Annex: Stress Testing Methodologies

As a part of quarterly surveillance, stress tests were conducted covering the following risks:

- *Credit risk, which estimates the impact on capital adequacy by stressing the Non-Performing Advances (NPAs) for the entire credit portfolio. This was done using scenario analysis, multivariate regression model and Vector Autoregressive (VAR) approach.*

- *Interest rate risk, which estimates the erosion in economic value of the balance sheet for a given interest rate shock using the "Duration of Equity" method both at the system and the individual bank levels.*

- *Liquidity risk, using different scenarios, which include sudden withdrawal of deposits on account of loss of confidence due to adverse economic conditions.*

The resilience of the commercial banks in response to the above shocks has been studied from the above three perspectives. The analysis covered all scheduled commercial banks. Single factor sensitivity analysis on credit risk of scheduled urban co-operative banks and non-banking financial companies were also conducted. The methodology adopted for the stress tests is in line with the stress tests conducted for the first FSR and second FSR and there is further evolvement in a few methodologies.

Credit Risk - Scenario Analysis

For scenario analysis, the balance sheet and profit and loss account of the banks are projected for March 2012. Plausible shocks are administered on the projected financials of the banks to gauge the impact and resilience of the system. The analysis is carried out both at the aggregate level as well as at the individual bank level based on supervisory data for March 2011. Under the assumed baseline scenario, the growth projection for balance sheet as well as profit and loss components are computed by applying compound growth rates as well as by using March 2011 proportions and applying adverse impact factors on them. The regulatory capital growth is assumed to remain at the minimum by assuming minimum mandated transfer of twenty five per cent of the profit to the reserves account. In addition to an enhancement in the provisioning requirements as proposed in the Monetary Policy Statement for the year 2011-12, it is also assumed that 30 per cent of outstanding restructured standards assets turn into NPAs. The baseline assumes that the existing loan loss provisioning coverage ratios remain intact. The result thus obtained in the baseline scenario is subjected to increase in NPAs by 50 per cent, 100 per cent and 150 per cent at the aggregate loan portfolio level for each bank. The systemic impact of such shocks is also worked out.

Interest Rate Risk

The duration of equity (DoE) or the net-worth duration approach in stress tests could help in calculating the erosion in capital due to unit increase in interest rates. The analysis takes into account the interest rate sensitive items in balance sheet of the banks' portfolio and also the off balance sheet items. Subject to certain limitations, DoE captures the interest rate risk and helps in moving towards the assessment of risk based capital. The higher the duration of equity, more is the interest rate risk and accordingly greater the requirement of capital.

- Duration Gap = (Duration of assets * total assets – Duration of liabilities * total liabilities) / total assets

- Duration of Equity = Duration Gap * Leverage Ratio
  = (Duration of assets * total assets – Duration of liabilities * total liabilities) / Capital & Reserves

- Interest rate shock required to wipe out the capital funds = % Change in Price / DoE = 100/ DoE

Under this approach, the duration of equity of a bank's portfolio is computed under two scenarios: the savings deposits are assumed to be withdrawn in the first time band *viz.* 1 to 28 days (scenario I); the savings deposits are assumed to be withdrawn in 3 to 6 months time band (scenario II). The time band-wise rate sensitive liabilities have been accordingly adjusted under the two scenarios.

Liquidity Risk

The aim of liquidity stress tests is to assess the ability of a bank to withstand unexpected liquidity drain without taking recourse to any outside liquidity support. The scenarios developed are based on very stringent assumptions, which are extreme. The analysis is done as at end-March 2011.

The scenario depicts different proportions (depending on the type of deposits) of unexpected deposit withdrawals on account of sudden loss of depositors' confidence and assesses the adequacy of liquid assets available to fund them. The deposit run is assumed to continue for five days.

- The objective is to capture the ability of the bank to meet unexpected withdrawal of deposits through sale of its available liquid assets without any outside support.
- Deposits are segregated into three types, current deposits, savings deposits and term deposits.
- Liquid assets consist of cash funds, excess CRR balances with the Reserve Bank, balances with other banks payable within one year and investments maturing within one year.
- Under the stress scenario the total unexpected withdrawal of deposits is assumed to take place in the following proportion:
    - Current deposits – three times the proportion of reported outflows of current deposits in 1-14 days time bucket.
    - Savings deposits – three times the proportion of reported outflows of savings deposits in 1-14 days time bucket.
    - Term deposits – two times the proportion of reported outflows of term deposits in 1-14 days time bucket.
- The bank is assumed to meet stressed withdrawal of deposits through sale of liquid assets.
- The sale of investments is done with a hair cut of 10 per cent of their market value.
- The stress test is done on a static mode.

Liquidity Sustainability Ratio = Liquid Assets / Outflows in 1-14 days time bucket

Macro-Stress Test – Multivariate Regression

To ascertain the resilience of banks, the credit risk was modeled as functions of macroeconomic variables. The analysis was carried out on ratio of non-performing advances to total advances at the aggregate level for the commercial banking system as a whole. With the help of the developed model the NPA ratio was forecasted for next few quarters. This included both baseline and stressed scenarios. On the forecasted values of NPAs, the capital adequacy ratios were derived keeping the existing loan loss provisions intact. The detailed methodology is described in the Financial Stability Report – December 2010.

Macro-Stress Test – VAR Model

A vast body of literature endorses the fact that the changes in the macroeconomic conditions of any economy do impact banks' performance, simultaneously or with lag. It is also possible that the feedback effects of bank instability on real economic activity could amplify the fluctuations especially during recessions. Therefore, in order to judge the resilience of banking on various macroeconomic shocks, Vector Autoregressive (VAR) approach has been adopted as done by Hoggarth, Sorensen and Zicchino (2005), Marcucci and Quagliariello (2005) and Renato Filosa (2007). The advantage of VAR model is that, it allows to fully capture the interaction among macroeconomic variables and banks' stability variable. It also captures the entailed feedback effect.

In notational form, mean-adjusted VAR of order p (VAR(p)) can be written as

$$y_t = A_1 y_{t-1} + \ldots\ldots + A_p y_{t-p} + u_t \quad ; t=0,1,2,3,\ldots.$$

Where, $y_t = (y_{1t}, \ldots, y_{Kt})'$ is a (K×1) vector of variables at time t, the A_i (i=1,2,...p) are fixed (K×K) coefficient matrices and $u_t = (u_{1t}, \ldots, u_{Kt})'$ is a K-dimensional white noise or innovation process.

This exercise has been done using quarterly data since first quarter of 2001-02 to third quarter of 2010-11 on four macroeconomic variables, namely, GDP growth, inflation based on WPI, call money rate and Real Effective Exchange Rate (REER). However, to judge banks' stability, slippage ratio has been taken. Further, call rate, REER and slippage ratio were tested for seasonality and since seasonality was found in call rate and slippage ratio, these variables were adjusted for seasonality.

Stationarity of the variables was tested based on Augmented Dickey-Fuller Test. The null hypothesis that the variable has unit root was tested to be negative for slippage ratio, inflation, call rate and REER at 5 per cent level of significance and for growth at 10 per cent level of significance. Therefore, all the selected variables were found to be stationary.

Table: Unit-Root test

	Slippage Ratio	Growth	Inflation	Call Rate	REER
ADF Test Statistics	-3.102467	-2.860975	-5.486368	-3.927392	-3.291593
P-value	0.0350	0.0595	0.0001	0.0044	0.0227

The appropriate order of VAR has been selected based on minimum information criteria as well as other diagnostics and suitable order was found to be two. Accordingly, VAR of order 2 (VAR(2)) was estimated and stability of the model was checked based on roots of AR characteristic polynomial. Since, all roots are found to be inside the unit circle, this selected model was found to be fulfilling the stability condition.

Chart: Stability of VAR(2)

Inverse Roots of AR Characteristic Polynomial
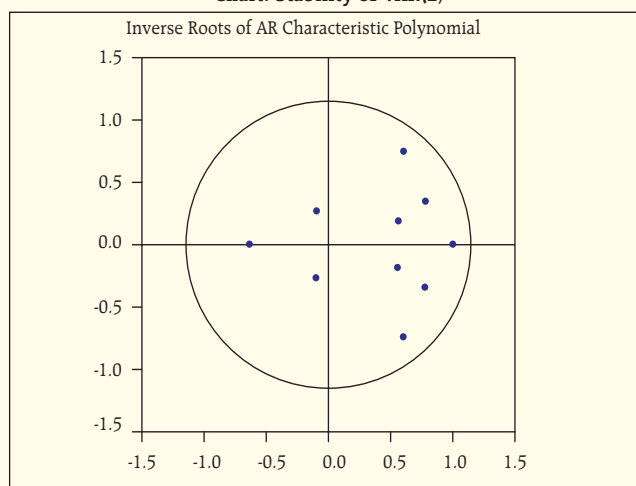
Urban Co-operative Banks – Credit Risk

Stress tests on credit risk were conducted on Scheduled Urban Co-operative Banks (SUCBs) using their asset portfolio as at end-March 2011. The tests were based on single factor sensitivity analysis. The impact on CRAR was studied under three different scenarios. The assumed scenarios were as under:

Scenario I:

- Shock applied: 50% increase in gross NPAs.
- Provisioning requirement is increased by 50%.
- Capital (Tier I & II) is reduced by additional provisions.

Scenario II:

- Shock applied: 100% increase in gross NPAs.

- Provisioning requirement is increased by 100%.

- Capital (Tier I & II) is reduced by additional provisions.

Scenario III:

- Shock applied: Loss or Zero profit by all SUCBs due to adverse macroeconomic conditions.

- Capital (Tier I & II) is reduced by amount of profits in respect of those banks that reported profit (no change if reported loss).

Non-Banking Financial Companies (ND-SI) – Credit Risk

Stress tests on credit risk were conducted on Non-Banking Financial Companies (Non-Deposit taking and Systemically Important) using their asset portfolio as at end-March 2010. The tests were based on single factor sensitivity analysis. The impact on CRAR was studied under two different scenarios. The scenario assumed increase in the existing stock of NPAs by 200 and 500 per cent. The assumed increase in NPAs was distributed across sub-standard, doubtful and loss categories in the same proportion as prevailing in the existing stock of NPAs. The additional provisioning requirement was adjusted from the current capital position.