

Macroprudential analysis of the financial system: the case of South Africa

Francis Selialia,¹ Thabo Mbeleki² and Kgomotso Matlapeng³

1. Introduction

Financial stability is crucial for sustained economic growth. Economic growth cannot be achieved without strong financial systems. Even with sound macroeconomic fundamentals, weak financial systems can destabilise economies, making them more vulnerable to external shocks. The interaction of financial markets and the real economy needs close monitoring since the instability of the financial system can be very costly. A smoothly operating, stable and efficient financial system is a major pillar for growth, output and employment.

Central banks have adopted macroprudential analysis as a widely used method of detecting vulnerabilities in the financial system. This involves, among other things, the identification of financial soundness indicators (FSIs) and the methods used to analyse them. Observing potential signs of heightened risks in the financial system is important for central banks, as they rely on such insights to be able to take both preventive measures and appropriate action in crisis management.

The rest of the paper is organised as follows. Section 2 defines macroprudential analysis and the FSIs. Section 3 provides methods of identifying FSIs. The main analytical tools are described in section 4. Section 5 discusses the methodology for modelling credit risk. Section 6 presents the bivariate regression results and a brief discussion of scenarios. Section 7 discusses the risk-bearing capacity of the banking sector and the model's forecasting accuracy. The last section concludes.

2. Macroprudential analysis

Macroprudential analysis is a method of economic analysis that evaluates the health, soundness and vulnerabilities of a financial system. The analysis involves the assessment and monitoring of the strengths and vulnerabilities of financial systems using quantitative information, largely in terms of FSIs, and other economic indicators that provide a broader picture of economic and financial circumstances. The assessment takes into account both

¹ South African Reserve Bank, Financial Stability Department, 370 Church Street, Pretoria, 0002, South Africa. E-mail: Francis.Selialia@resbank.co.za. Francis Selialia is an assistant general manager and head of the Macroprudential Analysis Division of the Financial Stability Department at the South African Reserve Bank. He joined the Bank in 1998 as an assistant economist in the Money and Banking Division of the Research Department. Later he joined the Monetary Policy Research Unit and was promoted to deputy economist. Before starting work at the South African Reserve Bank, he was a senior economist at the Central Bank of Lesotho and a deputy director at the South African National Treasury. He holds the following degrees: Master of Arts in economics and a postgraduate diploma in economic sciences from University College, Dublin, Ireland and a Bachelor of Arts in economics from the National University of Lesotho.

² South African Reserve Bank, Financial Stability Department, 370 Church Street, Pretoria, 0002, South Africa. E-mail: Thabo.Mbeleki@resbank.co.za.

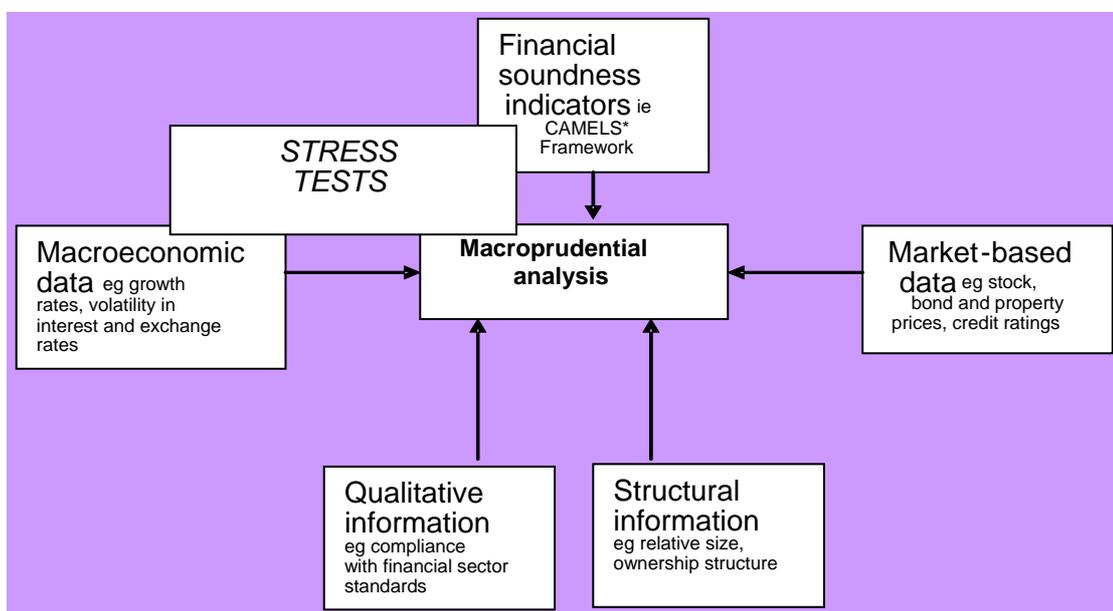
³ South African Reserve Bank, Financial Stability Department, 370 Church Street, Pretoria, 0002, South Africa. E-mail: Kgomotso.Matlapeng@resbank.co.za.

the risks facing the financial system and the system's capacity to withstand shocks. It also involves establishing or investigating the linkages between the financial system and the real sector of the economy. Scenario analysis and stress tests are major components of this analysis and they help in determining the system's sensitivity to economic shocks and its resilience to such shocks.

In its broad definition, macroprudential analysis encompasses an analysis of qualitative information relating to the structure of the financial system and its institutional and regulatory framework in order to get an additional sense of the strength of the financial system architecture. Qualitative assessment is done, among other things, through the assessment of compliance with international financial sector standards and codes and the Financial Sector Assessment Programme (FSAP). Figure 1 provides a diagrammatic summary of macroprudential analysis and Annex 2 shows macroprudential indicators recommended by the IMF.

Figure 1

Components of macroprudential analysis



* CAMELS stands for capital adequacy, asset quality, management soundness, earnings, liquidity and sensitivity to market risk.

Source: Evans et al (2000).

3. Identification of macroprudential indicators

Three main approaches are followed when identifying FSIs. The first approach followed is international best practice, which is suggested by international institutions such as the IMF, BIS and others, and by central banks. Examples of FSIs derived from this approach are summarised in Annex 2. The second approach is based on the underlying economic theories of financial instability as espoused by Davis (1999). He emphasises that data requirements for macroprudential analysis are dictated by the theories underpinning the concept of financial instability. Examples of the theories include the monetary approach and theories based on the concept of uncertainty and those based on asymmetrical information and agency costs. Annex 3 provides a summary of implied or recommended macroprudential indicators derived from these theories. The third approach is based on the linkages or

interaction between the financial sector and other sectors of the economy. It is summarised with the aid of the circular flow of income and expenditure⁴ (Annex 4).

In all the approaches discussed above, the indicators should be analytically and empirically relevant, that is, there should be a sensible basis for expecting a relationship between the indicator and financial instability, and indicators should have predictive power or be classified as leading indicators in the sense that changes in one variable precede changes in another.

4. Assessment methods

Central banks in different countries use different techniques to assess and monitor the exposure of financial systems to different types of risks and shocks. As mentioned earlier, in most cases, stress tests and scenario analysis are the main methods used to determine the system's sensitivity to economic shocks. Stress testing is a generic term describing various techniques used by financial firms to gauge potential vulnerability to exceptional but possible events.⁴ These methods are preferred because they perform a quantitative analysis of financial fragility.

Another method of conducting macroprudential analysis (the most basic and the most common) is to monitor indicators from a variety of sources and seek to identify broad patterns in the indicators that might suggest growing imbalances and the potential for financial instability. When the indicator breaches what is perceived to be a benchmark, it is interpreted as giving a warning signal of potential vulnerability. Annex 5 gives a snapshot of the main sectors monitored when conducting macroprudential analysis and the benchmarks/thresholds used.

Credit risk remains one of the most important sources of vulnerability in the South African banking sector. Annex 6 shows the increasing trend of impaired advances in the South African banking sector. However, the increase in impaired advances is not seen as a major systemic threat as banks remain well capitalised and profitable. The increase in credit impairments came after a prolonged period of extensive credit growth in recent years during a period of very low lending rates. Annex 6 gives an example of a credit risk financial soundness indicator (impaired advances) which is monitored on an ongoing basis. In an attempt to guard against credit risk, banks and other authorised credit providers introduced stringent lending standards (Annex 7).⁵

5. Effects of macroeconomic developments on credit risk

In estimating the effects of macroeconomic developments on credit risk, bivariate regressions are estimated.

⁴ The circular flow of income and expenditure is an analytical tool used in basic macroeconomic textbooks to demonstrate the linkages among the various sectors of the economy.

⁵ See CGFS (2000).

⁶ It should be noted, however, that there are other factors which may also have contributed to the stringent lending standards by authorised credit providers, such as the implementation of the National Credit Act (NCA), no 34 of 2005, in June 2006 and recent developments in global financial markets.

5.1 Model specification

The estimated model is a distributed lagged model specified as:

$$\text{BANRUP}_t = \beta_0 + \beta_1 \text{BANRUP}_{t-1} + \beta_2 X_{i,t-p} + \varepsilon \dots\dots (1)$$

where

BANRUP is the dependent variable (bankruptcies) used as a proxy for non-performing loans;

BANRUP_{t-1} is lagged bankruptcies;

X_i represents macroeconomic variables;

β represents regression coefficients that capture the sensitivity of bankruptcies (and hence, loan quality) to specific macroeconomic variables;

p is the number of lags, and

ε is the error term.

5.2 Data

The data used in the analysis ranged from the first quarter of 1980 to the fourth quarter of 2007, and bankruptcies were used as a proxy for non-performing loans.⁶ All variables were logarithmically transformed and differenced. There is a strong correlation between gross overdues and the number of bankruptcies (Annex 8). All time series variables included in the study were first tested for stationarity using the augmented Dickey-Fuller unit root test and the correlogram. Non-stationary variables were transformed to stationarity by differencing. They were, therefore, used at their differenced levels in the regression equations.

The explanatory variables used in the regression equations were divided into the following six categories: cyclical indicators, price stability indicators, household sector indicators, corporate sector indicators, market indicators and external sector variables.⁷ The expected sign(s) of each indicator is/are provided in Table 1.

⁷ Non-performing loans and gross overdues are used interchangeably. Data on bankruptcies were obtained by adding insolvencies and liquidations. Insolvencies refer to individuals or partnerships that are unable to pay their debts and are placed under final sequestration. Liquidations capture companies or close corporations for which the affairs have been wound up when liabilities exceed assets.

⁸ The categorisation contains some ambiguity and was chosen purely for convenience and ease of presentation. For example, private sector credit extension can also be included among indicators of the household sector.

6. Empirical analysis

Table 1
Bivariate regression results

$BANRUP_t = \beta_0 + \beta_1 BANRUP_{t-1} + \beta_2 X_{i,t-p}$					
	Expected sign	Coefficient	T-stats	R ²	DW ^a
Cyclical indicators					
GDP	–	–2.165	–2.205 ^b	0.612	1.937
Volume of production	–	–1.371	–2.233 ^b	0.612	1.961
Price stability indicators					
Inflation	+/-	–0.090	–1.507	0.619	1.921
Money supply	+/-	0.088	1.350	0.609	2.027
Household sector indicators					
Disposable income	–	0.675	1.483	0.607	2.015
Household wealth	–	–0.747	–1.428	0.601	2.000.
Household financial assets	–	–1.410	–3.422 ^b	0.635	1.849
Gross savings	–	0.258	2.325 ^c	0.619	2.004
Remuneration per worker	–	–0.291	–0.400	0.594	1.964
Mortgage advances	+	0.034	0.151	0.598	1.987
Corporate sector indicators					
Corporate profits	–	–0.088	–0.985	0.597	1.978
Total gross fixed capital formation	+/-	–0.361	–0.757	0.596	1.947
Gross fixed capital formation – residential construction +/-		–0.747	–2.353 ^b	0.614	1.960
Gross fixed capital formation – machinery and equipment	+/-	–0.547	–1.893	0.607	1.897
Business confidence	–	–0.194	–3.478 ^b	0.636	2.240
Private sector credit extension	+	1.463	2.575 ^b	0.618	2.083
Market indicators					
Prime lending rate	+	0.316	1.972 ^b	0.608	2.135
All-share index	–	–0.319	–2.405 ^b	0.615	2.033
External sector indicators					
Merchandise exports	–	–0.392	–3.431 ^b	0.644	2.104
Rand/US dollar	+/-	0.500	2.687 ^b	0.620	2.015
Rand/pound sterling	+/-	0.349	1.835	0.606	1.956
Rand/euro	+/-	0.556	2.776 ^b	0.622	1.944
Oil price	+	0.139	1.388	0.608	2.013

^a The Durbin-Watson *d*-statistic detects the presence of serial correlation in the regression residuals. As a rule of thumb, if *d* is found to be in the vicinity of 2 in an application, it is assumed that there is no first order autocorrelation, either positive or negative. It should be noted, however, that the Durbin-Watson statistic cannot be relied upon for distributed-lagged models. ^b Denotes statistical significance at 5 per cent level. ^c Denotes statistical significance at 5 per cent level but has a wrong sign.

Source: Authors' computation.

6.1 Scenario analysis

Scenario analysis was done in order to measure the impact of various adverse macroeconomic events (shocks) on the dependent variable (bankruptcies). The historical approach for selecting scenarios was adopted.

Adverse changes (scenarios) in the shock variables and the period in which they occurred are presented in Annex 9, while Annex 10 provides a graphical illustration of the scenarios.

7. Stress testing results

Table 2 gives stress testing results given historical moves in individual macroeconomic variables.

Table 2
Stress testing results

Significant macro factors	Worst case scenarios (in per cent)	Per cent change in bankruptcies (non-performing loans)
GDP	-0.1	0.2
Volume of production	-6.9	9.5
Household financial assets	-5.2	7.3
Gross fixed capital formation – residential construction	-9.8	7.3
Business confidence	-49.6	9.6
Private sector credit extension	8.1	11.9
Prime lending rate	21.9	6.9
Exports	-19.4	7.6
Rand/US dollar	21.3	10.7
Rand/euro	24.8	13.8
All-share index	-26.1	8.3

Source: Authors' calculations.

7.1 Impact on banks' core capital and capital adequacy ratio

In conducting the stress test and risk-bearing capacity of the banking sector, data as at the end of January 2007 are used for illustration purposes. During that period, gross overdues for the banking sector stood at ZAR 19.7 billion, core capital at ZAR 121.7 billion, and the capital adequacy ratio was 11.9 per cent. For example, the impact of a 21.9 per cent increase in the prime lending rate would result in an increase of about 6.9 per cent in loan losses for banks, which in monetary terms would amount to about ZAR 1.4 billion. This would, in turn, be approximately 1.1 per cent of core capital as at end-January 2007. With the restricting assumptions that loan loss provisions have been depleted and that there are no profits (such that increases in loan losses are deducted from capital), core capital would be reduced by 1.1 per cent. With the reduced level of core capital, the net impact would be a reduction in the capital adequacy ratio of 0.1 percentage points. The results for other shock variables or scenarios are given in Table 3.

Table 3

Impact on banks' share capital and capital adequacy ratio (January 2007)

Shock variables	Change in loan losses			
	(In per cent)	(Rand billions)	(As a percentage of core capital)	(As a percentage of CAR)
GDP	0.22	0.04	0.04	0.00
Volume of production	9.46	1.86	1.53	0.18
Household financial assets	7.33	1.44	1.19	0.14
Gross fixed capital formation – residential construction	7.32	1.44	1.19	0.14
Business confidence	9.62	1.90	1.56	0.19
Private sector credit extension	11.85	2.33	1.92	0.23
Prime lending rate	6.92	1.36	1.12	0.13
Exports	7.60	1.50	1.23	0.15
Rand/US dollar	10.65	2.10	1.72	0.21
Rand/euro	13.79	2.72	2.23	0.27
All-share index	8.33	1.64	1.35	0.16
			Sum of net effects	1.79

Source: Authors' computation.

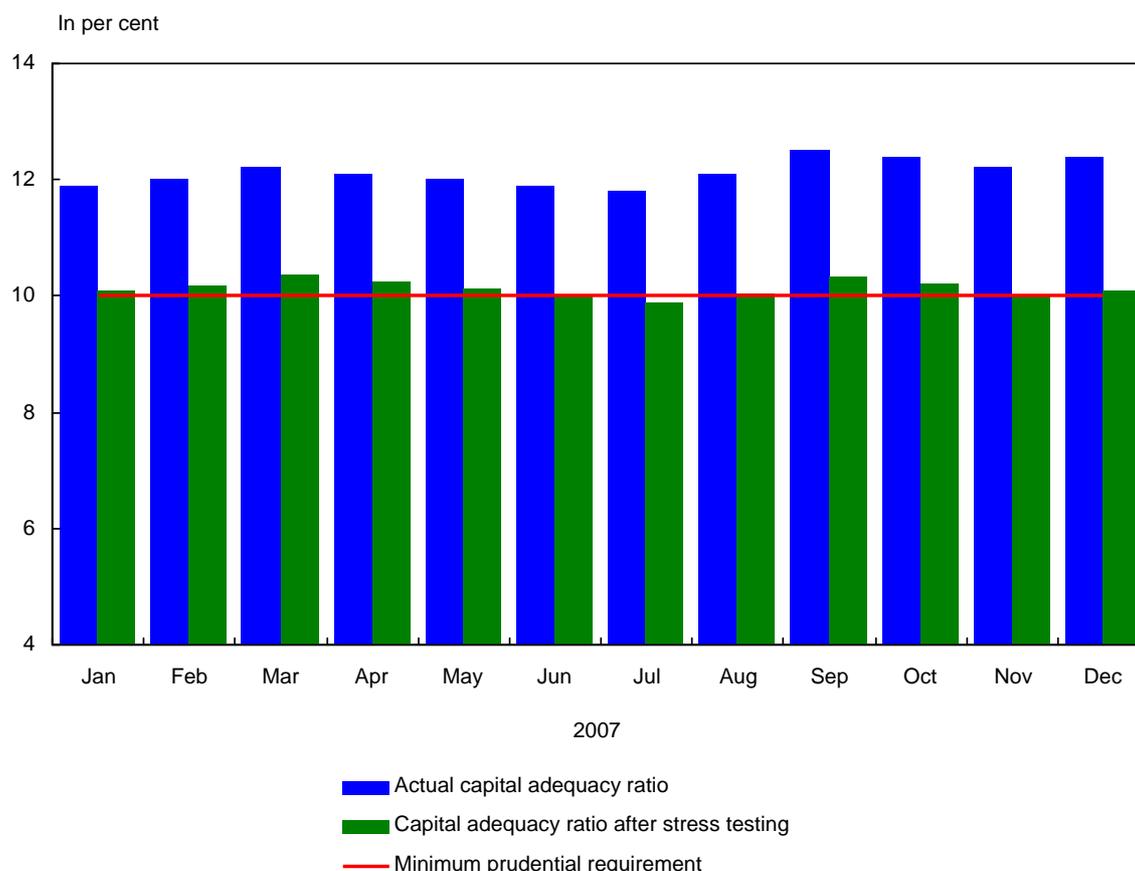
7.2 Resilience testing

The sum of the effects of all the shock variables is estimated at a reduction of 1.8 percentage points in the capital adequacy ratio (Table 3). Thus, the new capital adequacy ratio after the multifactor stress test is estimated at 10.1 per cent, suggesting that the banking sector would still be resilient to the shocks as the capital adequacy ratio after stress testing is still above the minimum prudential requirement of 10 per cent.⁸

Stress test results from January 2007 to December 2007 are given in Figure 2 and show that the South African banking sector was generally resilient to plausible macroeconomic shocks for the whole of 2007. The capital adequacy ratio after the stress tests remained above the minimum prudential requirement for 11 of the 12 months, with the exception of July, when it fell short by about 0.1 percentage points.

⁹ The internationally accepted benchmark for the capital adequacy ratio during this period (before the implementation of the Basel II Framework) was 8 per cent of risk-weighted assets. The South African benchmark was more stringent and set at 10 per cent of risk-weighted assets.

Figure 2
Risk-bearing capacity



Source: Authors' construction.

7.3 Forecasting accuracy

To assess how well different indicators predict future bankruptcies, the bankruptcy equations were estimated over a shorter period of time (from the first quarter of 1980 to the second quarter of 2006), omitting the six quarters from the third quarter of 2006 to the fourth quarter of 2007. The estimated coefficients were then used to produce forecasts of movements in bankruptcies for the out-of-sample period.

To evaluate the robustness of the model (out-of-sample forecasting), the mean forecasting error, calculated as the root mean squared error (RMSE), and the mean absolute percentage error (MAPE) were used (Annex 11). The RMSE measures the dispersion of the forecasted variable around the true value of the observations (bankruptcies). The smaller the forecasting error, the better the variable is in predicting movements in bankruptcies and hence loan losses. It implicitly weights large forecasting errors more heavily than small errors and is appropriate to situations in which the cost of an error increases with the square of that error. The MAPE is the average of the absolute values of the percentage errors. The RMSE and the MAPE are often used to evaluate the forecasting accuracy of a model. The two measures gave very similar results. They both gave the prime lending rate, private sector credit extension, business confidence and the ALSI as the first four macroeconomic variables with high forecasting power (Table 4). Annex 12 presents out-of-sample forecasts graphically.

Table 4

RMSE and MAPE between actual and estimated dependent variable⁹

	PRIM	PSCE	BUSCONF	ALSI	R/USD	VOP	R/EURO	GFCFRES	MEXP	GDP	HHDFA
Rank	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
06-q3	26	13	32	50	56	75	90	18954	39494	881954	3761589
06-q4	16	24	23	43	70	68	108	19004	44653	938802	4139116
07-q1	1	48	9	37	101	65	149	19072	53801	1184911	4456826
07-q2	30	14	36	63	57	83	101	18958	48507	1028419	4721013
07-q3	44	-13	48	67	15	81	47	18863	33168	734867	4797237
07-q4	0	38	6	30	68	49	112	18815	44593	947018	4679532
MAPE	19	21	26	48	61	70	101	18944	44036	952662	4425886
	PSCE	PRIM	BUSCONF	ALSI	R/USD	VOP	R/EURO	GFCFRES	MEXP	GDP	HHDFA
Rank	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
RMSE	115	126	146	232	264	319	432	18575	188693	4081442	4440960

Source: Authors' calculations.

8. Concluding remarks

This paper discusses macroprudential analysis in general and within the context of the South African financial system. It also assesses the resilience of the South African banking sector to macroeconomic shocks that can lead to an increase in credit risk. The main methods of identifying macroprudential indicators within the South African context are outlined as ensuring compliance with international best practice, making use of economic theories and taking into account the interlinkages between various sectors of the economy. The main analytical methods are identified as monitoring trends of macroprudential indicators and developing models to assist in the analysis. Stress testing is discussed as the most popular modelling technique used by most institutions.

The results of bivariate regressions confirmed the causal relationship between macroeconomic developments and credit risk (proxied by bankruptcies). The following macroeconomic variables were found to explain changes in bankruptcies and to have high predictive power in terms of bankruptcies: the prime lending rate, private sector credit extension, business confidence level and ALSI. Using a capital adequacy ratio of 10 per cent as a benchmark, the banking sector was found to be resilient to plausible macroeconomic shocks throughout 2007.

It has to be noted, however, that the analysis only provides an idea of what could happen if history were to repeat itself. The results should therefore be interpreted with care. The analysis also has some limitations. Firstly, the use of a bivariate framework may be unrealistic because in reality shocks may not take place in isolation. Bivariate regressions

⁹ See Annex 1 for a description of the acronyms and abbreviations used in the table.

may suffer from some flaws such as misspecification errors. Secondly, the use of a linear model to measure the impact of large shocks is restrictive because in reality shocks may have a non-linear impact. Thirdly, bankruptcies are a proxy for credit risk and thus an error-in-variables problem may be present. The analysis does, however, provide a foundation and backup for qualitative discussions that are always necessary when assessing the performance of the financial system.

Future research should focus on building rigorous models that can include both macroeconomic variables and FSIs as opposed to the bivariate approach used in this paper. This will allow for the simultaneous utilisation of all available information. Nevertheless, it is believed that the framework used does shed some light and is considered a reasonable starting point in attempting to assess the soundness of the South African financial system and its vulnerability to macroeconomic shocks.

Annex 1: Acronyms and abbreviations

ALSI	All-share index
BANRUP	Bankruptcies
BER	Bureau for Economic Research
BIS	Bank for International Settlements
BUSCONF	Business confidence index
CAMELS	Capital adequacy, asset quality, management soundness, earnings, liquidity and sensitivity to market risk
CAR	Capital adequacy requirements
FSIs	Financial soundness indicators
FSAP	Financial sector assessment programme
FSSA	Financial system stability assessment
GDP	Gross domestic product
GFCFRES	Gross fixed capital formation – residential construction
HHDFA	Household financial assets
HHDW	Household wealth
IMF	International Monetary Fund
JSE	Johannesburg Securities Exchange, SA
LLP	Loan loss provision
MAPE	Mean absolute percentage error
MEXP	Merchandise exports
MORTADV	Mortgage advances
MPIs	Macroprudential indicators
NPLs	Non-performing loans
OLS	Ordinary least squares
OENB	Oesterreichische Nationalbank
PRIM	Prime
PSCEGDP	Private sector credit extension as a percentage of GDP
R/EURO	Rand/euro exchange rate
RMSE	Root mean square error
R/POUND	Rand/pound sterling exchange rate
R/USD	Rand/US dollar exchange rate
SARB	South African Reserve Bank
STATSSA	Statistics South Africa
VOP	Volume of production
ZAR	South African rand

Annex 2: Summary of financial soundness indicators

Aggregated financial soundness indicators	Macroeconomic indicators
Capital adequacy	Economic growth
Aggregate capital ratios	Aggregate growth rates
Frequency distribution of capital ratios	Sectoral slumps
Asset quality	Balance of payments
<i>Lending institutions</i>	Current account deficit
Sectoral credit concentration	Foreign exchange reserve adequacy
Foreign currency denominated lending	External debt (including maturity structure)
Non-performing loans and provisions	Terms of trade
Loans to loss-making public sector entities	Composition and maturity of capital flows
Risk profile of assets	
Connected lending	
Leverage ratios	
<i>Borrowing entity</i>	Inflation
Debt-equity ratios	Volatility in inflation
Corporate profitability	
Other indicators of corporate conditions	
Household indebtedness	
Management soundness	Interest and exchange rates
Expense ratios	Volatility in interest and exchange rates
Earnings per employee	Level of domestic real interest rates
Growth in the number of financial institutions	Exchange rate sustainability
	Exchange rate guarantees
Earnings and profitability	Lending and asset price booms
Return on assets	Lending booms
Return on equity	Asset price booms
Income and expense ratios	
Structural profitability indicators	
Liquidity	Contagion effects
Central bank credit to financial institutions	Trade spillovers
Segmentation of interbank rates	Financial market correlation
Deposits in relation to monetary aggregates	
Loans-to-deposits ratios	
Maturity structure of assets and liabilities (liquid asset ratios)	
Measures of secondary market liquidity	
Sensitivity to market risk	Other factors
Foreign exchange risk	Directed lending and investment
Interest rate risk	Government recourse to the banking system
Equity price risk	Arrears in the economy
Commodity price risk	
Market-based indicators	
Market prices of financial instruments, including equity	
Indicators of excess yields	
Credit ratings	
Sovereign yield spreads	

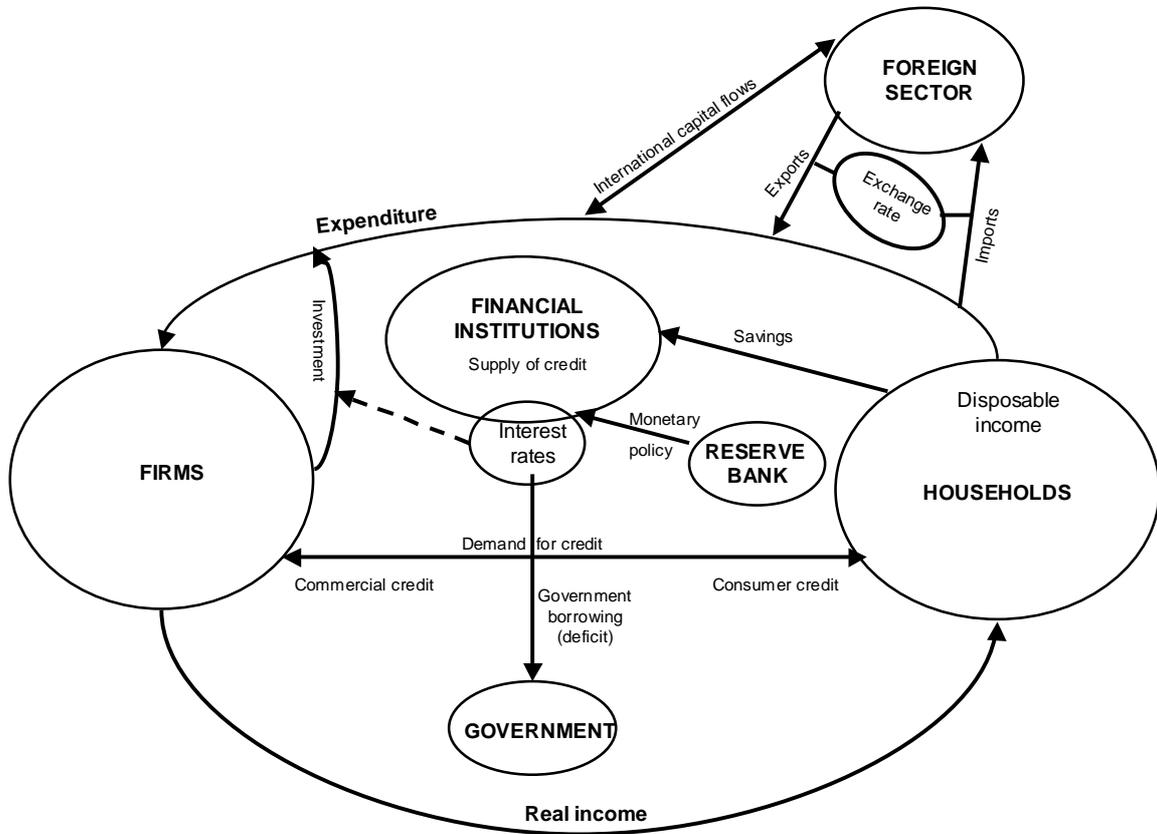
Source: IMF (2006).

**Annex 3:
Selected FSIs implied by economic
theories of financial stability**

Theories (models)	Main emphasis	Recommended indicators
Debt and financial fragility	Debt accumulation Rising corporate and household debt accumulation relative to assets	Macroeconomic variables, real estate sector, economic growth, asset prices, income gearing, corporate and household debt, sectoral balance sheet, credit markets and investment trends
Monetarist approach	Growth of monetary aggregates Monetary policy in general	Monetary aggregates, inflation, interest rates and exchange rates
Risks of bank runs	Use of micro data on the banks' balance sheets and profit and loss statements	Capital adequacy, overall interest rate margins, returns on assets or equity and banks' assets, bank share prices, interbank claims and liabilities
Uncertainty, credit rationing and asymmetrical information	"Disaster myopia" Emphasise and summarise other theories. Deviations from long-term averages are emphasised.	Loan spreads, rapid growth of markets, sectoral distribution of credit, bank capital ratios, net worth of customers
International aspects	Vulnerability to external shocks Role of international capital flows	Foreign reserves, balance of payments transactions, foreign currency borrowing, capital inflows and contagion and commodity prices

Source: Authors' construction based on Davis (1999 and 2001).

Annex 4: The circular flow of income and expenditure



Source: Fourie (1996).

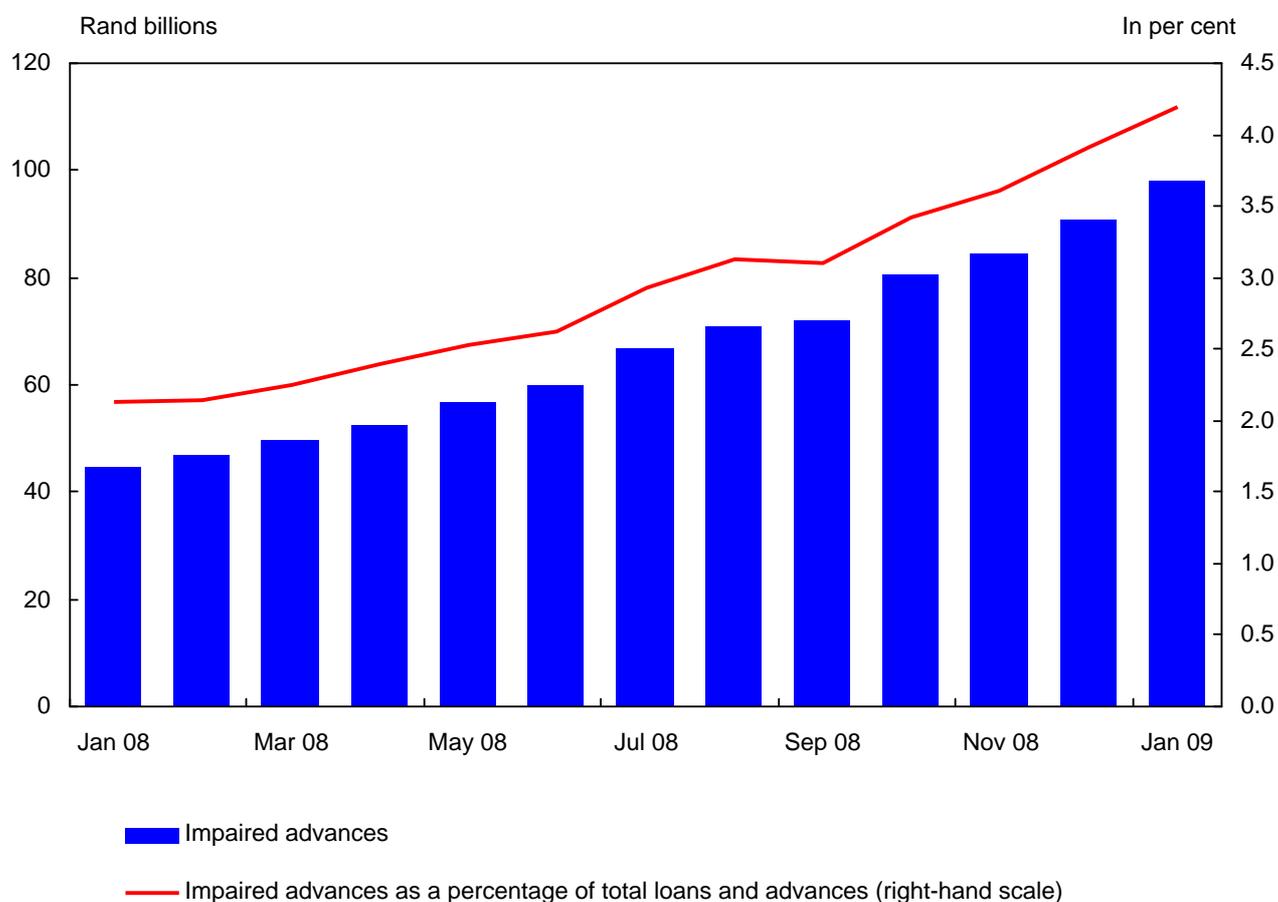
Annex 5: Snapshot of macroprudential indicators

Financial services index				
	Mean^a	Threshold^b	Actual (Q1 2009)	Signal issued
Retail banking confidence index	88	67	32	Yes
Investment banking and specialized finance confidence index	91	74	42	Yes
Investment managers confidence index	88	71	43	Yes
Life insurance confidence index	84	66	46	Yes
Financial services index	88	70	41	Yes
Banking sector				
	Mean	Threshold	Actual (Feb 2009)	Signal issued
Market share – top four banks, in per cent	83.9	84.3	84.4	No
Concentration – H-index	0.186	0.188	0.190	No
– Gini index	83.4	83.8	84.0	No
Capital adequacy ratio	12.6	12.2	13.0	No
Impaired advances (ZAR billions)	71.6	89.8	106.1	Yes
Impaired advances as a percentage of total advances	3.1	3.9	4.6	Yes
Total loans and advances (ZAR billions)	2266	2340	2316	No
Banking share prices (y-o-y), per cent change	-24.0	-30.9	-23.9 (Mar 2009)	No
Insurance sector				
5.1	Mean	Threshold	Actual (Q4 2008)	Signal issued
Surrenders, in per cent	21	27	13	No
Individual lapses, in per cent	36	47	59	Yes
Number of policies (y-o-y), per cent change	5	-4	6	No
Insurance share prices (y-o-y), per cent change	2.3	-20.5	-38.2 (March 2009)	Yes
Corporate sector				
	Mean	Threshold	Actual (Mar 2009)	Signal issued
Liquidations (y-o-y), per cent change	5.8	37.9	16.8	No
Business confidence index	49	26	27 (Q1 2009)	No
Household sector				
	Mean	Threshold	Actual (Q1 2009)	Signal issued
Insolvencies (y-o-y), per cent change	4.6	39.4	20.8 (Feb 2009)	No
Consumer confidence index	3.8	-6.2	1.0	No
Credit card lending (y-o-y), per cent change	10.2	16.6	2.18 (Feb 2009)	No
Real estate sector				
	Mean	Threshold	Actual (Apr 2009)	Signal issued
ABSA house price index (y-o-y), per cent change	12.7	2.6	-2.7	Yes
ABSA house price index (m-o-m), per cent change	0.92	0.09	-0.38	Yes
ABSA building cost index (y-o-y), per cent change	12.0	19.3	5.6 (Q1 2009)	No
Total mortgage advances (y-o-y), per cent change	18.6	22.5	12.9 (Feb 2009)	No
Real sector (annual growth rates)				
	Mean	Threshold	Actual (Mar 2009)	Signal issued
Building plans passed	11.4	-13.4	-36.2	Yes
Buildings completed	14.9	-8.3	-4.5	No
Retail sales	6.1	1.5	-5.1	Yes
Wholesale trade sales	5.7	-0.2	-10.4	Yes
Electric current generated	2.6	-1.6	-7.7	Yes
New vehicle sales	5.2	-16.0	40.2 (Apr 2009)	Yes

^a Data ranges for computing the mean are not the same for all indicators. ^b The benchmark (threshold) is calculated as the mean value of the indicator adjusted by the less favourable standard deviation. The actual value of the indicator is compared to the threshold value and is interpreted as giving a warning signal to vulnerability in the financial system if it crosses the threshold.

Source: Authors' computation.

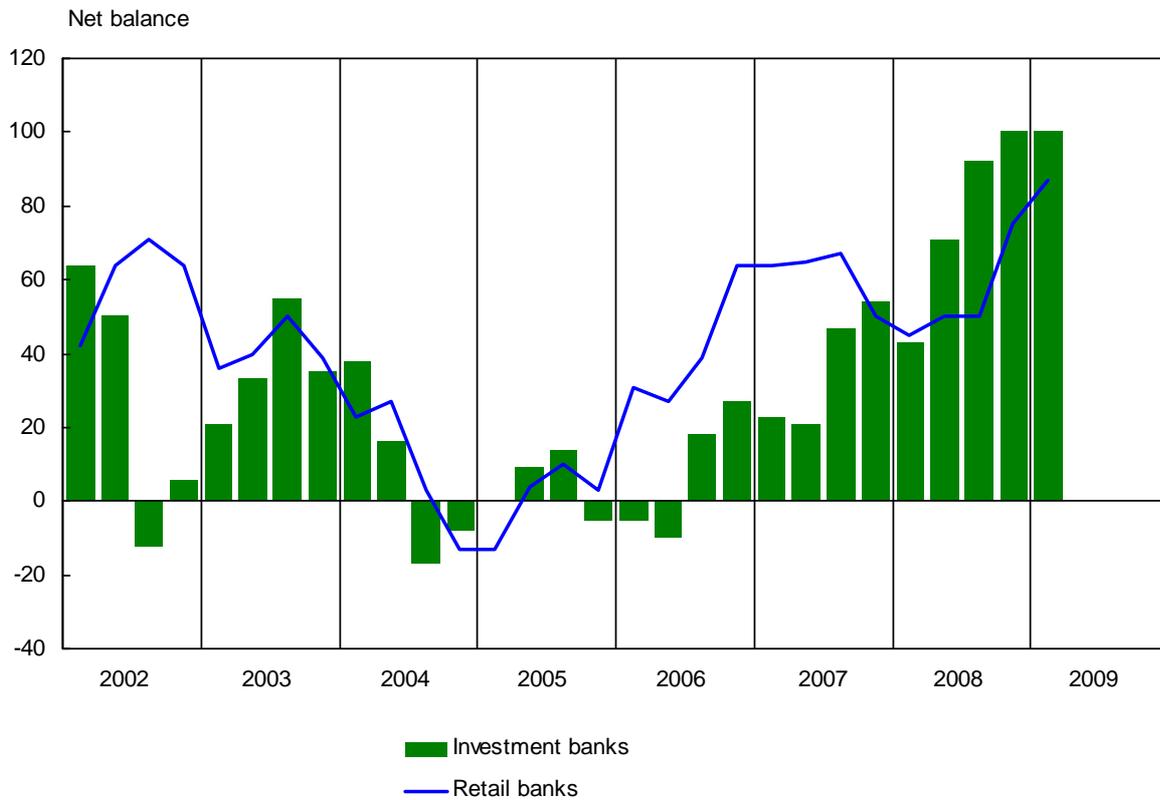
Annex 6: Impaired advances (South African banking sector)



Data collection forms were changed with the implementation of Basel II in January 2008 and the term “non-performing loans” was replaced with the term “impaired advances”, which has a more stringent definition and results in a technical increase from non-performing loans to impaired advances. Impaired advances are advances in respect of which a bank has raised specific credit impairment.

Source: South African Reserve Bank (2009), *Financial Stability Review*, March..

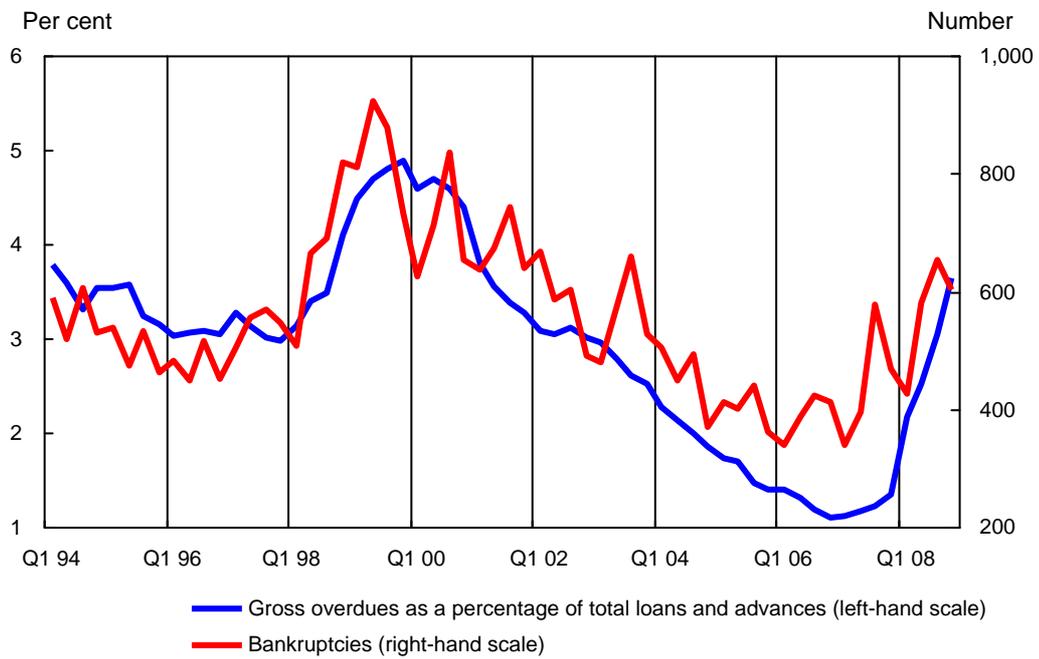
Annex 7: Credit standards in South African banks



The net balance statistic is used to interpret the survey results. The net balance is the percentage of bank survey respondents who tightened credit standards compared to the same quarter a year earlier minus those who eased credit standards.

Sources: Ernst & Young and Bureau for Economic Research..

Annex 8: Number of bankruptcies and gross overdues



Sources: South African Reserve Bank; Statistics South Africa.

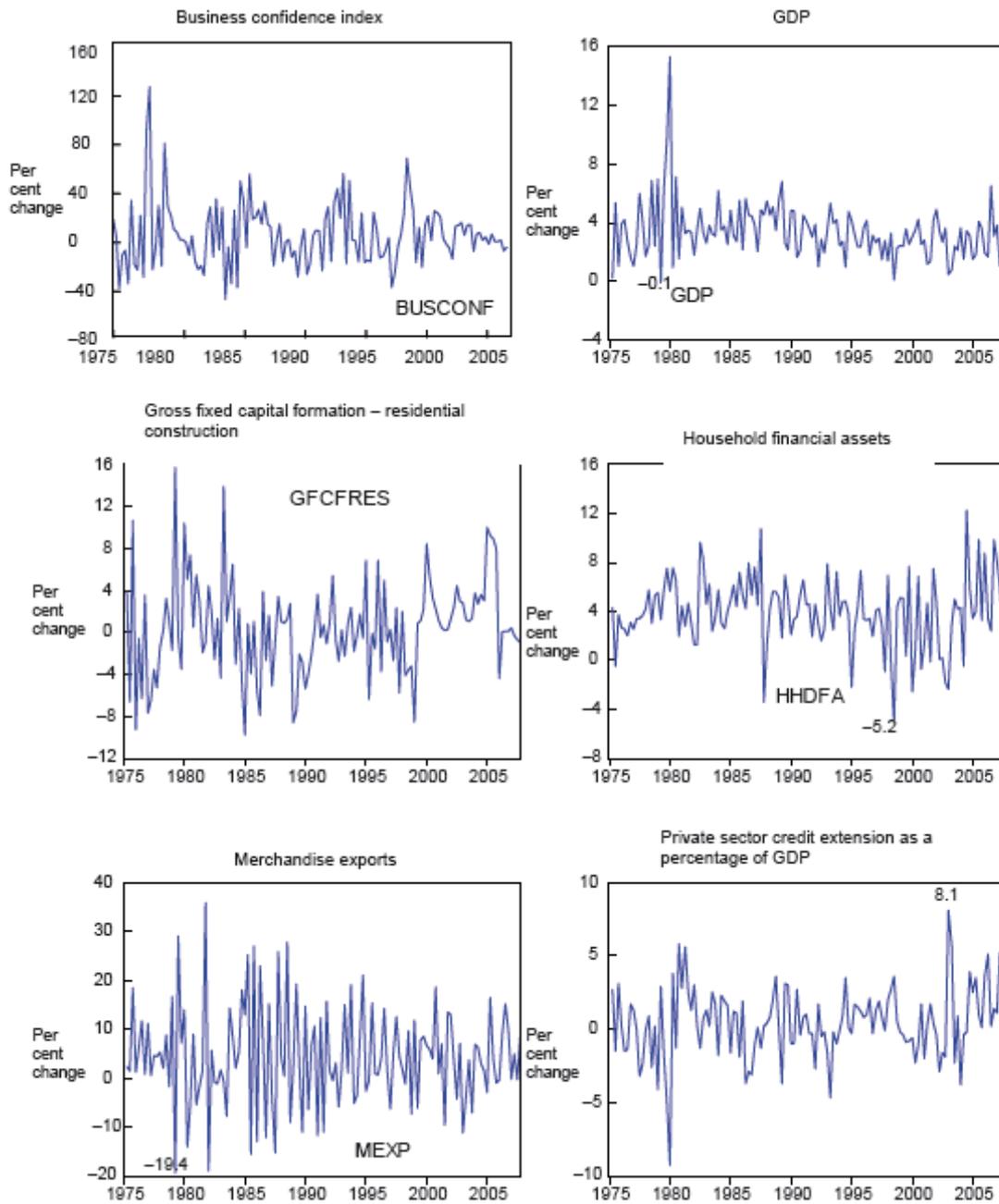
Annex 9: Scenarios

Shock variables	Historical moves (shocks)		
	Period	Range	Per cent change
Rand/euro*	1985 – quarter 3	ZAR 1.49–ZAR 1.86	24.8
Rand/US dollar	1985 – quarter 3	ZAR 1.95–ZAR 2.35	20.3
Prime lending rate	1998 – quarter 2	18.25%–22.25%	21.9
Private sector credit extension	2003 – quarter 1	56.51%–61.07% of GDP	8.1
Volume of production	1989 – quarter 1	95.49–88.93 (index)	–6.9
Business confidence index	1984 – quarter 3	46.00–23.00	–49.6
All-share index	1987 – quarter 4	36.64–27.08	–26.1
(Rand millions)			
GDP	1979 – quarter 2	44,592–44,552	–0.1
Merchandise exports	1979 – quarter 2	8,987–7,243	–19.4
Household financial assets	1998 – quarter 3	1,002,254–950,646	–5.2
Gross fixed capital formation – residential construction	1985 – quarter 1	21,610–19,544	–9.8

* The figures for the rand/euro exchange rate were calculated retrospectively by the South African Reserve Bank as the euro was only introduced in 2000.

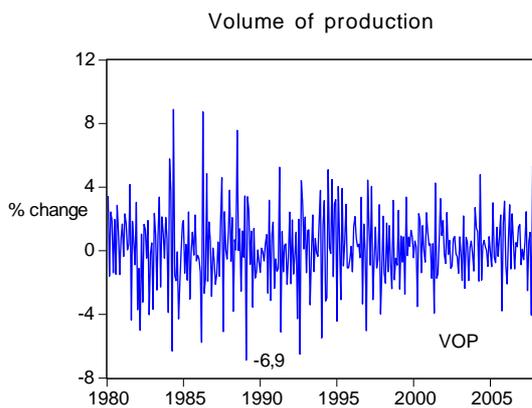
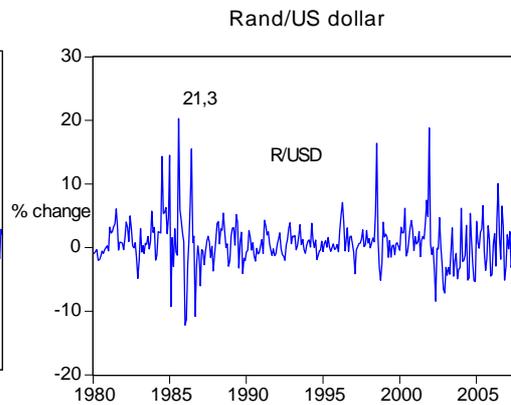
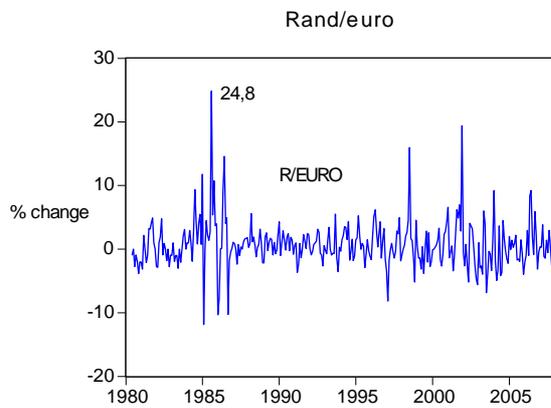
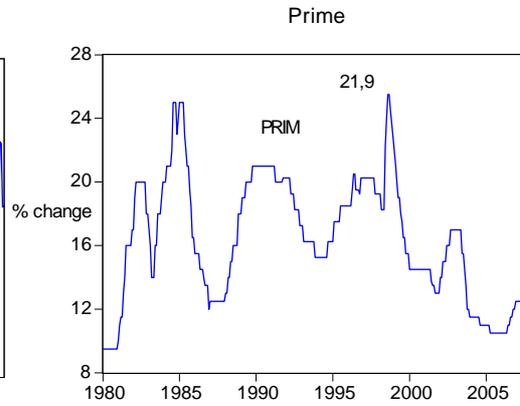
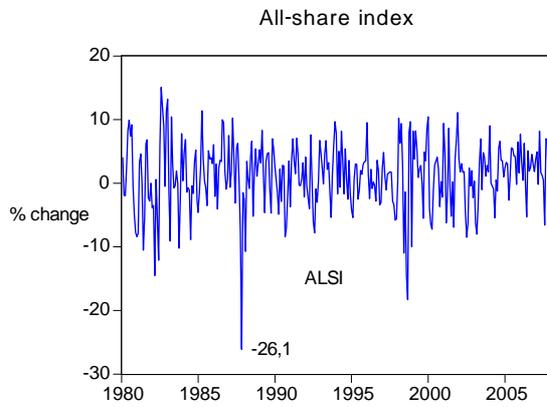
Source: Authors' computation.

Annex 10: Graphical illustration of scenarios



Source: South African Reserve Bank.

Annex 10: Graphical illustration of scenarios (cont)



Source: South African Reserve Bank.

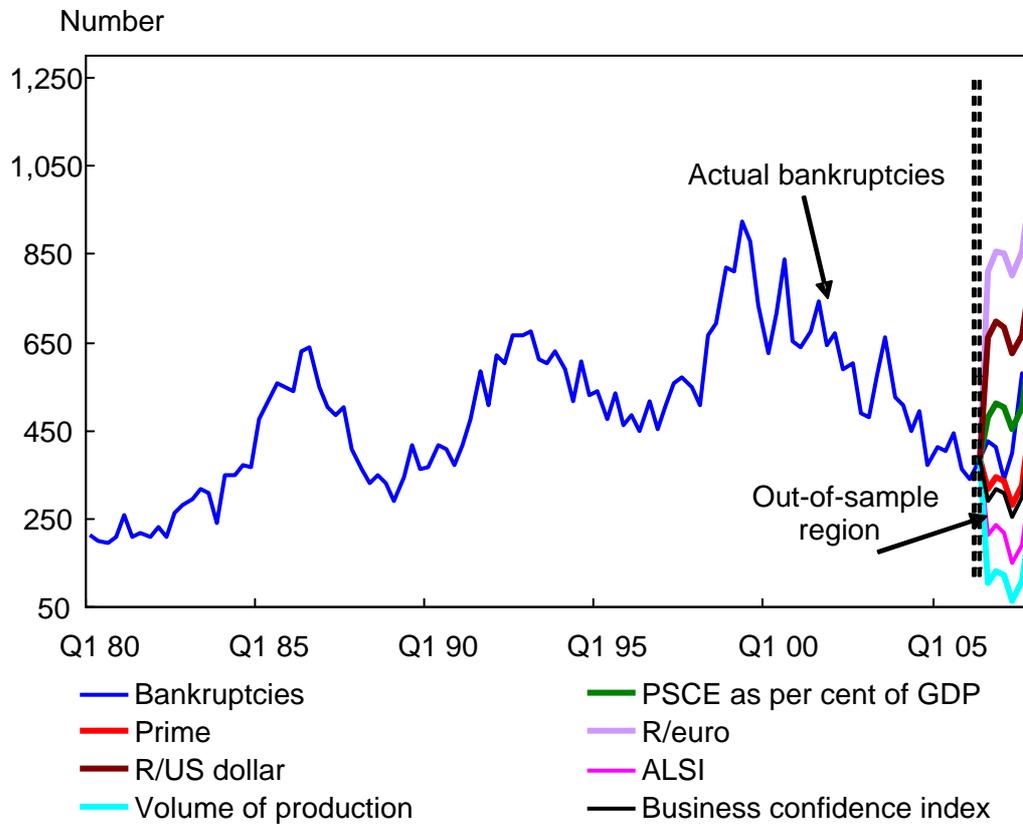
Annex 11:
The root mean squared error (RMSE) and the
mean absolute percentage error (MAPE)

$$\text{RMSE} = \sqrt{\frac{1}{n} \sum_{i=1}^n (Y_i - \hat{Y}_i)^2} \dots\dots\dots (2)$$

$$\text{MAPE} = 100 \left(\frac{Y_i - \hat{Y}_i}{Y_i} \right) \dots\dots\dots (3)$$

Where n is the sample size,
 Y_i is the actual observation, and
 \hat{Y}_i is the estimated value of Y_i .

Annex 12 Out-of-sample forecasting



Source: Statistics South Africa; authors' calculations.

References

- Bell, J and D Pain (2000): “Leading indicator models of banking crises – a critical review”, *Financial Stability Review*, Bank of England, issue 9, 14 December.
- Blaschke, W, M T Jones, G Majnoni and S M Peria (2001): “Stress testing of financial systems: an overview of issues, methodologies, and FSAP experience”, IMF Working Paper 01/88, Washington, DC, June.
- Caruana, J (2007): “Macroprudential stress testing: reflections on current practices and future challenges”, remarks at a conference sponsored by the European Central Bank, Frankfurt am Main, 8 August.
- Central Bank of Iceland (2008): *Financial Stability*, vol 4, May.
- Committee on the Global Financial System (CGFS) (2000): *Stress testing by large financial institutions: current practice and aggregation issues*, Basel, April.
- Davis, E P (1999): *Financial data needs for macroprudential surveillance – what are the key indicators of risks to domestic financial stability?*, Handbooks in Central Banking Lecture Series no 2, Centre for Central Banking Studies, Bank of England, May.
- (2001): “A typology of financial stability”, *Financial Stability Report 2*, Oesterreichische Nationalbank.
- Evans, O, A M Leone, M Gill and P Hilbers (2000): “Macroprudential indicators of financial system soundness”, IMF Occasional Paper no 192, April.
- Fourie, F C v N (1996): *How to think and reason in macroeconomics*, Juta & Co Ltd.
- Gujarati, D N (1995): *Basic Econometrics*, McGraw-Hill Inc, 1 September.
- International Monetary Fund (IMF) (2006): *Financial soundness indicators compilation guide*, March.
- Quantitative Micro Software, LLC (2007): *EViews 6 User’s Guide II*, 9 March.
- Selialia, L F, K C Matlapeng and T T Mbeleki (2002): *Macroprudential analysis of the South African financial system*, South African Reserve Bank Working Paper, December.
- Selialia, L F, P V Mabuza, K C Matlapeng and T T Mbeleki (2003): *Effects of macroeconomic developments on credit risk of the South African banking sector: a stress testing approach*, South African Reserve Bank Working Paper, June.
- South African Reserve Bank (2009): *Financial Stability Review*, March.
- Woolford, I (2001): “Macrofinancial stability and macroprudential analysis”, *Reserve Bank Bulletin*, Reserve Bank of New Zealand, vol 64, no 3, March, pp 29–43.