Banking stability and keeping up with the riches

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Abstract

This paper develops a dynamic stochastic general equilibrium model to capture the relationship between a heterogeneous banking sector and a heterogeneous household sector, which we consider a fair representation of the South African financial sector. We include endogenous default and liquidity injections in the interbank market. Furthermore, we introduce consumption inequalities between low-income households and high-income households to investigate the importance of the culture of "keeping up with the Jonesses" to the stability of the banking sector and the real economy. The model is calibrated against the South African banks' balance sheets data and used for simulations. We find that small banking crises have short-run effects on the stability of the economy, whereas the big banks seem to have long-run effects. The results highlight the systemic risk of the big banks in the South African economy.

1 Introduction

We develop a dynamic stochastic general equilibrium model to capture the relationship between a heterogeneous banking sector and a heterogeneous household sector, which we consider a fair representation of the South African financial sector. In particular, we want to capture the peculiarity of the banking sector in South Africa which after the end of the Apartheid regime in 1994 saw an influx of small to medium banks, mainly to serve low-income households or those who were previously financially excluded. These small to medium sized banks have been financed by in interbank market and repeatedly shown elements of financial instability.

The South African banking sector is characterised by a few big banks and small banks. Whilst most of the big banks has been able to increase their book size over time by acquiring some of the small banks and sustain market share and financial stability, the same cannot be said about the small banks. The influx of small banks between 1994 and 2004 was reversed when these banks faced liquidity pressures, resulting in about 22 banks exiting the banking system between the last quarter of 1999 and first quarter of 2003, Mboweni (2004). Despite the attribution of these failures to the consolidation in the banking system than failure of the small and medium banks (Mboweni (2004) and Hawkins (2003)), small bank failures remain a concern to the financial system[1]. This is evident from the recent bank failure by one of the small banks in 2014. Therefore, given such many failures of the small and medium banks and the stability of the big banks in South Africa, understanding this peculiarities between the two types of banks is important for the central bank and policy makers.

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[1]Some banks were acquired by the big banks, others were left to dissolve while others did not renew their licenses and exited the market, Hawkins (2003).

Financial instability is defined by Tsomocos (2003) as a combination of an increase in defaults by households and banks and a decrease in the profitability of the banks. The elements essential for the analysis of financial stability are liquidity, endogenous default and agent heterogeneity, Goodhart et al. (2009). A model of an active heterogeneous banks with different loan portfolios is needed for the existence of the interbank market and a contagious financial crisis, whereas endogenous default and incomplete financial markets are required for the possibility of a financial crises, Goodhart et al. (2004). A supervisory authority is also required to restore financial stability in the model by imposing penalties to defaulters, De Walque et al. (2010). Using these elements, several papers have developed dynamic stochastic general equilibrium (DSGE) models to analyse financial stability. Starting with Goodhart et al. (2005), the authors develop a partially-microfounded general equilibrium model. The model includes a heterogenous banking (net borrowers and a net lender in the interbank market) and household (borrowers and a depositor) sectors, a central bank and a regulator with endogenous default. Tabak et al. (2013) and Saade et al. (2007) simulate Goodhart et al. (2005)'s model for Brazil and Colombia respectively. In their papers, banking heterogeneity is based on ownership (private, public or foreign) in Tabak et al. (2013), whereas in Saade et al. (2007), the banking sector is divided into mortgage banks, domestic banks and foreign banks. Though the model by Goodhart et al. (2005) does include heterogeneity in both the household and the banking sector, it is not a micro-founded dynamic stochastic general equilibrium model and it is not dynamic, De Walque et al. (2010).

Therefore, De Walque et al. (2010) embed a close representation of Goodhart et al. (2005) banking sector in a dynamic stochastic general equilibrium model. The authors develop a model with a heterogeneous banking sector consisting of a deposit bank and a merchant bank, a firm, a household who owns the firm and the banks, a banking supervisor and a central bank with endogenous default, liquidity and bank regulation. The authors find that a positive productivity shock in the presence of endogenous default increases the repayment rate of both the firm and the borrowing bank, and amplifies the effects of the shock. However, one of the main limitations of the model discussed by the authors is treating liquidity injections as a commodity and ignoring the issue of inflation. Furthermore, the authors suggest the New-Keynesian approach to address this limitation. Lastly, Goodhart et al. (2009) develop a New-Keynesian dynamic stochastic general equilibrium model which include liquidity, endogenous default and agent heterogeneity. This model addresses the liquidity limitation raised by De Walque et al. (2010). The model consists of two heterogeneous households and two heterogeneous commercial banks. However, one of the households is treated as a farmer, collapsing the household sector to a firm (a simplified production sector) and a household. Furthermore, the model does not include the role of the supervisory authority to restore financial stability. Contrary to De Walque et al. (2010), the authors find that endogenous defaults in the financial system create short to medium-run adverse effect on the banks' profitability and firm's repayment rate following a positive productivity shock.

Although the above mentioned DSGE models incorporate the elements required for financial stability analysis, they do not have a heterogeneous household sector required in our model. Household heterogeneity is important in analysing the welfare effects of exogenous shocks as shocks might have asymmetric effects depending on the which part of the economy gets affected by the shock, Goodhart et al. (2009). Other dynamic stochastic general equilibrium models, such as those of Soler and Estrada (2010) and Gerali et al. (2010) do have heterogeneous household sector. However, they lack the heterogeneous banking sector. Klein and Krause (2014) develop a dynamic stochastic general equilibrium model with household heterogeneity and a firm to analyse the relation between consumer credit and real economic activity during the Great Moderation. The workers demand credit for their consumption, which they measure relative to that of the investors' consumption level. The authors incorporation of the relative consumption motive, which they term as *"keeping up with the riches"*, allows their model to produce positive correlation between consumption, labor and credit, and a negative correlation between wages and credit. However, their model does not include a financial system, and therefore there is no analysis on banking in (stability).

All of the above mentioned papers do not have models that characterise the South African banking sector and economy well and can help us achieve our research objective. Therefore, we see the opportunity to develop such a model. To do so, we follow the model by De Walque et al. (2010). Our aim is to develop a dynamic stochastic general equilibrium model of financial stability with a heterogeneous banking sector and a heterogeneous household sector. In our model, the heterogeneity of the banking sector is motivated by the structure of the banking sector in South Africa, which has enabled the existence of the big and the small banks serving the high-income and low-income households respectively. The two types of banks have different bank loan portfolios and enjoy monopolistic power in their respective markets. We depart from the De Walque et al. (2010) model by assuming household heterogeneity. In this regard, we follow Klein and Krause (2014)'s household structure which characterise the high inequality amongst the South African population that is divided between the have-nots (low-income) and the haves (high-income). Lastly, as in Goodhart et al. (2004), we assume limited participation in both the deposit and the loan market. Therefore, high-income households only deposit their funds into the big banks whereas the low-income households only borrows from the small banks.

The literature on the stability of the banking sector in South Africa has either focused on evaluating the banking performance using financial ratios (Kumbirai and Webb (2010)) or stress testing analysis (Falkena et al. (2004) and Havrylchyk (2010)). This paper contributes to the South African literature in understanding financial stability in the context of both our financial system structure and demographic dynamics. We calibrate the model using South African data - the banks' balance sheets and real economic data.

Notwithstanding its ability to reproduce some of the real business cycle moments, this model provides a starting point for modeling a DSGE model suitable for financial stability dynamics in the South African banking sector. Firstly, we look at the effects of introducing endogenous defaults in the model. Overall, the results indicate that endogenous default rates for both the small banks and the low-income households causes some financial instability by increasing the overall risk (non-performing loans). These results highlights the findings by Goodhart et al. (2009). The authors also find that in the presence of endogenous defaults for both banks and households, a positive technology shock has a negative effect on financial stability in the short run. Secondly, we look at the effects of liquidity injections in the absence and the presence of the relative consumption motive. We find that the inclusion of the relative consumption motive does not affect any of the variables, except the loan demand by the low-income households. Lastly, we investigate the effects of a negative market book shock on both the small and the big banks. We find that the effects of small banking crises on macroeconomic variables and low-income households welfare are only in the short-lived, whereas the big banks seem to have a longer impact. Therefore, central bank intervention is important to prevent any bank crisis, big or small. However, it is very important to ensure the financial stability of the domestically important banks as they pose higher risk to the economy and the banking sector.

The rest of the paper is as follows: Sub-section 1.1 provides an overview of the South African banking sector. Section 2 describes the characteristic of the DSGE model, in section 4 and 5 we discuss the simulations and calibration results while section 6 concludes.

1.1 Why Banking heterogeneity?

The banking sector in South Africa can be divided into small banks and big banks. This bank size is based on market share of the locally controlled South African banks. There is also high concentration in the banking sector, which has been prevalent for years. The big for banks have enjoyed a market share of 83.8%, 87.4% and 84.1% of total banking assets during 1994, 2006 and 2011 respectively[2]. The heterogeneity of the banks is based on the composition of the the balance sheets between the small and the big banks. Table 1 shows the averages of selected balance sheet variables during the period 2002Q1 and 2014Q3. On the liability side, the table indicate that the big banks have a higher reliance on deposits for funding than the small banks, averaging 88% over the period for the big banks and 58% for the small banks. This is different to the US (Japan) where small banks (regional banks) have similar percentages of deposits to total liabilities as that of the South African big banks. We can also see that small banks rely more on fund managers than the big banks, whereas corporates prefer to put their deposits in the big banks. The asset side shows that small banks rely heavily on the loans and advances, which averaged 90% of total assets. Overdrafts, loans and advances averaged 82% of the total loans, indicating a non-diversified loan portfolio. For the big banks, loans and advances averaged 76% of total assets, and the balance sheet indicates a well-diversified loan portfolio.

Table 1: Summary of the banks' balance sheets

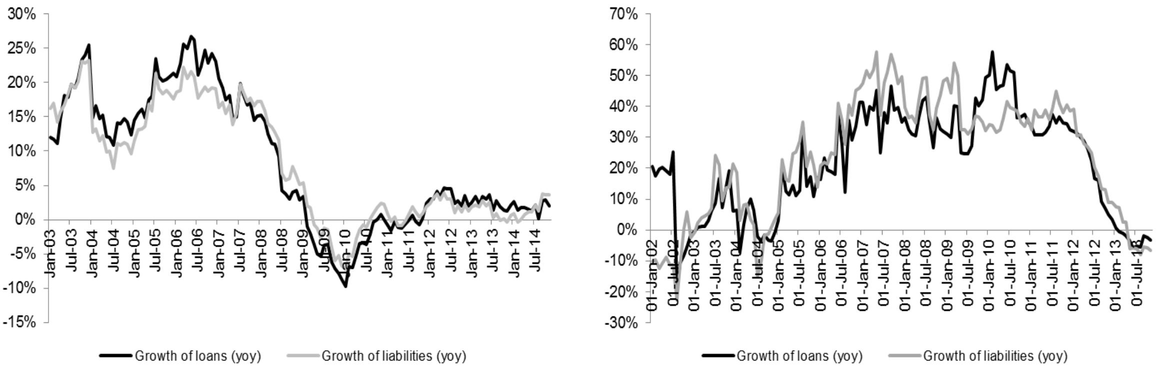
	Small banks	Big banks
Number of banks	2	4
Mean of assets (R thousands)	R402 779	R25 253 330
Median of assets (R thousands)	R231 889	R28 821 683
Total loans (% of total assets)	**90**%	**76**%
Real estate loans	0%	33%
Overdrafts	82%	18%
Instalments	1%	10%
Other credit	5%	16%
Other assets (% of total assets)	**10**%	**24**%
Total deposits (% of total liabilities)	**58**%	**88**%
Households	10%	18%
Corporates	0%	21%
Fund managers	23%	6%
Other deposits	25%	43%
Other liabilities (% of total liabilities)	**42**%	**12**%

Figure 1 presents the year-on-year growth of assets and liabilities between 2002Q1 and 2014Q3 by bank sizes. From Figure 1 (a), we can see that there is a positive co-movement between the liabilities and loans and advances. The effect of the 2008 financial crisis is also evident, with a sharp decrease in both loans and advances and liabilities. We can see that between almost mid-2008 and mid-2011, the growth rate of the liabilities is greater than that of loans. And the figure also shows that the growth rates post the crisis have been lower than the pre-crisis levels. Contrary to the big banks, figure 1

[2]The figures for 1994 and 2006 are for the big five banks, which includes the assets of the current big four and excludes any of the current two small banks. Only one of the current two small banks was in existence in 1994.

(b) shows that from 2004, there was an upward trend in both liabilities and loans and advances, even during the financial crisis. However, from mid-2011 (around the same time as the recovery by the big banks), there was a negative trend in both liabilities and loans and advances, which eventually led to a collapse of one the small banks in South Africa. Figure 2 (a) shows the profitability of the banks between 2002Q1 and 2014Q3. We can see that the profitability of the banks decreased after June 2008 to June 2011, highlighting the effects of the 2008 financial crisis on the banking sector. Figure 1 (b) shows the delinquency ratio, which is calculated as the ratio of loan impairments to total loans and advances by bank size. The darker-shaded area indicate the time around the 2008 financial crisis whereas the light-shaded are indicate the time around local banking *"crisis"*[3]. The darker-shaded area shows that non-performing loans started to increase from late 2007, reaching its peak during the first half of 2010 before stabilising and then declining for the big banks. The effects of the crisis on the small banks' non-performing loans is muted, with only a slight increase during the last quarter of 2009. Contrary, we can see a sharp increase in non-performing loans for the small banks during both cases of the local banking *"crises"*. This indicate that big banks do not seem to be much affected by local *"crisis"*, whereas small banks are more susceptible to it. The dynamics of the two types of banks raises important questions for both research and regulatory authorities.

Figure 1: Assets and Liabilities (year-on-year growth)



(a) (b)

Note: Figure 1 (a) shows the the year-on-year growth of liabilities and assets for the big banks. Figure 1 (b) hows the the year-on-year growth of liabilities and assets for the small banks.

[3] In some occasions, the central bank has let the small to medium banks fail. In other occasions, the central bank has prevented the crises. In 2014, the central bank prevented the failure of another small bank (the same bank which experienced failure in 1995), placing it under curatorships until the new formed bank began operations again in 2016.

Figure 2: Profitability and Non-performing loans

(a) (b)

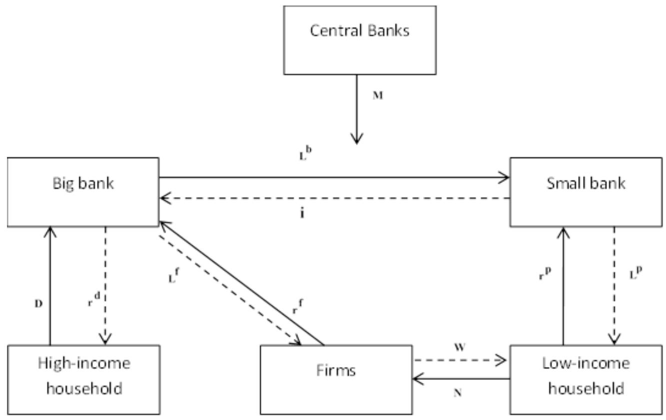
Note: Figure 2 (a) shows the return on assets (profitability) of the banks. Figure 2 (b) shows the ratios of loan impairments for the big banks (left-hand scale) and loan impairments for the small banks (right-hand scale) to their respective total loans and advances. *Source*: South African Reserve Bank FSR (ROA) and authors calculation from the SARB Banks Balance sheets

2 Model

Figure 3 provides the schematic representation of the model. We populate our model with the following agents: two households (low-income and high-income household), the representative firm, two banks (small and big bank), the central bank and the supervisory authority. The low-income household works for the firm and earns his/her wage. The low-income household also borrows from the small bank to smooth consumption due to credit market imperfections in the big bank's market. The high-income household owns the firm and the small and big banks. This household also deposits his/her savings into the big bank, which is assumed to be less risky than the small bank, and earn interest on their deposits. The representative firm hires labour from the low-income household. New investments by the firm are funded by new borrowing from the big bank. The banking sector is assumed to be heterogeneous, consisting of the more secure big bank and riskier small bank. These two types of banks enjoy monopolistic power in their respective markets. The big bank converts loans from the high-income households into business loans to the firm and lend to the small bank in the interbank market. Following De Walque et al. (2010), we assume that high-income households, firms and the banks are distinct from each other and therefore there are no dividend payments to the high-income households. All profits by the firms and the banks are either consumed or used for the next period's funding.

We follow the literature on financial stability by incorporating financial frictions, loan defaults and liquidity. As in Goodhart et al. (2009), loan defaults arise in equilibrium as agents decide how much of their loans they will pay back. Similarly to De Walque et al. (2010), we assume that the big bank cannot default on its obligations to the high-income household. We assume that the small bank and the low-income household can default on their obligations. This means that a low-income household default may lead to the small bank default on the interbank market, which in turn curtails business financing to the firm through the big bank and creates a reduction in output. For each agent defaulting on their obligation, the cost of default is given by a penalty that reduces both their utility and their ability to borrow. Liquidity in injected into the economy by the central bank through the interbank market. The big bank has excess liquidity whereas the small bank is short of liquidity. Therefore, the small bank borrows in the interbank market to be able to lend to the low-income households. The central bank intervenes in the interbank market through liquidity injections or withdrawals, thereby influencing the interbank rate and restoring financial stability. We also incorporate a supervisory authority to administer the fund requirements for the banks.

Figure 3: Nominal flow between agents



2.1 Firms

The firm is owned by the high-income household. The firm hires capital (K_t) and labour (N_t) from the low-income household and pays wages (W). It chooses new borrowing (L_t^f) from the big bank at the price $1/(1 + r_t^f)$ to fund new capital investment. The firm also chooses the amount to repay on the previous loan (α_t) to maximise the discounted sum of all the expected payoffs (π_f). The firm incurs both monetary and non-monetary costs for defaulting on a loan. Non-monetary cost include reputation losses are represented by d_f. Monetary costs (ω_f) include higher search costs to obtain new loans because of bad reputation, and it affect profits.

$$Y_t = \varepsilon_t K_t^u N_t^{1-u} \tag{1}$$

where ϵ_t is the total factor productivity, which is defined by:

$$\varepsilon_t = (\varepsilon_{t-1})^{\rho_\varepsilon} exp(\mu_t^\varepsilon) \tag{2}$$

The firm's maximisation programme is:

$$\max_{N_t, L_t^f, K_t, \alpha_t, \pi_t^f} \sum_{s=0}^{\infty} E_t\{\beta_f^s[\pi_{t+s}^f - d_f(1 - \alpha_{t+s})]\} \tag{3}$$

subject to the following constraints:

$$K_t = (1 - \tau)K_{t-1} + \frac{L_t^f}{1 + r_t^f} \tag{4}$$

$$\pi_t^f = \varepsilon_t K_t^u N_t^{1-u} - W_t N_t - \alpha_t L_{t-1}^f - \frac{\omega_f}{2}[(1 - \alpha_{t-1})L_{t-2}^f]^2 \tag{5}$$

Equation 3 is the equation of motion for capital. The equation shows that current capital investment equals the non-depreciated capital from the previous capital stock and new loan borrowing. Equation 5 defines the profit for the firm. Profits equals output less wages to the workers, loan repayment and default cost. The maximisation of the objective function (3) subject to budget constraints (4) and (5) yields the following first order conditions of the firms are:

$$(1-u)\varepsilon_t K_t^u N_t^{-u} = W_t \tag{6}$$

$$u\varepsilon_t K_t^{u-1} N_t^{1-u} = \lambda_t^f - E_t[\beta_f \lambda_{t+1}^f (1-\tau)] \tag{7}$$

$$\frac{\lambda_t^f}{1+r_t^f} = E_t[\beta_f \alpha_{t+1} + \beta_f^2 \omega_f (1-\alpha_{t+1})^2 L_t^f] \tag{8}$$

$$L_{t-1}^f = \beta_f \omega_f (1-\alpha_t) {L_{t-1}^f}^2 + d_f \tag{9}$$

Equation 6 equates the marginal product of labour to wages. Equation 7 equates the marginal product of capital to its shadow price today less the discounted shadow price of tomorrow. Loan demand by the firms is defined by equation 8, which states that the shadow price of capital is equal to the discounted expected total cost, part of it paid tomorrow based on the decided payment rate and the remaining cost (monetary cost for defaulting) paid in two periods time. Lastly, equation 9 equates the marginal cost of paying back the loan today to the discounted marginal search cost of tomorrow plus the marginal disutility cost.

2.2 Households

2.2.1 Low-income households

The low-income household work for the firm and earn wages for their labour. They borrow loans (L_t^p) from the small banks at the price of $1/(1+r_t^p)$ to smooth their consumptions (C_t^p). We assume that low-income households measure their consumption relative to the high-income household. The low-income household derives utility from own consumption (C_t^p) and disutility from working (N_t^p), defaulting on previous loan (d_p) and consumption of the high-income household (C_t^r). The parameter ϱ is the jealousy parameter, which measures how much low-income households want to keep up with the high-income households. The parameter ϕ_p is the leisure relative preference parameter. The objective function of the low-income household is:

$$\max_{C_t^p, L_t^p, N_t^p, \eta_t} \sum_{s=0}^{\infty} E_t\{\beta_p^s [ln(C_{t+s}^p - \varrho \frac{C_t^r}{C_t^p}) + \phi_p ln(1-N_t^p) - d_p(1-\eta_{t+s})]\} \tag{10}$$

subject to the following constraint:

$$C_t^p + \eta_t L_{t-1}^p + \frac{\gamma_p}{2}[(1-\eta_{t-1})L_{t-2}^p]^2 = W_t N_t^p + \frac{L_t^p}{1+r_t^p} \tag{11}$$

Equation (11) equates current expenses, which include consumption and loan repayments, of the low-income household to the current wages and loan borrowing. The maximisation of the objective funtion 10 subject to the budget constraint (11) yields the first order conditions:

$$\frac{1+\varrho \frac{C_t^p}{(C_t^r)^2}}{C_t^p - \varrho \frac{C_t^p}{C_t^r}} = \lambda_t^p \tag{12}$$

$$\frac{\lambda_t^p}{(1+r_t^p)} = E_t[\beta_p \lambda_{t+1}^p \eta_{t+1} + \beta_p^2 \lambda_{t+2}^p \gamma_p (1-\eta_{t+1})^2 L_t^p] \tag{13}$$

$$\lambda_t^p L_{t-1}^p = \gamma_p(1-\eta_t)(L_{t-1}^p)^2 E_t[\lambda_{t+1}^p] + d_p \tag{14}$$

$$\frac{\phi_p}{1-N_t^p} = \lambda_t^p W_t \tag{15}$$

Equation (13) defines the loan demand by the low-income households, which equates the shadow price of low-income loans to its discounted expected costs paid today and in two period time. Equation (14) equates the marginal cost of paying the loan today to the marginal cost of paying tomorrow. Lastly, substituting equation (12) into (15) gives you the marginal rate of substitution between consumption and leisure to the opportunity cost of an additional unit of leisure.

2.2.2 High-income households

The high-income household owns the firms and the banks. They derive utility from their consumption (C_t^r) and disutility ($\chi/2$) for deviating from their average savings. They maximise the following utility function:

$$\max_{C_t^r, D_t^r} \sum_{s=0}^{\infty} E_t\{\beta_r^s[ln(C_{t+s}^r) - \frac{\chi}{2}(\frac{D_{t+s}^r}{1+r_t^r} - \frac{\bar{D}_r}{1+r^r})^2]\} \tag{16}$$

subject to the budget constraint:

$$T_t + C_t^r + \frac{D_t^r}{(1+r_t^r)} = D_{t-1}^r \tag{17}$$

Equation (17) equates tax transfers (T_t), consumption (C_t^p) and deposits (D_t) to deposit payments from the big banks. The maximisation of the objective function (16) subject to the budget constraint (17) yield the following first order conditions:

$$\frac{1}{C_t^r} = \lambda_t^r \tag{18}$$

$$\frac{1}{C_t^r}\frac{1}{1+r_t^r} = \beta_r \frac{1}{C_{t+1}^r} - \chi(\frac{D_t^r}{1+r_t^r} - \frac{\bar{D}^r}{1+r^r}) \tag{19}$$

Equation (19) is the Euler equation for the rich households adjusted with the marginal cost of deviating from the deposit target.

2.3 Banks

2.3.1 Big banks

The big banks operate in a monopolistic market. These big banks can be likened to deposit banks in De Walque et al. (2010) and Carrera and Vega (2012). Unlike in the above mentioned papers where these type of banks only collect deposits and lend in the interbank market, the big banks also lend to the firms. Table 2 represents the balance sheet of the representative big bank. On the liabilities side, the bank collects deposits (D_t) from the high-income household at the deposit rate (r_t^d) determined by the banks. The assets side indicate that the bank lends to firms (L_t^f) at the lending rate $1/(1+r_t^f)$ and to the small bank (L_t^{bz}) in the interbank market at the interbank rate $1/(1+i_t)$.

Table 2: Balance Sheet of the Big Banks

Assets	Liabilities
Commercial loans (L_t^f)	Deposits (D_t)
Interbank loans (L_t^b)	Equity (F_t^b)

We follow the maximisation strategy of De Walque et al. (2010). Over and above its profit, the bank also enjoys utility d_F^b from keeping funds above the capital requirement by the supervisory authority. The parameter κ is a fixed coverage ratio of risky assets, and $\hat{w}_t^z$ and w_t^f are the weights on the interbank loans and firm loans respectively. Therefore the big bank chooses D_t^r, L_t^{bz} and F_t^b to maximise the sum of its expected payoffs subject to its budget constraints:

$$\max_{B_t^b,\pi_t^b,D_t^r,L_t^b,F_t^b} \sum_{s=0}^{\infty} E_t\{\beta_b^s[ln\pi_{t+s}^b + d_F^b(F_{t+s}^b - \kappa(\hat{w}_t^z L_t^b + w_t^z L_t^f + w_t^b B_t^b))]\} \tag{20}$$

subject to the following constraints:

$$F_t^b = (1-\xi_b)F_{t-1}^b + \nu_b \pi_{t-1}^b \tag{21}$$

$$\pi_t^b = \delta L_{t-1}^{bz} - \frac{L_t^{bz}}{1+i_t} + \alpha_t L_{t-1}^f - \frac{L_t^f}{1+r_t^f} + \frac{D_t^r}{1+r_t^r} - D_{t-1} + \zeta_b(1-\delta_{t-1})L_{t-2}^{bz} + \zeta_{bf}(1-\alpha_{t-1})L_{t-2}^f + (1+\rho_t)B_{t-1}^b + B_t^b \tag{22}$$

Equation 21 states that the bank accumulates its current funds from the share $(1-\xi_b)$ of previous funds F_{t-1}^b and the share ν_b of previous profit π_{t-1}^b not distributed into the insurance scheme to the supervisory authority. This equation allows a feedback loop between the real economy and the financial sector, Gerali et al. (2010). Equation 22 defines the bank's profit. Parameters ζ_b and ζ_{bf} represent the fraction of defaulted loans that the big bank recovered from the insurance scheme respectively, with ζ_b, ζ_{bf}, ν_b and $\xi_b \in [0,1]$.

The maximisation of the objective function (20) subject to the budget constraints (21) and (22) which yields the first order conditions of the big banks are:

$$\frac{\lambda_t^b}{1+r_t^r} = \beta_b \lambda_{t+1}^b \tag{23}$$

$$\frac{\lambda_t^b}{1+i_t} = E_t[\beta_b^2 \lambda_{t+2}^b \zeta_b(1-\delta_{t+1}) + \beta_b \lambda_{t+1}^b \delta_{t+1}] - d_F^b \kappa \hat{w}_t^z \tag{24}$$

$$\frac{\lambda_t^b}{(1+r_t^f)} = E_t[\beta_b \lambda_{t+1}^b \alpha_{t+1} + \beta_b^2 \lambda_{t+2}^b \zeta_{bf}(1-\alpha_{t+1})] - d_F^b \kappa w_t^f \tag{25}$$

$$d_F^b \nu_b = (\lambda_t^b - \frac{1}{\pi_t^b}) - E_t[\beta_b(1-\xi_b)(\lambda_{t+1}^b - \frac{1}{\pi_{t+1}^b})] \tag{26}$$

Equation 23 is the Euler equation for the deposit from the high-income households. Equation 24 defines the supply of interbank lending to the interbank market. The equation equates the marginal cost of interbank lending to the discounted expected payments by the small banks less the marginal cost of capital regulation. Similarly, equation 25 defines the supply of loans to the firms.

2.3.2 Small banks

The small bank borrow from the big bank in the interbank market and provide household loans (L_t^p) at the lending rate $1/(1+r_t^p)$ to the low-income households. Similarly to the big bank, we assume that the small bank enjoys a linear utility d_F^z for having funds over and above the minimum requirement. And as with the firms and the low-income households, the small bank also faces a non-monetary cost d_z and search costs ω_z for defaulting on its interbank loan with the big bank. The parameter κ is a fixed coverage ratio of risky assets. The parameters $\bar{w}_t^p$ and w_t^z are the weights on the loans to the low-income households and book value, respectively. Equation 29 defines the bank's profit. The parameter ζ_p represent the fraction of defaulted loans that the big bank recovered from the insurance scheme, with ζ_p, ν_p and $\xi_p \in [0,1]$.

Table 3: Balance Sheet of the Small Banks

Assets	Liabilities
Household loans (L_t^p)	Interbank loans (L_t^{bz})
	Equity (F_t^{bz})

The small bank's maximisation programme is:

$$\max_{\pi_t^z, L_t^{bz}, L_t^p, \delta_t, F_t^z} \sum_{s=0}^{\infty} E_t\{\beta_z^s[ln\pi_{t+s}^z - d_z(1-\delta_{t+s}) + d_F^z(F_{t+s}^z - \kappa(\bar{w}_t^p L_t^p + w_t^z B_t^z)]\} \tag{27}$$

subject to the following constraints:

$$F_t^z = (1-\xi_z)F_{t-1}^z + \nu_z \pi_{t-1}^z \tag{28}$$

$$\begin{aligned}\pi_t^z = \eta_t L_{t-1}^p - \tfrac{L_t^p}{1+r_t^p} + \tfrac{L_t^{bz}}{1+i_t} - \delta_t L_{t-1}^{bz} + \zeta_{zp}(1-\eta_{t-1})L_{t-2}^p - \tfrac{\omega_z}{2}[(1-\delta_{t-1})L_{t-2}^{bz}]^2 + \\ (1+\rho_t)B_{t-1}^z + B_t^z\end{aligned} \tag{29}$$

Similar to the big banks, equation (28) defines the evolution of the funds for the small banks. The maximisation of the objective function (27) subject to the budget constraints (28) and (29) which yields the first order conditions of the big banks are:

$$\frac{\lambda_t^z}{1+i_t} = E_t[\beta_z \lambda_{t+1}^z \delta_{t+1} + \beta_z^2 \lambda_{t+2}^z \omega_z (1-\delta_{t+1})^2 L_t^{bz}] \tag{30}$$

$$\frac{\lambda_t^z}{(1+r_t^p)} = E_t[\beta_z \lambda_{t+1}^z \eta_{t+1} + \beta_z^2 \lambda_{t+2}^z \zeta_{zp}(1-\eta_{t+1})] - d_F^z \kappa \bar{w}_t^p \tag{31}$$

$$\lambda_t^z L_{t-1}^{bz} = E_t[\beta_z \lambda_{t+1}^z \omega_z (1-\delta_t)(L_{t-1}^{bz})^2] + d_z \tag{32}$$

$$d_F^z \nu_z = (\lambda_t^z - \frac{1}{\pi_t^z}) - E_t[\beta_z(1-\xi_z)(\lambda_{t+1}^z - \frac{1}{\pi_{t+1}^z})] \tag{33}$$

Equation (30) defines the interbank loan demands by the small banks in the interbank market. Equation (31) defines the supply of loans to the low-income households. to the interbank market. Similar to the firms, equation 32 defines the cost of paying the interbank loans today to the monetary and non-monetary penalty costs of paying in the next period.

2.4 The Central bank and supervisory authority

The central bank conducts monetary policy operations by injecting ($M_t > 0$) or withdrawing ($M_t < 0$) liquidity in the interbank market through the open market operations. This allows the central bank to let the interbank rate be endogenously determined and clear the interbank market in equation 34:

$$M_t = L_t^{bz} - L_t^b \tag{34}$$

where the money supply follows an autoregressive process

$$M_t = \rho_m M_{t-1} + u_t^m \tag{35}$$

with the persistence parameter $\rho_m = 0.95$, liquidity shock $u_t^m \ N(0, \sigma_m^2)$ where $\sigma_m = 0.01$. To close the model, we follow De Walque et al. (2010)'s no financing constraints case and assume that the central bank finances the liquidity injections itself. Therefore, households only finance the insurance scheme via taxes defined by equation 36:

$$T_t = \zeta_b(1 - \delta_{t-1})L_{t-2}^{bz} + \zeta_{bf}(1 - \alpha_{t-1})L_{t-2}^f + \zeta_p(1 - \alpha_{t-1})L_{t-2}^p - \xi_z F_{t-1}^z - \xi_b F_{t-1}^b \tag{36}$$

The supervisory authority sets the capital requirement (κ) for both banks. It also assigns the risk weights w_t^f, $\bar{w}_t^p$, $\hat{w}_t^z$ and $w_t^a, a \in \{s, b\}$ to loans to the firms (L_t^f), low-income households (L_t^p), and small banks (L_t^{bz}) and market book investment ($B_t^a, a \in \{s, b\}$). Since we are not interested in analysing the effects of regulatory changes from Base I to II, we only follow the Basel I regime. Therefore, the risk-weights are constant and not risk-sensitive.

3 Aggregation and market clearing

There are 6 markets in the economy, which include the goods, labour, low-income household credit, high-income deposit, firm credit and interbank markets. The model consists of variables r_t^f, i_t, r_t^p, r_t^r,C_t^p, C_t^r, K_t, Y_t, L_t^f, L_t^{bz}, L_t^p, W_t, T_t , N_t, N_t^p, π_t^b, π_t^z, π_t^f, F_t^b, F_t^z, D_t and the TFP ε_t.

The labour market: Substituting equation (12) into (15) equates the marginal rate of substitution between consumption and leisure to the opportunity cost of an additional unit of leisure.

$$\phi_p \frac{C_t^p - \varrho \frac{C_t^p}{C_t^r}}{1 + \varrho \frac{C_t^p}{(C_t^r)^2}} \frac{1}{1 - N_t^p} = (1 - u)W_t \tag{37}$$

Equation 38 equates the demand for labour to the supply of labour, where N_t^p is the amount of labour by the low-income households and $N_t^p + N_t^r = 1$, the total population.

$$N_t = N_t^p \tag{38}$$

The Final goods and service market: The aggregate resources are:

$$Y_t = C_t + K_t + (1 - \tau)K_{t-1} \tag{39}$$

where $C_t = C_t^r + C_t^p$. *The credit market for the low-income households:* The credit market for the low-income market clears when the demand for loans equals the supply of loans by the small banks.

$$\frac{L_t^p}{1 + r_t^p} = L_t^p \tag{40}$$

The credit market for the firms: The credit market for firms clears when the demand for loans equals the supply of loans by the big banks.

$$\frac{L_t^f}{1+r_t^f} = L_t^f \tag{41}$$

The interbank market: The interbank market clears according to equation 34.

$$(M_t + L_t^b)(1+i_t) = L_t^{bz} \tag{42}$$

The Capital market:

$$K_t = (1-\tau)K_{t-1} + \frac{L_t^f}{1+r_t^f} \tag{43}$$

$$ln\varepsilon_t = \rho_\varepsilon(ln\varepsilon_{t-1}) + \mu_t^\varepsilon \tag{44}$$

In addition to the above equations, we also have Equation 5, 11, 12, 18, 19, 25, 23 and 36 which are the constraints for firms, banks, households and the central bank.

4 Calibration

The description of the data and data sources used for the calibration is provided in Appendix 7.2. Table 4 and 5 provide the calibrated parameter values and the implied steady state values, respectively. We refer to a period as a quarter. Therefore, the maturity of any loan or investment is one-quarter.

Table 4: Calibrated parameters

Banks			
$\kappa = 0.10$	$\beta_b = 0.99$	$\beta_z = 0.99$	$B^z = 0.27$
$\zeta_b = 0.80$	$\zeta_{bf} = 0.8$	$\zeta_{zp} = 0.80$	$\bar{w}^f = 1.20$
$\bar{w}^p = 1.50$	$\hat{w}^z = 0.50$	$\nu_b = 0.50$	$\nu_b = 0.50$
$\mathrm{d}_F^b = 4863.52$	$\mathrm{d}_F^z = 566.34$	$\mathrm{d}_z = 1127.61$	$\omega_z = 1.95$
$\xi_b = 0.01$	$\xi_z = 0.07$	$B^b = 0.27$	
Firms			
$u = 0.33$	$\tau = 0.025$	$\omega_f = 1.55$	$\mathrm{d}_f = 0.27$
Households			
$\chi = 0.01$	$\mathrm{N} = 0.24$	$\mathrm{D}^r = 0.97$	$\beta_r = 0.99$
$\mathrm{d}_p = 0.01$	$\gamma_p = 0.95$	$\beta_p = 0.99$	$\varrho = \{0.00, 0.10\}$

Table 5: Steady state values

Interest rates and repayment rates			
$i = 1.43\%$	$r^f = 2.07\%$	$r^p = 4.71\%$	$r^r = 1.01\%$
$\delta = 0.98$	$\alpha = 0.95$	$\eta = 0.83$	
Assets and Liabilities			
D/L=6.13	$B^z/B^b = 1$	π/L=1%	
Macroeconomic variables and profits			
$K/Y = 8$	$C/Y = 0.68$	L/Y= 0.26	T/Y =0.6%
$\epsilon = 1$			

Notes: $L = L^f + L^p$ = total loans. π/L = total profits over total assets of the banks = return on assets. $F = F^b + F^s$ = total funds for the banks, $\pi = \pi^b + \pi^s$ = total profits for the banks, $C = C^r + C^p$ = total consumption by the households.

4.1 Households

The discount factor for both households is set at the 0.99, which is the level common in the literature. The default rate for the low-income households is calculated using the ratio non-performing loans to total household loans from the balance sheets of the small banks between 2002Q1 and 2014Q3. This gives us an average default rate of 17%, implying that the repayment rate for the low-income households (η_t) is 0.83. This level is close to that by Ngalawa and Viegi (2013). According to the authors, the probability of loan repayment for a quasi-emerging market economy's informal financial sector is 0.85. Though we look at the formal financial sector for low-income households in an emerging market, the two markets are similar as the formal sector is a substitute for informal sector for low-income households. The total hours worked by the small households is 0.24[4].

4.2 Banking sector

Similarly to the households, we set the discount rate for both banks at 0.99. The steady state quarterly interest rates for the firms (r_t^f), interbank loans/deposits (i_t), high-income household deposits (r_t^r) and the loans to the low-income households (r_t^p) are set at their steady state values from equations. For the high-income household deposits, $r_t^r = 1/\beta - 1 = 0.01$. The steady state values for i_t ,r_t^f and r_t^p are 1.43%, 2.07% and 4.71% from equation 24, 25 and 31 respectively. The real return on market book is calculated as the return on the Johannesburg Stock Exchange All Share Index (ρ_t=3%). We assume the same return for both the big and the small banks. Similarly to De Walque et al. (2010), we use the z-score method to represent the probability of default by the small banks (δ_t). The Z-score measures the distance of the banking system from insolvency, with a high level implying sound financial stability, Andrianova et al. (2015). It is inversely related to financial fragility, and is given by:

$$Z_t = \frac{ROA_t + \frac{Equity_t}{Assets_t}}{\sigma_{ROA}} \tag{45}$$

where ROA is the return on asset and σ_{ROA} (financial fragility) is the standard deviation of the ROA. Higher levels of the z-score implies higher financial stability. The z-score is calculated using the 2 small

[4]The number is calculated assuming that on average low-income households work 10 hours a day for 5 days in a week for 42 weeks.

banks' balance sheet data. We find that the average probability of default for the small banks is 4%. However, we set the default rate lower at 2% ($\delta_t = 0.98$) to ensure that the repayment rate for small banks is greater than that of the firms. We follow De Walque et al. (2010) and assume every period, banks allocate 50% of their profits to own funds ($\nu_b = \nu_z$=0.50). The contribution to own funds by the bank is 0.01 for the big banks (ξ_b) and 0.07 for the small banks (ξ_z).

In South Africa, the capital requirement of 8% of risk-weighted assets was changed to 10% in 2001, Mboweni (2004). Therefore, we set $\kappa = 0.10$. Assets are allocated weight according to their riskiness, with risky assets receiving the highest weight, which is 1.50 according to the Basel agreement. Similar to De Walque et al. (2010), we also set the weight of the interbank ($\hat{w}^z$) and firm ($\bar{w^f}$) loans to 0.50 and 1.20 respectively. We set the weight for loans to the low-income households ($\bar{w}^p$) slightly above the loans to the firm at 1.00. This implies that we regard them as the riskiest loans in the economy. Lastly, as in De Walque et al. (2010), we also assume that 80% of defaulted loans (interbank, low-income and firms) are recovered from the insurance scheme ($\zeta_b = \zeta_{bf} = \zeta_{zp} = 0.80$).

4.3 Real sector

We follow De Walque et al. (2010) and assume a default rate (α_t) of 0.95 for the firms. Alternatively, we calculate the default rate for the non-financial corporations as a ratio of the number of liquidation and insolvency to the total number of tax paying firms[5]. The ratio is calculated across industries that are likely to have more big firms than small firms since we are only interested in big firms. These are the firms that have higher probabilities of getting a loan from the big banks than small firms. The selected industries are manufacturing, mining and quarrying and electricity, gas and water supply. We get α_t=0.99, which we think is too high to generalise for all firms. Given the above, we can then use the steady state equation to determine the disutility of firms for defaulting on loans. We set the capital share (u_t) to 0.33, and therefore the labour share ($1 - u_t$) to 0.67. The quarterly depreciation rate (τ) is set to 0.025. The discount rate for the firms is also set at 0.99.

5 Simulations

We are interested in effects of endogenous default, liquidity injection and relative consumption motives and banking profitability on the economy. Prior to investigating the effects of each shock, we first test our model against real data to see if it is able to reproduce the real business stylised facts. We then start our investigation by looking at the effects of introducing endogenous defaults rates in our model. We follow with the effects of liquidity injections by the central bank in the presence of the relative consumption motive by the poor households. Lastly, we investigate how instability in the banking sector is transmitted to the rest of the economy. We run our models under the Basel I regime[6].

5.1 Business cycle moments

To check the performance of our model to the real data, we run simulations with a positive productivity shock and endogenous default for both the small banks and the low-income households. These were the two vulnerable agents in the economy during the sample period. As with many papers which use the

[5]The data on the number of liquidation and insolvency of firms and the annual financial statements of the industries is compiled by the Statistics South Africa (StatsSA) and South African National Treasury. The data on the total number of tax paying firms is obtained from the South Africa Revenue Services (SARS)

[6]The Basel II regime was introduced in 2008.

data on loans from the banks, our data is in stocks and not flows as it is in our model. The positive productivity shock follows the following autoregressive process: $\varepsilon_t = (\varepsilon_{t-1})^{\rho_\varepsilon} exp(\mu_t^\varepsilon)$, with $\rho_\varepsilon = 0.95$, $u_t^\varepsilon \sim N(0, \sigma_\varepsilon^2)$ and $\sigma_\varepsilon = 0.01$. Table 6 compares the first and second moments of our model to that of the data. For the first moments, our model only does well for consumption and investment. For the second, the model is not able to reproduce the procyclicality of the interest rate for loans to the low-income households (r_t^p) as observed in the data. However, interest rates for the firms (r_t^f), the interbank rate (i_t) and deposit rate (r_t^r) are procyclical and consistent with the data. Our model also produces countercyclical interbank loans and deposit as in the data. And lastly, most variables in the data exhibit persistence levels than most of the variables in our model.

Table 6: Real Business Cycle moments

	Mean		Correlation with output		First-order autocorrelation	
	Data	Model	Data	Model	Data	Model
r_t^p	16.10%	12.62%	0.54	-0.22	0.89	-0.14
i_t	2.15%	5.14%	0.57	0.50	0.88	0.05
r_t^f	11.10%	9.88%	0.54	0.76	0.89	0.67
r_t^r	1.60%	4.13%	0.54	0.76	0.89	0.67
L_t^b	0.21	0.39	-0.22	-0.36	0.81	0.22
L_t^{bz}	0.01	0.39	-0.34	-0.36	0.64	0.22
L_t^f	0.97	0.25	0.11	0.93	0.92	0.79
L_t^p	0.11	0.00	-0.18	1.00	0.96	0.75
D_t^r	0.97	1.59	-0.03	0.90	0.94	0.69
Y_t	1.00	1.00	1.00	1.00	0.90	0.74
C_t	0.59	0.68	0.91	0.88	0.94	0.85
I_t	0.19	0.24	0.69	0.81	0.88	0.93

Notes: Interest rates are real terms and annualised. Except for interest rates, all variables have been logged. $F_t = F_t^b + F_t^s$ = total funds for the banks, $\pi_t = \pi_t^b + \pi_t^s$ = total profits for the banks, $C_t = C_t^r + C_t^p$ = total consumption by the households. Investment $I_t = K_t + (1-\tau)K_{t-1}$.

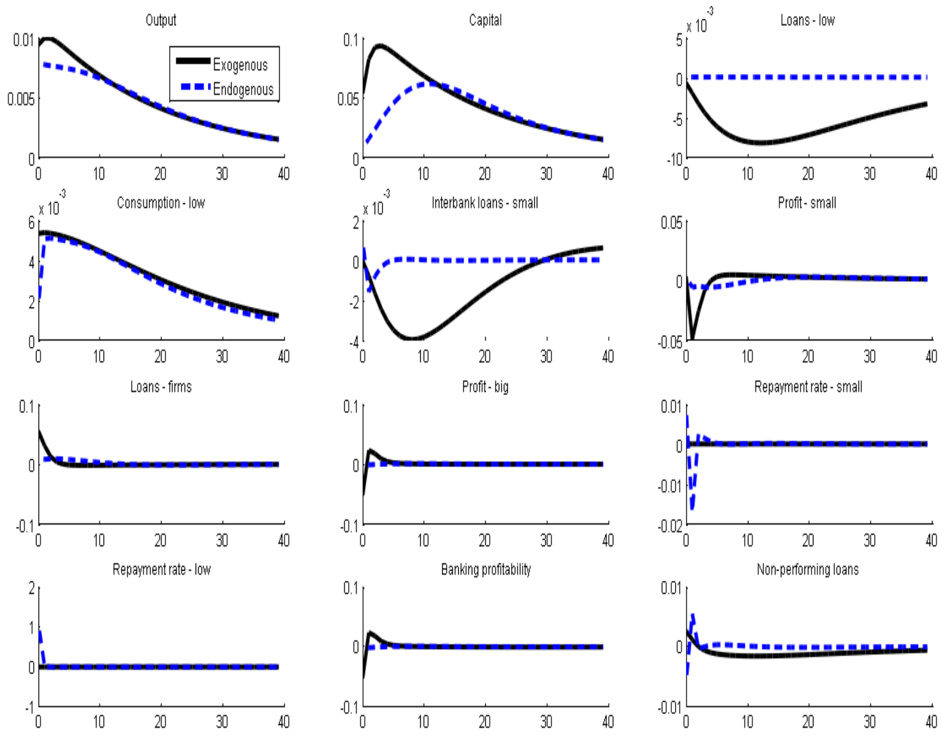
5.2 Endogenous default rates

We start our simulations by looking at the effects of a positive productivity shock in the absence and presence of endogenous default. We restrict our simulation to only look at endogenous default for small banks and low-income households. Figure 4 presents the results for both exogenous and endogenous default rates. The results for a positive productivity shock with exogenous default are as in the real business cycle literature: a positive productivity shock increases the total productivity factor, which then increases output, wages and capital investment. All interest rates increase except for the loan rate to the low-income households. Using our model, the results show that firms increase their borrowing to fund capital investment, increasing the firm loan rate. On the contrary, higher wages reduces the demand for loans by low-income households. This reduces the low-income households interest rate and thereby reducing the profitability of the small banks .

In the presence of endogenous default rates, a positive productivity shock increases the loan repayment by the low-income households and decreases the payment rate by the small firms. Since endogenous defaults for the small banks and low-income households also reduces output, wages and capital investment by the firms also decrease. The reduction in wages increases the low-income households' loan demand, which increases the low-income household interest rate. At the same time, the reduction in the repayment of the small banks increases the interbank rate. With lower interest rates on loans to low-income households and higher interbank rate, the credit spread for the small banks decreases, which reduces their profitability since they are now lending more loans at a lower rate.

Overall, the results indicate that endogenous default rates for both the small banks and the low-income households causes some financial instability by increasing the overall risk (non-performing loans). Even though we find that endogenous default rates for the small banks and low-income households stimulate the demand for low-income household loans and interbank borrowing by the small banks, the effects on output and capital investment are negative - dampening rather than accelerating the positive productivity shock. This is in contrast to the findings by De Walque et al. (2010). We obtain similar results when we make the default rate for the firms endogenous. With endogenous default rates for the firms only, the increase in output allows firms to repay more of their loans. This increases liquidity in the financial system, and limit the increase in the interbank interest rate, interest rate for the firms and the deposit rate, making it cheaper to borrow for the low-income households. These results highlight the findings by Goodhart et al. (2009). The authors also find that in the presence of endogenous defaults for both banks and households, a positive technology shock has a negative effect on financial stability in the short run.

Figure 4: Endogenous default and financial accelerator



Note: Variation from the steady state, in % points.

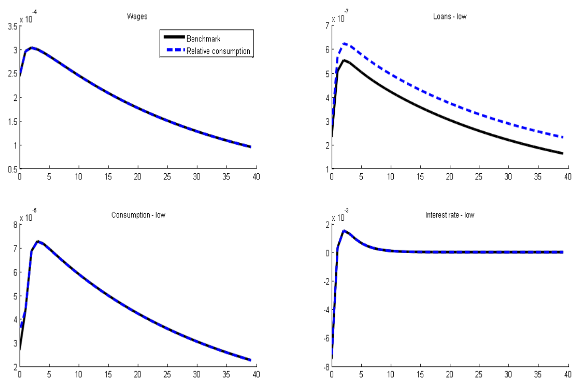
5.2.1 Liquidity shock and relative consumption motive

Liquidity injections provide cheap money to borrowers. Given the excess liquidity in the system, equilibrium in the credit and deposit markets would then be restored through lower interest rates. This would therefore reduce deposits by the savers, as evident in the literature [7]. Therefore, consumption of the savers will increase. Low-income households may aspire to live a certain lifestyle similar to the high-income households. This may result in a higher demand for credit than if there was no such desire as the low-income households wish to consume more than they can afford with their wages. We investigate the effect of this relative consumption motive on both the economy and the banks' behaviours. We estimate our model with a positive liquidity shock under two scenarios. In the first scenario, we assume that there is no relative consumption motive by the low-income households, $\varrho = 0$. Euler equation 12 collapses to the standard form. In the second case, we set $\varrho > 0$. We therefore set $\varrho = 0.1$. Figure 5 shows the results for the liquidity shock only (benchmark) model and the liquidity shock in the presence of the relative consumption motive.

Increase in liquidity results in cheap borrowing by all agents - both the firm loans and low-income household loans increase. This reduces interest rates in the credit market for the firms and low-income households. The repayment rates for the small banks, low-income households and firms increase and thereby reducing the overall risk in the banking sector as seen in the decrease of non-performing loans. However, both the increase in wages and the reduction in interest rate for low-income households' loans reduces the profitability of the small banks.

When we introduce the relative consumption motive, we find that the effects of the relative consumption motive is limited to the demand for loans, with no effect on consumption and other variables of the small banks. Therefore our model is not able to show any increase in consumption to support our story. Therefore, a better model specification is required.

Figure 5: Liquidity shock and Relative consumption motive



Note: Variation from the steady state.

5.3 Market book value shock and liquidity injections

In this section, we use our model to understand how a reduction in profitability of the banks impact the whole economy. Following De Walque et al. (2010), we introduce a negative market book shock, which is equivalent to a reduction in the banks' profitability, and no productivity shock. The return for the market book follows an autoregressive process of $\rho_t = \bar{\rho}^{(1-\rho_\rho)}(\rho_{t-1})^{\rho_\rho} exp(\mathrm{u}_t{}^{\rho})$, with $\rho_\rho = 0.50$, $u_t^\rho \sim N(0, \sigma_\rho^2)$ and $\sigma_\rho = 0.01$. According to the authors, a degree of persistence of 0.50 means that it takes a year for the shock to disappear. As in De Walque et al. (2010), the liquidity injections M_t follows

[7] De Walque et al. (2010).

the following rule:

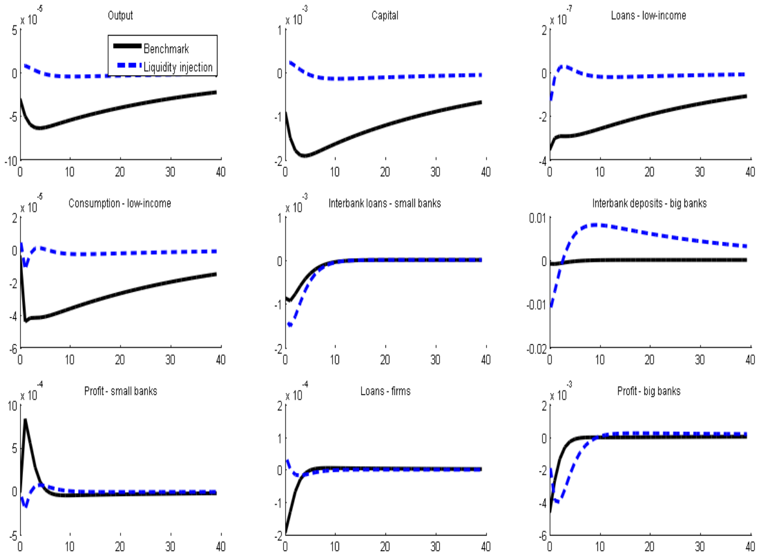
$$M_t = \upsilon(i_t - \bar{i}) \tag{46}$$

with $\upsilon \geq 0$, such that M_t increases (decreases) when the interbank rate is higher (lower) than the long run $\bar{i}$. To model liquidity, De Walque et al. (2010) set $\upsilon = 100$. According to the authors, this is equivalent to a 10% increase in liquidity by the central bank. All other shocks are set to their steady state values. We also set the repayment rates for all the agents to be endogenous. We consider the scenario of a market book without the central bank's intervention ($\upsilon = 0$) as our benchmark model and that with such an intervention ($\upsilon > 0$).

Figure 6 and 7 show the results for the benchmark model with no liquidity injections ($\upsilon = 0$) and the model with liquidity injections ($\upsilon > 0$). Starting with the scenario of no liquidity injection, a decrease in market book value for the banks reduces the liquidity in the interbank market. Agents who depend on loans from the big banks face a credit crunch - both the interbank loans and firm loans decrease. This increases the interbank rate and the firm loan rate. A decline in loans to the firm reduces capital investment, output and the demand for labour by the firms. Lower output reduces the repayment rate for the firms. With lower wages, loans to low-income households decline, reducing the interest rate. The reduction in the interest help low-income consumers to repay some of their loans in the short-run, temporarily reducing their default rates. The overall effects without the central bank's intervention is an increase in non-performing loans and a reduction of macroeconomic variables.

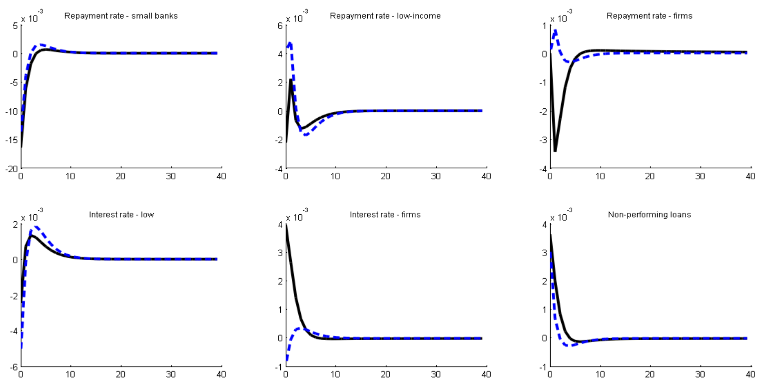
The intervention of the central bank mitigate the negative effect of the fall in market book on the economy and also improve financial stability. The increase in liquidity by the central bank increases liquidity in the interbank market. Therefore, the availability of funds reduces the increase in both the interbank rate and the firm loan rate and further reduces the loan rate for low-income households. This stimulate loan demand by the firms and the low-income households, thereby reducing the negative impact of the market book shock on output and low-income households' consumption. However, the profitability of the small banks (and the big banks) decrease as they are lending more at a lower rate. Overall, liquidity injections help to reduce the overall risk in the banking sector (non-performing loans) and help stabilise the financial system quicker.

Figure 6: Market book shock and Liquidity injections



Note: Variation from the steady state.

Figure 7: Market book shock and Liquidity injections (cont.)



Note: Variation from the steady state.

5.3.1 An illustration: Global vs. local banking crisis

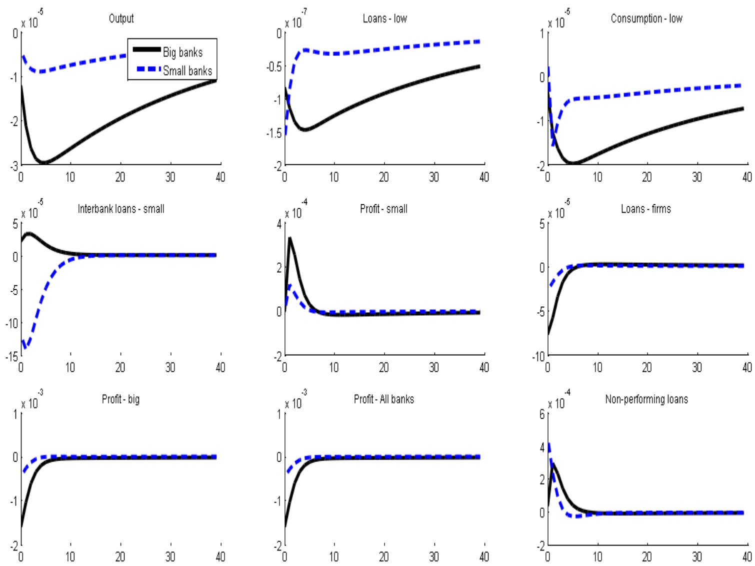
We conclude our analysis by investigating how a market book shock from either the small or the big banks are propagated through the rest of the financial sector and the economy. We consider two scenarios. In the first scenario, we look at the impact of a reduction in market book value for the domestically important banks on the interbank market and the whole economy. This is analogous to the impact of the 2008 financial crisis on the local big banks which reduced their profitability.

Small to medium bank crises in South Africa are mainly due to liquidity pressures. Therefore, in the second scenario we look at the reduction in market book value for the small banks. In both scenarios, we investigate the effects of market book value in the absence of liquidity injections by the central bank. The return on market book now follows an autoregressive process of $\rho_t = \bar{\rho}^{(1-\rho_\rho)}(\rho_{t-1})^{\rho_\rho} exp(\mathrm{u}_{tx}^{\rho})$, $x \in b, z$, and with ρ_ρ=0.50, $u_t^\rho \sim N(0, \sigma_\rho^2)$ and $\sigma_\rho = 0.01$.

Figure 8 presents the impulse response functions of a negative market book shock to the big banks and the small banks without liquidity injections. Since the effects on the interbank deposits and interbank loans are the same for the two scenarios, we only include interbank loans in our results. We start with the results for the big banks. From the figure, we can see that a negative market book shock to the big banks reduces the interbank deposits/loans by the big banks. Therefore, all interest rates increase. The loans to the firms decrease as the cost of borrowing is too high. Firms reduce their demand for capital and labour, reducing wages and output. As a result, consumption for low-income households decrease. Overall, the effects on the economy is high defaults across all borrowing agents - repayment rates for the firms, small banks and low-income households decrease, causing an increase in non-performing loans. Due to the size of the big banks, the total profitability of the small and the big banks decreases. Therefore, a negative market book shock to the big banks causes financial instability.

A fall in the market book of the small banks reduces interbank loans/deposits, increasing the interbank rate. Similar to the big banks, the lack of liquidity injections also reduce output, capital and wages. Consumption by the low-income households also decrease. However, the effects are smaller compared to that of the big banks.

Figure 8: Market book shocks by bank size



Note: Variation from the steady state, in % points.

From the results, we can see the importance of financial stability in both the small and the big banks. Both produce high default rates. The results also highlight the systemic risk that can be caused by the collapse of the big banks, causing increase in default rates across all borrowing agents. For example, even though low-income households do not borrow directly from the big banks, the big banks cause a much bigger negative welfare effects on their consumption. Again, this shows how the small bank acts as a transmitter of shocks to the low-income households. Effects of the small banking crises on macroeconomic variables and low-income households welfare are short-run, whereas the big banks seem to have longer impact. Therefore, central bank intervention is important to prevent any bank crisis, big or small. However, it is very important to ensure the financial stability of the domestically important banks as they pose higher risk to the economy and the banking sector.

6 Conclusion

In this paper we developed a DSGE model to capture the relationship between a heterogeneous banking sector and a heterogeneous household sector, which we consider a fair representation of the South African financial sector. Our aim is to study how financial shocks are transmitted to and from the rest of the economy. Given the many failures of the small and medium banks and the stability of the big banks in South Africa, understanding the peculiarities between the two types of banks is important for the central bank and policy makers.

Notwithstanding its ability to reproduce some of the real business cycle moments, this model provides a starting point for modeling a DSGE model suitable for financial stability dynamics in the South African banking sector. Our results for a negative market book shock in the presence of endogenous default is able to show how the South African economy has been able to survive banking crises by small banks, as has been evident from the 2014 African Bank crisis. Effects of the small banking crises on macroeconomic variables and low-income households welfare are short-run, whereas the big banks seem to have long-run effects. Even though the big banks have managed to be resilient during the 2008 financial crisis, the model shows that a financial crisis emanating from these banks will be detrimental for both the economy and the financial sector.

7 Appendices

7.1 Steady state solutions

Firms

$$W = (1-u)\varepsilon(\frac{K}{N})^{u} \tag{47}$$

$$u\varepsilon(\frac{N}{K})^{1-u} = \lambda^f(1-\beta_f(1-\tau)) \tag{48}$$

$$\frac{\lambda^f}{1+r^f} = \beta_f\alpha + \beta_f^2\omega_f(1-\alpha)^2L^f \tag{49}$$

$$L^f = \beta_f\omega_f(1-\alpha)(L^f)^2 + d_f \tag{50}$$

Big banks

$$\frac{1}{1+r^r} = \beta_b \tag{51}$$

$$\frac{1}{1+i} = \beta_b(\beta_b\zeta_b(1-\delta)+\delta) - \frac{d_F^b\kappa\hat{w}^z}{\lambda^b} \tag{52}$$

$$\frac{1}{(1+r^f)} = \beta_b(\alpha+\beta_b\zeta_{bf}(1-\alpha)) - \frac{d_F^b\kappa w^f}{\lambda^b} \tag{53}$$

$$(\lambda^b - \frac{1}{\pi^b}) = \frac{d_F^b\nu_b}{(1-\beta_b(1-\xi_b))} \tag{54}$$

Small banks

$$\frac{1}{1+i} = \beta_z\delta + \beta_z^{2z}\omega_z(1-\delta)^2 L^{bz}] \tag{55}$$

$$\frac{1}{(1+r^p)} = \beta_z(\eta + \beta_z\zeta_{zp}(1-\eta)) - \frac{d_F^z\kappa\bar{w}^p}{\lambda^z} \tag{56}$$

$$L^{bz} = \beta_z\omega_z(1-\delta)(L^{bz})^2 + \frac{d_z}{\lambda^z} \tag{57}$$

$$(\lambda^z - \frac{1}{\pi^z}) = \frac{d_F^z\nu_z}{(1-\beta_z(1-\xi_z))} \tag{58}$$

Low-income households

$$\frac{1+\varrho\frac{C^p}{(C^r)^2}}{C^p - \varrho\frac{C^p}{C^r}} = \lambda^p \tag{59}$$

$$\frac{1}{(1+r^p)} = \beta_p\eta + \beta_p^2\gamma_p(1-\eta)^2 L^p \tag{60}$$

$$L^p = \gamma_p(1-\eta)(L^p)^2 + \frac{d_p}{\lambda^p} \tag{61}$$

$$\frac{\phi_p}{1-N^p} = \lambda^p W \tag{62}$$

High-income households

$$\frac{1}{C^r} = \lambda^r \tag{63}$$

$$\frac{1}{C^r}\frac{1}{1+r^r} = \beta_r\frac{1}{C^r} - \chi(\frac{D^r}{1+r^r} - \frac{\bar{D}^r}{1+r^r}) \tag{64}$$

7.2 Data

We use real monthly data from 2002Q1 to 2014Q3. All nominal data are deflated using the GDP deflator. All BA900 data is obtained in the balance sheets of the South African banks from the South African Reserve Bank (SARB).

Banks

- Interbank deposits: quarterly average of the monthly deposits denominated in Rands from South African bank (s). Includes NCD's/PN's and other deposits. *Source*: SARB BA900, line item 3.
- High-income consumer deposits: quarterly average of the monthly deposits by households. *Source*: SARB BA900, line item 27.
- Interbank loans: quarterly average of the monthly deposits, loans and advances to SA banks. Includes NCDs/PNs issued by banks with maturity of up to 1 month, more than 1 month to 6 months (unexpired maturity), more than 6 months (unexpired maturity) and other deposits and loans and advances to SA banks. *Source*: SARB BA900, line item 111.

- Market book: quarterly average of the monthly investment and bills by the banks. *Source*: SARB BA900, line item 195.
- Loans to firms: quarterly average of the monthly overdrafts, loans and advances to non-financial corporate sector. *Source*: SARB BA900, line item 214.
- Loans to the low-income consumer: quarterly average of the monthly overdrafts, loans and advances to the household sector. *Source*: SARB BA900, line item 216.
- Own funds: quarterly average of the monthly total equity. *Source*: SARB BA900, line item 96.
- Profits: defined as net income to total assets. Because there is no data on net income for the banks, net income is calculated as a product of the return on assets published in the SARB Financial Stability report and total assets in BA900. The data covers the period 2003Q1 to 2015Q4.
- Other assets: the difference between total assets and the sum of market book value, interbank deposits and loans to firms.
- Other liabilities: the difference between total liabilities and the sum of deposits and interbank loans.
- Interbank rate: quarterly average of the weekly 3 months Johannesburg Interbank Average Rate (JIBAR/JIBA rate). *Source*: SARB.
- Deposit rate: deposits rates were taken from the current available data from the large banks' websites. Average of the rates for 3 months (or closest to 3 months) fixed deposits. Following which, the calculated difference between the calculated current average rate and the current interbank rate is 120 (negative) basis points. Therefore we computed the series for other previous periods as the interbank rate less 120 basis points.
- Borrowing rate (firms): using the prime rate by banks, which is the prime plus 350 basis points.
- Borrowing rate (low-income consumers): calculated as the prime rate plus 500 basis points. This assumes that low-income consumers are riskier than firms. This can be justified by the ability for banks to attach firms' assets.
- Return on market book: quarterly average real return on the Johannesburg Stock Exchange All Share Index.
- Default rate (small banks): calculated Z-score for the small banks, as discussed in sub-section 4.2.

Firms and Consumers

- Investment: quarterly seasonally adjusted real gross fixed capital formation (investment). *Source*: SARB.
- Gross Domestic Product: quarterly seasonally adjusted gross domestic product at market prices (GDP). *Source*: SARB.
- Consumption: seasonally adjusted individual consumption expenditure of total domestic economy. Quarterly data is an interpolation of annual values. *Source*: SARB.

- Default rate (firms): as already discussed in sub-section 4.3, the default rate for the non-financial corporations can be calculated as a ratio of the number of liquidation and insolvency to the total number of tax paying firms.

- Default rate (low-income consumer): as already discussed in sub-section 4.1, we calculate the default rate for the low-income households as the ratio of non-performing loans to total household loans from the balance sheets of the small banks.

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