Stress Test of Banks in India Across Ownerships : A VAR Approach

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Abstract

Banking crisis have serious repercussion causing loss of household savings and decline in confidence and soundness in the banking sector. The present study is an attempt to analyze this aspect in light of the challenges of financial sector reforms faced by banks in India . Stress test of banks operating in India is undertaken to identify factors that adversely influence banks' non-performing assets (NPA) which is the key indicator of banks' soundness. We examine the response of bank's NPA to unexpected shocks from external and domestic macroeconomic factors namely interest rate, exchange rate, GDP. NPAs are regressed in Vector Auto Regressive model on a set of macroeconomic variables with quarterly data from 1997 to 2012 to examine whether there is divergence in the response across the four types ownership: public, old private, new private, and foreign. Granger Causality, IRF and FEVD are used to verify the VAR results. Interest rate significantly impairs asset quality for all banks in two-way causality. Exchange rate, net foreign institutional investor flow and deposits Granger cause public banks' NPA. GDP gap Granger cause NPA in old private and foreign banks. IRF show banks are vulnerable to inflation shock requiring 8 quarters to stabilize. The stress test clearly demonstrates that all banks need to re-capitalize and improve asset quality.

Keywords: *Macro Stress test, Non-performing Assets, Impulse response function, Vector Auto Regression, Granger Causality*

JEL Codes: *C33, E32 E37*

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INTRODUCTION

In 2009 the Reserve Bank of India (RBI) announced that the Indian banking system is resilient to the shocks from high non–performing assets[1] (NPA) and the global economic crisis[2]. However, Indian banks can no longer claim to be insulated from external and internal economic forces, macroeconomic shocks can be transmitted to banks through different channels of the external sector and the domestic macroeconomic factors. The persisting global financial crisis re-affirms the need for macro stress test to assess banks' vulnerability, particularly in the light of the recent downgrade of a major Indian public bank.

The literature provides evidence of bank failures being closely related to deterioration of asset quality, to doubtful loans and write offs. An asset becomes non-performing when the borrower defaults in payment of interest and principal according to the agreed terms. So deterioration of asset quality has a direct bearing on the bank's stability. Mishra and Dhal (2010) show that business cycles are the primary cause for NPAs.

Despite the acute need for macro stress test of the banking sector, there is scarce research in emerging economies. In this paper, we seek to answer the following question: if banks face unexpected shocks from a spurt in credit default or exchange rate volatility, can they remain stable? To answer this question, we apply the vector auto regressive (VAR) model to test asset quality of banks across the four different types of banks ownership, and assess their robustness.

[1] The Global Financial Stability Report of International Monetary Fund (IMF 2009), proposed that identifying and dealing with distressed assets, and recapitalizing weak but viable institutions and resolving failed institutions are the two important priorities which directly relate to NPAs.

[2] Business Standard August 28, 2009

The importance of this question has to be appreciated against the backdrop of the major economic reforms that have been rolled in since early the 1990s - the first and second Narasimhan Committee Reports, and secondly the liberalization of the exchange rate regime since February 1993. The impact of these changes in the regulatory regime is visible in the second decade of the 21st century. The thrust of the financial sector reforms was market orientation that can be witnessed in the shift from administered interest rate regime to market determined rate.

The establishment of large private sector banks to usher in a competitive environment for bank operations is a dramatic shift from the dominance of public sector banks. So, we can expect that the liberal exchange rate and market determined interest rates would be forces to reckon with banks functioning in India. The announcement of new licenses to open banks is a policy that shows the government's commitment towards financial reforms. Banks are classified according to their ownership: public sector banks, old private sector banks, new private sector banks and foreign banks. The data for all the banks are pooled for the VAR.

The caveat here is that the public sector banks that have been the major players in the Indian banking system providing support to social sector through priority sector lending are now exposed to competitive environment that could jeopardize their asset quality. The questions that emerge: (1) can these banks survive and prosper in this unprotected era? (2) can they compete with home grown private banks and foreign banks that are flocking to India to start operations? The answer lies in the quality of the banks' assets in their loan portfolio.

We find evidence of the vulnerability of banks' assets and hence their soundness and stability due to the market orientation of interest rates and the liberalized exchange rate regime. Both interest rate and exchange rate significantly impair bank asset quality indicating that bankers need to understand how external and domestic macroeconomic forces impact their balance sheet. This evidence is consistent with the results of Bhattacharya and Roy (2008), the only other paper in India applying the VAR model to examine this issue till date.

The key variable to capture the banks' soundness is the net non-performing assets (NPA). Gross non-performing assets are the total loan outstanding of all the borrowers classified as non-performing assets (viz. substandard, doubtful and loss asset). Banks recognize a loan as NPA if either the principal or the interest is overdue for 180 days. From March 2004 the RBI changed the NPA definition and mandated that banks adopt stricter norms of '90 days overdue for calculating non-performing assets. NNPA is the Gross NPA minus gross provision made, it is computed taking the unrealized interest and unadjusted credit balances with regard to various NPA accounts divided by the total assets.

To test the banks' ability to withstand shocks from macroeconomic factors, NPAs are subjected to shock in a VAR framework from interest rate, GDP output gap, inflation rate, deposits Cash Reserve Ratio (CRR) exchange rate, and, net FII inflow.

Before the subprime crisis imploded, most bank stress tests applied the Value–at–Risk (VaR) method. It is a technique where probabilities were assigned to each event based on historical incidents. Evidently, this popular method proved to be grossly inadequate to measure the true risk. Berkowitz (1999) and Boss et al. (2006), among others, had applied this popular technique that Haldane (2009) has labeled as 'wrong' models. He says "….. 2008 might well be remembered as the year stress-testing failed."

The Vector Autoregressive (VAR) model has now been recognized as a superior technique for stress tests. Foglia (2009) proposes that central banks develop macro-econometric models to forecast and assess policy impact, recommending the VAR or vector error correction models (VECM). Sorge (2009) asserts that econometric analyses of financial soundness indicators have progressed but argues that methodological challenges remain.

The period of study is divided into two phases:– 1997 Q4 to 2003 Q3 and 2003 Q3 to 2012 Q1. The rationale for this bifurcation of data lies in the change in definition of NPA. The relevant domestic macro variables, GDP output gap, interest rate, and WPI, and for assessing the impact of the external sector, exchange rate and net foreign institutional investment are included. Bank specific variables - deposits and RBI's policy tool, the cash reserve ratio (CRR) - are introduced.

The objectives of this paper are as follows:

1. To examine whether the non-performing loans/assets are adversely influenced by domestic macroeconomic factors and external factors.
2. To examine whether there is any variation in the response of banks of different ownership to shocks from domestic and external sector forces.

Our results indicate that in the first phase NPAs of public sector banks are significantly impaired by exchange rate and portfolio funds of foreign institutional investors (net FII), output gap and interest rate. The liberalized regime of interest in the second phase is significant for all the different categories of banks, implying the shock from interest rate can de-stabilize the system. The impulse response function (IRF) captures the speed and direction of the adjustment to induce shocks on the macroeconomic variables within the structural model. The different structural shocks in our model are isolated through Choleski decomposition.

GDP output gap, interest rate, exchange rate are the variables used in the macro-stress test (Hogarth et al 2005, Bofondi and Repelo 2011). The IRF indicates the period of response to revert to equilibrium due to exchange rate and net FIIs shocks. We find that the period is shorter in the first phase, clearly highlighting the fragility of the banking system in the second phase.

Thus macroeconomic shocks transmitted to the banking sector from external and domestic sources are a cause of concern in India. Stock market index is a variable used to factor the risk in banks' portfolio (Bofondi and Repelo 2011), however, the introduction of capital market index BSE Sensex, alternatively NSE Nifty and the BANKEX proved ineffective and hence not reported.

The rest of the paper is organized as follows: the second section contains the literature review which is followed by a description of the methodology, database and of the econometric model in section three. Section four reports the results and the analysis of the empirical exercise that precedes the conclusion and limitations of the study.

LITERATURE REVIEW

The banking crisis that have erupted periodically and more frequently in the 21st century highlight the need for a robust econometric model like the vector-auto regression (VAR) to test banks' ability to withstand stress from domestic and foreign source.

van den End, Hoeberichts, and Tabbae (2006) apply two steps stress test on the deviations of the macroeconomic variables of the credit-risk equations to estimate a VAR(2) model. Jim´enez, G., and J. Menc´ıa (2007) apply the VAR (1) estimation for the macroeconomic variables for the Bank of Spain.

The VAR methodology is used when the macro-economic shocks are incorporated in the financial system to analyse their impact. There are studies which are a cumulative representation of the various practices around the globe, which provide an opportunity to innovate and develop existing practices for greater safety.

Hoggarth, Sorensen and Zicchino (2005) apply VAR for macro stress test on British banks. Quarterly data from 1988-2004 of bank write-offs ratio is used as the dependent variable with the nominal interest rate, exchange rate and inflation and output gap representing the macro-economic variables. They analyze the impact of a shock through output gap on aggregate loan write-offs, to find that shocks from output gap significantly impact write offs by an increase of 0.7%, up to six quarters.

Ambediku (2006) apply VAR model to stress test Ghanaian banking sector. Using quarterly data from 1995 -2005, he finds that following an adverse output shock and a rise in inflation, the banks' non-performing loans (NPL) ratio increases. The impulse response functions also suggest that the NPL ratio increases after eight quarters following an unexpected increase in output gap and after nine quarters following an unexpected increase in inflation. Also an unexpected increase in the prime lending rate leads to a significant increase in the NPL ratio with the maximum after 6 quarters. These results resonate with findings of this study.

Marcucci and Quagliariello (2008) focus on the Italian banking system, employing a reduced form VAR to assess, among other things, the effects of business cycle conditions on bank customers' default rates over the period 1990–2004. They show that the default rates follow a pro-cyclical pattern. Moreover, this evidence is robust to different measures of the output gap and holds for households, firms and the non-financial sector as a whole.

In the Indian context Bhattacharya and Roy (2008) regress the default rate of banks in the recursive VAR model to monthly data from 1994-2003, along with Granger causality tests. However Impulse Response Functions reveal the existence of cyclical and pro-cyclical patterns over two months. Moreover, shocks to exchange rate and monetary policy instruments significantly affect bank asset quality. They suggest full capital account convertibility will increase the stress on banking sector in India due to greater exchange rate volatility and consequent rise in interest rates. They propose that the central banks needs to focus on financial stability rather than focusing on price stability alone.

Lokare (2014) explores the macro-financial linkages and micro-level sources underlying the asset quality deterioration using OLS technique. In line with the ongoing international intellectual discourse, his paper finds the evidence of pro-cyclicality in the Indian context as reflected in past credit boom-bust episodes as well as economic and interest rate cycles. Anaemic external macroeconomic situation post-crisis, high inflation and dwindling asset prices have eroded the debt servicing capacity of borrowers and contributed to the asset quality problems.

Bock and Demyanets (2012) assess the vulnerability of emerging markets and their banks to aggregate shock to find significant links between banks' asset quality, credit and macroeconomic aggregates. Lower economic growth, exchange rate depreciation, weaker terms of trade and a fall in debt-creating capital inflows reduce credit growth while loan quality deteriorates. Particularly noteworthy is the sharp deterioration of balance sheets following a reversal of portfolio inflows. GDP growth falls after-shocks that drive non-performing loans higher or generate a contraction in credit.

Bofondi and Repelo (2011) use a single-equation time series approach to examine the macroeconomic determinants of banks' loan quality in Italy measured by the ratio of new bad loans to the outstanding amount of loans in the previous period. They find that i) the quality of lending to households and firms can be explained by the general state of the economy, the cost of borrowing and the burden of debt; ii) changes in macroeconomic conditions generally affect loan quality with a lag.

METHODOLOGY

Vector Auto Regressive model, popularly known as the VAR is an extension of the uni-variate autoregressive models. Developed by Sims in 1980, this is superior to the conventional dynamic simultaneous equation models used traditionally for multivariate regressions.

VAR modelling is less dependent on prior theoretical restrictions than the simultaneous equation models i.e., it is a-theoretical. The model is flexible, dynamic, and robust and captures the linear interdependencies among a set of chosen K endogenous variables.

Thus, in a VAR model, K endogenous variables are specified as linear functions of each other over a sample period t. The model also allows for the introduction of exogenous variables.

A VAR model of p-order, written VAR (p) is given by

$$Y_t = V + A_1Y_{t-1} + \ldots\ldots + A_pY_{t-p} + U_t \qquad (1)$$

Where,

Y_t = Vector of length of the endogenous variables K. They also denote the number of equations in the VAR model

P = VAR order denoting the lag length

T	=	Sample time period
V	=	Vector of constants (K*1)
A	=	Co-efficient matrix (K*K)
U_t	=	Serially uncorrelated error terms

For instance, for K = 2 and p =1, VAR will be represented as below:

$$\begin{bmatrix} Y_{1t} \\ Y_{2t} \end{bmatrix} \begin{matrix} = \\ = \end{matrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix} \begin{matrix} + \\ + \end{matrix} \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \begin{bmatrix} Y_{1,t-1} \\ Y_{2,t-1} \end{bmatrix} \begin{matrix} + \\ + \end{matrix} \begin{bmatrix} U_{1t} \\ U_{2t} \end{bmatrix}$$

This would translate to two equations:

$$Y_{1t} = V_1 + A_{11}\, Y_{1,t-1} + A_{12}\, Y_{2,t-1} + U_{1t}$$
$$Y_{2t} = V_2 + A_{21}\, Y_{1,t-1} + A_{22}\, Y_{2,t-1} + U_{2t}$$

If exogenous variables enter the analysis the VAR model equation will be as follows:

$$Y_t = V + A_1Y_{\ t-1} + \ldots\ldots + A_pY_{t-p} + B_0X_t + B_0X_{t-1} + \ldots\ldots B_sX_{t-s} + U_t \qquad (2)$$

Where all the terms are the same as in (1) above except we have

$x_{\ t}$	=	M * 1 vector of exogenous variables,
B_0 through B_s	=	coefficients matrices of (K *M)

Given the dynamic interactions among the K variables, interpretation of VAR is aided by a set of post-VAR estimations: Granger Causality test, Impulse Response Functions (IRF), and Forecast Error Variance Decomposition (FEVD). These help meaningfully break down and interpret the complex dynamic interrelationships of the K variables that VAR captures.

After fitting a VAR, the first step is to find out the direction of causality among two endogenous variables by through the pairwise Granger Causality test, so that we can observe whether there exists causality and if so the direction between NPA and the macroeconomic variables and bank specific variables.

Once Causality is established, the next step is to carry out the Impulse Response Function (IRF). An IRF traces the effect of a one -time shock to one of the innovations on current and future values of the endogenous variables. The different structural shocks are isolated through Choleski decomposition, which helps to identify variables that influence the dependent variable NPA that reflects the banking sectors ability to withstand shock hence the nomenclature stress test. IRF describe how the K endogenous variables react over time to a one-time shock to one of the K disturbances.

Obtaining the Forecast Error Variance Decomposition (FEVD) is the last step in completing the VAR estimation. The FEVD measures the fraction of the forecast-error variance of an endogenous variable that can be attributed to orthogonalised shocks to itself or to another endogenous variable, it enables interpretation of the orthogonalised innovations that affect the of K variables over time.

The Econometric Model

The econometric model used to capture the various macro effects on a bank's NPA for different bank types separately is explained below:

$NPA_i = f\,(NEX, NetFII, GAP, LDEPOSIT_i, LNIR, CRR, WPI)$

Where

NPA is the net nonperforming asset the dependent variable

i represents the bank type

NEX is the log of nominal exchange rate,

Net FII is the Net Foreign Institutional Investor' investment entering the country

GAP is the GDP output gap derived by the Hoddrick Prescott Filter

LDEPOSIT is the log of deposits for a given bank type

NIR is the log of nominal interest prime lending rate
CRR is the Cash Reserve Ratio the Central bank's monetary policy tool
WPI is the wholesale price index a measure of inflation

The emphasis of this model is to assess the impact of both external macro factors alongside domestic macro factors on the net NPAs for various bank types.

Database

The period of study is from the fourth quarter of 1997 to the first quarter of 2012, divided into two with phase one being 1997 Q4 to 2003 Q3 and phase two 2003 Q3 to 2012 Q1 this is done to accommodate the change in definition of NPA.

Variables and *Database*

- Output gap (GAP): is the difference between the actual and potential GDP. Quarterly GDP at Factor Cost (Constant Prices) with 2004-05 base is used to derive the GAP using HP filter
- Inflation: Derived from the Wholesale Price Index with 2004-05 base, data obtained from the Office of the Economic Advisor's website.
- Exchange Rates: Nominal exchange rate of the 3rd month of a quarter,
- Prime lending rate: Average of the 3rd month of a quarter's maximum and minimum of the lending rates for the month.
- Net Foreign Institutional Investment data represents the difference between the FII inflow and FII outflow in billions of rupees.
- The weighted NPA's[3] for the various bank types was compiled accessing individual bank's quarterly statement and then collated according to the bank type to arrive at the final value.

[3] Weighted NPA_i= (NPA for the $quarter_i$* number of reporting banks for that $quarter_i$)/ Sum of the total reporting $banks_i$ for the period of analysis Where i = bank group(public, old pvt, new pvt, foreign).

- CRR (Cash Reserve Ratio) the 3rd month of a quarter's value was taken as the quarter's rate.
- Deposits are the weighted aggregate deposit[4] of individual banks .
- Dummy variable D2, D3 and D4 are introduced to factor seasonality.

All data are sourced from different sections of the Reserve Bank of India website unless mentioned otherwise. The summary statistics for are reported in Tables 1 and 2, bank specific variables NPA and deposits are reported for the all the banks consolidated.

Diagnostics

Stationarity: To test for presence of unit root in the variables the Augmented Dickey Fuller (ADF) test is used. All the variables are found to be stationary except GDP output gap and deposits in the first level in both phases and Net FII in phase 2. However, given the low power of the ADF test in small sample (Bock and Demyanets 2012 and Hoggarth et al 2005), we proceed by assuming stationarity.

Stability: The VAR stability conditions tests if the model is stable i.e., devoid of any unit root. The VAR is considered stable if all roots have modulus <1 and lie inside the Unit circle otherwise the results from the Impulse response and standard errors are invalid. The stability test of inverse roots of VAR, characteristic polynomial test assess whether all the variables lie inside the root circle.

Lag order: The lag order for each model is selected by the Akaike information criterion (AIC) and Hannan-Quinn (HQ) information criterion. Both HQ and the AIC result with the minimum value are taken as the optimum lag length. In phase 1 optimum lag is 1 and for phase 2 its 2.

[4] Weighted aggregate deposits$_i$= (aggregate deposits of the 3rd month of a quarter$_i$* number of reporting banks for that quarter$_i$)/ Sum of the total reporting banks for the period of analysis Where i = bank groups.

Table 1: Summary Statistics of Variables Phase 1-: 1997-2003

	NEX	NETFII	GAP	NIR	CRR	WPI	NPA	Deposit
Mean	0.01	1.88	0.00	-0.01	-0.03	0.03	0.00	0.02
Median	0.01	1.16	0.01	0.00	0.00	-0.15	0.00	0.01
Maximum	0.07	26.67	0.09	0.06	0.10	2.80	0.01	0.04
Minimum	-0.02	-23.46	-0.11	-0.11	-0.31	-2.90	-0.02	0.01
Std. Dev.	0.02	12.85	0.07	0.03	0.07	1.44	0.01	0.01
Skewness	1.59	0.30	-0.19	-1.16	-2.00	0.07	0.43	0.77
Kurtosis	5.73	2.58	1.43	5.69	8.99	2.74	6.36	2.44
Jarque-Bera	19.06	0.57	2.81	13.70	56.07	0.10	13.02	2.89
Probability	0.00	0.75	0.25	0.00	0.00	0.95	0.00	0.24
Sum	0.24	48.87	0.03	-0.28	-0.80	0.70	-0.01	0.43
Sum Sq Dev.	0.01	4124.68	0.13	0.03	0.14	51.69	0.00	0.00
Observations	26	26	26	26	26	26	26	26

Table 2: Summary Statistics of Variables Phase 2-: 2004-2012

	NEX	NETFII	GAP	NIR	CRR	WPI	NPA	Deposit
Mean	0.01	58.73	0.01	0.00	0.00	0.08	-0.01	0.02
Median	0.00	46.24	0.01	0.00	0.00	-0.10	0.003	0.017
Maximum	0.11	295.07	0.09	0.17	0.14	5.70	0.111	0.0471
Minimum	- 0.08	-104.29	- 0.06	-0.39	-0.49	-5.10	-0.23	0.00
Std. Dev.	0.04	78.01	0.05	0.09	0.11	2.11	0.058	0.013
Skewness	0.39	0.93	0.15	-2.76	-3.03	0.19	-1.43	0.372
Kurtosis	2.80	4.74	1.73	15.40	14.06	4.08	7.915	2.321
Jarque-Bera	0.90	8.93	2.35	253.45	218.62	1.82	44.413	1.395
Probability	0.64	0.01	0.31	0.00	0.00	0.40	0.000	0.498
Sum	0.22	1938.05	0.30	-0.04	0.05	2.80	-0.24	0.59
Sum Sq. Dev.	0.06	194758.30	0.07	0.23	0.39	143.12	0.11	0.01
Observations	33	33	33	33	33	33	33	33

Empirical Results of the VAR Models

The First phase 1997-2003

In the first phase we examine the influence of both external and domestic factors, hence for the external sector we include exchange rate and Net FII inflow. From the external sector we find that both exchange rates as well as the Net FII are significant at 1% for the overall banking sector (Total) and the public sector Table 3. This finding is supported by the Granger Causality as we cannot reject the null hypothesis that NPA of public and total does not Granger cause exchange rate and Net FII. (Table 3a). The Variance Decomposition shows that Net FII comprises of 22.74 and 17.48 for total and public sector banks respectively. The GDP output gap, significant at 5% is supported by the Granger Causality see Table 3b. The public sector banks' NPA is impacted by domestic factors of GDP output gap, interest rate, CRR as well as deposits all of which are significant at 5% level. For the total banks in the sample the exchange rate net FII flow and deposits significantly influence NPA. Thus the public sector bank's asset quality is adversely influenced by external factors as well as domestic factors of interest rate and CRR (see Table 3). In this phase the other bank types appear to be more stable.

Table 3: Model Estimates for Phase 1: 1997-2003

	NPAPUB	NPAOLDPVT	NPANEWPVT	NPAFOREIGN	NPATOTAL
NEX(-1)	-0.1023**	-0.023	-0.039	0.001	-0.174***
	(0.040)	(0.024)	(0.035)	(0.010)	(0.072)
NETFII(-1)	-0.000***	-0.005	0	0	-0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
NPA(-1)	-0.104	-0.35	-0.092	-0.335	-0.056
	(0.234)	(0.374)	(0.279)	(0.225)	(0.255)
GAP(-1)	-0.088	0.030	0	0.011	-0.057
	(0.042)	(0.027)	(0.037)	(0.001)	(0.075)
LDEPOSITS(-1)	-0.173***	0.010	-0.012	-0.015	-0.250*
	(0.070)	(0.027)	(0.014)	(0.009)	(0.130)
NIR(-1)	-0.057**	0.017	0.005	0.002	-0.051
	(0.028)	(0.017)	(0.021)	(0.005)	(0.053)
CRR(-1)	0.024**	0.002	0.095	0.001	0.038
	(0.011)	(0.007)	(0.010)	(0.003)	(0.020)
WPI(-1)	0	0	0	0.000	0
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
C	0.018	-0.001	0.003	-0.001	0.008
	(0.003)	(0.00)	(0.003)	(0.001)	(0.006)
D2	-0.006	0.002	-0.001	0.002	-0.001
	(0.004)	(0.00)	(0.004)	(0.001)	(0.008)
D3	-0.011	0.004	-0.003	0.002	-0.401
	(0.007)	(0.004)	(0.006)	(0.002)	(0.008)
D4	0.000	0	0.002	0.002***	0.005
	(0.002)	(0.001)	(0.002)	(0.000)	(0.003)
R-squared	0.733	0.198	0.357	0.811	0.518
Adj. R-squared	0.506	-0.479	-0.188	0.651	0.111
Sum sq. resids	0.000	0.000	0.000	0.000	0.003
S.E. equation	0.003	0.002	0.003	0.000	0.005
F-statistic	3.237	0.293	0.655	5.071	1.272
Log likelihood	120.090	130.16	122.056	155.847	104.479
Akaike AIC	-8.647	-9.452	-8.805	-11.508	-7.398
Schwarz SC	-8.062	-8.867	-8.219	-10.922	-6.813
Mean dependent	-0.001	0	0.000	0.000	0
S.D. dependent	0.004	0.000	0.000	0.001	0.005

*** - significant at 1% level; **- significant at 5% level; * significant at 10% level Standard error in brackets

Table 3a: Granger Causality Test for Phase 1: 1997-2003

Null Hypothesis: NPAs [Public, Old Private, New Private, Foreign, Total] ***Does Not Granger Cause*** [NEX, Net FII, GAP, Deposits, NIR, CRR, WPI]														
Variable Order: NEX, Net FII, NPA, GAP, Deposits, NIR, CRR, WPI														
NPA	NEX		Net FII		GAP		Deposits		NIR		CRR		WPI	
Public	6.06	[0.02] **	13	[0.00] ***	0.23	[0.64]	0.28	[0.60]	0.01	[0.91]	1.19	[0.29]	1.03	[0.32]
Old Pvt	0.08	[0.78]	0.45	[0.51]	0.3	[0.59]	6.15	[0.02] **	0.02	[0.89]	0	[0.93]	3.3	[0.08] *
New Pvt	0	[0.95]	1.66	[0.21]	0.5	[0.49]	1.85	[0.19]	0.11	[0.74]	0.07	[0.79]	2.39	[0.14]
Foreign	2.41	[0.13]	0.08	[0.78]	0.27	[0.61]	2.15	[0.16]	0.1	[0.76]	3.82	[0.06] *	1.23	[0.27]
Total	1.97	[0.17]	10.69	[0.00] ***	0.08	[0.78]	1.59	[0.22]	0.04	[0.84]	0.25	[0.62]	4.77	[0.04] **

*** - significant at 1% level; **- significant at 5% level; * significant at 10% level p values in brackets

Table 3b: Granger Causality Test for Phase 1: 1997-2003

Null Hypothesis: [NEX, Net FII,GAP, Deposits, NIR, CRR, WPI] Does Not Granger Cause NPAs [Public, Old Private, New Private, Foreign, Total]										
Variable Order: Exchange, Net FII, NPA, Output Gap, Deposits, Interest Rate, CRR, Inflation										
NPA	Public		Old Pvt		New Pvt		Foreign		Total	
NEX	3.41	[0.08]*	0.12	[0.72]	0.00	[0.97]	0.00	[0.96]	1.39	[0.25]
Net FII	0.28	[0.60]	0.43	[0.52]	0.48	[0.49]	0.35	[0.56]	0.87	[0.36]
GAP	3.14	[0.09]*	0.15	[0.73]	1.31	[0.27]	5.8	[0.02]**	0.24	[0.63]
Deposits	0.00	[0.97]	0.00	[0.97]	1.66	[0.21]	3.04	[0.10]*	0.43	[0.52]
NIR	2.02	[0.17]	0.52	[0.48]	0.00	[0.93]	0.12	[0.74]	0.47	[0.50]

*** - significant at 1% level; **- significant at 5% level; * significant at 10% level p values in brackets

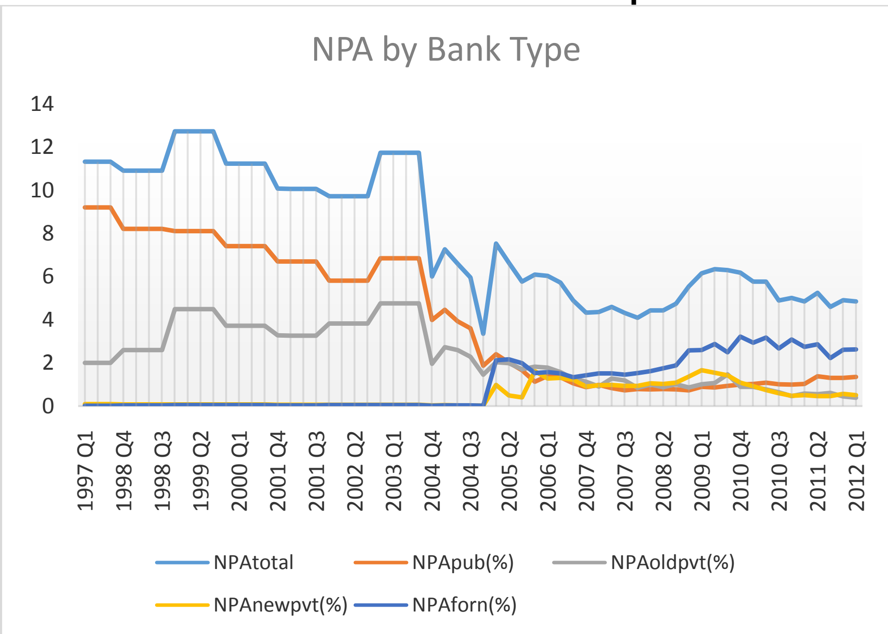
Table 3c: FEVD Phase 1: 1997-2003

Variance Decomposition Forecast for the 10th Quarter ahead								
NPA	NEX	Net FII	NPA	GAP	Deposits	NIR	CRR	WPI
Public	9.38	**17.48**	**35.40**	12.84	3.14	**13.57**	4.67	3.52
Old Private	1.12	0.94	**85.10**	5.85	1.02	2.41	0.23	3.32
New Private	1.93	10.37	**74.23**	0.91	7.32	0.14	1.35	3.74
Foreign	2.64	30.42	**52.62**	1.59	6.96	2.75	1.78	1.26
Total	8.53	**22.74**	**49.42**	3.62	0.50	5.91	5.78	3.53

The Second phase 2004-2012

In the second phase, the criterion for NPA is tightened to 90 days the results reflect the new regulation. In this phase the impact of the market determined interest rate impacts is observed across all ownerships. Chart 1 clearly shows the structural break that occurred in 2003-04. This is supported by the Granger causality see Table 3.b when we cannot reject the hypothesis that interest rate does not Granger cause NNPA. The public sector banks' own non-performing assets negatively impact their NPA in both lags (Table 4).Granger causality test supports this for all banks (Table 4c). The market interest is significant in lag 2 at 5% level of confidence for all the banks.

Chart 1: NPA of All Banks in Sample



Variance Decomposition shows that interest rate contributes 16.8 and 13.07 percent for public and all banks. The external sector factors exchange rate and Net FII continue to be factors that influence bank asset quality as is demonstrated in Table 4b for public, old private and foreign banks. Thus, it is obvious that banks in India are not impervious to shocks from macroeconomic factors from home and abroad. The FEVD Table 4c shows that 65.7% is attributed to interest rate, exchange rate and NetFII for public banks and 46.2% of external sector forces on old private banks.

Domestic banking related variables NPA, deposits and interest rate are found to influence bank asset quality. Interest rate significant for all types this is the reflection of the shift in central banks' policy of market orientation permitting banks to decide the rate of interest they will pay savings account holders and the rate charge for advances. This is a paradigm shift as banks in India have always been very closely monitored and controlled by the RBI and enjoyed the patronage of the central government as they were publicly owned. Old private banks being smaller have thrived for over a century pursuing prudential cautious approach lending largely to the community to which the bank belonged. Deposits are the economy's savings and should impact the banking sector. Not surprisingly the variable is significant for public and all banks.

The banks own NPAs in a feedback deteriorate its own NPA. So bad loans accumulate and past loans influence the present. So when banks write off some loans in the past they have cumulative effect, simply because bankers tend to behave pro-cyclically and that is not surprising euphoria begets euphoria, until the downturn emerges.

This brings us to the discussion on the GDP which has not been highlighted till now. In phase 1 we do not find any significant relation between GDP output gap and the NPAs, but the analysis of phase 2 throws up interesting light on the linkage between business cycles and non-performing loans of banks. The FEVD shows 12% contribution of GDP to NPA for New private banks in phase 2.

There is abundant literature that provides evidence of decline in GDP and bank soundness, as banks tend to behave in pro-cyclical manner (Hoggarth et al 2005 Mishra and Dhal 2010, Bock and Demyanets (2012). What needs to be highlighted is that in India business cycles were not focus of academicians nor policy makers because being a developing economy heavily dependent on agriculture it was the monsoon rains that drove the economic cycles (Patnaik and Sharma 2001). Only after the launch of financial sector reforms and the government's agenda of opening the economy through liberalized exchange rate regime and broad based reforms that business cycles as perceived in developed economies are emerging. A broad based active bond market with yield spreads to link the money market to the rest of the economy is the path forward. Never the less the cautious optimism expressed by the RBI in 2009 quote given in the introduction now needs to be re-visited.

Table 4: Model Estimates for Phase 2: 2004-2012

	NPAPUB	NPAOLDPVT	NPANEWPVT	NPAFOREIGN	NPATOTAL
NEX(-1)	-0.078*	0.009	0.0021	0.112	-0.357
	(0.055)	(0.009)	(0.008)	(0.345)	(0.323)
NEX(-2)	-0.077	0.0075	0.004	-0.445	-0.742*
	(0.079)	(0.010)	(0.010)	(0.414)	(0.495)
NETFII(-1)	0.000	-0.000	-0.000	-0.000	-0.000*
	(0.005)	(0.000)	(0.000)	(0.000)	(0.000)
NETFII(-2)	0.000*	0.000	0.000	-0.000	-0.000
	(0.000)	(0.00)	(0.000)	(0.000)	(0.000)
NPA(-1)	0.212	-0.106	0.224	0.071	0.055
	(0.112)	(0.168)	(0.184)	(0.186)	(0.176)
NPA(-2)	0.405***	0.191	-0.004	0.327**	0.293
	(0.110)	(0.149)	(0.180)	(0.162)	(0.189)
GAP(-1)	-0.055	-0.021	-0.001	-2.100**	-1.809**
	(0.175)	(0.026)	(0.026)	(1.178)	(0.988)
GAP(-2)	-0.004	0.001	-0.011	1.211	0.721
	(0.152)	(0.023)	(0.02277)	(0.975)	(0.812)
LDEPOSITS(-1)	-0.087	-0.016	-0.006	0.660	-2.477*
	(0.231)	(0.015)	(0.013)	(0.836)	(1.678)
LDEPOSITS(-2)	-0.211	-0.006	0.024**	-1.059	-2.198
	(0.242)	(0.016)	(0.012)	(0.894)	(1.799)
NIR(-1)	0.022	0.004	0.003	-0.200	-0.129
	(0.025)	(0.004)	(0.004)	(0.180)	(0.142)
NIR(-2)	-0.144***	-0.016***	-0.0124***	0.765***	0.634***
	(0.025)	(0.004)	(0.004)	(0.180)	(0.156)
CRR(-1)	-0.042**	0.000	-0.002	-0.022	-0.080
	(0.019)	(0.003)	(0.003)	(0.127)	(0.108)
CRR(-2)	0.020	0.004	0.001	0.051	-0.033
	(0.022)	(0.003)	(0.003)	(0.148)	(0.130)
WPI(-1)	-0.001	-0.000	-0.000	0.012	0.006
	(0.001)	(0.000)	(0.000)	(0.007)	(0.006)
WPI(-2)	0.001	-0.000	0.000	-0.012	-0.007
	(0.001)	(0.000)	(0.000)	(0.010)	(0.006)
C	0.011	0.001	0.000	0.095	0.214**
	(0.015)	(0.001)	(0.001)	(0.057)	(0.098)
D2	-0.007	-0.002	-0.001	-0.1560	-0.149
	(0.016)	(0.002)	(0.003)	(0.101)	(0.095)
D3	-0.001	-0.002	0.000	-0.208***	-0.209***
	(0.012)	(0.002)	(0.002)	(0.085)	(0.075)
D4	-0.004	-0.000	-0.001	0.092	0.006
	(0.013)	(0.002)	(0.002)	(0.089)	(0.070)
R-squared	0.909	0.823	0.736	0.819	0.797
Adj. R-squared	0.752	0.516	0.280	0.506	0.447
Sum sq. resids	0.001	0.000	0.000	0.028	0.0213

Contd …Table 4

Contd…Table 4

	NPAPUB	NPAOLDPVT	NPANEWPVT	NPAFOREIGN	NPATOTAL
S.E. equation	0.008	0.001	0.001	0.050	0.044
F-statistic	5.798	2.684	1.615	2.617	2.276
Log likelihood	122.945	180.820	180.56	64.890	68.931
Akaike AIC	-6.642	-10.376	-10.36	-2.896	-3.157
Schwarz SC	-5.716	-9.450	-9.434	-1.971	-2.232

*** - significant at 1% level; **- significant at 5% level; * significant at 10% level; standard error in brackets.

Table 4a: Granger Causality Test for Phase 2: 2004-2012

Null Hypothesis: NPAs [Public, Old Private, New Private, Foreign, Total] ***Does Not*** Granger Cause [NEX, Net FII, GAP, Deposits, NIR, CRR, WPI]

Variable Order: NEX, Net FII, NPA, GAP, Deposits, NIR, CRR, WPI

NPA	NEX		Net FII		GAP		Deposits		NIR		CRR		WPI	
Public	0.65	[0.53]	0.09	[0.92]	1.03	[0.37]	0.84	[0.44]	1.10	[0.35]	0.22	[0.80]	0.66	[0.53]
Old Pvt	0.07	[0.94]	0.11	[0.90]	2.00	[0.15]	0.06	[0.94]	0.84	[0.44]	0.13	[0.88]	0.91	[0.41]
New Pvt	0.44	[0.65]	0.13	[0.88]	1.23	[0.31]	0.12	[0.89]	1.72	[0.20]	0.03	[0.97]	0.94	[0.41]
Foreign	0.70	[0.51]	2.37	[0.11]	0.07	[0.92]	0.89	[0.42]	5.21	[0.01]***	0.07	[0.93]	0.03	[0.97]
Total	0.67	[0.52]	3.41	[0.05]**	0.49	[0.62]	0.10	[0.90]	5.93	[0.01]***	0.15	[0.86]	0.00	[1.00]

*** - significant at 1% level; **- significant at 5% level; * significant at 10% level; p values in brackets

Table 4b: Granger Causality Test for Phase 2: 2004-2012

Null Hypothesis: [NEX, Net FII, GAP, Deposits, NIR, CRR, WPI] ***Does Not*** Granger Cause NPAs [Public, Old Private, New Private, Foreign, Total]

Variable Order: Exchange, Net FII, NPA, Output Gap, Deposits, Interest Rate, CRR, Inflation

NPA	Public	Old Pvt	New Pvt	Foreign	Total
NEX	0.39 [0.68]	0.08 [0.92]	0.05 [0.95]	0.74 [0.49]	0.98 [0.39]
Net FII	6.79 [0.00]***	4.74 [0.02]**	1.97 [0.16]	3.03 [0.07]***	2.14 [0.14]
GAP	0.47 [0.63]	1.96 [0.16]	1.28 [0.30]	0.45 [0.65]	0.38 [0.69]
Deposits	0.90 [0.42]	0.89 [0.42]	1.21 [0.31]	0.22 [0.80]	1.08 [0.35]
NIR	35.03 [0.00]***	16.68 [0.00]***	10.59 [0.00]***	17.24 [0.00]***	11.05 [0.00]
CRR	0.07 [0.93]	0.07 [0.93]	0.44 [0.65]	0.80 [0.46]	1.38 [0.27]
WPI	0.69 [0.51]	0.32 [0.73]	0.72 [0.50]	0.28 [0.76]	0.17 [0.84]

*** - significant at 1% level; **- significant at 5% level; * significant at 10% level; p values in brackets

Table 4c: Variance Decomposition Phase 2: 2004-2012

Variance Decomposition Forecast for the 10th Quarter ahead								
NPA	NEX	Net FII	NPA	GAP	Deposits	NIR	CRR	WPI
Public	**15.24**	**33.66**	7.59	12.61	6.60	**16.80**	4.4	3.1
Old Private	**21.26**	**24.93**	**20.74**	10.74	2.62	13.99	0.19	5.55
New Private	9.66	9.00	**33.71**	**11.85**	**17.87**	11.63	2.14	4.14
Foreign	12.97	**21.83**	**30.02**	9.41	2.90	10.69	3.74	8.44
Total	10.38	**20.36**	**27.97**	8.64	9.03	**13.07**	7.62	2.94

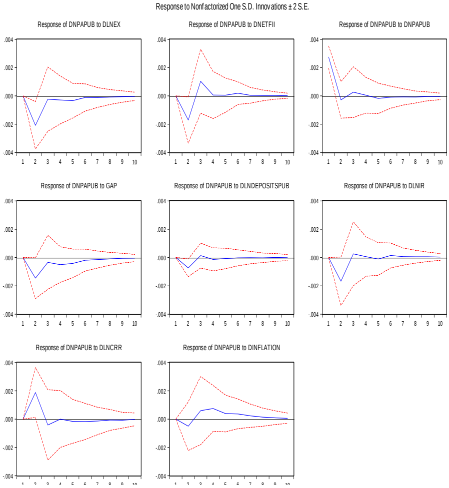
The IRF in the First phase 1997-2003

The Impulse Response Function (IRF) traces the effect of a one-time shock to one of the innovations (error terms) on the current and future values of the endogenous variables. In the first phase the NPA of public sector banks take nearly 3 quarters to revert back to original point after exchange rate shock, 4 quarters to a shock from net FII which is hot money, 2.5 quarters to respond to its own shock, 2 quarters to respond to output gap shock, deposits shock, and interest rate shock. All of which is less than one year thus banks react quickly revealing their relative robustness.

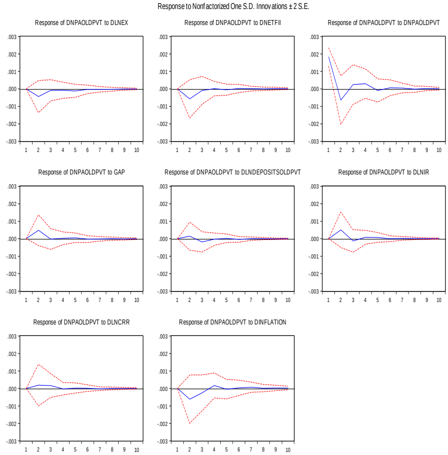
But foreign banks need 6 quarters to realign to output gap shock. In all the graphs in Chart 2 there is eventual convergence even if it is after two years, this is because there was relative stability and India was growing at a robust 8% to 9% rate benefiting from the buoyant environment of the global economy. The results for the second phase are dramatically different as in this phase the global financial meltdown occurs. It is clearly visible from all the Charts which tend to be on a divergent mode opposite of what is observed in phase 1 the first 5 booming years in the second millennium.

Chart 2: IRF Phase 1: 1997-2003

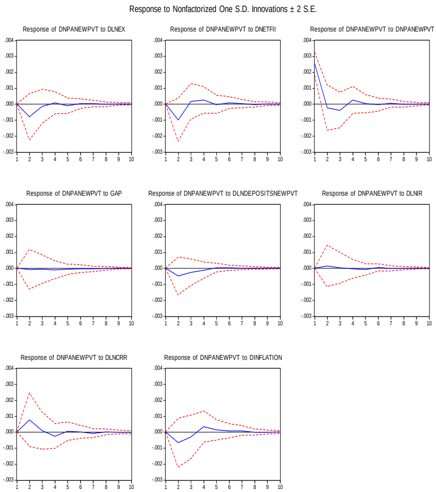
Public Sector Banks



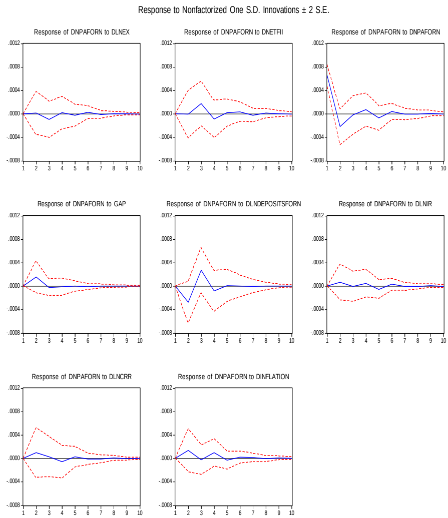
Old Private Banks



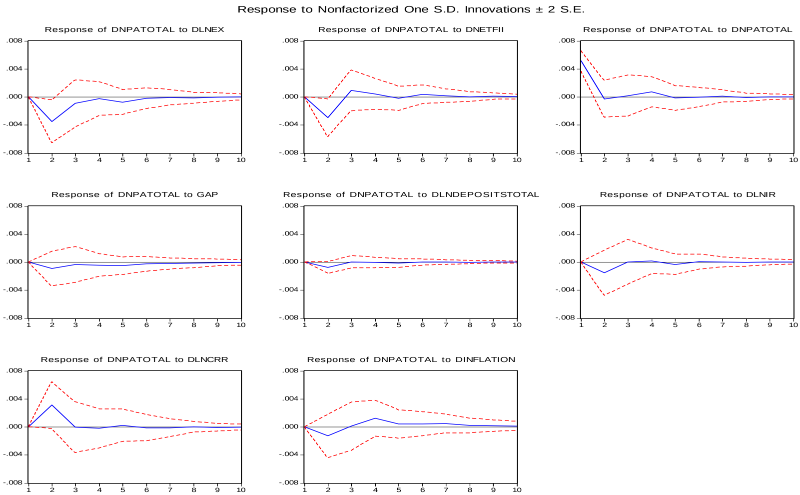
New Private Banks



Foreign Banks



All Banks

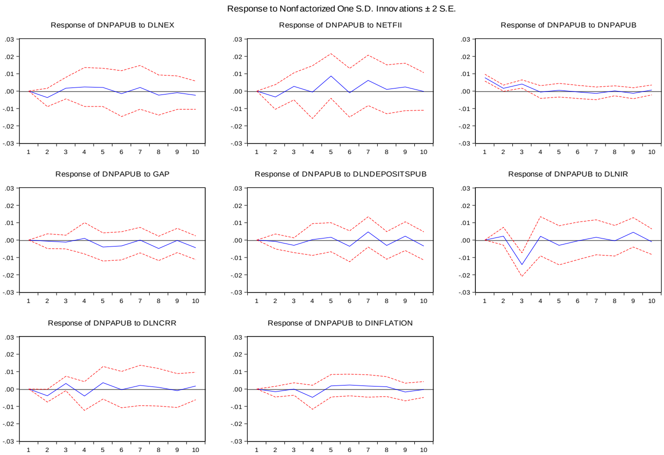


The IRF in the Second phase 2004-2012

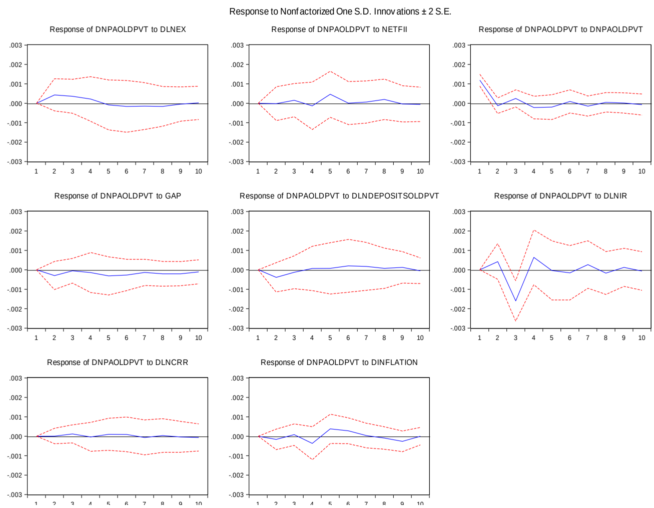
In the second phase of 2004-2012 we find that the NPA of public sector banks falls after 4 quarters to an unexpected shock from itself. A shock from net FII results in increase in NPA and approaches zero after 9 quarters which is more than two years. It takes 5 quarters for the NPA's to adjust to a shock from exchange rate, inflation, interest rate. But old private banks the NPA take only 4 quarters to adjust to a shock from exchange rate, net FII, interest rate, and deposits.

The NPA of new private takes nearly 5 quarters to adjust to a shock from exchange rate, output gap, and deposits. The NPA of foreign banks take 4 quarters to adjust to a shock from exchange rate, 6 quarters to adjust to a shock from FII, 7 quarters to adjust to its own shock, 6 quarters to adjust to a shock from output gap, and interest rate, 5 quarters to adjust to a shock from deposits and inflation. For the entire sample 8 quarters lapse in response to exchange rate shock, inflation shock, and its own shock. There does not appear to be any convergence although the fluctuations subside (Chart 3).

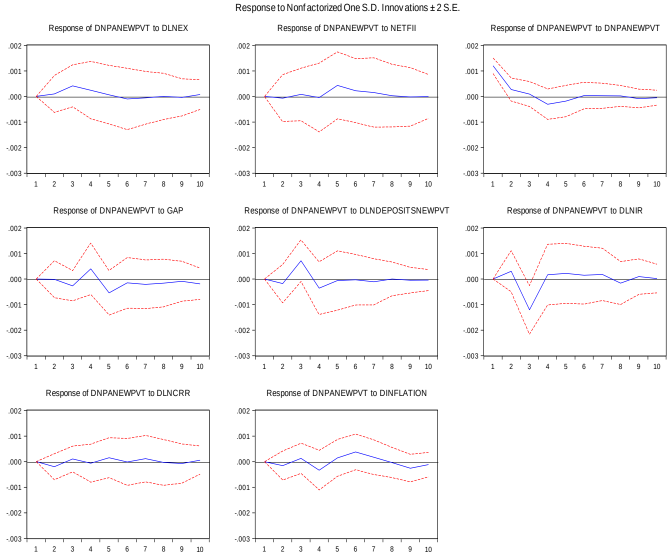
Chart 3: IRF Phase 2: 2004-2012
Public Sector Banks



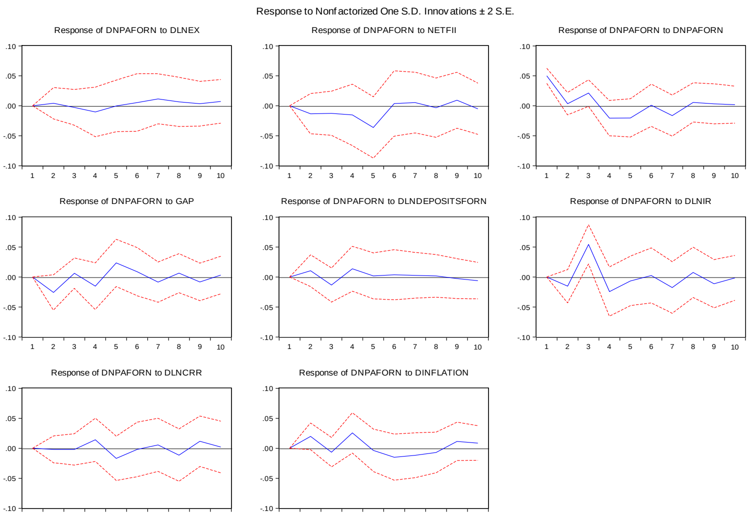
Old Private Banks



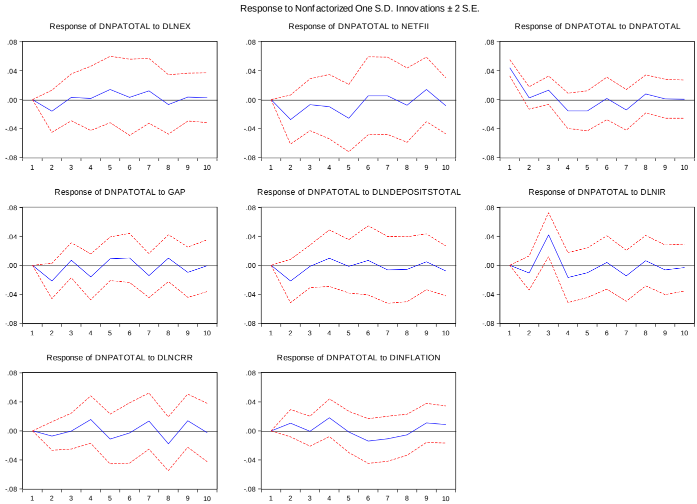
New Private Banks



Foreign Banks



All Banks



Shocks from deposits, the economy's savings adversely impact total as well as public and new private banks. It must be noted that the exogenous variable D08 that was introduced to capture the global financial crisis does not figure significantly in the model. What can be inferred is, perhaps macroeconomic weaknesses within the economy were instrumental in causing the deterioration of asset quality, though exchange rate depreciation and volatility did play a role. Even the several tranche of stimulus package handed out by the government was not adequate. To ride through tough times that lies ahead banks will need to re-capitalize to manage the write offs in their loan portfolio. The RBI has infused Rs.6,990 crores to re-capitalize 9 out of the 28 public sector banks based on the return on equity and return on assets[5].

CONCLUSION

A vector of macroeconomic variables was used in a VAR basic model to assess the degree of robustness of banks operating in India with 15

[5] Financial Express 8th Febraury 2015

years quarterly data. The significance of undertaking this exercise was to understand if the newly liberalized interest and exchange rate regime and greater competitive market oriented environment would impair the asset quality of banks and render them weak. The study done across four different types of bank ownership give in depth image how they are interacting in the new regulatory era. The study had to be undertaken in two phases because the key variable measuring bank fragility the non-performing loans had been defined differently prior to March 2003.

The picture emerging from this empirical exercise is fairly obvious; public sector banks take longer time to return to their original level of business. In the first phase the VAR model with one lag shows except for public sector banks whose NPA was found to be negatively influenced by exchange rate, Net FII, output gap, interest rate, the other banks were relatively stable. The entire sample however showed sensitivity to Net FIIs, exchange rate and deposits. The Granger causality tests supported these findings. Overall banking sector have causal relation with inflation and Net FII flow. In a nut shell both internal and external; factors are of concern. The results are bolstered by the IRF graphs.

The tighter definition of NPA indicates the central bank RBIs proactive stance to strengthen the banking system. Since interest rate has been gradually become market oriented, it was a significant variable influencing the NPAs of all the banks types. Portfolio funds from foreign institutional investors also played a major role in impairing asset quality. Exchange rate, interest rate deposits and the GDP are all instrumental here in adversely impacting the banks' portfolio. The results of the stress test shows there is little scope for complacence, the Indian banking sector needs to re-capitalize and strengthen its loan portfolio to face the onslaught of competition of an open economy.

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