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Short-term impacts and interaction of macroprudential policy tools

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Abstract

We develop a large macro-econometric model with a detailed financial block to study the impacts of changes to capital requirements and the loan-to-value (LTV) ratio on key economic and financial indicators. The model dynamics reflect the relationships between bank capital, risk-taking behaviour of the financial sector, lending spreads and economic activity. The results show that an increase in the capital adequacy ratio (CAR) raises the banks' effective lending spreads and leads to a decline in economic activity. Similarly, a decrease in the LTV ratio has a strong negative impact on wealth and household consumption and a smaller impact on investment expenditure. Our analysis shows a strong interaction between the different macroprudential tools. Changes to capital requirements and the LTV ratio affect the liquidity coverage ratio (LCR) and net stable funding ratio (NSFR). This can significantly amplify the economic and financial impacts of macroprudential policy, and in some cases become a source of financial instability. Effective use of macroprudential policy tools requires an understanding of how the different tools individually (and jointly) affect economic activity and financial behaviour as well as the transmission of other macroeconomic policies.

JEL classification: C22, C53, E17, G21, E52, E58

Keywords: econometric modelling, macroprudential policy

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1. Introduction[1]

We analyse how different macroprudential tools interact and affect the financial sector and economic activity in South Africa. The analysis employs a large macro-econometric model with a detailed financial block. The emphasis is on the short-run dynamics rather than on the long-term financial stability benefits.[2]

The role of macroprudential policy has become increasingly more important since the global financial crisis (GFC). Regulatory failures prior and during the GFC required comprehensive changes to the regulatory framework. The role of macroprudential policy in the macroeconomic framework was elevated. Yet, work assessing these policy interventions lags similar assessments of monetary and fiscal policies. This can reduce the effectiveness of policy interventions, lead to policy errors and reduce central bank accountability.

Analysis of macroprudential policy is particularly important for South Africa as the country has an extremely well-developed financial sector for an emerging market economy. The Global Competitiveness Report 2019 ranks South Africa 19th in terms of its level of financial sector development. The South African rand is the 20th most-traded currency globally, and the country has one of the highest market capitalisation-to-gross domestic product ratios. South Africa's deep and liquid financial markets allow for effective monetary policy implementation and the funding of private and public institutions to support economic development (BIS 2009). This high level of development suggests that changes to macroprudential policy can easily transmit to

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2 The theoretical foundations for some of these positive benefits are well established in the literature. For example, higher capital tends to increase the probability of survival through raising the incentives for banks to monitor borrowers, attenuating the moral hazard of asset substitution and reducing the appeal of risky products (Acharya, Mehran, and Thakor 2015; Allen, Carletti, and Marquez 2011; Holmstrom and Tirole 1997; Mehran and Thakor 2011; Thakor 2012). The short-term transition, however, can be costly (Borio and Zhu 2012).

the real economy through multiple financial markets. More importantly, the interaction of different instruments can significantly amplify economic impacts.

South Africa implemented BASEL III over the period 2013 to 2019 through regulations under which banks are required to hold significantly more capital than the Basel minima. Other important elements of the Basel framework include the liquidity coverage ratio (LCR), the net stable funding ratio (NSFR) and the loan-to-value (LTV) ratio. The LCR was introduced at the beginning of 2015, with the minimum requirement set at 60% and proposed to rise in equal annual steps to reach 100% by January 2019. The ratio measures the proportion of high-quality liquid assets (HQLA) held by financial institutions, to ensure their ongoing ability to meet short-term obligations. The NSFR links the bank's available stable funding (ASF) to its required stable funding (RSF),[3] and should either equal or exceed 100%. Its primary aim is to address maturity mismatches between the liability (sources of funding) side and the asset (uses of funding) side. The LTV ratio limit indicates the share of a property price covered by a mortgage loan. Lower values indicate that buyers need a higher deposit amount.

Unlike previous studies in South Africa, we study the individual and joint impact of these macroprudential tools on key economic variables in the short run (i.e. three to four years). Our analysis employs a modified version of the South African Reserve Bank macro-econometric model (the core model), which includes macroprudential channels. The new model features a more detailed representation of the financial sector. We simulate the impact of an increase in the capital adequacy CAR and LTV ratios. The impact of the CAR shock also reflects the likely impact of changes to capital buffers, since the transmission mechanism is the same.

3 Both the total ASF and RSF reflect supervisors' view of the stability of bank funding. A total ASF factor of 100% is assigned to a bank's capital and liabilities if they have been earmarked to remain within the institution for more than a year – similarly, a factor of 0% suggests that this form of funding is short term and deemed unreliable. The RSF refers to the amount of stable funding that the bank should hold to cover the maturity structures of its assets (loans), as well as the liquidity risk associated with its off-balance sheet exposures. The RSF also ranges from 100% to 0%, where a factor of 100% suggests the asset (loan) or exposure needs to be entirely financed by stable funding because it is considered illiquid.

The results show that a 1% temporary increase in the CAR increases lending spreads by between 0.6 and 0.8 percentage points and reduces growth by roughly 0.15% after six quarters. Gross domestic product (GDP) in the simulation is 0.1% lower compared to the baseline after three years. A decrease in the LTV ratio lowers household consumption and house prices, which in turn lowers growth and inflation. The joint simulation suggests strong interaction between the different instruments. The increase in the CAR impacts both the NSFR and LCR. The NSFR improves by more than 1% as the higher cost of credit reduces overall credit extension, while the LCR shows a deterioration of just below 1% as the slowdown in economic activity negatively impacts bank balance sheets and reduces the size of HQLA. This suggests that macroprudential interventions need to be coordinated, not only within the macroprudential space but also with other policies. Otherwise, the short-term impacts associated with macroprudential interventions can easily offset any long-term benefits and even become a major source of financial risks via their impact on economic activity.

We proceed with a review of the relevant literature in the next section. This is followed by a short review of South Africa's macroprudential tools. Section 4 describes the changes to the baseline model. In section 5, we present our results. The conclusion follows and highlights the implications of our analysis for policy makers.

2. Related literature

The theoretical frameworks of Borio and Zhu (2012) and Woodford (2010) provide an explanation as to how changes to capital requirements affect the balance sheets of various institutions in a general equilibrium framework, and how these balance sheet effects interact with and affect economic activity. In the model developed by Woodford (2010), raising the level of capital is costly, and leverage is limited by regulatory requirements. Shocks that impair the capital of a bank or financial institution or create new capital requirements translate into higher lending spreads and lower volumes of lending and economic activity. Breaching the minimum capital threshold is costly for a bank in Borio and Zhu's framework (2012). In the face of a possible breach, banks will take defensive action to avoid the high costs, which will affect the availability and pricing of funding extended to customers. These effects depend on the economic cycle, which impact the probability of default, valuations, the perception of risk change, and ultimately the relative position of a bank's capital to the regulatory threshold. The theoretical frameworks generate strong accelerator effects driven by the relationship between capital, lending spreads and economic activity.

Liquidity requirements are justified by an externality on public finance or by fire-sales externality on banks. In the framework developed by Dewatripont and Tirole (2018), banks under-invest in liquidity as they anticipate that the state will rescue them when necessary. Regulation forces banks to internalise the public finance externality. Lorenzoni (2008) develops a model with borrowers and lenders who do not internalise the impact of asset sales on asset prices. Both groups have limited ability to commit to future payments. This limits access to liquidity and generates inefficient results. While liquidity is important to address these externalities, improving liquidity can generate large costs for banks if it is scarce. Similarly, reducing maturity mismatches can be welfare-enhancing by reducing fire sales and the impacts of tightening financial conditions on the economy, as in the model developed by Stein (2012), or by improving the alignment of interest rates between long-term and short-term creditors that leads to a 'maturity rat race'[4] as in Brunnermeier and Oehmke (2013). Segura and Suarez (2017) develop and calibrate a tractable infinite horizon model focused on banks' maturity transformation functions. They find a strong rationale for limiting banks' maturity mismatches, but their results also show that the reduction in maturity transformation can imply a net welfare loss under certain conditions.

Early assessment of Basel III requirements often relied on large econometric models with exogenous shocks to interest rates to assess the economic impacts. The Macroeconomic Assessment Group MAG (BIS 2010) found small negative impacts in the short run, which were dependent on the tool used to assess the impacts, the response of monetary policy, and the spillover effects across countries. The impacts were largely driven by higher interest rate margins. The average impact on the annual

4 A 'maturity rat race' occurs when individuals shorten the maturity of their loans (financing terms) from banks before other creditors can. Other lenders may feel obliged to shorten their maturities as well, leading to an excessive increase in short-term financing. Financial market volatility aggravates this situation, which can cause unnecessary rollover risk.

GDP growth was around 0.03%.[5] Slovik and Cournède (2011) and ECD (2011) found similar results.

Recent studies use more sophisticated models to capture the relationships between changes in capital requirements and economic activity. For example, Burgess et al. (2016) employ a stock-flow consistent model with a detailed financial sector and find that higher risk-weighted capital ratios achieved through raising equity capital has a small impact on economic activity. Mendicino et al. (2020) develop a micro-founded model with detailed financial dynamics. Capital requirements make the banking system safer in the long run, but the transition costs amount to 25% of the long-term welfare gains. Hinterschweiger et al. (2021) develop a two-sector dynamic stochastic general equilibrium (DSGE) model with a detailed banking sector and highlight the importance of macroprudential policy coordination. They find that staggered interest rates may alter the transmission of macroprudential tools that work through interest rates.

Empirical studies tend to find much larger economic impacts than simulation analysis using large economic models. The transmission of policy operates through domestic and cross border lending (Aiyar et al. 2014; Bridges et al. 2014; De Jonghe, Dewachter and Ongena 2020; De Schryder and Opitz 2021; Noss and Toffano 2016). The impacts, however, depend on how banks choose to achieve the higher capital requirements. For example, achieving the new ratio through reducing dividends is unlikely to have the same impact on the credit cycle as reducing the loan portfolio. Cohen and Scatigna (2016) find that most banks over the period 2009 to 2012 achieved their capital requirements through an increase in retained earnings rather than a reduction in loans. There are, however, some differences across countries. For some banks in advanced economies, a reduction in risk-weighted assets has helped with the adjustment to higher capital ratios.

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5 The MAG finds that bringing the global common equity capital ratio to a level that would meet the agreed minimum and the capital conservation buffer would result in a maximum decline of 0.22% of GDP after 35 quarters. The spillover effects across countries are estimated at 0.17% of GDP (BIS, 2010).

South Africa's literature on macroprudential policy is scarce, dominated by studies using large economic models to simulate possible impacts. Grobler and Smit (2014) and Havemann (2014) employ econometric models, very similar to our model. Their approach is to introduce an equation in the model structure that links the lending spread directly to the CAR. There are no balance sheet dynamics and the capital ratio is not a function of the financial sector balance sheet. Havemann (2014) finds that an increase of 100 basis points in the capital ratio leads to a GDP contraction of 0.07 percentage points. The lending rate increases by 0.4 percentage points. Grobler and Smit (2014) generate a stronger impact on GDP, which declines by 0.2 to 0.3 percentage points relative to the baseline. Davies, Harris and Makrelov (2019) assess how different strategies to achieve a higher capital ratio impact the results in a stock-flow consistent computable general equilibrium (CGE) model. They argue that banks in South Africa have increased their capital by increasing retained earnings and thus the impacts on lending spreads are small. Maredza (2016) provides panel data estimates for the impact of Basel II on bank intermediation costs. The results suggest that higher capital is associated with higher intermediation costs.

This study also relates to the literature on macroprudential policy coordination. While the area of monetary and macroprudential policy coordination has generated a large number of studies,[6] the interaction of different macroprudential tools has received less coverage. Boissay and Collard (2016) assess the transmission mechanism of liquidity and capital regulations in a DSGE model. Their study finds that both sets of policies reinforce each other. Liquidity regulation can have feedback effects that could reduce the effectiveness of capital regulation. In a model with long-term debt, housing transaction costs and a zero lower bound, Chen et al. (2020) study the impact of LTV and loan-to-income (LTI) ratio limits in the long and short run. The results show that although long-term costs of the tools are moderate, the LTV ratio could be twice as costly in terms of consumption compared to the LTI policy in the short run at the zero lower bound. The coordination of macroprudential policy has important implications for

[6] See for example Tayler and Zilberman (2016) and Angelini, Neri and Panetta (2014), and for South Africa see Liu and Molise (2018).

welfare. Hinterschweiger et al. (2021) find that co-ordination of macroprudential tools may have a welfare-improving effect, but there are some trade-offs between improving welfare and reducing welfare volatility. Garbers and Liu (2018) develop a generic small open economy real business cycle model with domestic and foreign borrowing. Their study shows how the LTV ratio and capital requirements can be used to reduce the impact of a positive foreign interest rate shock. Their results show that the LTV ratio regulation is associated with the largest shock attenuation benefits. Capital requirements are associated with a lower equity premium and higher household consumption. The combination of LTV ratio regulation and capital requirements reduces welfare trade-offs and it is the most effective way to achieve both macroeconomic and financial stability objectives, when the application is countercyclical. Despite the growing body of literature, there are still large gaps, as the complexity of financial regulations requires complex model frameworks with detailed financial dynamics, which are not available. Empirical studies are often better suited to look at the impacts of specific elements rather than the interaction of different instruments.

These gaps in understanding the joint impact of multiple instruments are highlighted by the Basel Committee on the Global Financial System. In a recent study, they find that the application of the leverage ratio and NSFR and LCR can generate ambiguous impacts on long-term unsecured markets (BIS 2015). The leverage ratio is likely to reduce volumes and rates, while the NSFR and LCR will work in the opposite direction. It is not clear which effect is likely to dominate.

Our contribution to the literature in South Africa is twofold. Firstly, we develop a large macro-econometric model with a more detailed financial block to illustrate the use of macroprudential tools. The model also contains some balance sheet information. The financial sector dynamics are more detailed than other structural econometric and DSGE models. Secondly, we use the model to study the interaction between various macroprudential tools, highlighting key economic and financial channels as well as their interdependencies. This supports more informed policy decision making.

3. Basel III changes in South Africa

In this section, we provide a brief overview of South Africa’s macroprudential framework with relevance to this study. South Africa began phasing in the Basel III regulations from the beginning of 2013 and completed the process in 2019.

Table 1 summarises the capital requirements structure. Banks are required to hold significantly more capital than the Basel minima. The systemic risk capital (Pillar 2A) should not exceed 3.5% together with the systemically important banks buffer. Individual bank capital requirements fall under Pillar 2B. These can vary substantially and there are no upper limits. Smaller banks and those that are unsecured lenders have higher 2B pillar requirements. In addition, banks are required to maintain a buffer stock comprising a countercyclical buffer, a capital conservation buffer and a systemically important banks buffer.

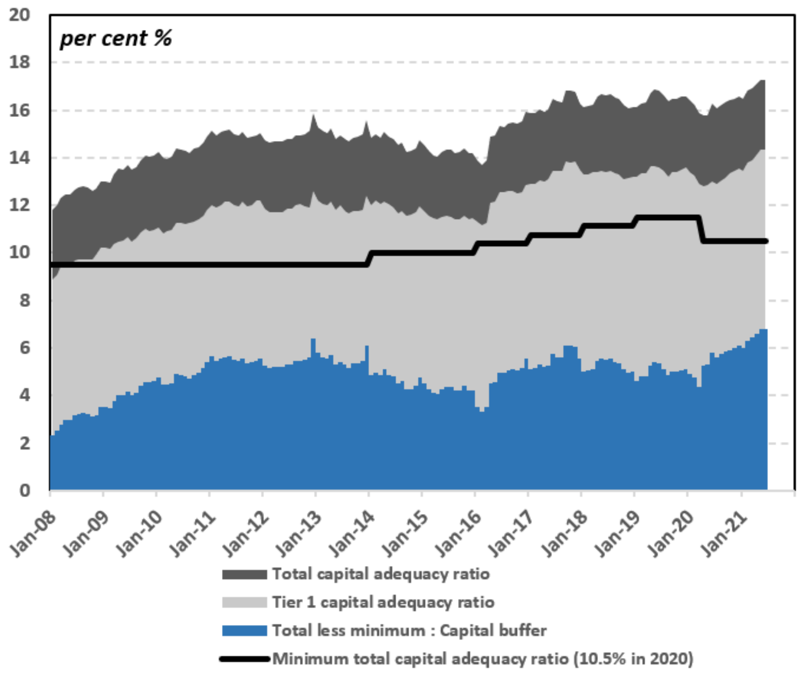
Table 1: Structure of capital requirements

	%
Basel III minima	8
South African minima	8
Pillar 2A	0.5 to 2
South African base minima	8 +Pillar 2A
Pillar 2B (ICR)	no specific range
Prudential minima	8+Pillar2A+ICR
Systemically important buffer	0.5 to 2.5
Capital conservation buffer	0 to 2.5
Countercyclical buffer	0 to 2.5

Source: SARB

Figure 1 shows the evolution of the total CAR in South Africa and compares it to the regulatory requirements. The ratios have increased in line with the regulatory requirements since 2013. The capital buffer – the portion of capital held by banks above their regulatory requirements (shown by blue bars) – has remained elevated post the GFC. This reflects rising domestic risks, including fiscal risks (Makrelov, Pillay and Morule 2021).

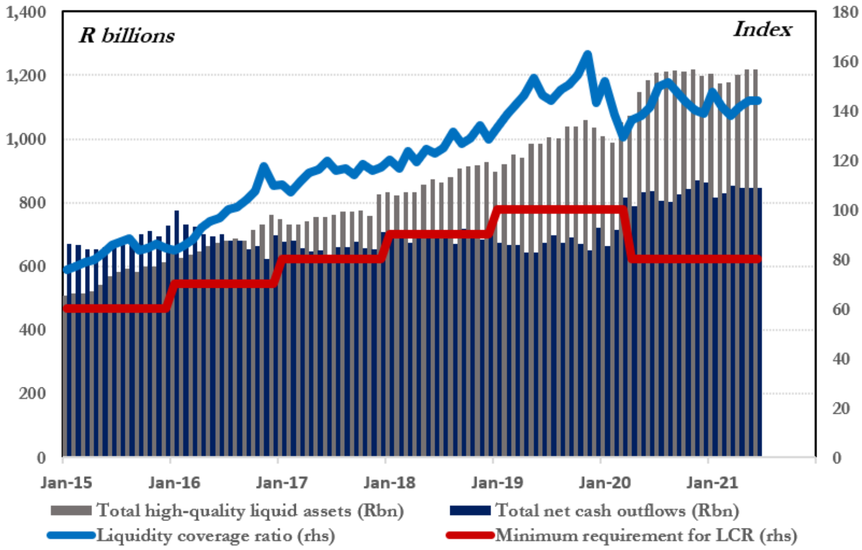
Figure 1: Evolution of capital ratios in South Africa



Source: Prudential Authority and Financial Stability, SARB

Another important element of the Basel framework is the LCR. The LCR has increased from 75% in 2015 to over 160% in late 2019 (see Figure 2). This increase was mainly driven by accumulation of government bonds, which are considered an HQLA instrument. In response to the COVID-19 crisis, the Prudential Authority reduced the required ratio from 100% to 80%. Despite the regulatory relief, banks chose to maintain high levels of LCR, well above the regulatory requirements. This reflected a preference for highly liquid instruments in a volatile market, and weak demand for household and corporate loans. In this environment, government bonds had the advantage of being low-risk, high-yield instruments that were comparatively easer to convert to cash.

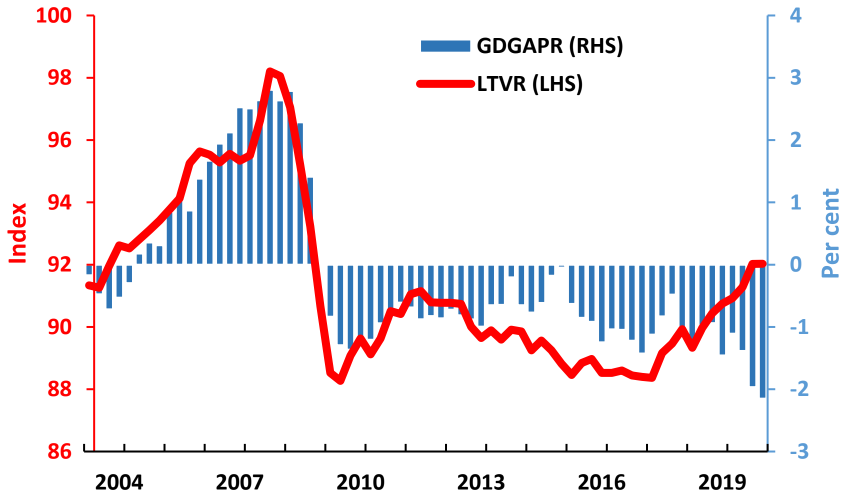
Figure 2: Evolution of actual vs regulatory LCR



Source: SARB

The LTV ratio limit indicates the down-payment (deposit) required relative to the full mortgage amount. The LTV ratio is yet to be used by the SARB as an official macroprudential tool. In our framework, the LTV ratio is calibrated using data from the Lightstone property group on all home (residential) bond loans and transactions up to R5 million. Despite the instrument not being officially used in South Africa yet, it has great potential for future use, as seen in other countries such as New Zealand. Figure 3 shows how the actual aggregate LTV ratios acted pro-cyclically by becoming more relaxed (higher) in the economic boom period prior to the GFC in 2009, and more restrictive thereafter. There was also a slight divergence after 2013, possibly related to when more restrictive National Credit Regulator (NCR) and Basel II and III regulations began to gain traction.

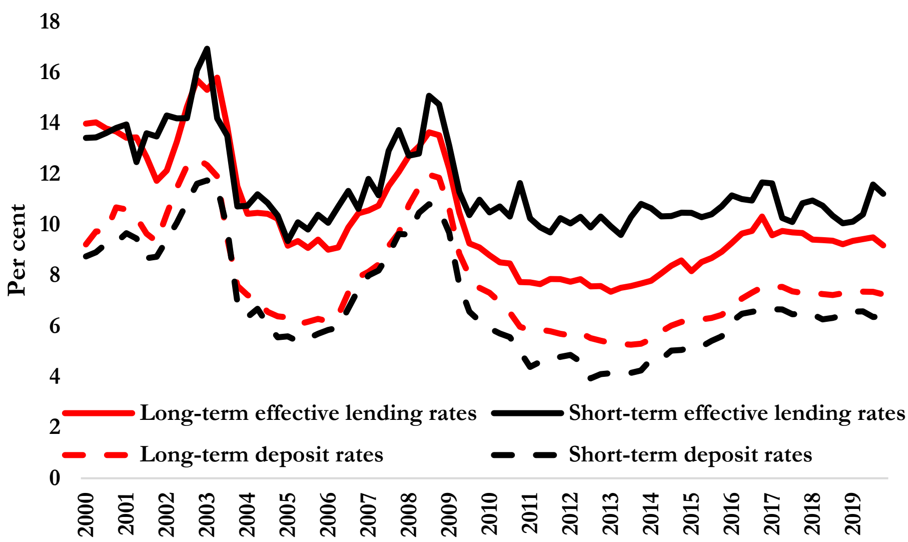
Figure 3: The LTV ratio and the output gap



Source: Own calculation and Prudential Authority

Figure 4 compares lending and deposit rates. The increase in long-term deposit rates coincides with the introduction of the NSFR and it is also accompanied by higher lending rates. Olds and Steenkamp (2021) and Naidoo, Nkuna and Steenkamp (2020) find that funding costs have increased for the financial sector, driven by deposit spreads and the longer tenor of debt issuance, partially driven by the NSFR requirements.

Figure 4: Long- and short-term lending and deposit rates

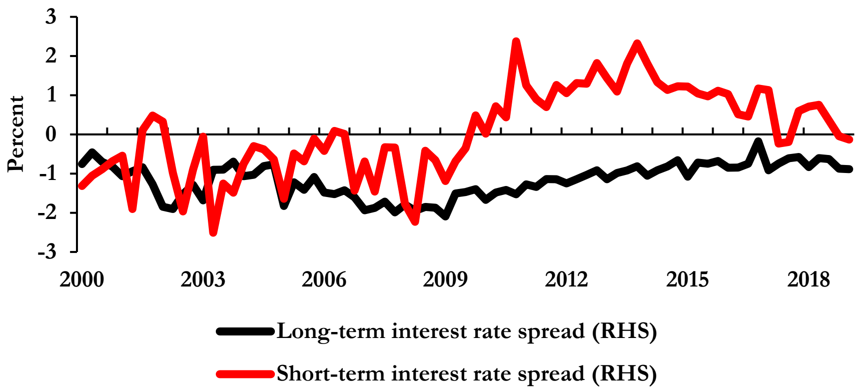


Source: SARB

The introduction of Basel III coincides with a period of rising lending spreads (see

Figure 5). While the introduction of the National Credit Act and higher domestic risks have contributed to the increase, the literature (as outlined earlier) suggests that Basel III compliance has also been a major driver of the escalated spread.

Figure 5: Lending spreads (calculated as the gap between the effective lending rates and the official prime overdraft interest rate)



Source: SARB and author calculations

4. Methodology

We use a modified version of the Reserve Bank's core macro-econometric model. The structure of the economy is represented by a set of econometric equations and identities based on economic theory and the relationships set out in the reporting standards of the system of national accounts. Long-term dynamics are represented by a set of co-integrating relationships. The methodology also allows for deviations in the short run from the long-run equilibrium.

This type of model has been subject to the Lucas critique (Lucas 1976). Yet it has remained the workhorse of many central banks and ministries of finance due to its ability to incorporate more channels relevant to a particular policy question than other macroeconomic models, its better fit with the data, and its flexibility when used to create different economic scenarios. It is for these reasons that we have chosen to develop and use an econometric model.

Each equation is estimated as a single dynamic regression equation following an approach proposed by Wickens and Breusch (1988). This approach produces similar results to the Engle and Granger two-step method and eliminates the small sample bias associated with the latter. It involves simultaneous estimation of the long- and short-term parameters and is based on an unrestricted error correction autoregressive distributed lag model, or ARDL(p,q). The same approach is used in the semi-structural models of Smal, Pretorius and Ehlers (2007) and Grobler and Smit (2014). Due to data limitations, some of the relationships are calibrated to improve the fit to the data and ensure that impulse response functions replicate the general trends and long-run properties of other models used in related research studies as well as the observed economic trends.

Next, we describe the model and its properties, followed by a discussion of our model simulations. The emphasis is on the macroprudential channels. Smal, Pretorius and Ehlers (2007) provide a detailed description of the real economy model.

4.1 Non-technical summary

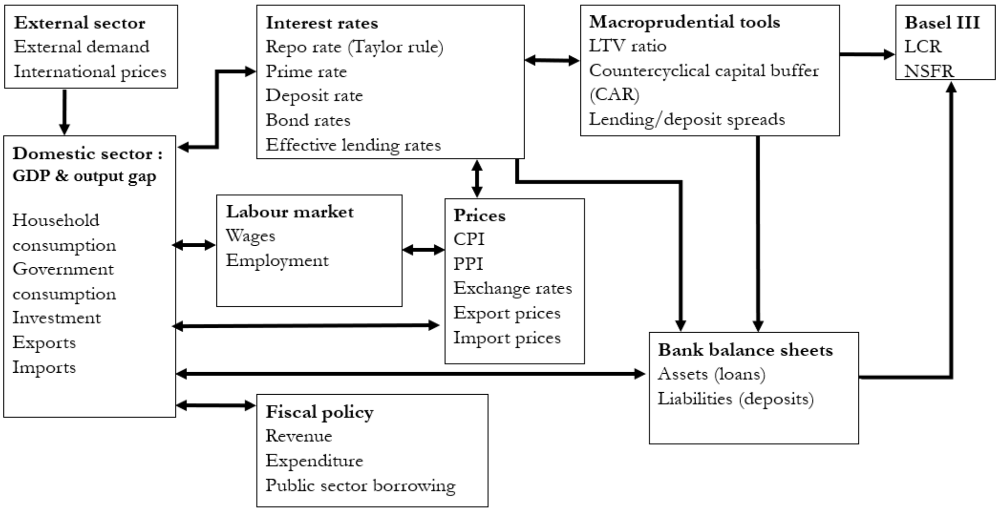
Figure 6 provides diagrammatic representation of the core model. The model has labour, product and financial markets, which are interlinked and interact with the external sector. Firms hire labour and invest in capital to produce goods and services in the economy. Over the long run, the costs of additional workers are compensated by the extra revenue they generate, implying that the pace of growth in real wages cannot exceed the growth in labour productivity. There is a homogenous relationship between growth and employment, such that employment growth only exceeds output if it is accompanied by reduced real wages. However, over the short(er) term, prices and wages are ‘sticky’, so labour can temporarily make relative gains (or losses) against firms through higher (or lower) real wages or employment. Inflation expectations are adaptive in the model. This specification is supported by Kabundi and Schaling (2013) and Crowther-Ehlers (2019), who find that expectations formation tends to be more adaptive in South Africa.[7]

The growth in nominal wages is a function of real wage growth and inflation

[7] The presence of empirical evidence supporting adaptive expectations suggests that some elements of the Lucas critique are less applicable to our analysis.

expectations. Wages, in turn, affect the demand for goods and services in the economy. Interest rates and balance sheet effects also affect household consumption and investment.

Figure 6: Diagrammatic representation of the Reserve Bank's core macro-econometric model



Source: Model Development Group, SARB

The macroprudential features of the model operate via lending spreads and their impact on the economy, and then the impact of these changes on the balance sheet of financial institutions. This creates feedback loops, which reflect the ability of the financial sector to amplify economic shocks.

Changes to the CAR or the countercyclical capital buffer affect lending spreads, which in turn impact credit extension, household consumption and private sector investment. The impact on the balance sheets of financial institutions affects their compliance with other regulatory measures such as the LCR and the NSFR. This can generate additional changes in bank behaviour, which impact both financial and real economy indicators. For example, falling bond prices (i.e. raised yields) will require banks to increase their bond holding, generating crowding-out effects as funds are redirected away from bank lending.

The macroprudential tools impact the effectiveness of monetary policy via the credit and asset channels. Changes to lending spreads can amplify or offset monetary policy decisions, highlighting the importance of policy coordination. The monetary policy reaction function is specified in Smal, Pretorius and Ehlers (2007). The impact of macroprudential tools on inflation is indirect and it operates through the output gap and the exchange rate. The real effective exchange rate is determined by the uncovered interest rate parity condition, fiscal balances and capital flows.

Figure 7 summarises the transmission of changes to the CAR and the LTV ratio to real economic activity inflation, and their eventual impact on the financial stability indicators NSFR and LCR.

Figure 7: The transmission mechanism of the CAR and LTV ratios

CAR → Spreads → Interest rates → Private sector credit → HCE → Output gap → Inflation
↘ Private sector credit → Bank balance sheets → NSFR and LCR

LTV → Spreads → Lending rates → House prices and credit → Household consumption → Demand → Inflation
↘ Private sector credit → Bank balance sheets → NSFR and LCR

4.2 Key model equations

In this section we present some of the key equations in the model and their diagnostic statistics.

4.2.1 Interest rate spread on long-term bank loans

The long-term interest rate spread of banks (primarily mortgage loans) to the official prime overdraft lending rate is modelled as a function of the CAR, the LTV ratio and the output gap. The spreads represent a measure of risk that the bank associates with long-term loans. The specification aims to capture some of the financial channels identified in the theoretical models of Borio and Zhu (2012) and Woodford (2010). Sample = 2003Q4–2019Q1.

$$\Delta \text{ SpreadL} = \left[-\beta_1 * \left(\text{SpreadL}_{(-1)} \right) + \beta_2 * \sum_{j=1}^{4} (\text{CAR}_{(-j)})/4 \; -\beta_3 * \sum_{j=1}^{4} (\text{LTVR}_{(-j)})/4 \right]$$

$$+ \beta_4 + \beta_5 * \Delta(\text{Gdgapr}) + \varepsilon_{\text{SpreadL}}$$

β_1 = 0.7; β_2 = 0.6; β_3 = 0.2; β_4 = 8.99620; β_5 = 0.36

Where:

- $SpreadL$ = Long-term interest rate spread
- CAR = Capital adequacy ratio
- $Gdgapr$ = Output gap
- $LTVR$ = Loan-to-value ratio

4.2.2 Interest rate spread on short-term bank loans

The short-term interest rate spread of banks (credit cards, other loans and overdrafts) to the official prime overdraft rate is modelled as a function of the CAR and the output gap. The spreads represent a measure of risk that the bank associates with short-term loans. Sample = 2005Q1–2019Q1.

$$\Delta \text{ SpreadS} = \left[-\beta_1 * \left(\text{SpreadS}_{(-1)}\right) + \beta_2 * \sum_{j=1}^{4} (\text{CAR}_{(-j)})/4 \right] + \beta_3 + \beta_4 * \Delta(\text{Gdgapr})$$

$$+ \beta_5 * \text{Dum17q2} + \beta_6 * \text{Dum08q3} + \varepsilon_{\text{SpreadS}}$$

R2 = 0.27

DW = 1.92

β_1 = 0.36093;	β_2 = 0.3;	β_3 = -4.12327;	β_4 = 0.20948;	β_5 = -1.53682;	β_6 = 1.51027
(-4.36)		(-46.56)	(1.92)	(-2.48)	(2.29)

Where:

- $SpreadS$ = Short-term interest rate spread
- CAR = Capital adequacy ratio
- $Gdgapr$ = Output gap
- $Dum08q3$ = Dummy for irregular data (2008Q3 = 1)
- $Dum17q2$ = Dummy for irregular data (2017Q2 = 1)

4.2.3 Total bank assets (investments and bills)

Total bank assets including investment and bills is estimated in real terms and explained by the real JSE All-Share Index and the yield on government stock with a maturity exceeding 10 years. Sample = 2006Q2–2019Q1.

$$\Delta \log\left(\frac{Bnkast5}{Cpitd}\right) = \left[-\beta_1 * \log\left(\frac{Bnkast5_{(-1)}}{Cpitd_{(-1)}}\right) + \beta_2 * \log\left(\frac{ALSI_{(-1)}}{Cpitd_{(-1)}}\right)\right] + \beta_3$$

$$- \beta_4 * \Delta\left(\sum_{j=0}^{3}(Lbondi_{(-j)})/4\right) + \beta_5 * Dum08q4 + \beta_6 * Dum07q1$$

$$+ \beta_7 * Dum08q1 + \beta_8 * Dum06q4) + \varepsilon_{Bnkast5}$$

R2 = 0.62

DW = 2.21

β_1 = 0.22785; β_2 = 0.10119; β_3 = 1.99026; β_4 = 0.03441; β_5 = 0.37425; β_6 = -0.18440;
(-4.30) (1.72) (2.24) (5.45) (-2.55)

β_7 = 0.18096; β_8 = -0.20048
(2.57) (-2.91)

Where:

- $Bnkast5$ = Total bank assets (investments and bills)
- $ALSI$ = Johannesburg Stock Exchange All-Share Index
- $Cpitd$ = Targeted headline consumer price index
- $Lbondi$ = Yield on government stock with maturity exceeding 10 years
- $Dum06q4$ = Dummy for irregular data (2006Q4 = 1)
- $Dum07q1$ = Dummy for irregular data (2007Q1 = 1)
- $Dum08q1$ = Dummy for irregular data (2008Q1 = 1)
- $Dum08q4$ = Dummy for irregular data (2008Q4 = 1)

4.2.4 High quality liquid assets (HQLA)

High-quality liquid assets (HQLA) include those assets that are viewed as collateral by central banks and that have a high potential to be converted easily and quickly to cash during times of liquidity stress. It is modelled in real terms as a function of real GDP growth, real all-share prices and yield on government stock with maturity exceeding 10 years. Sample = 2009Q3–2019Q1.

$$\Delta\log\left(\frac{Hqla5}{Cpitd}\right) = \left[-\beta_1 * \left(\log\left(\frac{Hqla5_{(-1)}}{Cpitd_{(-1)}}\right) - \log\left(Gdpmp6_{(-1)}\right)\right) + \beta_2 * \log\left(\frac{Alsi_{(-1)}}{Cpitd_{(-1)}}\right)\right]$$

$$+ \beta_3 + \beta_4 * \Delta\left(\sum_{j=0}^{3}(Lbondi_{(-j)})/4\right) + \varepsilon_{Hqla5}$$

R2 = 0.62

DW = 2.21

β_1 = 0.29973; β_2 = 0.60; β_3 = 8.50508; β_4 = -0.040

(-5.50) (-20.81)

Where:

- $Hqla5$ = High-quality liquid assets
- $ALSI$ = Johannesburg Stock Exchange All Share Index
- $Cpitd$ = Targeted headline consumer price index
- $Lbondi$ = Yield government stock with maturity exceeding 10 years
- $Gdpmp6$ = Gross domestic product at constant 2000 market prices (seasonally adjusted)

4.2.5 Non-performing loans

Real non-performing loans are credit impairments of banks in respect of loans and advances, where debtors have not made the scheduled payments for a specified period of time. Here, non-performing loans are estimated as a function of real personal disposable income of households, and the prime interest rate. Sample = 2007Q3–2019Q1.

$$\Delta\log\left(\frac{NPL}{Cpitd}\right) = \left[-\beta_1 * \left(\log\left(\frac{NPL_{(-1)}}{Cpitd_{(-1)}}\right) - \log\left(Pdinc6_{(-1)}\right)\right) + \beta_2 * \left(Primei_{(-2)}\right)\right]$$

$$+ \beta_3 + \beta_4 * \Delta\log(Pdinc6) + \beta_5 * Dum16q2 + \varepsilon_{NPL}$$

R2 = 0.52

DW = 2.10

β_1 = 0.15075; β_2 = 0.00660; β_3 = -0.35228; β_4 = -1.5; β_5 = 0.15432
(-4.04) (1.43) (-5.03) (2.82)

Where:

- NPL = Non-performing loans (credit impairments in respect of loans and advances)
- $Cpitd$ = Targeted headline consumer price index
- $Pdinc6$ = Real personal disposable income (constant 2010 prices)
- $Primei$ = Prime overdraft rate
- $Dum16q2$ = Dummy for irregular data (2016Q2 = 1)

4.2.6 Total qualifying bank capital

A bank's total qualifying capital is the sum of its Tier 1 (Cet1) capital elements and Tier 2 (Cet2) capital components as well as some other prudential minima and conservation buffers. The aggregate bank capital is subject to various limits and restrictions, but less certain deductions. Bank capital is determined by real GDP growth, the prime interest rate and the output gap. Sample = 2005Q1–2019Q1.

$$\Delta\log\left(\frac{\mathbf{Bancap5}}{\mathbf{Cpitd}}\right) = \left[-\beta_1*\left(\log\left(\frac{\mathbf{Bancap5}_{(-1)}}{\mathbf{Cpitd}_{(-1)}}\right) - \log\left(\mathbf{Gdpmp6}_{(-1)}\right)\right) + \beta_2*\left(\mathbf{Primei}_{(-1)}\right)\right]$$

$$+ \beta_3 + \beta_4*\Delta(\mathbf{Gdgapr}) + \beta_5*\mathbf{Dum16q2} + \beta_6*\mathbf{Dum12q4} + \varepsilon_{\mathbf{Bancap5}}$$

R^2 = 0.45
DW = 2.46

β_1 = 0.06181; β_2 = 0.00331; β_3 = -0.09078; β_4 = 0.02451; β_5 = -0.05593; β_6 = 0.06737
(-2.52) (1.85) (-3.56) (2.86) (-2.78) (3.32)

Where:

- $Bancap5$ = Bank capitalisation across the banking sector (Cet1+Cet2)
- $Cpitd$ = Targeted headline consumer price index
- $Primei$ = Prime overdraft rate
- $Dum12q4$ = Dummy for irregular data (2012Q4 = 1)
- $Dum16q2$ = Dummy for irregular data (2016Q2 = 1)

4.2.7 Short-term bank claims on the private sector

Real claims on the private sector are explained by real GDP and effective lending rates. Higher lending rates increase the short-term claims. The short-run makes allowance for financial regulation impacts such as changes in the CAR of banks as well as M3 money supply to GDP ratio. Sample = 1999Q4–2019Q1.

$$\Delta \log\left(\frac{Psces5}{Cpitd}\right) = \left[-\beta_1 * \left(\log\left(\frac{Psces5_{(-1)}}{Cpitd_{(-1)}}\right) - \log(Gdpmp6_{(-1)})\right) + \beta_2 * (Eflendsi_{(-1)})\right]$$

$$+ \beta_3 + \beta_4 * \Delta\left(\sum_{j=0}^{3}(CAR_{(-j)})/4\right) + \beta_5 * \Delta\left(\frac{M3mon5}{Gdpmp5*4}\right)$$

$$+ \beta_6 * Dum01q1 + \varepsilon_{Psces5}$$

R2 = 0.28

DW = 2.10

β_1 = -0.06547; β_2 = -0.00237; β_3 = 0.06637; β_4 = -0.0162; β_5 = 0.66792; β_6 = -0.09288;

(-2.32) (-1.20) (2.20) (2.69) (-3.26)

Where:

- $Psces5$ = Short-term claims on the private sector by the banking sector
- CAR = Capital adequacy ratio
- $Cpitd$ = Targeted consumer price index
- $Eflendsi$ = Short-term effective lending rate
- $Gdpmp5$ = Gross domestic product at current market prices (seasonally adjusted)
- $Gdpmp6$ = Gross domestic product at constant 2010 market prices (seasonally adjusted)
- $M3mon5$ = Nominal M3 money supply (seasonally adjusted)
- $Dum01q1$ = Dummy for irregular data (2001Q1 = 1)

4.2.8 Long-term bank claims on the private sector

Long-term claims on the private sector in real terms is explained by real GDP as the income variable and effective mortgage rates as the price variable. Higher lending rates increase the long-term bank claims. The short-run dynamic component of the equation makes allowance for financial fragilities such as changes in the CAR of banks and M3 money supply to GDP ratio. Sample = 2002Q4–2019Q1.

$$\Delta\log\left(\frac{Pscel5}{Cpitd}\right) = \left[-\beta_1 * \left(\log\left(\frac{Pscel5_{(-1)}}{Cpitd_{(-1)}}\right) - \log\left(Gdpmp6_{(-1)}\right)\right) + \beta_2 * \left(Eflendli_{(-1)}\right)\right]$$

$$+ \beta_3 + \beta_4 * \Delta\left(\sum_{j=0}^{3} (CAR_{(-j)})/4\right) + \beta_5 * \Delta\left(\frac{M3mon5_{(-1)}}{4*Gdpmp5_{(-1)}}\right) +$$

$$+ \beta_6 * \Delta\log\left(Gdpmp6_{(-1)}\right) + \beta_7 * Dum11q114q4 + \beta_8 * Dum06q3 + \beta_9 * Dum15q2 + \varepsilon_{Pscel5}$$

R2 = 0.64

DW = 1.76

β_1 = 0.03092; β_2 = -0.00100; β_3 = 0.02211; β_4 = -0.0133; β_5 = 0.53912; β_6 = 1.533213;
(-2.53) (-1.84) (1.57) (3.32) (4.90)

β_7 = -0.02008; β_8 = 0.03578; β_9 = -0.03387
(-3.66) (2.25) (2.12)

Where:

- $Pscel5$ = Long-term claims on the private sector by the banking sector (primarily mortgages)
- CAR = Capital adequacy ratio
- $Cpitd$ = Targeted headline consumer price index
- $Eflendli$ = Long-term effective lending rate
- $Gdpmp5$ = Gross domestic product at current market prices (seasonally adjusted)
- $Gdpmp6$ = Gross domestic product at constant 2010 market prices (seasonally adjusted)
- $M3mon5$ = Nominal M3 money supply (seasonally adjusted)
- $Dum06q3$ = Dummy for irregular data (2006Q3 = 1)
- $Dum11q4$ = Dummy for irregular data (2011Q4 = 1)
- $Dum15q2$ = Dummy for irregular data (2015Q2 = 1)

4.2.9 Liquidity coverage ratio (LCR)

The LCR is modelled as a function of HQLA and short-term deposits. The identity is calibrated to replicate the trend of the official LCR. An increase in the short-term deposits requires banks to increase HQLA to compensate for the higher short-term liabilities and maintain the ratio:

$$LCR=\left(\frac{Hqla5}{(\beta_1*Stdep5)/1000}\right)*100 + \varepsilon_{LCR}$$

β_1 = 0.65

Where:

- LCR = Liquidity coverage ratio
- $Hqla5$ = High-quality liquid assets
- $Stdep5$ = Short-term deposits (money balances)

4.2.10 Risk-weighted assets (RWAs)

RWAs are used to determine the minimum amount of regulatory capital that must be held by banks. Since we do not have detailed balance sheets, we generate a proxy calculation of RWAs. It is a function of bank assets and short- and long-term claims on the domestic private sector. The equation is calibrated to replicate the trend of the official RWAs.

$$RWAs= \beta_1* \left(\sum_{j=0}^{3}(Pscel5_{(-j)})/4\right) + \beta_2* \left(\sum_{j=0}^{3}(Psces5_{(-j)})/4\right) + \beta_3* \left(\sum_{j=0}^{3}(Bankast5_{(-j)})/4\right) /1000 + \varepsilon_{RWAs}$$

β_1 = 0.3; β_2 = 0.9; β_3 = 0.4

Where:

- $RWAs$ = Risk-weighted assets
- $Bankast5$ = Total bank assets (investments and bills)
- $Pscel5$ = Long-term claims on the domestic private sector (seasonally adjusted)
- $Psces5$ = Short-term claims on the private sector by the banking sector (seasonally adjusted)

4.2.11 Net stable funding ratio (NSFR)

The NSFR is modelled as a function of the ratio of long- and short-run deposits plus bank capital relative to the weighted aggregate of long- and short-term loans extended to the domestic private sector. This specification proxies the actual calculation and provides for a close approximation of the actual NSFR.

$$\textbf{NSFR}=\left(\frac{(\textbf{Ltdep5}+\beta_1*\textbf{Stdep5}+\textbf{Bancap5})}{(\beta_2*\textbf{Psces5}+\beta_3*\textbf{Pscel5})}\right)*100+\varepsilon_{NSFR}$$

β_1 = 0.65; β_2 = 0.46; β_3 = 0.5

Where:

- $NSFR$ = Net stable funding ratio
- $Bancap5$ = Bank capitalisation
- $Ltdep5$ = Long-term deposits balances
- $Pscel5$ = Long-term claims on the domestic private sector (seasonally adjusted)
- $Psces5$ = Short-term claims on the private sector by the banking sector (seasonally adjusted)
- $Stdep5$ = Short-term deposits (money balances)

The weights are calibrated to roughly match the SARB's official NSFR. Econometric estimates are not reliable as the official estimate is only available on a half-yearly basis from the end of 2016. The set of explanatory variables and weights generates a close approximation of the actual ratio.

4.2.12 Capital adequacy ratio (CAR)

The CAR for South African banks measures the extent of the bank's capital in relation to its credit exposures. It is the ratio of the aggregate amount of qualifying capital and reserve funds to risk-weighted assets (RWAs).

$$\textbf{CAR}=\left(\frac{(\textbf{Bancap5/1000})}{\textbf{RWAs}}\right)*100+\varepsilon_{CAR}$$

Where:

- CAR = Capital adequacy ratio
- $Bancap5$ = Bank capitalisation
- $RWAs$ = Risk-weighted assets

The CAR data is available from 2008. In order to create a longer time series, our proxy measure relies on the model estimated measures for RWAs and bank capital. This approach generates very close model approximation of the actual CAR.

The new model captures additional macroprudential measures. These include the household debt-to-income (DTI) ratio and a measure for liquidity mismatches proxied by the bank's credit extension to M3 deposit ratio (see graphs in the Annexure). These measures respond to changes in the model economy but do not affect other model variables.

The DTI ratio is used together with the LTV ratio to constrain the cyclicality of collateralised lending by adding another limit to households' capacity to borrow. The bank's credit extension to M3 deposit ratio illustrates the bank's cash inflow/outflow vulnerability. Higher credit extension relative to M3 deposits indicates that the maturity mismatches are increasing.

5. Results

We use three simulations to illustrate the short-run economic impacts of changes to capital requirements and the LTV ratio. The results show the economic impacts and the interaction of macroprudential tools. Table 2 provides a summary of the three simulations.

Table 2: Summary of simulations

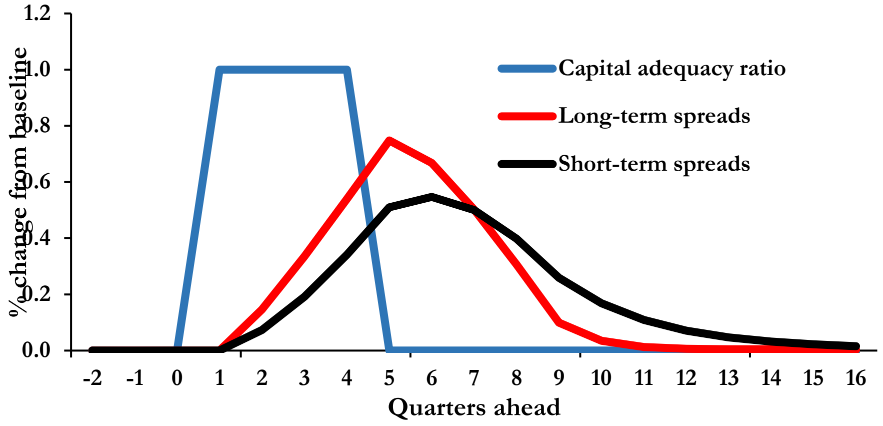
Simulation 1	The CAR is increased by 1 percentage point for one year. This increase also reflects an increase in the counter-cyclical capital buffer.
Simulation 2	There is a decrease of 10 percentage points in the LTV ratio.
Simulation 3	Combined simulation.

The model is linear and symmetric. This indicates that shocks of the same magnitude and opposite direction will generate impacts of the same magnitude but with opposite signs.

5.1 CAR shock

Following the mechanism outlined by Borio and Zhu (2012), the increase in the CAR causes effective lending spreads to increase. Both the long- and short- term interest rate spreads gradually increase with roughly 70 basis points (bps) and 60 bps respectively. The shock to the CAR is temporary, and the increase in the spreads reach their maximum after five to six quarters before starting to trend downwards (see Figure 8).

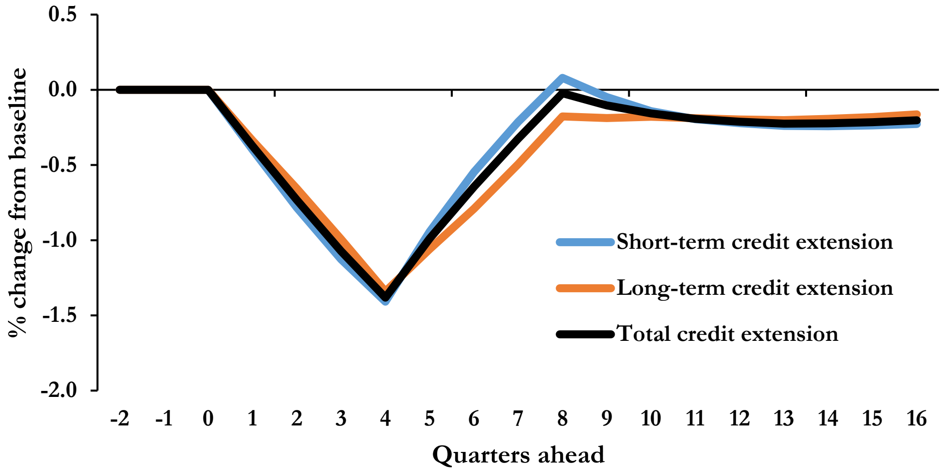
Figure 8: Impact on lending spreads



Source: Model simulations

Short-term and long-term lending decreases in response to the higher capital requirements. The level of total credit extension temporarily declines by 1.5% after four quarters (see Figure 9).

Figure 9: Response of credit extension



Source: Model simulations

Higher lending rates and lower credit extension have a negative impact on household consumption expenditure and investment (see Table 3). GDP declines by 0.15 percentage points after six quarters. This impact is smaller than the effect identified by Haveman (2014), but smaller than the results in Grobler and Smit (2014).[8] While the impact on growth rates is temporary, the impact on the level of GDP is more permanent (see Table 3). The real value of the currency depreciates marginally as inflation slows down and the nominal exchange rate depreciates. This generates a small increase in net exports.

These negative effects on economic activity are desirable if macroprudential policy is countercyclical. Increasing capital ratios in an environment of weak economic activity can amplify the slowdown and become a source of financial stability concerns. The impact on the outer years depends on the response of monetary policy. In our framework, the repo rate is exogenised and does not decline in response to the slower pace of economic activity and inflation relative to the baseline.

Table 3: Impact of higher capital requirements on key economic variables

Real variable (deviation from baseline %)	4 quarters	8 quarters	12 quarters
Household consumption	-0.13	-0.27	-0.20
Investment (private)	-0.17	-0.14	-0.12
Investment (total)	-0.17	-0.14	-0.12
GDP	-0.07	-0.12	-0.09
Net exports (deviation in R millions)	390	544	397
Exchange rate (real)	-0.02	-0.07	-0.05

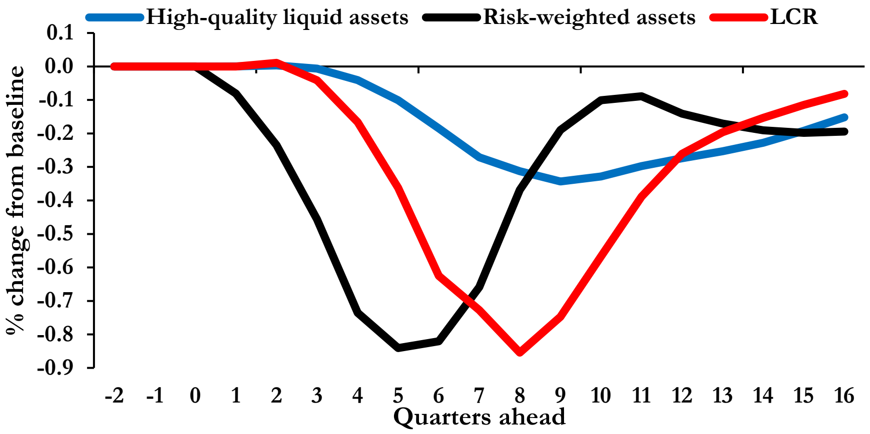
Source: Model simulations

The results from the shock also highlight the importance of considering feedback loops in macroprudential policy decisions. The increase in the CAR increases the capital holding of banks, but it also negatively impacts bank balance sheets through the impact on economic activity and asset prices. For example, the banks' RWAs and HQLA

8 Our model does not have stock and flow consistency as in Davies, Harris and Makrelov (2019), hence we do not identify how banks adjust their balance sheet to fulfill the higher requirements and whether this leads to different outcomes. We assume that any future increases in capital requirements are funded following the approach used in the past by increasing retained earnings and appropriating capital.

decline as credit growth weakens and bond prices fall (see Figure 10). The LCR declines, which may require banks to purchase more HQLA (such as government bonds) to remain Basel III compliant. This causes secondary crowding-out effects as funding is re-allocated to bond purchases, rather than to the extension of credit facilities.

Figure 10: Macroprudential reactions



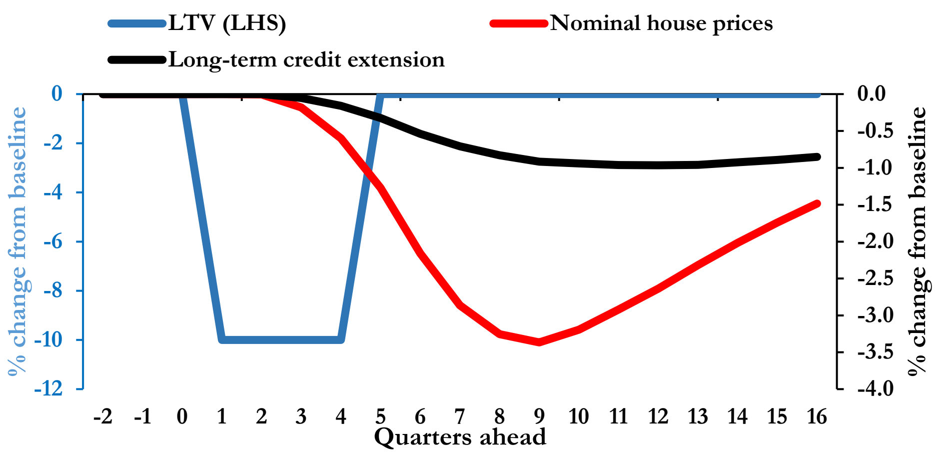
Source: Model simulations

5.2 LTV ratio shock

In the second simulation the LTV ratio is decreased by 10 percentage points for one year – the lower LTV ratio means new homeowners need to provide a larger deposit to qualify for a home loan (i.e. an additional 10% of the purchase price).

Figure 11 shows the impacts on long-term credit extension and nominal house prices. Nominal house prices decrease by 3.5% relative to the baseline after two years, and the level of long-term (mortgage) credit extension is 1% lower by the third year after the shock.

Figure 11: LTV ratios, house prices and mortgage credit extension



Source: Model simulations

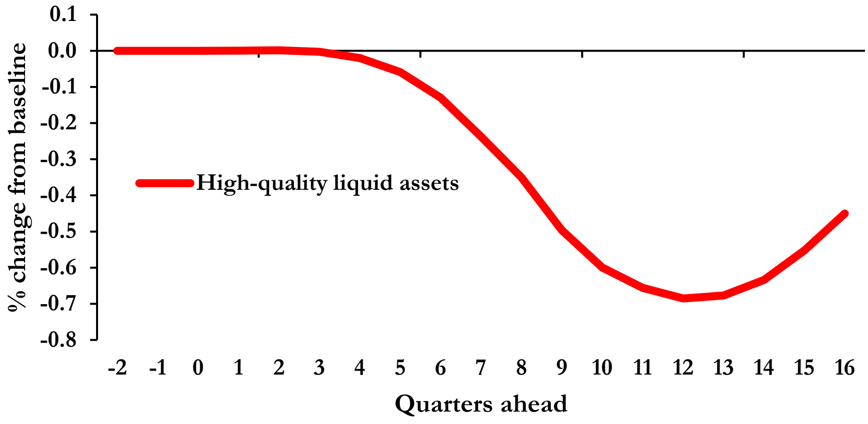
Table 4 shows the impacts on key expenditure components as well as the exchange rate. The decline in house prices reduces household wealth relative to the baseline, which in turn affects household consumer spending. Household consumption is 0.5% lower compared to the baseline after eight quarters. The impact on output reflects the feedback loop channels between the real and financial sectors in our framework. The initial decline in household wealth and credit extension (linked to the lower LTV ratio) reduces domestic equity prices, causing a deterioration in the banks' balance sheets. This increases lending spreads and reduces economic activity. The results show that a 10% decrease in the LTV ratio has a similar impact on GDP as a 1% increase in the capital buffer. However, the transmission mechanism is different, with the LTV ratio being more effective at slowing down household prices and household consumption.

Table 4: Impact of the lower LTV ratio on key economic variables

Real variable (deviation from baseline %)	4 quarters	8 quarters	12 quarters
Household consumption	-0.10	-0.49	-0.57
Investment (private)	-0.03	-0.20	-0.35
Investment (total)	-0.02	-0.13	-0.24
GDP	-0.04	-0.22	-0.24
Net exports (deviation in R millions)	260	1 132	1 211
Exchange rate (real)	-0.02	-0.12	-0.16

Source: Model simulations

Figure 12: Response of HQLA to the LTV ratio shock



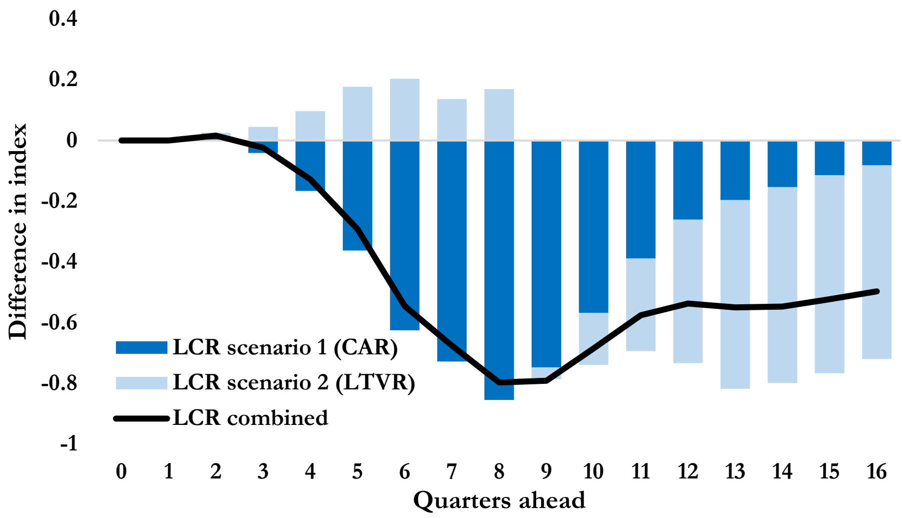
Source: Model simulations

Similar to the previous simulation, the slower growth relative to the baseline reduces the value of HQLA's as bond prices decline, causing banks to buy more bonds. Any negative shock to the value of qualifying assets (such as bonds) creates an additional demand for these assets by the financial sector as it tries to replenish the loss in value. Under conditions of 'sustainable' fiscal finances, this mechanism enhances the effectiveness of the LTV ratio and capital requirements. Under 'unsustainable' fiscal conditions, it becomes a source of financial instability as it increases the exposure of the financial sector to fiscal risks. The decline in HQLA also causes the LCR to decline marginally.

5.3 Combined shock

In the last simulation, we highlight the interaction between different macroprudential indicators. We show the combined impact on the LCR as well as on indicators such as credit extension to M3 money supply. The simulation shows how the combined use of macroprudential instruments can generate a sizable impact on other instruments or indicators. The impact on the LCR is close to a percentage point with the short term being dominated by the capital adequacy shock and the longer term by the LTV ratio shock, which generates more permanent economic and financial impacts. Procyclical use of the two instruments can generate significant crowding-out effects as banks buy more bonds instead of extending credit.

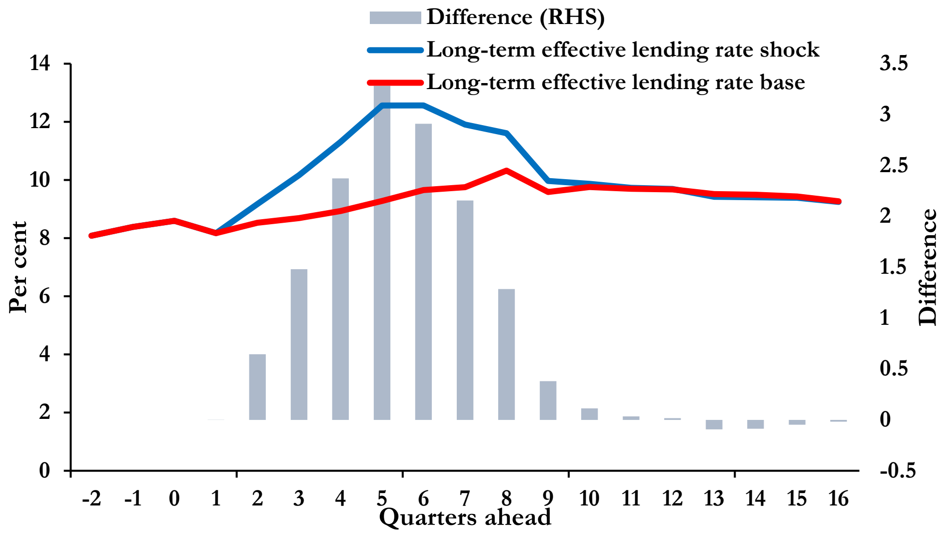
Figure 13: The combined impact on the LCR



Source: Model simulations

In Figure 14, we show the impact on the long-term effective lending rate. It increases by over 3.5 percentage points and then it declines as the shocks dissipate. This increase can significantly amplify or offset monetary policy interventions depending on the monetary policy cycle.

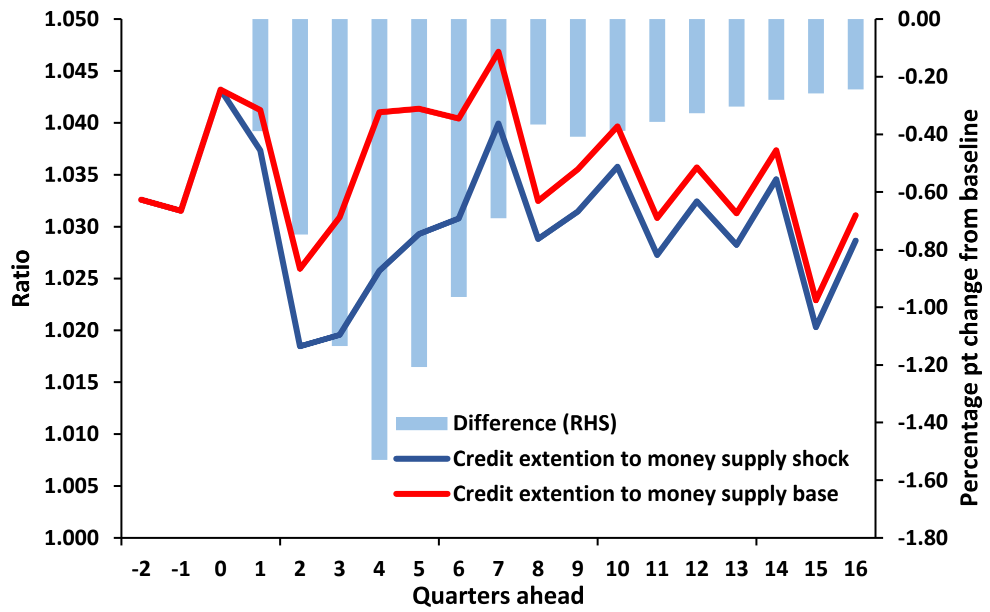
Figure 14: The combined impact on the long-term effective lending rates



Source: Model simulations

Finally, we show the impact on the credit extension to M3 money supply ratio (see Figure 15). This measure is used as an indicator for liquidity mismatches, and shows how the decline in credit exceeds the decline in M3 liabilities to improve the ratio after the shock, indicating that the level of liquidity mismatch has been reduced.

Figure 15: Liquidity mismatch



Source: Model simulations

6. Conclusion

Our results show that changes to macroprudential tools have large impacts on economic and financial indicators. More importantly, there are strong feedback loops based on both economic and financial linkages, but also based on the interaction between the different macroprudential tools. A change in the CAR impacts the banks' LCR and NSFR ratios. These interactions have the potential to either diminish or amplify the impact of specific tools and generate unintended effects as highlighted by the Basel Committee on Financial Stability.[9]

Our results highlight the importance of including endogenous macroprudential channels, which capture the important linkages between the real economy and the financial sector. Future efforts will focus on improving the linkages between the NSFR and LCR ratios and economic and financial behaviour in the model, as well as studying

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9 See BIS (2015).

the optimal monetary and macroprudential mix under different conditions.

Annexure

Figure 16: Interest rate spreads and household debt to income ratio

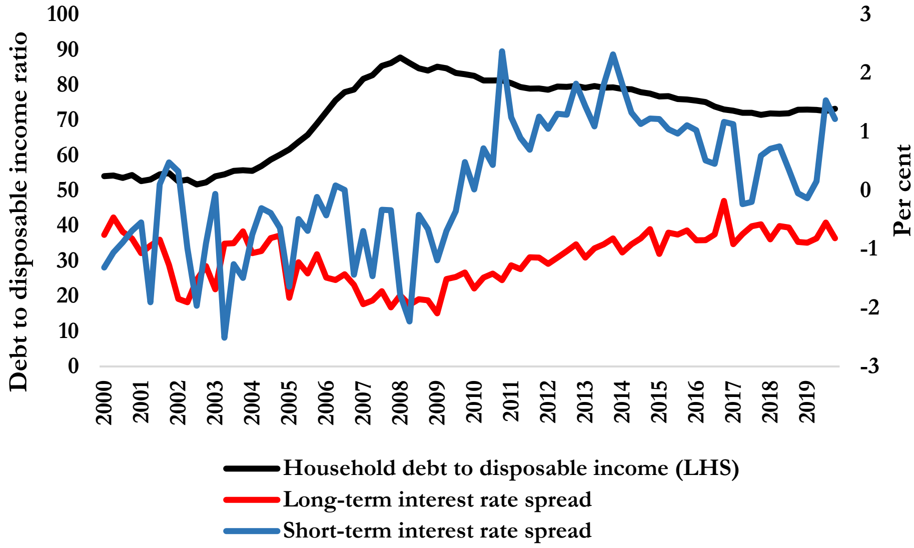
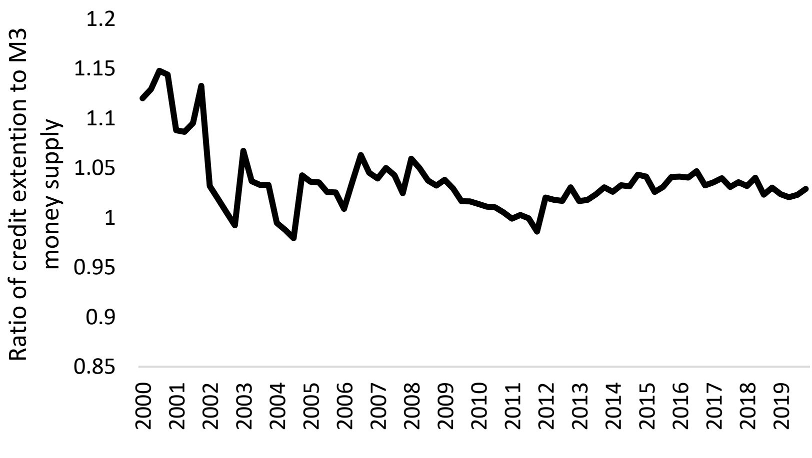


Figure 17: Liquidity mismatch



References

Acharya, V V. 2018. ‘Understanding and managing interest rate risk at banks’. *Macroeconomics and Finance in Emerging Market Economies* 11(2): 218–231.

Acharya, V V, Mehran, H and Thakor, A. 2015. ‘Caught between Scylla and Charybdis? Regulating bank leverage when there is rent seeking and risk shifting’. *Review of Corporate Finance Studies* 5(1): 36–75.

Agénor, P, Gambacorta, L, Kharroubi, E and Pereira da Silva, L A. 2018. ‘The effects of prudential regulation, financial development, and financial openness on economic growth’. *BIS Working Paper No. 752*. Bank for International Settlements.

Aikman, D, Giese, J, Kapadia, S and McLeay, M. 2019. ‘Targeting financial stability: macroprudential or monetary policy?’ *ECB Working Paper Series No. 2278.* May 2019.

Aiyar, S, Calomiris, C W, Hooley, J, Korniyenko, Y and Wieladek, T. 2014. ‘The international transmission of bank capital requirements: evidence from the UK’. *Journal of Financial Economics* 113: 368–382.

Allen, F, Carletti, E and Marquez, R. 2011. ‘Credit market competition and capital regulation’. *Review of Financial Studies* 24: 983–1018.

Angelini, P, Neri, S and Panetta, F. 2011. ‘Monetary and macroprudential policies’, *Bank of Italy Working Paper Series No. 801*.

Angelini, P, Neri, S and Panetta, F. 2014. ‘The interaction between capital requirements and monetary policy’. *Journal of Money, Credit and Banking* 46(6): 1073–1112.

Basel Committee on Banking Supervision. 2009. *Strengthening the resilience of the banking sector*. Consultative Document, Bank for International Settlements.

Basel Committee on Banking Supervision. 2013. *Basel III: The liquidity coverage ratio* *and liquidity risk monitoring tools.* Bank for International Settlements.

BIS. 2010. 'Assessing the macroeconomic impact of the transition to stronger capital and liquidity requirements'. Final report prepared by the Macroeconomic Assessment Group established by the Financial Stability Board and the Basel Committee on Banking Supervision, Bank for International Settlements.

BIS. 2015. 'Regulatory change and monetary policy'. *Committee on the Global Financial System, CGFS, BIS markets committee papers, No 54.*

Boissay, F and Collard, F. 2016. 'Macroeconomics of bank capital and liquidity regulations'. *BIS Working Paper No. 596*. Bank for International Settlements.

Borio, C and Zhu, H. 2012. 'Capital regulation, risk-taking and monetary policy: A missing link in the transmission mechanism?' *Journal of Financial Stability* 8: 236–251.

Borio, C. 2016. 'Towards a financial stability-oriented monetary policy framework?' Paper presented at the Conference on the Occasion of the 200th Anniversary of the Central Bank of the Republic of Austria, Vienna.

Bridges, J, Gregory D, Nielsen Mette, Pezzini, S, Radia A and Spaltro M. 2014. 'The impact of capital requirements on bank lending'. *Bank of England Working Paper Series No. 486*.

Brunnermeier, M K and Oehmke, M. 2013. 'The maturity rat race'. *The Journal of Finance* 68: 483–521.

Burgess, S, Burrows, O, Godin A, Kinsella S, and Millard, S. 2016. 'A dynamic model of financial balances for the United Kingdom'. *Bank of England Staff Working Paper No. 614*.

Carreras, O, Davis, E P and Piggott, R. 2016. 'Macroprudential tools, transmission and modelling'. *NIESR Discussion Paper 470.* National Institute of Economic and Social Research.

Caruna, J. 2010. ‘Systemic risk: how to deal with it?’ BIS (other publications) paper, Bank for International Settlements.

Cerutti, E, Claessens, S and Laeven, L. 2017. ‘The use and effectiveness of macroprudential policies: new evidence’. *Journal of Financial Stability* 28, 203–224.

Chen, M J, Finocchiaro, D, Lindé, J and Walentin, K. 2020. ‘The costs of macroprudential deleveraging in a liquidity trap’. *IMF Working Papers WP/20/89.* International Monetary Fund.

Cohen, B H and Scatigna, M. 2016. ‘Banks and capital requirements: channels of adjustment’. *Journal of Banking & Finance* 69, Supplement 1: S56–S69.

Crowther-Ehlers, N. 2019. ‘Inflation expectations in South Africa: non-rational, intertemporal and idiosyncratic heterogeneity represented by a term structure approach’. Doctoral dissertation, Stellenbosch University, Stellenbosch.

Davies, R, Harris, L and Makrelov, K. 2019. ‘The impact of a higher leverage ratio on the South African economy’. *SA-TIED Working Paper #51*.

De Jonghe, O, Dewachter, H and Ongena, S. 2020. 'Bank capital (requirements) and credit supply: evidence from pillar 2 decisions’. *Journal of Corporate Finance* 60: 101518.

De Schryder, S and Opitz, F. 2021. ‘Macroprudential policy and its impact on the credit cycle’. *Journal of Financial Stability* 53: 100818.

Dewatripont, M and Tirole, J. 2018. ‘Liquidity regulation, bail-ins and bailouts’. Technical report, Toulouse School of Economics, Working Paper. https://www.tse-fr.eu/sites/default/files/TSE/documents/doc/by/tirole/prudential_treatment_of_liquidity_080618.pdf

ECD (European Commission Directorate). 2011. ‘Economic impacts of changes in capital requirements in the Euro-area banking sector’. *Quarterly Report on the Euro*

Area 10(2011):1: 26–31. European Commission.

Garbers, C and Liu, G. 2018. 'Macroprudential policy and foreign interest rate shocks: a comparison of loan-to-value and capital requirements'. *International Review of Economics & Finance* 58: 683–698.

Grobler, C and Smit, B. 2014. 'Enhancing the financial sector linkages in the Bureau for Economic Research's core macroeconometric model'. *Stellenbosch Economic Working Paper Series No. 21/15*.

Havemann, R. 2014. 'Counter-cyclical capital buffers and interest-rate policy as complements: the experience of South Africa'. *Economic Research Southern Africa Working Paper Series No. 476*.

Hinterschweiger, M, Khairnar, K, Ozden, T and Stratton, T. 2021. 'Macroprudential policy interactions in a sectoral DSGE model with staggered interest rates'. *Bank of England, Staff Working Paper No. 904.*

Hlongwane, B. 2017. 'Loan-to-value ratio: macroprudential policy instrument for South Africa'. Financial Stability Department Topical briefing. South African Reserve Bank.

Holmstrom, B and Tirole, J. 1997. 'Financial intermediation, loanable funds, and the real sector.' *The Quarterly Journal of Economics* 112: 663–691.

Kabundi, A and Schaling, E. 2013. 'Inflation and inflation expectations in South Africa: an attempt at explanation'. *South African Journal of Economics* 81: 346–355.

Liu, G and Molise, T. 2018. 'Is Basel III counter-cyclical: the case of South Africa?' *Economic Research Southern Africa, Working Paper Series No. 757.*

Lorenzoni, G. 2008. 'Inefficient credit booms'. *The Review of Economic Studies* 75: 809–833.

Lucas, R E. 1976. 'Econometric policy evaluation: a critique'. *Carnegie-Rochester*

Conference Series on Public Policy 1: 19–46.

Makrelov, K, Pillay, N and Morule, B. 2021. ‘Fiscal risks and their impact on banks’ capital buffers in South Africa’. *South African Reserve Bank Working Paper Series No. WP 2021/08*.

Maredza, A. 2016. ‘Do capital requirements affect cost of intermediation? Evidence from panel of South African banks’. *The Journal of Developing Areas* 50: 35–51.

Mehran, H and Thakor, A. 2011. ‘Bank capital and value in the cross-section’. *Review of Financial Studies* 24: 1019–1067.

Mendicino, C, Nikolov, K, Suarez, J and Supera, D. 2020. ‘Bank capital in the short and in the long run’. *Journal of Monetary Economics* 115: 64–79.

Nelson, B and Pinter, G. 2018. Macroprudential capital regulation in general equilibrium. *Bank of England Working Papers No. 770*, Bank of England.

Noss, J and Toffano, P. 2016. ‘Estimating the impact of changes in aggregate bank capital requirements on lending and growth during an upswing’. *Journal of Banking & Finance* 62: 15–27.

RBNZ. 2007. Capital adequacy ratios for banks – simplified explanation and example of calculation. Reserve Bank of New Zealand. http://www.rbnz.govt.nz/finstab/banking/regulation/0091769.html 11/07/2007.

Segura, A and Suarez, J. 2017. ‘How excessive is banks’ maturity transformation?’ *The Review of Financial Studies* 30: 3538–3580.

Shin, H. 2016. ‘Macroprudential tools, their limits, and their connection with monetary policy’. In *Progress and Confusion: The State of Macroeconomic Policy*, edited by O Blanchard, R Rajan, K Rogoff and L H Summers. Cambridge: The MIT Press: 99–106.

Slovik, P and Cournède, B. 2011. ‘Macroeconomic impact of Basel III’. *OECD*

Economics Department Working Paper No. 844.

Smal, D, Pretorius, C and Ehlers, N. 2007. 'The core forecasting model of the South African Reserve Bank'. *South African Reserve Bank Working Paper Series No. 3195*.

Stein, J C. 2012. 'Monetary policy as financial stability regulation'. *The Quarterly Journal of Economics* 127: 57–95.

Svensson, L E. 2018. 'Monetary policy and macroprudential policy: Different and separate?' *Canadian Journal of Economics/Revue Canadienne d'Économique* 51(3): 802–827.

Tayler, W J and Zilberman, R. 2016. 'Macroprudential regulation, credit spreads and the role of monetary policy'. *Bank of England Working Paper Series No. 599*.

Thakor, A V. 2012. 'Incentives to innovate and financial crises'. *Journal of Financial Economics* 103: 130–48.

Woodford, M. 2010. 'Financial intermediation and macroeconomic analysis'. *Journal of Economic Perspectives* 24: 21–44.