Annex

Methodologies

Financial Stability Map

The Financial Stability Map depicts the overall stability condition in the Indian financial system. The Financial Stability Map is based on the three major indicators namely, Macroeconomic Stability Indicator (MSI), Financial Market Stability Indicator (FMSI) and Banking Stability Indicator (BSI). The methodologies for calculation of above indicators are described below.

Macroeconomic Stability Map and Indicator

The Macroeconomic Stability Map and Indicator is based on seven sub-indices, each pertaining to specific area of macroeconomic risk. Each sub-index on macroeconomic risk includes select parameters representing risks in that area. These sub-indices have been validated by assessing their appropriate impact on macroeconomic or financial variable such as GDP, inflation, interest rates or the quality of assets of the banks. The seven sub-indices of the overall macroeconomic stability index and their components are described below:

Global Risk Index

The Global Risk index is based on real output and the prices in the advanced economies. In respect of real output, a composite index based on the weighted average of the growth rate of GDP of U.S., Euro Area and Japan has been constructed. Using a similar procedure, index for inflation in these advanced economies was also constructed. GDP index is ranked in ascending order while that of inflation is ranked in descending order. Global Risk Index is a composite index of these indices having equal weights for each index.

External Vulnerability

The index of external vulnerability is based on current account deficit/GDP, current payments/current receipts, average monthly imports/reserve, share of short term debt in total debt, debt stock - GDP ratio and debt service ratio.

Fiscal Vulnerability

Initially, an index of fiscal stress is constructed based on the gross primary deficit (GPD), gross fiscal deficit (GFD) and the total liabilities of the centre and state governments. This is based broadly on the methodology suggested in two IMF Working Papers by Baldacci, McHugh and Petrova (2011) and Baldacci, Petrova, Belhocine, Dobrescu and Mazraani (2011). The weights in respect of GFD and GPD so obtained were applied to recent data on GPD and GFD provided by the Office of the Comptroller General of Accounts to assess the change in fiscal risks.

Growth

For obtaining the outlook on domestic growth, the relationship of growth with a number of variables were attempted, viz. exports/GDP, growth of core industry, GFCF/GDP, real bank credit, PMI and yield curve (difference between the ten-year and one-year yield). Amongst these variables, the yield curve and PMI Manufacturing were found to be the most appropriate indicators of growth.

Inflation

The outlook for inflation is based on the changes in international oil prices, exchange rate, and world inflation.

Corporate Sector

The health of the corporate sector is captured through profit margin. The risks emanating from the sector is inversely related to it. In order to capture the relationship of the corporate sector with the financial sector, the share of interest in sales is also captured in the index for the corporate sector.

Household Sector

In the absence of frequent data on indebtedness of household, the outstanding credit from the bank to the household sector, viz. retail credit, is taken as a proxy for household indebtedness. Further, in view of the delay in availability of data on personal disposable income, private final consumption expenditure (PFCE) is used as its proxy. Based on these two variables, and the retail NPA, the index for household sector attempts to capture the risks originating from the household sector.

Financial Markets Stability Map and Indicator

With the objective to measure stability of the financial market, Financial Market Stability Map and Indicator has been prepared based on the indicators of four sectors/markets namely banking sector, foreign exchange market, equity market and debt market. The indicators selected from various sectors/markets are following; i) Banking Sector: Banking Beta of CNXBANK Index and NIFTY Index, CD Rate and CD rate minus Implied Forward rate, ii) Foreign Exchange Market: CMAX of daily INR-US Dollar exchange rate, which is defined as X_t/Max(X_i, i=1,2,..upto one year). Where, X_t is the INR-US Dollar exchange rate at time t, and 25 Delta Risk Reversals of foreign exchange rate, iii) Equity Market: Inverse of NIFTY CMAX and India VIX, and iv) Debt Market: Corporate bond which is average return of corporate bonds rated A, AA, and AAA, 10-years Government bond yield and CP Rate.

Because of different levels of the selected indicators, they cannot be added straightaway. Therefore, to bring all the indicators at same level, variance-equal transformation has been used.

At first level, four indicators for the four selected sectors/market were prepared based on simple average of elementary indicators and thereafter FMSI was derived based on simple average of the four indicators derived at first level. FMSI was estimated based on daily data.

Further, projection of FMSI was done based on monthly FMSI which is monthly average of daily FMSI, credit growth, WPI-Manufactured Products inflation and REER using following regression equation:

$$FMSI_t = -\alpha_1 + \beta_1 * FMSI_{t-1} - \beta_2 * FMSI_{t-2} + \beta_3 * Credit\ Growth_{t-1} + \beta_4 * Inflation(Manufactured\ Products)_{t-1} - \beta_5 * DL(REER)_{t-4}$$

Where, α_1 , $\beta_1, \beta_2, \beta_3, \beta_4$ and $\beta_5 > 0$.

Banking Stability Map and Indicator

The Banking Stability Map and Indicator present an overall assessment of changes in underlying conditions and risk factors that have a bearing on stability of the banking sector during a period. Following ratios are used for construction of each composite index:

Table : Indicators used for construction of Banking Stability Map and Banking Stability Indicator

Dimension	Ratios			
Soundness	CRAR	Tier-I Capital to Tier-II Capital	Leverage ratio as Total-Assets to Capital and Reserves	
Asset-Quality	Net NPAs to Total-Advances	Gross NPAs to Total-Advances	Sub-Standard-advances to gross NPAs	Restructured-Standard-Advances to Standard-Advances
Profitability	Return on Assets	Net Interest Margin	Growth in Profit	
Liquidity	Liquid-Assets to Total-Assets	Customer-Deposits to Total-Assets	Non-Bank-Advances to Customer-Deposits	Deposits maturing within-1-year to Total Deposits
Efficiency	Cost to Income	Business (Credit + Deposits) to staff expenses		Staff Expenses to Total Expenses

The five composite indices represent the five dimensions viz., Soundness, Asset-quality, Profitability, Liquidity and Efficiency. Each index, representing a dimension of bank functioning, takes values between zero (minimum) and 1 (maximum). Each index is a relative measure during the sample period used for its construction, where a high value means the risk in that dimension is high. Therefore, an increase in the value of the index in any particular dimension indicates an increase in risk in that dimension for that period as compared to other periods. For each ratio used for a dimension, a weighted average for the banking sector is derived, where the weights are the ratio of individual bank asset to total banking system assets. Each index is normalized for the sample period as 'Ratio-on-a-given-date minus Minimum-value-in-sample-period divided by maximum-value-in-sample-period minus Minimum-value-in-sample-period'. A composite measure of each dimension is calculated as a weighted average of normalised ratios used for that dimension, where the weights are based on the marks assigned for assessment for CAMELS rating. Based on the individual composite indices for each dimension, the Banking Stability Indicator is constructed as a simple average of these five composite sub-indices.

For the current map and indicator, the sample period for assessment was taken from March 2006 to March 2012. Projection of BSI was done using Auto Regressive Moving Average (ARMA) method.

Stress Testing of Derivatives Portfolio of Select Banks

The stress testing exercise focused on the derivatives portfolio of a representative sample set of banks. The top 26 banks in terms of notional value of derivatives portfolio as at end December 2011 were selected for the analysis. The methodology adopted involved designing a set of stress conditions. Each bank in the sample was asked to assess the impact of these stress conditions on their respective derivatives portfolios as on March 31, 2012.

In case of domestic banks, the derivatives portfolio of both domestic and overseas operations were reckoned. In case of foreign banks, only the domestic (i.e. Indian) position was considered for the exercise. Derivatives trade where hedge effectiveness was established was exempted from the tests, while all other trades were included.

The stress scenarios incorporated six historical scenarios and four sensitivity tests. For constructing the historical scenario, six parameters (market variables) were chosen and the 1 day rate of change over a horizon of 2007-2011 was calculated for each variable. The date corresponding to the maximum change (in each variable) was selected as the stress period. For each of the six stress periods, the 1 day rate of change for rest of the market variables needed for valuation of derivative portfolio of banks was calculated to arrive at six different scenarios

Table : Parameters and Dates used to construct scenario Analysis

Parameter	Highest 1 day change in the period 2007-2011
USD/INR	Rate of change of -3.1 per cent
MIFOR 6 MONTHS	Absolute change of -240 bps
OIS INR 2YEARS	Absolute change of -60.5 bps
USD LIBOR 3 MONTHS	Absolute change of -38.6 bps
EURIBOR 6 MONTHS	Absolute change of 17.5 bps
USD LIBOR SWAP CURVE 5 YEARS	Absolute change of -8.5 bps

The sensitivity tests were constructed using the spot USD/INR rate and domestic interest rates as parameters

Table: Shocks for Sensitivity Analysis

	Domestic Interest Rates	
Shock 1	Overnight	**+250 bps**
	Upto 1yr	**+150 bps**
	Above 1yr	**+100 bps**

	Domestic Interest Rates	
Shock 2	Overnight	**-250 bps**
	Upto 1yr	**-150 bps**
	Above 1yr	**-100 bps**

	Exchange rates	
Shock 3	USD/INR	**+20 per cent**

	Exchange Rates	
Shock 4	USD/INR	**-20 per cent**

Single Factor Sensitivity Analysis – Stress Testing

As a part of quarterly surveillance, stress tests are conducted covering credit risk, interest rate risk, equity price risk, foreign exchange risk, liquidity risk etc. Resilience of the commercial banks in response to these shocks is studied. The analysis covers all scheduled commercial banks. Single factor sensitivity analysis on credit risk of scheduled urban co-operative banks and non-banking financial companies are also conducted.

Credit Risk

To ascertain the resilience of banks, the credit portfolio was shocked by increasing NPA levels, for the entire portfolio as well as for select sectors, along with a simultaneous increase in provisioning requirements. For testing the credit concentration risk, default of the top individual borrowers and the largest group borrower is assumed. The estimated provisioning requirements so derived were adjusted from existing provisions and the residual provisioning requirements, if any, were deduced from banks' capital.

The analysis was carried out both at the aggregate level as well as at the individual bank level, based on supervisory data as on March 31, 2012. The scenario assumed enhanced provisioning requirements of 1 per cent, 30 per cent and 100 per cent for standard, sub-standard and doubtful/loss advances, respectively. 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 applied to the altered composition of the credit portfolio.

Equity price risk, foreign exchange risk and interest rate risk

The fall in value of the portfolio or income losses due to change in equity prices, appreciation/ depreciation of INR, shifting of INR yield curve are accounted for the total loss of the banks because of the assumed shock. The estimated total losses so derived were reduced from the banks' capital.

For interest rate risk in the banking Book, two kinds of approaches were considered: (1) Income Approach, which impacts the earnings of banks because of shift in INR yield curve and (2) Duration Gap Analysis, which computes the valuation impact (portfolio losses). The income losses, on interest bearing exposure gap, are calculated for one year for each time bucket separately, to reflect the impact on the current year profit & loss and income statement.

The portfolio losses, on interest bearing exposure gap, are calculated for each time bucket, using duration gap analysis. The total (net) impact on the banking book was calculated by adding income losses/gains and portfolio losses/gains[1], and the resultant losses/gains were used to derive the impacted CRAR. The valuation impact for the tests was calculated under the assumption that the HTM portfolio would be marked to market. For interest rate shocks in trading book, the valuation losses are calculated for each time bucket on the interest bearing assets using duration approach.

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 analysis is done as at end-March 2012. 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 definition of liquid assets are taken as:

1. Cash + Excess CRR + Inter Bank Deposits + SLR Investments
2. Cash + Excess CRR + Inter Bank Deposits maturing-within-1-month + Investments maturing-within-1-month
3. Cash + Excess CRR + Inter Bank Deposits maturing-within-1-month + Excess SLR Investments
4. Cash + CRR + Inter Bank Deposits maturing-within-1-month + Investments maturing-within-1-month
5. Cash + CRR + Inter Bank Deposits maturing-within-1-month + Excess SLR Investments

- It is assumed that banks would 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.

Bottom-up Stress Testing

Bottom-up sensitivity analysis was performed by 25 scheduled commercial banks (comprising about 75 percent of the total assets). A set of common scenarios and shock sizes were provided to select banks. The tests were conducted using March 2012 data. Banks used their own methodologies for calculation of losses in each case.

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 2012. The tests were based on single factor sensitivity analysis. The impact on CRAR was studied under two different scenarios. The assumed scenarios were as under:

Scenario I:

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

[1] Total (Net) losses/gain = Income (losses/ gain) + Portfolio (losses/ gain)

Scenario II:

- Shock applied: 100 per cent increase in gross NPAs.
- Provisioning requirement is increased by 100 per cent.
- Capital (Tier I & II) is reduced by additional provisions.

Liquidity stress test based on cash flow basis in 1-28 days time bucket was also conducted, where mismatch [negative gap (cash inflow less than cash outflow)] exceeding 20 per cent of outflow in 1 to 28 days time bucket was considered stressful.

Scenario I: Cash out flows in 1-28 days time bucket goes up by 50 per cent (no change in cash inflows)

Scenario II: Cash out flows in 1-28 days time bucket goes up by 100 per cent (no change in cash inflows)

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-December 2011. 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. The stress were conducted at individual NBFCs as well as at an aggregate level.

Systemic Liquidity Index (SLI)

The SLI uses the following four indicators representing various segments of the market:

1. Weighted Average Call Rate – RBI Repo Rate
2. 3 month Commercial Paper (CP) Rate – 3 month Certificate of Deposits (CD) Rate
3. 3 month CD Rate – 3 month Implied Deposit Rate
4. Weighted Average Call Rate - 3 Month Overnight Index Swap (OIS) Rate

In order to create the SLI, variance-equal or standard normal transformation was used.

Macro Stress Testing

To ascertain the resilience of banks, the credit risk was modeled as functions of macroeconomic variables. Credit risk stress tests have been computed using several econometric models that relate banking system aggregates to the macroeconomic variables, such as (i) multivariate logit regression on aggregate systems' NPA data; (ii) multivariate regression in terms of the slippage ratio (inflow of new NPAs); (iii) aggregate VAR using slippage ratio; (iv) quantile regression of slippage ratio, (v) multivariate panel regression on bank-group wise slippage ratio data; and (vi) multivariate regressions for aggregate sectoral NPAs. The banking system aggregate includes current and lagged values of aggregate NPAs (NPA ratio) and inflow of new NPAs (slippage ratio), while macroeconomic variables include GDP growth, short term interest rate (call rate), WPI inflation, exports-to-GDP ratio $\left(\frac{Ex}{GDP}\right)$, gross fiscal deficit-to-GDP ratio $\left(\frac{GFD}{GDP}\right)$ and REER.

While the multivariate regressions allows evaluating the impact of selected macroeconomic variables on the banking system's NPA and capital, the VAR model reflects the impact of the overall economic stress situation on the banks' capital and NPA ratio, which also take into account feed-back effect. In these methods, conditional

mean of NPA/slippage ratio is estimated and assumed that the impact of macro variables on credit quality will remain same irrespective of the level of the credit quality, which may not always be true. In order to relax this assumption, quantile regression has been adapted to project credit quality, in which, in place of conditional mean the conditional quantile has been estimated.

The Modeling Framework

The following multivariate models were run to estimate the impact of macroeconomic shocks on the aggregate NPA (npa) / slippage ratio (SR): [1]

- Aggregate banking system multivariate logit[2] regression:

$$logit\_npa_t = \alpha_1 + \beta_1\, logit\_npa_{t-1} - \beta_2\, \Delta \mathrm{GDP}_{t-2} + \beta_3\, call_{t-1} - \beta_4 \left(\frac{Ex}{GDP}\right)_{t-2}$$

  Where, $\alpha_1, \beta_1, \beta_2, \beta_3$ and $\beta_4 > 0$.

- Aggregate banking system multivariate regression:

  The analysis was carried out on slippage ratio at the aggregate level for the commercial banking system as a whole.

$$SR_t = \alpha_1 + \beta_1\, SR_{t-1} - \beta_2\, \Delta GDP_{t-2} + \beta_3\, Call_{t-1} - \beta_4 \left(\frac{Ex}{GDP}\right)_{t-2} + \beta_5 \Delta WPI_t + \beta_6 \left(\frac{GFD}{GDP}\right)_{t-1}$$

  Where, $\alpha_1, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ and $\beta_6 > 0$.

- Vector AutoRegression (VAR):

  In order to judge the resilience of banking on various macroeconomic shocks, Vector Autoregressive (VAR)[3] approach has been adopted. 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, $y_t = (y_{1t}, \ldots\ldots, y_{Kt})'$ is a (K×1) vector of variables at time t, the A_1 (i=1,2,…p) are fixed (K×K) coefficient matrices and $u_t = (u_{1t}, \ldots\ldots, u_{Kt})'$ is a K-dimensional white noise or innovation process.

  In order to estimate, VAR system, slippage ratio, call rate, inflation, growth and REER were selected, however, because of limited data points, GFD-to-GDP could not be taken. 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. The impact of various macroeconomic shocks was determined using impulse response function of the selected VAR.

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[1] Slippage ratio, exports/GDP, and the call rate are seasonally adjusted.

[2] For detailed model specifications, please refer to FSR – December 2010. The logit transformation of NPA ratio is define as:

$$Logit\_npa_t = L(NPA_t) = Ln\left(\frac{NPA_t}{1-NPA_t}\right)$$

[3] For detailed VAR model specifications, please refer to FSR – June 2011.

- Quantile Regression:

  In order to estimate slippage ratio at desired level of conditional quantile, following quantile regression at 0.60 quantile (which is the present quantile of the slippage ratio) was used:

$$SR_t = \alpha_1 + \beta_1 SR_{t-1} - \beta_2 \Delta GDP_{t-1} + \beta_3 Call_{t-4} - \beta_4 \left(\frac{Ex}{GDP}\right)_{t-1} + \beta_5 \Delta WPI_t + \beta_6 \left(\frac{GFD}{GDP}\right)_{t-1}$$

  Where, $\alpha_1, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ and $\beta_6 > 0$.

- Bank-group wise panel fixed-effect regression:

  Bank-group wise panel regression was modeled where slippage ratio was considered as functions of macroeconomic variables. The bank-group effect were identified along with the overall model specifications.

$$SR_{it} = \alpha_i + \beta_1 SR_{i(t-1)} - \beta_2 \Delta GDP_{t-1} + \beta_3 Call_{t-2} - \beta_4 \left(\frac{Ex}{GDP}\right)_{t-1}$$

  where, α_i is the bank-group specific parameter and $\alpha_i, \beta_1, \beta_2, \beta_3$, and $\beta_4 > 0$.

- Sectoral multivariate regression:

  The impact of macroeconomic shocks on various sectors was assessed by employing multivariate regression models using aggregate NPA ratio for each sector separately. The dependent variables consisted of lagged NPAs, sectoral GDP growth, inflation, and short-term interest rate.

Derivation of the NPAs and CRAR from the slippage ratios, which were projected from the above mentioned credit risk econometric models, were based on the following assumptions: credit growth of 17 per cent; recovery rate of 5 per cent; write-offs at 3.5 per cent; risk weighted assets growth of 18 per cent; and profit growth of 10 per cent. The regulatory capital growth is assumed to remain at the minimum by assuming minimum mandated transfer of 25 per cent of the profit to the reserves account. The distribution of new NPAs in various sub-categories was done as prevailing in the existing stock of NPAs. Provisioning requirements for various categories of advances are 0.4 per cent for standard advances, 10 per cent for sub-standard advances, 75 per cent for doubtful advances, and 100 per cent for loss advances. The projected values of the ratio of the non-performing advances were translated into capital ratios using the "balance sheet approach", by which capital in the balance sheet is affected via the provisions and net profits. It is assumed that the existing loan loss provisioning coverage ratios remain constant for the future impact.