509***	1.596***	0.986	1.000	0.693	7.998***	-4.718***	0.473	99.592	26.698**
(b) Bank A										
Household	0.993***	0.601***	0.495	0.152	0.021**	2.010	-4.688***	0.354	-85.262	8.091
Corporate	0.351***	0.701***	0.011**	0.071*	0.052*	3.894*	-4.456***	0.395	-96.760	23.622**
(c) Bank B										
Household	0.887***	0.649***	0.396	0.022**	0.068*	3.788*	-5.298***	0.570	-17.958	37.758***
Corporate	1.080***	1.001***	0.658	0.505	0.785	3.541*	-6.468***	0.480	172.350	81.801***
(d) Bank C										
Household	0.887***	1.020***	0.120	0.576	0.078*	4.382**	-6.244***	0.763	-205.184	18.853*
Corporate	0.861***	1.307***	0.354	0.754	0.298	5.320**	-5.019***	0.429	119.447	49.997***
(e) Bank D										
Household	1.025***	1.123***	0.547	0.856	0.642	4.326*	-4.723***	0.472	-26.383	135.933***
Corporate	0.791***	1.171***	0.049**	0.997	0.019**	5.883***	-5.721**	0.733	-239.156	53.908***
(f) Bank E										
Household	2.010***	1.062**	0.959	0.565	0.000***	3.611*	-3.882***	0.508	-15.378	20.426*
Corporate	0.438***	0.442***	0.040**	0.019**	0.509	2.852	-3.117*	0.478	-23.779	30.656***

NOTE: See notes to Tables 3 and 4.

Pass-through into corporate overdraft interest rates differs in several notable respects. First, using aggregate data, we find evidence of significant excess sensitivity with respect to both rate hikes and rate cuts, with a 1% hike/cut in the repo rate being associated with a 1.509/1.596% increase/decrease in the aggregate corporate overdraft rate. However, this finding is not substantiated by the bank-level results, indicating that it may result from aggregation bias. At the bank-level, the long-run pass-through coefficients are considerably smaller-for rate hikes, we obtain point estimates of the pass-through coefficients in the range 0.351 to 1.080, while the corresponding range for rate cuts is 0.442 to 1.307. The hypothesis of complete long-run pass-through is rejected at the 5% level of significance with respect to rate hikes for three out of five banks and with respect to rate cuts for two out of five banks at at least the 10% level. Likewise, long-run symmetry is rejected for two out of five banks, with rate cuts being passed through more strongly than rate hikes in both cases. Lastly, as in the case of mortgage interest rate pass-through, the LR test results indicate that it is important to control for bank funding cost spreads in the estimation of both household and corporate overdraft equations.

The asymmetric pass-through to corporate overdrafts, whereby rate cuts are passed through more strongly than rate hikes, is puzzling. However, overdrafts may change between positive and negative balances during a specific month, which may impact the overall net rate (yield) banks submit to SARB. As with flexible mortgage rates, another explanation could be changes in the composition of banks' overdraft books, as larger clients may be able to negotiate more favourable pricing during tightening cycles.

Overall, our results suggest that policy rate changes tend to be passed through completely to household overdraft rates but may be passed through incompletely to corporate borrowers, at least by some banks. In addition, there is evidence that some banks adjust corporate overdraft rates asymmetrically to favour rate cuts over rate hikes. This is consistent with banks electing to smooth corporate overdraft interest rates relative to household overdraft rates. There are several possible reasons for this, including the larger relative magnitude of corporate overdraft facilities, which lowers per-rand switching and informational costs; the prevalence of relationship banking among corporate borrowers; and the greater implicit security offered by corporate borrowers. In addition, banks may find it easier to assess the credit risk of corporate borrowers, such that corporate overdrafts may be viewed by banks as less risky than household overdrafts and may therefore be subject to lower risk premia.

4.1.3 Credit card interest rates

Table 6 shows the long-run pass-through estimates into both household and corporate credit card interest rates. Using aggregate data, our model indicates that repo rate hikes and cuts are passed through to household credit card interest rates symmetrically but incompletely, with long-run pass-through parameters of 0.609 and 0.675, respectively. This indicates that household credit card interest rates are sticky in the aggregate and are not strongly affected by SARB's interest rate policy. However, as in the case of overdrafts discussed above, this finding is not substantiated by bank-level analysis, where we find that complete pass-through is only rejected for two out of five banks in the case of rate cuts and for no banks in the case of rate hikes, while long-run symmetry is rejected for three out of five banks, with two of those banks passing rate cuts through to credit card interest rates more strongly than rate hikes.[21]

For corporate credit cards, estimation using aggregate data indicates that pass-through is symmetric and complete, exhibiting excess sensitivity to changes in the repo rate. In this case, bank-level analysis provides partial support of the aggregate results. For three out of four banks, long-run pass-through is complete with respect to both rate hikes and rate cuts and it is symmetric for two of these banks, with the last (Bank A) passing on rate hikes more strongly than rate cuts.[22] Bank E is a notable outlier, with incomplete pass-through regardless of the sign of the repo rate change. Interestingly, Bank E is the only bank for which controlling for funding costs does not improve the model for either household or corporate credit card interest rates, as is the case for the model for the aggregate household credit card interest rate. In all other cases, the model including funding costs is preferred.

[21] Bank A has recorded several drops in its household credit card interest rates over our sample period that are large relative to the corresponding adjustments made by other banks and that may explain the large estimated pass-through coefficient associated with repo rate cuts. Meanwhile, the credit card interest rate data for Bank B is more volatile over much of the sample period than the data for most other banks, which may be related to the large pass-through coefficient associated with repo rate hikes.

[22] Bank B is dropped from the sample due to a large number of missing observations in the first half of the sample period.

Table 6: Long-run repo rate pass-through into credit card interest rates

	Long-run pass-through		Complete pass-through		Symmetric	Long-run relationship		Fit		
	Hike	Cut	Hike	Cut	pass-through	PSS	BDM	$\bar{R}^2$	AIC	LR
(a) Aggregate										
Household	0.609***	0.675***	0.000***	0.000***	0.518	11.993***	-7.246***	0.521	20.719	17.744
Corporate	1.357***	1.604***	0.921	0.999	0.009***	4.970**	-7.546***	0.524	110.595	45.349***
(b) Bank A										
Household	0.668***	2.113***	0.211	0.999	0.000***	5.147**	-4.161***	0.758	-110.128	22.355**
Corporate	1.238***	0.907***	0.838	0.276	0.041**	4.970**	-6.158***	0.520	-194.875	47.051***
(c) Bank B										
Household	2.231***	0.404***	1.000	0.005***	0.000***	14.139***	-6.584***	0.557	165.111	49.391***
Corporate	–	–	–	–	–	–	–	–	–	–
(d) Bank C										
Household	1.000***	1.132***	0.500	0.911	0.658	3.546*	-3.165*	0.654	-179.866	27.882**
Corporate	0.981***	0.931***	0.483	0.404	0.887	3.729*	-3.545**	0.699	-119.352	23.350**
(e) Bank D										
Household	0.772***	1.423***	0.187	0.973	0.000***	5.190**	-5.347***	0.603	-174.800	19.091***
Corporate	1.194***	1.390***	0.906	1.000	0.057*	5.087**	-7.028***	0.628	97.848	32.810***
(f) Bank E										
Household	0.877***	0.625***	0.250	0.001***	0.040**	9.159***	-7.323***	0.558	255.181	17.172
Corporate	0.941***	0.373***	0.000***	0.000***	0.000***	8.351***	-6.174***	0.504	252.275	13.377

NOTE: See notes to Tables 3 and 4.

The overall picture arising from Table 6 is that repo rate changes tend to be passed through completely to bank-level credit card interest rates for both households and firms, while evidence of asymmetry is mixed. The evidence suggests that there is considerable heterogeneity across banks, which may reflect strategic behaviour (e.g. passing on rate cuts more strongly than rate hikes to gain market share) or market segmentation (e.g. banks targeting particular market segments and pricing their credit card offerings accordingly). An interesting aspect of our results is that we do not find any systematic difference between pass-through to household and corporate credit card interest rates, despite the differences between household and corporate borrowers discussed above. One explanation for this phenomenon is that corporate credit card balances account for just 0.3% of total loans to corporate customers, so there may be little competition among banks in this market segment, limiting the scope for negotiation on the part of corporate borrowers.

4.2 Pass-through into deposit interest rates

Pass-through into deposit interest rates is a particularly important issue in South Africa, because South Africans hold large deposit balances despite the low and sometimes sticky interest rates on offer and banks make extensive use of deposits as a cheap source of local-currency funding, a behaviour that became more pronounced post-GFC. Deposit rates are typically set as a mark-down to funding costs, with offsetting remuneration to reflect the value of deposits as a source of funding for banks.

4.2.1 Cheque account interest rates

First consider long-run pass-through into aggregate household and corporate cheque account interest rates, results are reported in Table 7. For both household and corporate depositors, we find evidence of weak pass-through with respect to both repo rate hikes and cuts. For household cheque accounts, a 1% repo rate hike is reflected in a 0.455% increase in the aggregate cheque account interest rate, while the corresponding figure for a rate cut is just 0.356%. Likewise, for corporate cheque accounts, the two pass-through coefficients are 0.547% and 0.509%. Household cheque account pass-through is estimated to be slightly lower than for corporates, which may reflect their proximity to an effective zero lower bound from mid-2012, which left banks little room to cut household cheque account rates over much of our sample period. While pass-through into aggregate cheque account interest rates appears to be symmetric in the long-run, the hypothesis of complete long run pass-through is rejected at at least the 10% level in all four cases. These findings are consistent with the interest rate dynamics visible in Figure 5, where cheque account interest rates exhibit pronounced stickiness relative to the repo rate.

Table 7: Long-run repo rate pass-through into cheque account interest rates

	Long-run pass-through		Complete pass-through		Symmetric	Long-run relationship		Fit		
	Hike	Cut	Hike	Cut	pass-through	PSS	BDM	$\overline{R}^2$	AIC	LR
(a) Aggregate										
Household	0.455***	0.356***	0.000***	0.000***	0.424	11.931**	-5.179***	0.515	-216.740	24.821**
Corporate	0.547**	0.509***	0.062*	0.002***	0.854	3.629*	-5.211***	0.408	-29.810	64.465***
(b) Bank A										
Household	0.472***	0.388***	0.000***	0.000***	0.123	8.676***	-8.243***	0.430	-75.649	37.391***
Corporate	0.351***	0.701***	0.011**	0.071*	0.052*	3.894*	-4.331***	0.395	-96.760	67.653***
(c) Bank B										
Household	0.361***	0.812***	0.012**	0.029**	0.008***	4.544**	-4.888***	0.494	-86.543	57.092***
Corporate	0.586***	0.819***	0.002***	0.005***	0.051*	7.499**	-5.736***	0.594	102.466	83.062***
(d) Bank C										
Household	–	–	–	–	–	–	–	–	–	–
Corporate	–	–	–	–	–	–	–	–	–	–
(e) Bank D										
Household	0.336***	0.422***	0.038**	0.000***	0.787	6.520***	-4.268***	0.634	-296.595	106.491***
Corporate	0.357***	0.723***	0.019**	0.016**	0.008***	3.677*	-3.098*	0.481	61.778	15.170
(f) Bank E										
Household	0.931***	1.892***	0.454	0.986	0.000***	4.669**	-3.796**	0.455	-509.102	35.933***
Corporate	0.205***	0.149***	0.000***	0.000***	0.068*	4.189**	-4.075***	0.424	-272.347	47.325***

NOTE: See notes to Tables 3 and 4.

Bank-level analysis provides a generally similar picture to the aggregate results. Bank C is dropped from the analysis because it has no household cheque account interest rate data and it only has corporate cheque account data from 2017 onward. Of the remaining eight bank-level regression models reported in Table 7, complete long-run pass-through is rejected at the 10% level or higher in seven cases with respect to rate hikes and also with respect to rate cuts. Interestingly, long-run symmetry is rejected on three occasions, with rate cuts being passed through more strongly than rate hikes in each case.

Lastly, it is worthwhile to note that controlling for the bank funding spread is also important when modelling interest rate pass-through into deposit rates. For both aggregate models and for seven out of eight bank-level models reported in Table 7, the LR test rejects the adequacy of the model excluding bank funding cost variables at at least the 5% level. In practice, the exclusion of funding cost variables changes inference regarding the completeness and symmetry of long-run pass-through for several banks and reduces the fit of the models severely, with the adjusted R^2 falling by as much as 88% (detailed results available on request).

4.2.2 Call deposit interest rates

Call deposit interest rates for both households and corporates are less sticky than cheque account interest rates and track the repo rate more closely, as seen in Figure 6. The spread between call deposit rates and the the repo rate has narrowed appreciably over our sample, becoming positive during the COVID-19 crisis. This narrowing is more marked for household than corporate call deposits, because household call deposits were remunerated at a lower rate than corporate call deposits early in our sample period. This phenomenon partly reflects greater competition for call deposits among banks driven by the impact of the stable funding requirements under Basel 3, which encourage banks to attract stable deposits. Household deposits are generally considered more stable than corporate deposits, which may explain why the spread on household call deposits has reduced proportionately more than the spread for corporate call deposits. Based on these observations, a reasonable ex ante expectation is that long-run pass-through into call deposit rates should be more complete than in the case of cheque account rates. We find that this is the case, both using aggregate data and also bank-level data.

Table 8: Long-run repo rate pass-through into call deposit interest rates

	Long-run pass-through		Complete pass-through		Symmetric	Long-run relationship		Fit		
	Hike	Cut	Hike	Cut	pass-through	PSS	BDM	$\overline{R}^2$	AIC	LR
(a) Aggregate										
Household	1.383***	1.042***	0.992	0.667	0.012**	4.330**	-5.299***	0.602	-124.933	53.461***
Corporate	0.711***	0.732***	0.000***	0.000***	0.705	14.068***	-5.212***	0.632	-148.014	48.896***
(b) Bank A										
Household	0.778***	0.220***	0.033**	0.000***	0.000***	9.387***	-6.442***	0.722	-201.900	31.719***
Corporate	0.351**	0.701***	0.011**	0.071*	0.002***	3.894*	-8.105***	0.395	-96.760	63.893***
(c) Bank B										
Household	1.265***	0.898***	0.874	0.220	0.047**	4.841**	-3.287**	0.747	-255.077	10.501
Corporate	0.768***	1.109***	0.290	0.698	0.023***	4.602**	-3.950***	0.545	-37.482	12.001
(d) Bank C										
Household	1.254***	0.873***	0.929	0.102	0.043**	4.695**	-7.164***	0.577	-46.990	39.169***
Corporate	1.005***	1.040***	0.511	0.626	0.851	4.182*	-4.131***	0.576	52.244	42.585***
(e) Bank D										
Household	0.789***	1.207**	0.033**	0.995	0.007***	6.167***	-7.508***	0.840	-157.570	235.133***
Corporate	1.195***	1.142***	0.976	0.981	0.560	4.629**	-5.951***	0.667	-125.471	200.870***
(f) Bank E										
Household	1.043***	0.891***	0.686	0.077*	0.104	5.367**	-4.857***	0.786	-191.025	16.302
Corporate	1.019***	0.951***	0.751	0.005***	0.207	4.701**	-5.254***	0.952	-447.946	25.577**

NOTE: See notes to Tables 3 and 4.

Using aggregate data, we find that a 1% repo rate hike is associated with a 1.383% increase in household call deposit interest rates and a 0.711% increase in the rate payable on corporate deposits, while the corresponding values for a 1% rate cut are 1.042% and 0.732%. Completeness with respect to rate hikes and rate cuts cannot be rejected at any standard significance level for household call deposits, although long-run symmetry is rejected at the 5% significance level, with rate hikes being passed through more strongly than rate cuts. This is consistent with increased competition among banks for household term deposits discussed above. Meanwhile, completeness is rejected at the 1% level for both rate hikes and rate cuts in the case of corporate call deposits, while symmetry is not rejected.

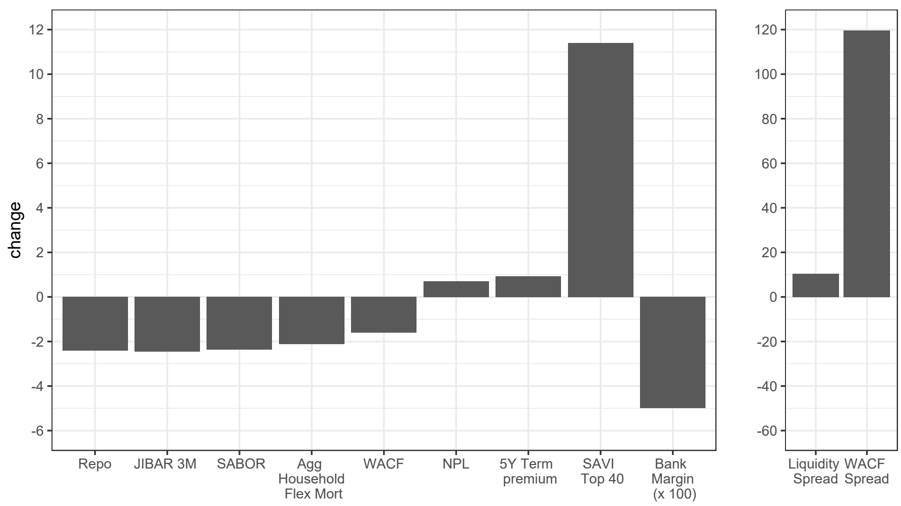
Bank-level analysis confirms the general point that pass-through into call deposit interest rates tends to be stronger than for cheque deposit rates. However, the difference in pass-through to household versus corporate call deposit rates observed at the aggregate level is not so clear-cut at the bank level due to the heterogeneity across banks. Bank A passes both repo rate hikes and cuts through to both household and corporate call deposit interest rates incompletely and asymmetrically. Bank E passes rate hikes through to both household and corporate call deposit rates completely, while passing rate cuts through incompletely. For the remaining three banks, pass-through to household and corporate call deposit rates is generally complete for both rate hikes and rate cuts (there is just a single rejection of completeness for bank D), with mixed evidence of asymmetry affecting household call deposits and no evidence of asymmetry affecting corporate call deposits. As in the case of cheque deposits, controlling for bank funding costs is once again important, with the LR test indicating that the cut-down specification is inferior for both aggregate regression models and for seven out of ten bank-level models.

Overall, our results suggest that repo rate changes are typically passed though to call deposit interest rates completely, which likely reflects competition among banks for deposits as a cheap source of funds. The fact that this behaviour does not extend to deposits held in cheque accounts is somewhat surprising at first sight, as both and call and cheque deposits are treated equivalently as high-quality liquid assets under the Basel 3 framework. The explanation is likely to be rooted in the higher unit cost faced by banks in providing cheque account services than call deposit services; including the costs of operating branch and ATM networks; providing transaction services. In addition, because households and firms use cheque accounts for transaction purposes, they may face high switching costs due to the necessity to update standing orders, direct debits, invoicing details, thereby reducing the incentive for banks to compete for cheque deposits on price. Nonetheless, the relative insensitivity of cheque account interest rates to repo rate changes has at least two important implications. First, it is likely to have distributional consequences, as poorer individuals may hold proportionately larger balances in cheque accounts than wealthier individuals. Second, it means that the opportunity cost of holding cash does not adjust to fully reflect monetary policy actions, weakening the transmission of monetary policy.

5 How did the COVID-19 crisis affect household borrowing costs?

In addition to characterising policy rate pass-through into bank interest rates, our models can be used to construct counterfactual scenarios for policy analysis. This offers a valuable opportunity to study the degree to which bank interest rates have changed during the COVID-19 crisis relative to a counterfactual ‘business as usual’ (BAU) scenario with no pandemic. In response to the COVID-19 crisis, SARB eased monetary policy substantially, driving money market rates down. This can be seen clearly in Figure 13, which plots the change in selected indicators between December 2019 and May 2020. Because deposit interest rates and debt issuance costs did not fall by the same magnitude as short-term money market rates, the WACF spread increased even though the level of aggregate funding costs fell in percentage terms (see Olds and Steenkamp 2021 for further discussion of this issue). Figure 13 also reveals that both sovereign risk and banking sector credit risk increased substantially during the early months of the COVID-19 crisis, which may have weakened the transmission of monetary policy by placing upward pressure on bank rates in a manner that partially offsets SARB rate cuts.

Figure 13: Change in selected indicators, December 2019 to May 2020



NOTE: The left (right) panel of the figure reports the change in the value of variables that are expressed in percent (basis points).

To assess the extent of the change in bank interest rates during the COVID-19 crisis, we must first create a counterfactual BAU scenario. For this exercise, we focus solely on household flexible mortgage interest rates, as the pass-through of policy rate changes to household mortgage servicing costs is a particular focus of policymakers during cutting cycles.[23] To construct our BAU scenario, we generate forecasts over the period March–December 2020 using models estimated on a sample ending in February 2020, immediately prior to the sequence of repo rate cuts undertaken to manage the COVID-19 crisis. Because our NARDL models comprise only a single equation, they are not suitable for use in forecasting on their own as they provide no means to recursively forecast the right-hand side variables. Consequently, for bank i, we specify an auxiliary vector autoregression (VAR) in $\boldsymbol{z}_t = \left(r_t^p, \boldsymbol{f}_t, \boldsymbol{m}_{it}\right)'$, the lag order of which is selected using the Schwarz information criterion.[24] The VAR model is estimated using data up to February 2020 and is then used to construct point forecasts through to December 2020. We then use the VAR forecasts to update the partial sum processes, r_t^{p+} and r_t^{p-}, through to

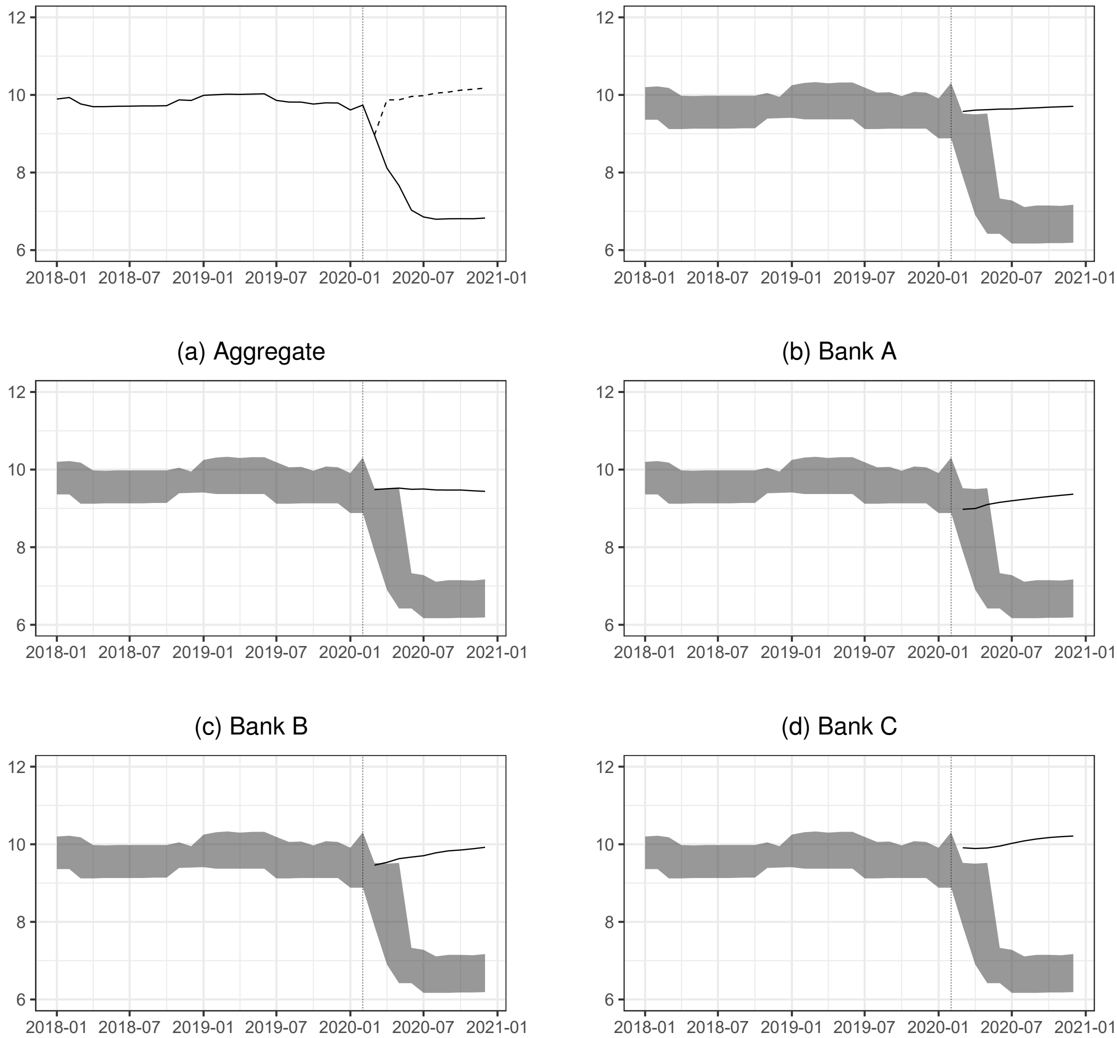
[23] Counterfactual exercises focusing on other bank interest rates are available from the authors on request.

[24] The VAR is estimated on the levels of the data. We verify that all of the auxiliary VAR models that we estimate are dynamically stable using the usual eigenvalue condition. Because our interest is not in characterising the long-run equilibrium relations among the variables in $\boldsymbol{z}_t$, we do not estimate the model in vector error correction form; rather, the cointegrating relations are implicitly captured by the parameters of our levels VAR models.

the end of 2020. In this way, we obtain counterfactual paths for all of the explanatory variables in the NARDL model for Bank i, which allows us to use the parameters of the NARDL model estimated on data up to February 2020 to recursively generate a counterfactual BAU path for the flexible mortgage interest rate offered by Bank i extending to the end of 2020.

Panel (a) of Figure 14 plots the flexible mortgage interest rate implied by our BAU scenario at the sector-wide aggregate level against the observed rate. Panels (b) to (f) provide similar output at the bank level, although we refrain from plotting observed bank-level interest rate data to maintain the anonymity of the banks in our sample; rather, in each panel, we plot a band that represents the range of flexible household mortgage interest rates reported by the five largest banks in each month. In each case, under the BAU scenario, household flexible mortgage interest rates remain approximately constant over 2020. In reality, flexible mortgage interest rates fell sharply over 2020 such that, as of December 2020, the aggregate rate was more than 300 bps lower than the rate implied by the BAU scenario, with similar reductions observed at the bank level. This implies that SARB's accommodative policy has been passed through to mortgage interest rates powerfully during the COVID-19 period. This is expected, given the indexation of a large proportion of mortgage loans to the prime rate, and anemic credit extension over recent years. Nevertheless, it is important to realise that increases in risk and liquidity premia during the COVID-19 crisis have weakened the transmission of policy easing to the real economy (see Figure 13 and refer to Soobyah and Steenkamp 2020 for a related discussion).

Figure 14: Counterfactual analysis of the impact of the COVID-19 crisis on household flexible mortgage interest rates



(a) Aggregate

(b) Bank A

(c) Bank B

(d) Bank C

(e) Bank D

(f) Bank E

NOTE: The solid line in panel (a) shows the path of the aggregate household flexible mortgage interest rate until January 2020, the end of the estimation sample used to construct the BAU scenario. The path of the aggregate flexible mortgage interest rate implied by the BAU scenario until the end of 2020 is shown as a dotted line and the actual path as a dashed line. In panels (b) to (f), the shaded interval represents the range of household flexible mortgage interest rates provided by the five largest banks in each month. In each panel, a vertical dotted line is drawn in February 2020, the last period of the estimation sample used to construct the BAU scenario. The unit of measurement is percent.

6 Sensitivity analysis

An important limitation of the preceding analysis is the assumption that the repo rate provides an adequate summary of the policy stance of the SARB. However, especially in the most recent expansionary phase, other short-term reference interest rates may provide a better summary. Specifically, the shift to a money market surplus regime and the introduction of an asymmetric corridor around the repo rate in 2020 mean that the policy stance may be imperfectly reflected by the repo rate. To address this possibility, we conduct sensitivity analysis by replicating our analysis using two alternative measures of short-term market interest rates: the South

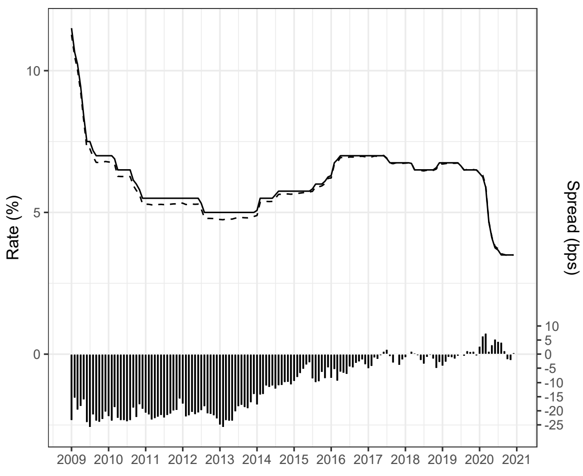
African Benchmark Overnight Rate (SABOR) and the three-month JIBAR. This approach is also consistent with the finding of Banerjee et al. (2013) that loan and deposit interest rates are adjusted in a manner that anticipates changes in short-term market rates based on French aggregate and bank-level data.

The SABOR is a widely used overnight benchmark interest rate. It is a volume-weighted rate, based on total interbank funding at rates other than the repo rate, the weighted average of the twenty highest rates paid by banks on demand deposits from non-bank clients (by rate and then volume) and 5% of rand funding in the foreign exchange swap market.

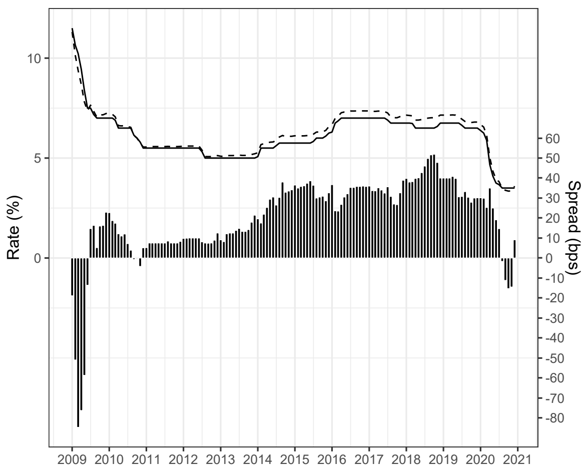
The three-month JIBAR is the most commonly used short-term benchmark interest rate in South African financial markets. There are some limitations of the JIBAR as a reference rate, given the sporadic issuance of the NCDs on which it is based and the dominance of non-bank financial corporate deposits as a source of funding at that maturity (South African Reserve Bank, 2018b). Unfortunately, however, no alternative money market reference rate is available in South Africa.

In Figure 15, we compare the evolution of the repo rate, the SABOR and the JIBAR in both level and spread terms. Figure 15(a) shows that the SABOR is somewhat more variable than the repo rate, which may help to achieve more precise estimation of the pass-through coefficients in our NARDL models. The narrowing of the SABOR-repo spread over time likely reflects regulatory frictions that placed upward pressure on funding costs.[25] Meanwhile, Figure 15(b) reveals that the JIBAR has tracked the repo typically subject to a positive spread that rose post-GFC but has been relatively stable over the last five years.

Figure 15: SABOR and three-month JIBAR vs. the repo rate



(a) SABOR vs. repo



(b) three-month JIBAR vs. repo

Tables 9 to 13 provide a concise summary of the long-run pass-through estimates obtained using all three proxies for the policy interest rate. The long-run pass-through coefficients ob-

[25] For example, since their introduction in 2015 and 2019, respectively, the liquidity coverage ratio (LCR) and net stable funding ratio (NSFR) requirements induced banks to pay more for corporate cash in light of its favourable regulatory treatment.

tained in each case are generally very similar, although differences in the precision with which they are estimated generate some variation in the tests for completeness and symmetry of long-run pass-through. Overall, however, the interpretation of our results does not depend critically on which proxy of SARB's policy stance is used.

Table 9: Sensitivity of flexible mortgage interest rate pass-through estimates

	Long-run pass-through (Repo)		Complete pass-through (Repo)		(Repo)	Long-run pass-through (JIBAR)		Complete pass-through (JIBAR)		(JIBAR)	Long-run pass-through (SABOR)		Complete pass-through (SABOR)		(SABOR)
	Hike	Cut	Hike	Cut	Symmetric pass-through	Hike	Cut	Hike	Cut	Symmetric pass-through	Hike	Cut	Hike	Cut	Symmetric pass-through
(a) Aggregate															
Household	1.249***	0.819***	0.999	0.000***	0.000***	1.262***	0.954***	0.182	0.002***	0.000***	1.132***	0.836***	0.989	0.020**	0.000***
Corporate	1.235***	0.861***	0.932	0.007***	0.010**	1.238***	0.992***	0.193	0.091*	0.013**	1.335***	0.965**	0.068*	0.011**	0.064*
(b) Bank A															
Household	1.011**	0.681***	0.575	0.000***	0.000***	0.949***	0.671***	0.085*	0.000***	0.000***	1.071***	0.943***	0.008***	0.041**	0.000***
Corporate	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
(c) Bank B															
Household	1.086***	1.045***	0.889	0.905	0.586	0.904***	0.946***	0.950	0.588	0.419	1.031***	1.035***	0.954	0.657	0.391
Corporate	1.020***	0.965***	0.918	0.894	0.183	0.960***	1.002***	0.950	0.901	0.346	0.965***	0.954***	0.854	0.341	0.886
(d) Bank C															
Household	0.988***	0.864***	0.448	0.005***	0.254	0.930***	0.844***	0.007***	0.003***	0.150	1.047***	1.024***	0.854	0.565	0.719
Corporate	0.977***	0.892***	0.312	0.004***	0.163	0.971***	0.859***	0.087*	0.041**	0.108	1.024**	1.116**	0.025**	0.986	0.360
(e) Bank D															
Household	1.167***	0.826***	0.901	0.007***	0.029*	1.123***	0.884**	0.245	0.963	0.087*	1.140***	0.910***	0.911	0.986	0.313
Corporate	1.420***	1.338***	0.643	0.731	0.939	1.466***	1.346***	0.976	0.973	0.363	1.521**	1.539**	0.222	0.886	0.872
(f) Bank E															
Household	1.227***	0.782**	1.000	0.000***	0.000***	1.104***	0.797***	0.014**	0.000***	0.000***	1.186***	0.872***	1.000	0.000***	0.000***
Corporate	1.164***	1.047***	0.951	0.769	0.144	1.124***	1.043***	0.154	0.989	0.692	1.009***	1.0855***	0.991	0.868	0.456

NOTE: See notes to Tables 3 and 4.

Table 10: Sensitivity of overdraft interest rate pass-through estimates

	Long-run pass-through (Repo)		Complete pass-through (Repo)		(Repo)	Long-run pass-through (JIBAR)		Complete pass-through (JIBAR)		(JIBAR)	Long-run pass-through (SABOR)		Complete pass-through (SABOR)		(SABOR)
	Hike	Cut	Hike	Cut	Symmetric pass-through	Hike	Cut	Hike	Cut	Symmetric pass-through	Hike	Cut	Hike	Cut	Symmetric pass-through
(a) Aggregate															
Household	0.891***	0.589***	0.328	0.005***	0.034***	1.026***	0.724***	0.967	0.016**	0.007***	0.942**	0.674**	0.972	0.031**	0.005***
Corporate	1.509***	1.596***	0.986	1.000	0.693	1.525***	1.583***	0.981	0.999	0.511	1.643***	1.656***	0.942	0.999	0.925
(b) Bank A															
Household	0.993***	0.601***	0.495	0.152	0.021**	0.933***	0.557***	0.174	0.880	0.003***	0.940**	0.688**	0.122	0.897	0.037**
Corporate	0.351***	0.701***	0.011**	0.071*	0.052*	0.496**	0.777***	0.321	0.926	0.058*	0.414***	0.782***	0.233	0.915	0.084*
(c) Bank B															
Household	0.887***	0.649***	0.396	0.022**	0.068*	0.809**	0.538**	0.000***	0.066*	0.037**	0.822**	0.683***	0.000***	0.928	0.061*
Corporate	1.080***	1.001***	0.658	0.505	0.785	1.066**	1.063***	0.999	1.000	0.010***	1.062**	1.052***	0.997	1.000	0.022**
(d) Bank C															
Household	0.887***	1.020***	0.120	0.576	0.078*	0.947**	1.167*	0.000***	0.854	0.064*	0.892**	1.103**	0.000***	0.934	0.171
Corporate	0.861***	1.307***	0.354	0.754	0.298	0.871*	1.449**	0.794	0.979	0.000***	0.911**	1.474**	0.769	0.979	0.002***
(e) Bank D															
Household	1.025***	1.123***	0.547	0.856	0.642	1.046**	0.912***	0.792	0.995	0.372	1.006**	0.968***	0.873	0.997	0.408
Corporate	0.791***	1.171***	0.049**	0.997	0.019**	0.909***	1.145***	0.891	0.999	0.083*	0.862***	1.219***	0.969	0.999	0.001***
(f) Bank E															
Household	2.010***	1.062**	0.959	0.565	0.000***	1.546*	1.793**	0.692	0.973	0.049***	2.046*	0.839**	0.645	0.984	0.000***
Corporate	0.438***	0.442***	0.040**	0.019**	0.509	0.315***	0.440**	0.162	0.512	0.850	0.778***	0.771***	0.120	0.487	0.759

NOTE: See notes to Tables 3 and 4.

Table 11: Sensitivity of credit card interest rate pass-through estimates

	Long-run pass-through (Repo)		Complete pass-through (Repo)		(Repo)	Long-run pass-through (JIBAR)		Complete pass-through (JIBAR)		(JIBAR)	Long-run pass-through (SABOR)		Complete pass-through (SABOR)		(SABOR)
	Hike	Cut	Hike	Cut	Symmetric pass-through	Hike	Cut	Hike	Cut	Symmetric pass-through	Hike	Cut	Hike	Cut	Symmetric pass-through
(a) Aggregate															
Household	0.609***	0.675***	0.000***	0.000***	0.518	0.706***	0.730***	0.021**	1.000	0.635	0.707***	0.715***	0.007***	0.001***	0.977
Corporate	1.357***	1.604***	0.921	0.999	0.009***	1.410***	1.561***	1.000	1.000	0.107	1.382***	1.610***	0.996	1.000	0.019**
(b) Bank A															
Household	0.668***	2.113***	0.211	0.999	0.000***	0.784*	1.477**	0.776	0.920	0.022**	0.412**	1.750**	0.872	0.961	0.006***
Corporate	1.238***	0.907***	0.838	0.276	0.041**	1.156**	0.901**	0.288	0.990	0.235	1.025***	0.879***	0.455	0.997	0.077*
(c) Bank B															
Household	2.231***	0.404***	1.000	0.005***	0.000***	1.413**	0.486***	0.090*	1.000	0.001***	1.778***	0.503***	0.999	0.048**	0.000***
Corporate	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
(d) Bank C															
Household	1.000***	1.132***	0.500	0.911	0.658	1.308***	1.375***	0.092*	0.576	0.729	1.270**	1.143***	0.138	0.350	0.391
Corporate	0.981***	0.931***	0.483	0.404	0.887	1.132**	0.896**	0.668	0.865	0.538	1.141***	1.044**	0.430	0.867	0.834
(e) Bank D															
Household	0.772***	1.423***	0.187	0.973	0.000***	0.742***	1.253**	0.935	0.999	0.009***	0.726***	1.383**	0.945	1.000	0.001***
Corporate	1.194***	1.390***	0.906	1.000	0.057*	1.171***	1.478***	0.996	0.998	0.022**	1.165***	1.394***	0.991	0.984	0.051*
(f) Bank E															
Household	0.877***	0.625***	0.250	0.001***	0.040**	0.922*	0.846*	0.024**	0.961	0.549	0.783**	0.788**	0.045**	0.983	0.863
Corporate	0.941***	0.373***	0.000***	0.000***	0.000***	0.953**	0.407**	0.030**	0.482	0.044**	0.985**	0.468**	0.059*	0.096*	0.017**

NOTE: See notes to Tables 3 and 4.

Table 12: Sensitivity of cheque account interest rate pass-through estimates

	Long-run pass-through (Repo)		Complete pass-through (Repo)		(Repo)	Long-run pass-through (JIBAR)		Complete pass-through (JIBAR)		(JIBAR)	Long-run pass-through (SABOR)		Complete pass-through (SABOR)		(SABOR)
	Hike	Cut	Hike	Cut	Symmetric pass-through	Hike	Cut	Hike	Cut	Symmetric pass-through	Hike	Cut	Hike	Cut	Symmetric pass-through
(a) Aggregate															
Household	0.455***	0.356***	0.000***	0.000***	0.424	0.451**	0.533***	0.000***	0.000***	0.931	0.558*	0.478**	0.000***	0.003***	0.987
Corporate	0.547**	0.509***	0.062*	0.002***	0.854	0.504***	0.445***	0.000***	0.000***	0.291	0.498***	0.565***	0.000***	0.000***	0.810
(b) Bank A															
Household	0.472***	0.388***	0.000***	0.000***	0.123	0.575***	0.311***	0.000***	0.000***	0.209	0.557***	0.456***	0.000***	0.000***	0.149
Corporate	0.351***	0.701***	0.011**	0.071*	0.052*	0.357**	0.895*	0.000***	0.068*	0.002***	0.371**	0.824***	0.002***	0.001***	0.000***
(c) Bank B															
Household	0.361***	0.812***	0.012**	0.029**	0.008***	0.315***	0.895**	0.016**	0.009***	0.000***	0.416**	0.936**	0.003***	0.081*	0.000***
Corporate	0.586***	0.819***	0.002***	0.005***	0.051*	0.464**	0.690**	0.911	0.957	0.076*	0.518**	0.897***	0.006**	0.003**	0.075*
(d) Bank C															
Household	–	–	–	–	–	–		–	–	–	–	–	–	–	–
Corporate	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
(e) Bank D															
Household	0.336***	0.422***	0.038**	0.000***	0.787	0.429**	0.659**	0.000***	0.000***	0.323	0.482**	0.510**	0.000***	0.005***	0.499
Corporate	0.357***	0.723***	0.019**	0.016**	0.008***	0.475***	0.828***	0.044**	0.072*	0.000***	0.311**	0.791***	0.057*	0.006***	0.000***
(f) Bank E															
Household	0.931***	1.892***	0.454	0.986	0.000***	0.729***	1.562***	0.045**	0.993	0.000***	0.941***	1.449***	0.984	0.999	0.019**
Corporate	0.205***	0.149***	0.000***	0.000***	0.068*	0.132**	0.137*	0.007***	0.044**	0.791	0.275**	0.246*	0.013**	0.084*	0.901

NOTE: See notes to Tables 3 and 4.

Table 13: Sensitivity of call deposit interest rate pass-through estimates

	Long-run pass-through (Repo)		Complete pass-through (Repo)		(Repo)	Long-run pass-through (JIBAR)		Complete pass-through (JIBAR)		(JIBAR)	Long-run pass-through (SABOR)		Complete pass-through (SABOR)		(SABOR)
	Hike	Cut	Hike	Cut	Symmetric pass-through	Hike	Cut	Hike	Cut	Symmetric pass-through	Hike	Cut	Hike	Cut	Symmetric pass-through
(a) Aggregate															
Household	1.383***	1.042***	0.992	0.667	0.012**	1.466**	1.235**	0.865	0.990	0.093*	1.259***	0.922***	0.755	0.999	0.075*
Corporate	0.711***	0.732***	0.000***	0.000***	0.705	0.894***	0.931***	0.852	0.999	0.520	0.895***	0.896***	0.023**	0.069*	0.983
(b) Bank A															
Household	0.778***	0.220***	0.033**	0.000***	0.000***	0.869**	0.577***	0.893	0.861	0.068*	0.610**	0.454***	0.000***	0.000***	0.011**
Corporate	0.351**	0.701***	0.011**	0.071*	0.002***	0.582***	0.458***	1.000	1.000	0.771	0.458***	0.641***	0.000***	0.000***	0.080*
(c) Bank B															
Household	1.265***	0.898***	0.874	0.220	0.047**	1.246**	0.861**	0.975	0.015**	0.033**	1.363***	0.939**	0.862	0.086*	0.029**
Corporate	0.768***	1.109***	0.290	0.698	0.023**	0.876**	1.250***	0.012**	0.901	0.005***	0.822**	1.161***	0.022**	0.878	0.044**
(d) Bank C															
Household	1.254***	0.873***	0.929	0.102	0.043**	1.354***	1.042***	0.998	0.101	0.060*	1.398***	0.996***	0.999	0.004***	0.016**
Corporate	1.005***	1.040***	0.511	0.626	0.851	1.062***	0.999***	0.826	0.998	0.261	1.033***	0.919**	0.683	0.980	0.633
(e) Bank D															
Household	0.789***	1.207**	0.033**	0.995	0.007***	0.954***	1.117***	1.000	0.753	0.357	0.920***	1.113***	1.000	0.910	0.104
Corporate	1.195***	1.142***	0.976	0.981	0.560	1.266**	1.131**	0.290	0.737	0.387	1.133***	1.166***	0.660	0.735	0.561
(f) Bank E															
Household	1.043***	0.891***	0.686	0.077*	0.104	1.022**	0.963***	0.974	0.434	0.682	0.992***	1.076***	0.143	0.999	0.283
Corporate	1.019***	0.951***	0.751	0.005***	0.207	0.938***	0.967***	0.782	0.999	0.957	1.033***	1.012***	0.359	0.998	0.579

NOTE: See notes to Tables 3 and 4.

7 Conclusion

The effectiveness of monetary policy depends crucially on its impact on the deposit and lending rates that banks offer to households and firms. We use a suite of asymmetric error correction models to analyse the pass-through of policy rate hikes and cuts to a range of lending and deposit interest rates at both the sectoral (aggregate) level and at the level of individual financial institutions. Because many factors aside from policy rate changes are also known to affect the rates at which banks extend credit or remunerate deposits, our models include a comprehensive set of controls, including term premia, risk premia, proxies for bank margins and funding spreads. The latter is particularly noteworthy, as published measures of bank funding costs are rare - we use a liability side measure of the weighted average cost of bank funding from Olds and Steenkamp (2021), which is derived from bank balance sheet data and that is among the most sophisticated measures of bank funding costs yet developed.

We show that the long-term pass-through from policy rate changes to the rates banks pay on deposits and charge on loans varies by bank and by loan/deposit category. Pass-through into household flexible mortgage interest rates at the bank level is typically complete in the case of rate hikes but is often incomplete in the case of rate cuts. This asymmetry is considerably less prevalent in the case of corporate mortgages. We also find that banks tend to smooth corporate overdraft interest rates relative to household overdraft rates. We interpret these findings in terms of the switching costs and information frictions faced by different classes of borrowers.

Several international studies suggest that pass-through to deposit and lending rates has been incomplete in other jurisdictions since the global financial crisis (see, for example, Krylova et al. 2014, Illes et al. 2015 or Illes et al. 2019 for recent studies focusing on European economies). Our approach allows us to consider asymmetries in pass-through over monetary policy easing and tightening cycles and heterogeneities across banks and loan and deposit products. We find that pass-through into call deposit interest rates is typically complete, which is consistent with competition among banks for deposits as a cheap source of high-quality liquid assets. However, we show that cheque account interest rates are sticky and only respond weakly to repo rate changes. This may result from the higher unit cost faced by banks in providing cheque account services than call deposit services, as well as the high costs faced by households and firms seeking to switch cheque accounts given their transactional nature. Nevertheless, incomplete pass-through into cheque account interest rates is undesirable to the extent that it has distributional consequences and it weakens the effectiveness of monetary policy by limiting the degree to which policy decisions affect the opportunity cost of holding liquid funds.

Given that our sample period spans the outbreak of the COVID-19 crisis, we take the opportunity to analyse the effect of SARB's monetary expansion on household mortgage servicing costs. By drawing comparisons against a counterfactual scenario in which the pandemic does not occur, we show that household mortgage interest rates were approximately 300 bps lower in December 2020 than they would have been under business-as-usual. This indicates that SARB's monetary easing was passed through forcefully to household borrowing costs despite offsetting increases in risk and liquidity premia.

Our analysis has several implications for the conduct of monetary policy in South Africa, three of which we wish to highlight. First, the long-run pass-through parameters that we estimate can be used to refine the calibration of existing models of monetary policy transmission to better capture the asymmetries that we document, thereby providing an enriched framework for the analysis of policy trade-offs and for forecasting. Second, our evidence of heterogeneity in pass-through across banks indicates that the competitive structure of the banking sector is relevant to the analysis of monetary policy transmission. This is an important and nuanced issue, because the effective degree of competition is likely to vary by product type. Finally, our finding that the pass-through of rate cuts to household cheque account interest rates is constrained by their proximity to zero indicates that issues related to the zero lower bound on nominal interest rates are already relevant in South Africa even though the repo rate itself is not close to zero. Specifically, it points to the notion of a zero lower bound issue operating at the product level that warrants careful attention, as it may alter the macroeconomic response to further repo rate cuts.

We close by noting three important avenues for continuing research. First, estimating the effect of rate hikes and cuts on lending volumes as opposed to rates would provide a valuable input into the conduct of monetary policy.[26] In the absence of a credit registry in South Africa, data on loan volumes is currently unavailable, so work to develop alternative lending volume proxies should be viewed as a priority. Second, if a longer span of data were available, it would be interesting to test for asymmetry with respect to the size of interest rate changes in addition to their sign. Unfortunately, this is not possible in our dataset because there are too few large changes in the repo rate to yield reliable estimates, but it may become possible with the passage of time. Finally, although our model uses the best available measure of bank funding costs, it is based purely on information from the liability side of bank balance sheets. As a consequence, the asset-side impact of the Basel 3 regulations on bank funding costs is captured imperfectly. The development of new funding cost indicators that exploit information from both sides of the balance sheet would therefore represent a significant step forward.[27]

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[26] A preliminary assessment by Greenwood-Nimmo et al. (2021) finds that pass-through to credit extension has been weaker since the GFC, possibly reflecting weaker credit demand and the offsetting impact of increases in risk and liquidity premia embedded in market interest rates.

[27] Efforts to produce estimates of the cost of complying with Basel 3 liquidity regulations include, for example, Diesel et al. (2022, forthcoming).

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Appendices

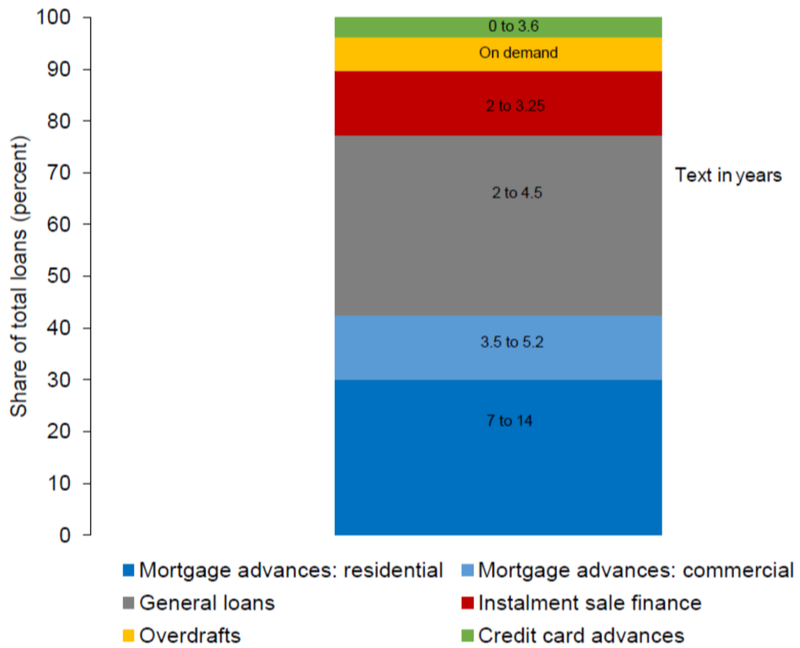
A Data sources

Table A1: Variable identifiers and sources

Description	Ticker(s) / Description	Identifier	Source
Flexible mortgage rates		Mrt_{Fl}	BA-930, Olds and Steenkamp (2021)
Overdraft rates		$Overdraft$	BA-930, Olds and Steenkamp (2021)
Credit card rates		CC	BA-930, Olds and Steenkamp (2021)
Cheque account rates		$Deposit_{Cheque}$	BA-930, Olds and Steenkamp (2021)
Call deposit rates		$Deposit_{Call}$	BA-930, Olds and Steenkamp (2021)
SARB repurchase rate	SARPRT Index	$repo$	Bloomberg
SABOR	SAONBOR Index	$SABOR$	Bloomberg
Three-month JIBAR	JIBA3M Index	$JIBAR\_3M$	Bloomberg
Weighted average cost of funding spread		WACF Spread	BA-900, BA-930, Olds and Steenkamp (2021)
SAVI Top 40 volatility index	SAVIT40 Index	SA_VIX	Bloomberg
Non-performing loans	Impaired advances over total loans and advances	NPL	BA-200 and BA-900, Author Calculations
Liquidity spread		Liq_{spread}	Bloomberg, Author Calculations
Five-year South African Treasury term Premium		SA_5^{TP}	Estimates updated from Soobyah and Steenkamp (2020)
Net interest proxy	Net interest income over gross loans and advances	NI	BA-100, Author Calculations

NOTE: All interest rates, funding costs and lending rates are expressed as monthly averages.

Figure A1: Estimates of total loan shares and average durations by category (2020)



NOTE: The figure is based on SARB calculations for a combination of household and corporate sector loans.