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# Working Paper

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**Stress tests of the Ghanaian Banking Sector : A VAR Approach**

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— **BANK OF GHANA** —

# Working Paper

## Stress tests of the Ghanaian Banking Sector : A VAR Approach

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## **Abstract**

This paper applies a VAR methodology to stress test the Ghanaian banking system. It estimates the changes in some macroeconomic variables on the Non performing loan (NPL) ratio of the banking industry. Using quarterly data from 1995 -2005, we find that following an adverse output shock and a rise in inflation, the banks' NPL ratio increase. The impulse response functions also suggest that the NPL ratio increases after eight quarters following an unexpected increase in output gap but after nine quarters following an unexpected increase in inflation. Also an unexpected increase in the Prime rate also leads to a significant increase in the NPL ratio with the maximum after six quarters. The results also show that the most likely outlook for the quality of the banking sector's loan portfolio is that up to the end of 2007 the NPL ratio will follow a slightly downward trend below double-digit rates.

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## 1.0 Introduction

Stress tests of the vulnerability of financial institutions to macroeconomic shocks are a valuable aid in assessing financial stability. They permit a forward-looking analysis and a uniform approach to identifying potential risks to the banking system as a whole. Central banks and financial regulators increasingly use this approach in calibrating the risks facing the financial system. Stress tests are important, from a central bank's perspective, since they are tractable and provide a useful benchmark to assess the risks to the financial system (see Bunn *et al* (2005)). A number of recent policy initiatives also aim to formalise a role for stress tests. One of these has been the inclusion of stress tests in the International Monetary Fund (IMF) Financial Sector Assessment Programme (FSAP).

The purpose of this paper is to use Vector Autoregressive (VAR) methodology to empirically investigate the dynamics between Non Performing Loans (NPL)<sup>1</sup> and key macroeconomic variables so as to; create a forecast of the quality of the Ghanaian banking sector's loan portfolio; secondly, to offer an insight into the functioning of the economy and to determine the macroeconomic factors that influence the quality of the loan portfolio by impulse response analysis; and finally, to perform stress tests in order to assess the banking sector's vulnerability to credit risk as far it can be detected on a macroeconomic level, as well as determine macroeconomic early warning indicators of any worsening in loan portfolio quality. The advantages VAR has over other forms of stress tests is that it estimates NPL changes as a result of macroeconomic shocks<sup>2</sup>, has a clear focus on macroeconomic shocks as distinct idiosyncratic shocks, supports links to well established macroeconomic theories and to research in the area of monetary policy and facilitates stress testing of the stability of the banking system both in the form of sensitivity analysis

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<sup>1</sup> The IMF argues that the impact of macroeconomic shock works through the NPL of the financial system. See IMF Financial Soundness Indicators Compilation Guide, 2006 Item 1.25

<sup>2</sup> See T Jones, P Hibers and G. Slack (2004) and W. Blaschke, T Jones, G. Majnoni and S. Martinez (2001) for review of various stress test methodology

which covers shock caused by a single factor, and in the form of scenario analysis, which covers a combination of shocks .

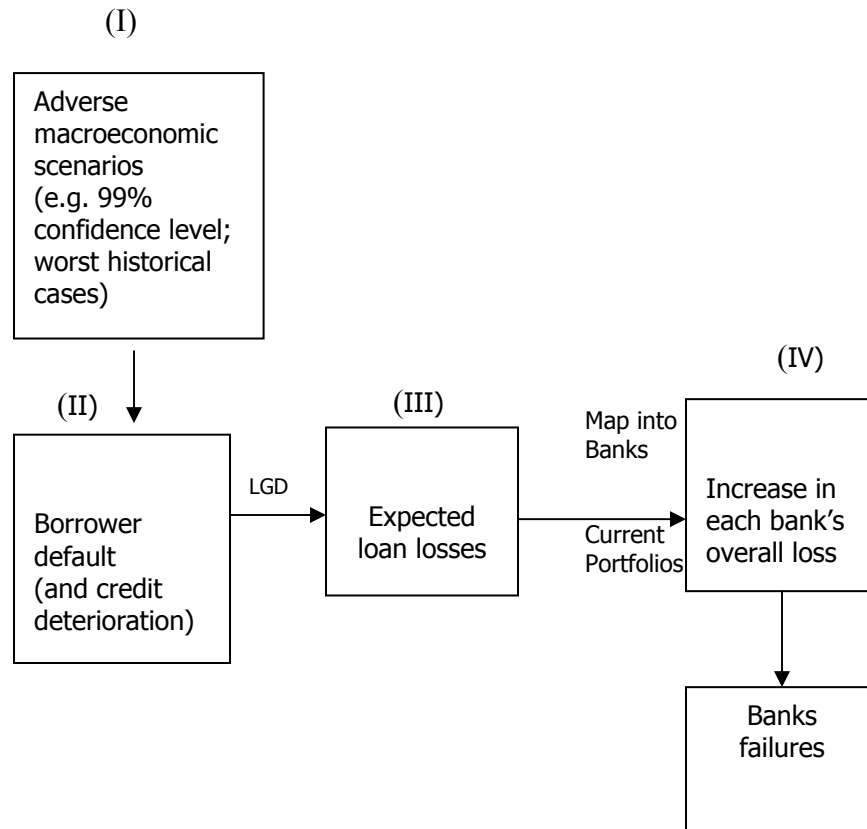
The novelty of this paper is that it provides an attempt of linking the banking industry's NPL, a key financial fragility index, and macroeconomic shocks. It shows a macro-prudential concept of credit risk linked to financial stability indicators and presents the simulation results. In addition to applying the standard battery of tests for stationarity of time series, exogeneity of the variables included in the model it also assesses the robustness of the simulation results with respect to re-ordering of the variables of the VAR model. The rest of the paper is organized as follows. Section 2 presents literature survey on stress testing while section 3 discusses the transmission and the VAR model. Section 4 explains data and estimation issues as well as conducts robustness checks. Section 5 concludes.

## **2.0 Review of Literature**

In the past a number of approaches were used to stress test the credit risk of the banking system including the IMF country FSAP single factor sensitivity tests which look at a change in one variable such as interest rate or exchange rate on banks' balance sheets. These stress tests do not provide the opportunity for the interaction between macroeconomic variables such as inflation on real activity and its pass through on the quality of the banks' loan portfolio. This investigation can be carried out with the use of macro-prudential concept of credit risk whose essential feature is the treatment of credit risk as an endogenous variable of a macroeconomic model.

The use of macro-prudential analysis to stress tests the banking sector stability involves a number of elements. First, plausible and internally consistent but 'challenging' macroeconomic scenarios need to be devised to illustrate possible extreme downside risks – so-called tail events' and secondly the effects of macroeconomic variables on real activity

and thus on banks balance sheets. The diagram below provides a framework for macro-test of Ghanaian banks.



**Chart 1: Macro Test Framework**

The banking sector stability depends on the banks' operating environment, risk exposures, and their ability to manage risks and withstand adverse outcomes. The above framework consists both of macroeconomic indicators, which relate to operational environment and of aggregate prudential data describing general risk exposures of banks and their financial buffers to withstand crystallization of risks. Theoretically, we expect increase in the Prime rate, inflation and output gap to result in increase in borrowers default. Increase in expected loan losses will culminate in deterioration of banks loan portfolio which may result in banks failures.

Blaschke et al. (2001) propose applying the VAR methodology to investigate the transmission from inflation, interest rate, output (GDP) and the terms of trade to a Financial Soundness Indicator (FSI), for example the ratio of NPLs to the total loans or total assets of the banking sector. Since the seminal work of Sims (1980), the VAR approach to empirical investigation of monetary policy shocks has gained momentum. Several studies have used the VAR models to investigate the monetary policy transmission mechanism in the United States<sup>3</sup>. Gambera (2000), using bivariate VAR models, investigates the influence of the development of the US economy on the loan portfolio quality of a large sample of US banks. The study employs unemployment rate, non-farm income, farming income, bankruptcy filings, car sales and building permits, as indicators of macroeconomic developments and the ratio of NPLs to total loans as the indicator of the quality of the loan portfolio. Arpa et al. (2001) present a single-equation regression analysis focusing on the risk provisions and operating income of Austrian banks, and conclude that the share of risk provisions in the total loans of the Austrian banking sector varies indirectly with real GDP growth and real interest rates and directly with CPI inflation and real estate price inflation. Hoggarth, Logan and Zicchino (2005) apply the VAR approach to investigate the link between loan write-offs and the UK output gap, retail and house price inflation, the nominal short-term interest rate and the real exchange rate. Keeton (1999) investigates the relationship between the growth of business loans granted by US banks on the one hand and the banks' credit standards and the share of NPLs in business loans. The VAR model involves growth in business loans, the share of NPLs in business loans and non-farm earnings. It supports the hypotheses that faster loan growth leads to higher loan losses, that an increase in earnings reduces the delinquency rate and that an increase in the delinquency rate causes a decrease in loans. In addition, deterioration in the quality of loan portfolio causes a subsequent increase in the ratio of NPLs. Shu (2002) examines the impact of macroeconomic developments on the asset quality of the Hong Kong banking sector and concludes that the increase in non-performing loans between 1995 and 2002 was largely attributable to changes in macroeconomic

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<sup>3</sup> See Leeper, Sims and Zha (1996) for detailed review

conditions. The single-equation regression analysis indicates that the NPL ratio rises with increasing nominal interest rates and faster growth in bankruptcies, but decreases with higher CPI inflation, economic growth and property price inflation.

### **3.0 Macroeconomic Variables and the VAR model**

The choice of macroeconomic variables is based on the existing literature (see for example Ball 1998, Blake and Westaway 1996). We identify three (3) main transmission channels. The first transmission characterizes the competitiveness of the economy and the theory of the real effective exchange rate. The second part of the transmission connects the real sector with interest rate, inflation and the quality of the banks credit portfolio and the third transmission mechanism is the output gap.

#### **3.1 Real Effective Exchange Rate and Imports**

The Ghanaian economy is a small and very open one. Hence one of our investigated transmissions is the real effective exchange rate and imports. An open economy, which is heavily dependent on imports of crude oil, gas and other intermediate inputs, will experience a shock caused by an increase in world prices of these commodities. Imports rise with domestic incomes and domestic currency appreciation. We expect a rise in inflation to cause depreciation of the local currency and appreciation to lead to increase in imports.

#### **3.2 Inflation, Prime Rate and Non- Performing Loans**

The choice of these variables are underpinned by the assumed trade off between unemployment and inflation i.e. the Phillips curve and by the hypothesis that economic growth tends to improve the quality of banks credit portfolio whereas a rise in the Central

bank's policy rate leads to increase in retail rates, which finally impacts negatively on banks' portfolio quality. A rise in inflation impacts negatively on banks network as a result of the subsequent increase in NPLs. The NPL ratio is the measure of banks' fragility index. It is defined as loans and advances classified as substandard, doubtful and loss divided by total credit portfolio. The IMF (2006) includes the NPL ratio in its set of FSI for macro-prudential analysis<sup>4</sup>. The NPL ratio is usually not included in small reduced-form macro models or large structural model but it is the variable of interest in this paper.

### 3.3 Output Gap

The output gap is defined as the difference between actual and potential output. Based on a number of single reduced form studies, NPLs are shown to depend on output gap and the real interest rate (see Pain 2003). The NPLs ratio increases (decrease) with increase (decrease) in output gap.

### 3.4 The VAR Model

Using a small-scale macroeconomic model, we combine the selected macroeconomic variables with the measure of bank's fragility – the NPL ratio- to perform stress tests with the VAR methodology. We can write the VAR in a more general form as:

$$M_{t+1} = \lambda + \sum_{j=1}^r \beta_j M_{t+1-j} + \varepsilon_{t+1} \quad (1)$$

where  $\lambda$  is a constant vector,  $\beta_j$  are matrices and  $\varepsilon_{t+1}$  is a vector of residuals / shocks.  $M_{t+1}$  is the vector of endogenous variables including the CPI, the output gap, the nominal short-

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<sup>4</sup> FSI No. 6.54. This FSI is intended to identify problems with asset quality in the loan portfolio. It can be interpreted in combination with NPLs less specific provisions for the capital ratio described above. An increasing ratio may signal deterioration in credit portfolio quality, although this is typically a backward looking indicator in that NPLs are identified when problems emerge. Appropriate recognition of NPLs is essential for this ratio to be meaningful. The indicator can be viewed side-by-side with those for the non-financial corporate sector, as a deteriorating financial position for non-financial corporations in particular might well be mirrored in this ratio. See IMF (2006).

term interest rate, the real exchange rate and imports.  $M_{t+1}$  also includes the NPL ratio. The NPL ratio equation in the model and the shock to it is defined as:

$$ko_{t+1} = \eta_{ko} + \beta_{ko} M_t + \varepsilon_{ko, t+1} \quad (2)$$

where  $ko_t$  represents the NPL to aggregate loan ratio,  $\varepsilon_{ko, t+1}$  is a white noise shock,  $\eta_{ko}$  is a constant,  $\beta_{ko}$  is a row vector of parameters corresponding to the row of coefficients in  $\beta_1$  in the NPL ratio equation.  $M_t$  is the vector of variables included in the VAR including the NPL ratio. Equation (2) shows the determinants of the NPL ratio to aggregate loans, which are, lagged values of the variables included in the VAR.

The macroeconomic model on which the above VAR specification is based on can be described as:

$$\bar{a}_t = \psi \bar{a}_{t-1} + \beta (i_{t-1} - E_{t-1} \pi_t) + \Omega X_{t-1} + \gamma Z_{t-1} + \varepsilon_{IS,t} \quad (3)$$

where  $\bar{a}$  is the output gap,  $i$  is the nominal interest rate,  $E_{t-1} \pi_t$  is the expectation at time  $t-1$  of inflation at time  $t$  (and therefore  $i_{t-1} - E_{t-1} \pi_t$  is the real interest rate)  $X_{t-1}$  is the real exchange rate,  $Z_{t-1}$  imports and  $\varepsilon_{IS,t}$  is a white noise shock.

$$\pi_t = \pi_{t-1} + \lambda a_{t-1} + \theta \Delta X_t + \varepsilon_{\pi,t} \quad (4)$$

where  $\Delta X_t$  is the first difference of the real exchange rate and  $\varepsilon_{\pi,t}$  is a white noise shock. Following Hoggarth, Logan and Zicchino (2005) and Batini and Haldane (1999) equation (3) is the IS curve suggesting that the current output gap depends on its lagged level, the real interest rate, real exchange rate and imports. Equation (4) is an open economy aggregate supply curve. This is similar to the Phillips curve in Batini-Haldane model.

## **4.0 Data Description, Estimation and Results**

In this study, we used quarterly data from the Banking Supervision and Research departments of the Bank of Ghana and Ghana Statistical Service (GSS) covering 1995-2005. All the variables used are plotted in chart 1 and explained below.

### **4.1 Non Performing Loans Ratio**

The non-performing loans are facilities which payments of principal and interest are past due by three months or more. The 90-day criterion is the time period that is most widely used by countries to determine whether a loan is non performing (see Cortavarria et al 2000). The non-performing loan ratio is obtained by dividing the NPL by the gross loans and advances. During the 1980s, as a result of undue political influence, weak management, inadequate capital, accounting and information systems and poor internal controls, banks in Ghana had large portfolios of non-performing loans. The NPL of banks were either replaced with Financial Sector Adjustment Programme bonds (FINSAP bonds) held by the Bank of Ghana or transferred to Non Performing Asset Recovery Trust (NPART) a body set up under the Financial Sector reform program in 1988 to recover overdue loans on behalf of the banks (see Brownbridge and Gockel 1996). We have isolated these distressed periods by concentrating on events after the financial sector reform program. We expect an increase (decrease) in the CPI and output gap (GAP) to cause the NPL ratio to increase (decrease).

### **4.2 Real Effective Exchange Rate, Output Gap, CPI and Imports**

There exist different definitions of Real Effective Exchange rate (REER) in the literature. For the purpose of this paper, we define REER (R1) as the product of the nominal effective exchange rate (NEER) and the effective relative price indices (in this instance the weighted wholesale price index of trading partners and the consumer price index for the home

country). This is defined in domestic currency terms using the Arithmetic Mean (AM) method of averaging as:

$$REER_{jt} = \sum_{i=j}^k (NEER_{jit}) (P_{it}^* / P_{jt})$$

where subscripts  $j$ ,  $i$  and  $t$  represent country, trading partner and period respectively.  $P_{it}^*$  is the total trade weighted wholesale price index of the trading partners representing the price of tradables, and  $P_{jt}$  is the CPI of the domestic country (a proxy for price of non-tradables). The  $NEER_{jit}$  denotes the nominal effective exchange rate for the home country with respect to each partner  $i$ . This is defined as an index reflecting movements in the nominal exchange rate between a home country and trading partners adjusted for by the respective weights of the trading partners. The REER (R1) is defined such that an increase (decrease) in the value represents depreciation (appreciation). An appreciation causes deterioration in the quality of the loan asset hence increase in the NPL ratio and decelerates inflation (Theory of real effective exchange rate)

We use the HP filter in the eviews5 software to obtain the potential output. The NPL ratio increases (decrease) with the GAP increase (decrease). The nominal interest rate (LNI) is the log of the Bank of Ghana's principal monetary tool, the Prime rate. The Central bank introduced the prime rate in 2001 as a monetary tool hence we used the rediscount rate for the periods before 2001. The Consumer Price Index (CPI) is the actual quarterly CPI obtained from the GSS. We also use quarterly imports obtained from the Research Department of the Bank of Ghana. Rising import growth causes decrease in the CPI<sup>5</sup>.

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<sup>5</sup> Theory of one price of tradable good; impact of competitive pressures on domestic prices of tradable goods

### 4.3 Stationarity and Cointegration

We test for the stationarity of all the variables using Augmented Dicker Fuller(ADF) unit root test. To conduct the ADF test the Akaike and Schwartz properties as well as the associated DW statistics of each variable is examined to find which lag level to use in performing the test on each variable. The Dickey and Fuller (1981) F- statistic is employed to find out whether or not to include an intercept term or a trend term in performing the ADF test for stationarity. In carrying out the ADF test, the ADF model containing no intercept and trend is used. Some of the variables are not stationary in level but after differencing at 1 all of them are stationary. The non-stationarity may be due to the sample period where we have high inflationary period especially in year 2000. Unit root testing is a challenging one since most tests have very low power<sup>6</sup>. The results of the unit root test are reported in Table 2. We conducted a Johansen Cointegration Test to investigate cointegration of the variables and the results show at least two cointegrating equations at the 1% significant level (see Table 3).

### 4.4 Causality Test

The testing for exogeneity follows the methodology proposed by Greene (2003). Its starting point is the concept of Granger causality. Granger causality is inferred when lagged values of a variable say  $x_t$ , have explanatory power in the regression of a variable  $y_t$  on the lagged variables of  $y_t$  and  $x_t$ .

The symmetric structure of the tested VAR model implies that tests for Granger causality can be based on simple F tests in the single equations of the VAR model. The notion can be extended in a system of equations to attempt to ascertain if a given variable is weakly

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<sup>6</sup> See Maddala and Kim (1999) for detailed review.

exogenous to the system. If lagged values of a variable  $x_t$  have no explanatory powers for *any* of the variables in the system, then  $x_t$  is seen as *weakly exogenous* to the system. The above-mentioned F tests are, however wedded to the normal distribution and this fact limits their generality. This is why more general Wald tests are applied. The Wald test computes the test statistic by estimating the unrestricted regression without imposing the coefficient restrictions specified by the null hypothesis. The Wald statistic measures how close the unrestricted estimates come to satisfying the restrictions under the null hypothesis. If the restrictions are in fact true, then the unrestricted estimates should come close to satisfying the restrictions. The equations tested by the Wald tests are identical to the equations of the VAR model. The null hypothesis is that five regression coefficients belonging to an explanatory variable are jointly equal to zero. If these restrictions are true, then the variable does not significantly contribute to the estimation of the dependent variable. If they are not true, then the F statistics and chi-square statistics are high and support the hypothesis that the tested variable contributes to the explanation of the dependent variable. The results show that GAP (Chi-test, 14.479, F-test, 3.09) and LNI (Chi-test 12.872, F-test, 6.3086) granger cause NPL.

#### **4.5 Industry Results**

The model considered in this paper included the following variables:

$M_{t+1} = \{NPL, GAP, R1, LNI, CPI, IM\}$  where GAP is the output gap, R1 is the Real effective exchange rate, LNI is log of nominal central bank interest rate, CPI quarterly consumer price index and IM is the import. The impulse response functions and the residuals for the aggregate VAR over the 1995 Q1- 2005Q4 periods are shown in chart 4 and 5 respectively. The detailed results from the estimated VAR summarized below are shown in Table 4.

	Constant	NPL	GAP	R1	LNI	CPI	IM
NPL	-31.303 [-0.99]	-0.262 [-0.64]	0.004 [2.55]	1.411 [1.35]	0.002 [0.02]	4.472 [4.67]	1157.66 [3.81]
GAP	0.071 [0.527]	58.028 [0.64]	2.067 [5.30]	-71.498 [-0.31]	2.425 [1.09]	-765.908 [-3.62]	182697.9 [-2.72]
R1	-162.053 [-2.02]	0.109 [0.910]	-0.001 [-1.538]	0.559 [1.83]	0.002 [0.76]	-0.615 [-2.20]	-166.29 [-1.87]
LNI	1.899 [2.45]	18.814 [1.16]	-0.072 [-1.04]	-74.482 [-1.81]	0.946 [2.38]	-157.602 [-4.18]	-32175.8 [-2.69]
CPI	364.396 [4.97]	0.295 [1.66]	4.040 [-0.05]	-1.443 [-3.20]	0.006 1.35	-1.751 [-4.25]	-66.273 [-0.506]
IM	728.20 [3.13]	-0.001 [-1.259]	3.240 [1.370]	0.005 [3.81]	4.930 [0.364]	0.007 [5.63]	1.194 [2.93]

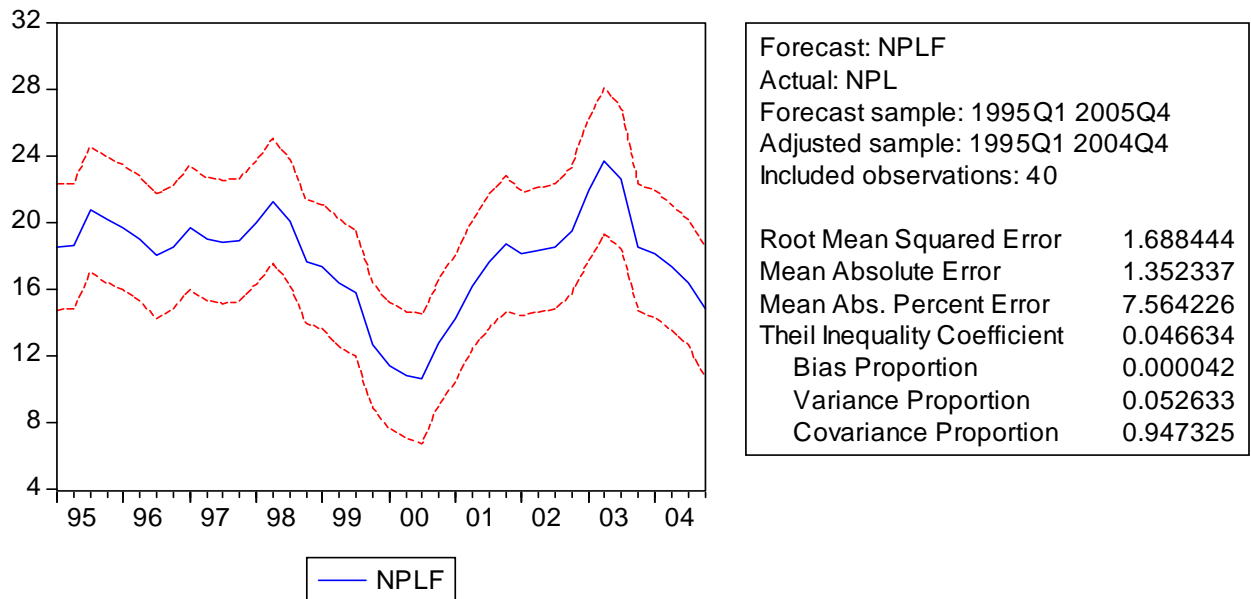
Note: In brackets are the t-statistics

**Table 1:** Summarized estimated parameters from the VAR

The first row in Table 1 shows a significant relationship between changes in CPI and the banking industry NPL ratio. Theoretically, a consumer price shock primarily reflects the “demand-pull” or “cost-push” theories of inflation. Both theories are reconcilable with the empirical phenomena summarised by the Phillips Curve: as unemployment decreases, wage inflation (and price inflation) rises, or, more generally, there is the trade-off between unemployment and inflation. In an open economy, which is heavily dependent on imports of crude oil, gas and other intermediate inputs, this shock can also be caused by an increase in world prices of these commodities. The impulse response functions suggest that the NPL ratio increases after eight quarters following unexpected increase in output gap but after nine quarters following unexpected increase in inflation. Unexpected increase in nominal interest rate (the prime rate) leads to significant increase in NPL ratio with the maximum after six quarters. The model also suggests that rising inflation causes depreciation and appreciation leads to increase in imports. These results are consistent with the theory of the real effective exchange rate.

#### 4.6. Forecast of the share of NPLs in the aggregate loan portfolio

The in-sample forecast of the NPL ratio fits the data sample well. The forecast expresses a truly dynamic statistical interpretation of the macro-prudential concept of credit risk created by simulating interactions between all the variables included in the model. It is drawn from the data using the forecasted dynamics of the NPL ratio. Chart 1 demonstrates that under the normality assumption the forecasted values vary within the boundaries determining the 95% confidence interval for two tailed tests. Therefore, the in-sample forecast of the NPL ratio is unbiased. Needless to say, the same holds *mutatis mutandis* for the in sample forecasts of the remaining endogenous variables.



**Notes:** NPL stands for the observed NPL ratio; NPLF denotes the forecasted NPL ratio,  
**Chart 2:** Forecast of NPL ratio of the Banking Industry

The most likely outlook for the quality of the banking sector's loan portfolio is that up to the end of 2007 the NPL ratio will follow a slightly downward trend below double-digit rates. Chart A presents this out-of-sample forecast. It follows that a macro prudential

forecast like this one is conditional on the absence of large idiosyncratic shocks. The forecast's robustness to huge macroeconomic shocks is supported by stress testing, which indicates that neither individual huge macroeconomic shocks nor a combination thereof in a worst-case scenario are likely to cause the NPL ratio to rise beyond the forecasted band.

#### **4.7 Robustness Test**

The responses gained within the framework of impulse response analysis are tested for robustness by re-ordering of the variables as well as for robustness to reduction of the data sample. It is necessary to examine the sensitivity of the responses to re-ordering of the variables. When we changed the positions of the variables in the original model we find significant relationships between the NPL ratio and output gap as well as consumer price index. Unexpected increase in consumer price index would lead to reduction in economic agents' net worth and this will cause NPL ratio to rise. Similarly, output gap shock and increase in the Prime rate will lead to NPL ratio to rise.

#### **4.8 Variance Decomposition**

The most prominent early warning signals of worsening loan portfolio quality are rising growth in the NPL ratio itself, followed by the Prime rate, consumer price inflation and output gap (see Table 5). The trends in the responses of the growth in the share of non-performing loans in total loans are identical to the trend produced by standard impulse response analysis.

## 5.0 Conclusions

This paper applies VAR methodology to stress test the Ghanaian banking system. It estimates the changes in macroeconomic variables on the NPL ratio of the banking industry. The empirical findings agree with the theoretical assumptions underlying the investigated transmission and with the empirical findings presented in the VAR literature. The impulse responses do not vary from similar studies on other countries. Significant positive relationships have been established between the banking industry's NPL ratio and the CPI as well as the output gap. The in-sample forecast of the NPL ratio fits the data sample well. The forecast expresses a truly dynamic statistical interpretation of the macro-prudential concept of credit risk created by simulating interactions between all the variables included in the model. The most likely outlook for the quality of the banking sector's loan portfolio is that up to the end of 2007 the NPL ratio will follow a slightly downward trend below double-digit rates. The impulse response functions also suggest that the NPL ratio increases after eight quarters following unexpected output gap but after nine quarters following unexpected increase in inflation. Unexpected increase in Prime rate leads to significant increase in NPL ratio with the maximum after six quarters.

The model has a promising outlook for further development in assessing the fragility of the banking system stemming from adverse shocks.

## References

Arpa, M., Guilini, I., Ittner, A., and Pauer, F. (2001): "The Influence of Macroeconomic Developments on Austrian Banks: Implications for Banking Supervision" BIS Paper No. 1 (Basle: Bank for International Settlements). Also available via the Internet: <http://www.bis.org>.

Ball, L (1998), 'Policy rules for open economies', *NBER Working Paper no. 6760*.

Batini, N and Haldane, A (1999), 'Forward-looking rules for monetary policy', *Bank of England Working Paper no. 91*.

Blake, A P and Westaway, P F (1996), 'Credibility and the effectiveness of inflation targeting regimes', *The Manchester School Supplement*, Vol. 64, pages 28-50.

Blaschke, W., Jones M. T. ET AL. (2001): "Stress Testing of Financial Systems: An Overview of Issues, Methodologies, and FSAP Experiences" IMF Working Paper No.01/88. Washington D.C.: IMF. Also available via the Internet: <http://www.imf.org>.

Brownbridge M and Gockel F (1996) "The impact of Financial Sector Policies on Banking in Ghana" Institute of Development Studies, University of Sussex, Working Paper No.38

Bunn, P, Cunningham, A and Drehmann, M (2005), 'Stress testing as a tool for assessing systemic risk', *Bank of England Financial Stability Review*, June, pages 116-26.

Dickey, D.A. and W.A. Fuller (1981), "Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root", *Econometrica*, 49(4), 1057-1072.

Gambera, M. (2000): *Simple Forecasts of Bank Loan Quality in the Business Cycle*. Chicago: Federal Reserve Bank of Chicago. Also available via the Internet: <http://www.chicagofed.org/publications/publicpolicystudies/emergingissues/pdf/S&R-2000-3.pdf>.

Greene, W. (2003): *Econometric Analysis*. New Jersey: New York University, 5th edition.

Hoggarth, G., Logan, A., and Zicchino, L. (2005): "Macro stress tests of UK banks". BIS papers No.22. Basle: Bank for International Settlements. Also available via the Internet: <http://www.bis.org>.

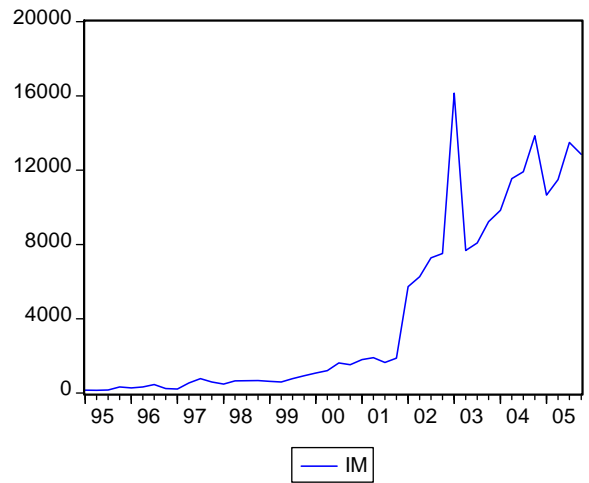
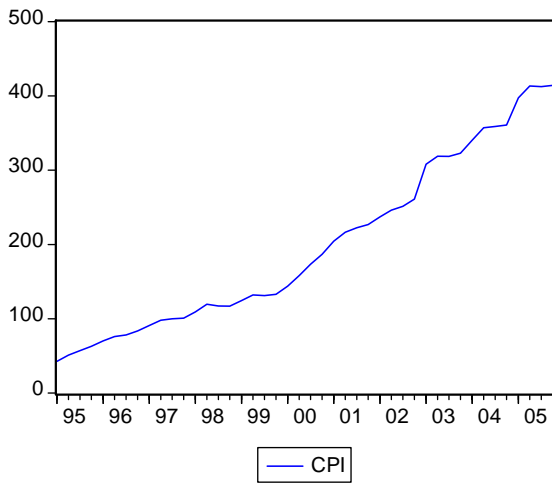
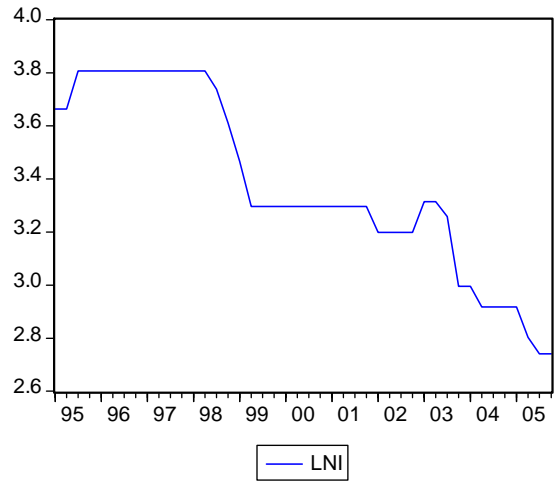
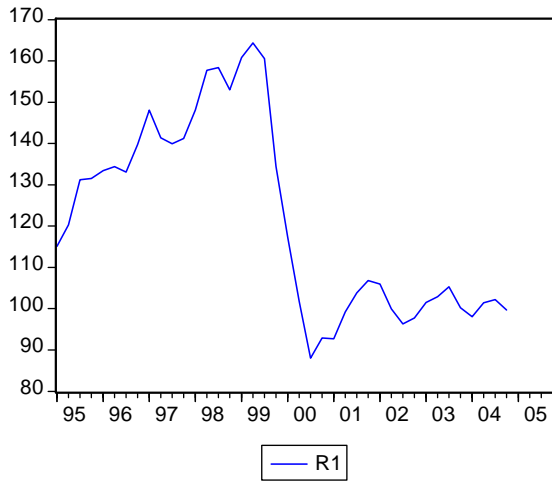
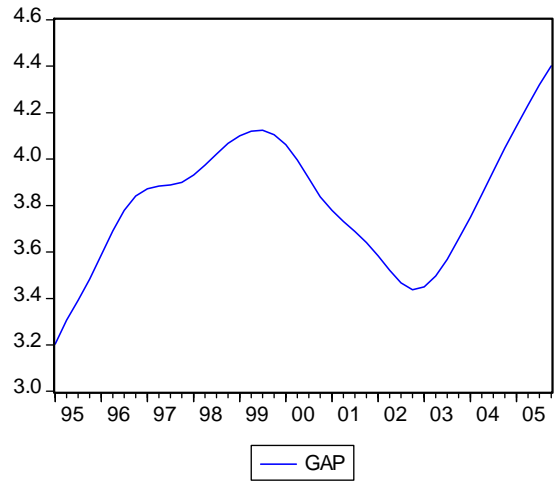
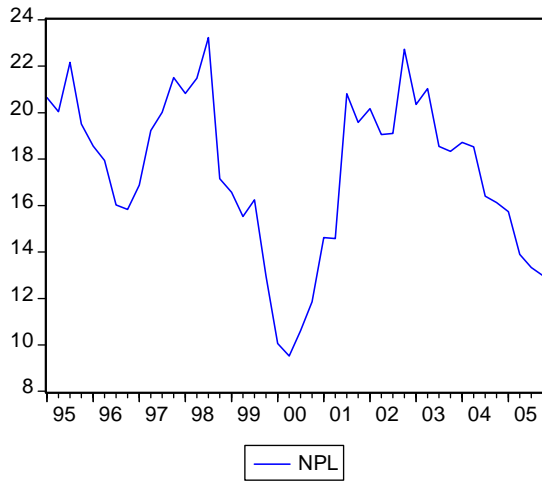
International Monetary Fund (2006): *A Compilation Guide on Financial Soundness Indicators*. Washington D.C.: International Monetary Fund. Also available via the Internet: <http://www.imf.org/external/nplstal/bsi/eng/2006/guide/index.htm>.

Keeton, W. (1999): "Does Faster Loan Growth Lead to Higher Loan Losses?" *Economic Review*. Kansas City: Federal Reserve Bank of Kansas City. Also available via the Internet: <http://www.kc.frb.org/Econres/staff/wrk.htm>

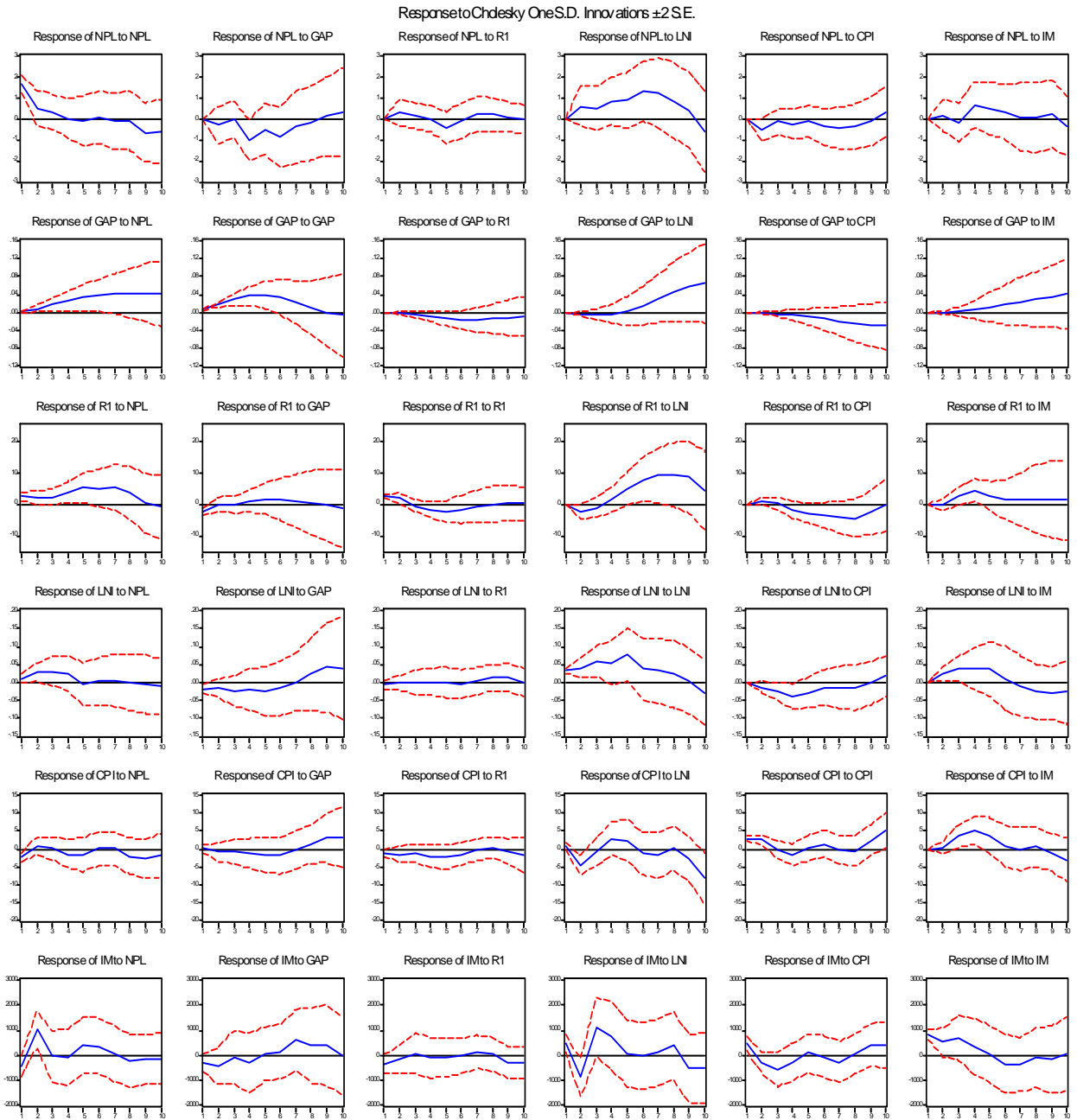
Sims, C. (1980): "Macroeconomics and Reality". *Econometrica*, Vol. 48.

Shu, C. (2002): "The Impact of Macroeconomic Environment on the Asset Quality of Hong Kong's Banking Sector" Hong Kong Monetary Authority Research Memorandum. Hong Kong: Hong Kong Monetary Authority. Also available via the Internet: [www.info.gov.hk/hkma/eng/research/index.htm](http://www.info.gov.hk/hkma/eng/research/index.htm).

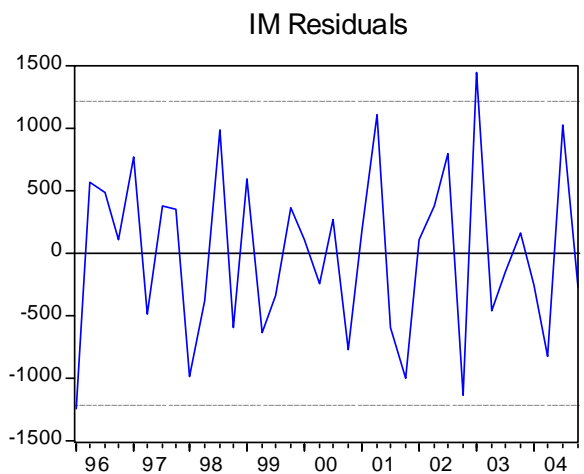
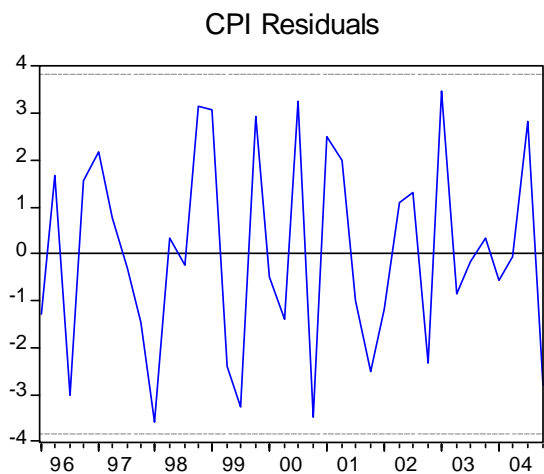
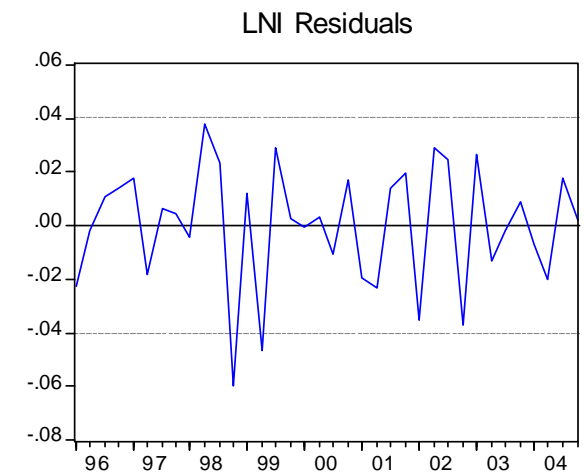
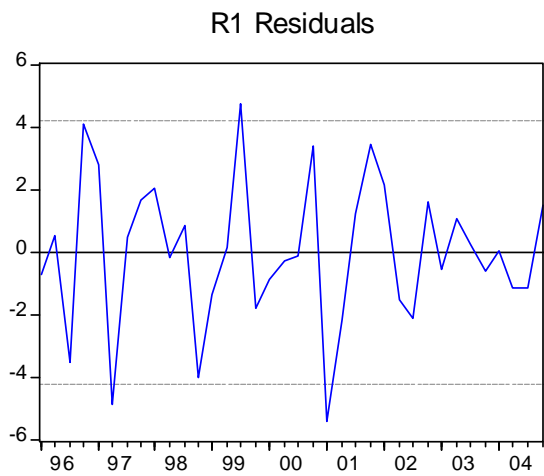
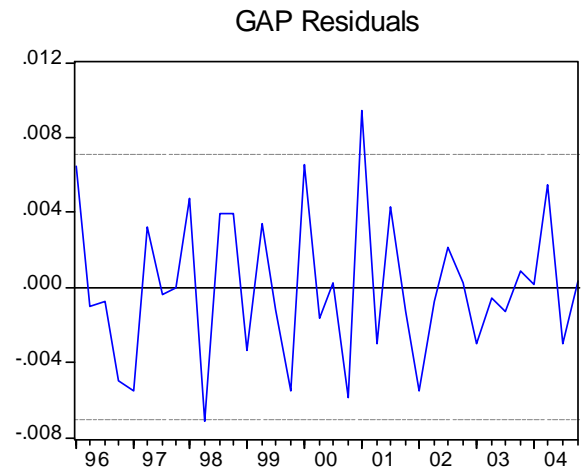
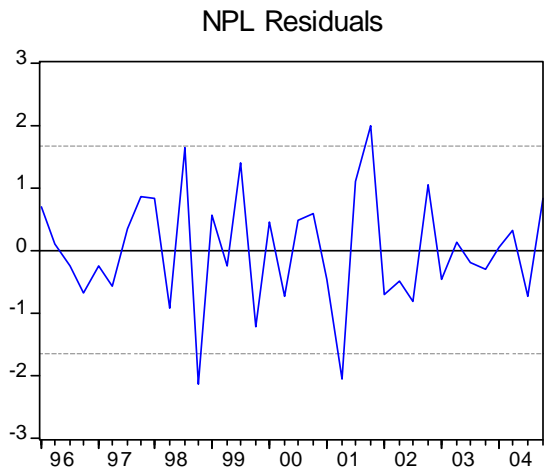
**Chart 3: Time Series of endogenous variables**



**Chart 4: Impulse Response Functions for the estimated model, 1995Q1-2005Q4**



### Chart 5: Residuals



## Table2: Unit Root Test Results

Null Hypothesis: D(NPL) has a unit root  
 Exogenous: None  
 Lag Length: 0 (Automatic based on SIC, MAXLAG=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-6.759187	0.0000
Test critical values:		
1% level	-2.621185	
5% level	-1.948886	
10% level	-1.611932	

\*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation  
 Dependent Variable: D(NPL,2)  
 Method: Least Squares  
 Date: 08/22/06 Time: 11:50  
 Sample (adjusted): 1995Q3 2005Q4  
 Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(NPL(-1))	-1.053385	0.155845	-6.759187	0.0000
R-squared	0.527030	Mean dependent var		0.005952
Adjusted R-squared	0.527030	S.D. dependent var		2.998152
S.E. of regression	2.061913	Akaike info criterion		4.308667
Sum squared resid	174.3109	Schwarz criterion		4.350040
Log likelihood	-89.48201	Durbin-Watson stat		1.939048

Null Hypothesis: D(GAP) has a unit root  
 Exogenous: None  
 Lag Length: 2 (Automatic based on SIC, MAXLAG=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-2.015432	0.0433
Test critical values:		
1% level	-2.624057	
5% level	-1.949319	
10% level	-1.611711	

\*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(GAP,2)

Method: Least Squares

Date: 08/22/06 Time: 11:57

Sample (adjusted): 1996Q1 2005Q4

Included observations: 40 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(GAP(-1))	-0.040843	0.020265	-2.015432	0.0512
D(GAP(-1),2)	1.200319	0.124577	9.635121	0.0000
D(GAP(-2),2)	-0.455481	0.128136	-3.554676	0.0011
R-squared	0.795501	Mean dependent var		-0.000226
Adjusted R-squared	0.784447	S.D. dependent var		0.016794
S.E. of regression	0.007797	Akaike info criterion		-6.798070
Sum squared resid	0.002249	Schwarz criterion		-6.671404
Log likelihood	138.9614	Durbin-Watson stat		2.108157

Null Hypothesis: D(LNI) has a unit root

Exogenous: None

Lag Length: 0 (Automatic based on SIC, MAXLAG=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-4.430927	0.0000
Test critical values:		
1% level	-2.621185	
5% level	-1.948886	
10% level	-1.611932	

\*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(LNI,2)

Method: Least Squares

Date: 08/22/06 Time: 12:01

Sample (adjusted): 1995Q3 2005Q4

Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNI(-1))	-0.647604	0.146155	-4.430927	0.0001
R-squared	0.323802	Mean dependent var		0.000000

Adjusted R-squared	0.323802	S.D. dependent var	0.081272
S.E. of regression	0.066831	Akaike info criterion	-2.549767
Sum squared resid	0.183124	Schwarz criterion	-2.508394
Log likelihood	54.54511	Durbin-Watson stat	1.960811

Null Hypothesis: CPI has a unit root

Exogenous: None

Lag Length: 2 (Automatic based on SIC, MAXLAG=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		4.810309	1.0000
Test critical values:	1% level	-2.622585	
	5% level	-1.949097	
	10% level	-1.611824	

\*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(CPI)

Method: Least Squares

Date: 08/22/06 Time: 12:04

Sample (adjusted): 1995Q4 2005Q4

Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CPI(-1)	0.052555	0.010925	4.810309	0.0000
D(CPI(-1))	0.160426	0.153905	1.042369	0.3038
D(CPI(-2))	-0.499467	0.161978	-3.083542	0.0038

R-squared	0.202552	Mean dependent var	8.705610
Adjusted R-squared	0.160581	S.D. dependent var	9.389322
S.E. of regression	8.602479	Akaike info criterion	7.212333
Sum squared resid	2812.100	Schwarz criterion	7.337717
Log likelihood	-144.8528	Durbin-Watson stat	1.909553

Null Hypothesis: D(IM) has a unit root

Exogenous: None

Lag Length: 0 (Automatic based on SIC, MAXLAG=9)

	t-Statistic	Prob.*
--	-------------	--------

Augmented Dickey-Fuller test statistic		-9.827379	0.0000
Test critical values:	1% level	-2.621185	
	5% level	-1.948886	
	10% level	-1.611932	

\*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(IM,2)

Method: Least Squares

Date: 08/22/06 Time: 12:05

Sample (adjusted): 1995Q3 2005Q4

Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(IM(-1))	-1.405056	0.142974	-9.827379	0.0000
R-squared	0.701981	Mean dependent var		-14.72140
Adjusted R-squared	0.701981	S.D. dependent var		3581.564
S.E. of regression	1955.216	Akaike info criterion		18.01791
Sum squared resid	1.57E+08	Schwarz criterion		18.05928
Log likelihood	-377.3761	Durbin-Watson stat		2.141298

### Table 3: Cointegration Test Results

Date: 08/22/06 Time: 08:33  
 Sample (adjusted): 1995Q3 2004Q4  
 Included observations: 38 after adjustments  
 Trend assumption: Linear deterministic trend  
 Series: NPL GAP R1 LNI CPI IM  
 Lags interval (in first differences): 1 to 1

#### Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.01 Critical Value	Prob.**
None *	0.788894	143.3251	104.9615	0.0000
At most 1 *	0.606699	84.22015	77.81884	0.0023
At most 2	0.481982	48.75928	54.68150	0.0410
At most 3	0.293955	23.76493	35.45817	0.2105
At most 4	0.240801	10.53804	19.93711	0.2416
At most 5	0.001823	0.069350	6.634897	0.7923

Trace test indicates 2 cointegrating eqn(s) at the 0.01 level

\* denotes rejection of the hypothesis at the 0.01 level

\*\*MacKinnon-Haug-Michelis (1999) p-values

#### Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.01 Critical Value	Prob.**
None *	0.788894	59.10499	45.86900	0.0001
At most 1	0.606699	35.46087	39.37013	0.0321
At most 2	0.481982	24.99435	32.71527	0.1036
At most 3	0.293955	13.22689	25.86121	0.4316
At most 4	0.240801	10.46869	18.52001	0.1829
At most 5	0.001823	0.069350	6.634897	0.7923

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.01 level

\* denotes rejection of the hypothesis at the 0.01 level

\*\*MacKinnon-Haug-Michelis (1999) p-values

#### Unrestricted Cointegrating Coefficients (normalized by $b^*S_{11}b=I$ ):

NPL	GAP	R1	LNI	CPI	IM
0.585411	6.988152	-0.122880	-3.293672	-0.052078	0.000630
0.090630	-0.607177	0.024047	3.432449	0.037247	-0.000410
-0.044169	2.144770	-0.060066	7.499839	0.018801	-0.000272
0.548653	5.956824	-0.044358	-3.776719	0.000271	-0.000566

-0.126135	-1.545800	0.054358	5.362399	0.004578	0.000352
0.108210	9.207555	-0.079421	-1.145543	-0.034846	0.000696

Unrestricted Adjustment Coefficients (alpha):

D(NPL)	-0.190634	-0.371157	0.717241	-0.521287	-0.276884	0.034871
D(GAP)	0.007958	0.006915	-0.000336	-0.003805	0.001204	-9.63E-05
D(R1)	3.532125	-0.436097	3.177233	0.534749	-0.445867	-0.006411
D(LNI)	0.023890	-0.033791	-0.011095	-0.007475	-0.009014	0.000657
D(CPI)	2.271970	-0.506262	-0.096288	-1.495502	-1.590660	-0.232749
D(IM)	353.5215	289.7987	-248.9917	-110.3603	-671.7714	-26.30420

1 Cointegrating Equation(s):      Log likelihood      -448.6738

Normalized cointegrating coefficients (standard error in parentheses)

NPL	GAP	R1	LNI	CPI	IM
1.000000	11.93717	-0.209905	-5.626255	-0.088959	0.001077
	(1.37750)	(0.01892)	(1.52292)	(0.01042)	(0.00020)

Adjustment coefficients (standard error in parentheses)

D(NPL)	-0.111599
	(0.19161)
D(GAP)	0.004659
	(0.00134)
D(R1)	2.067745
	(0.54934)
D(LNI)	0.013985
	(0.00591)
D(CPI)	1.330036
	(0.75311)
D(IM)	206.9554
	(172.190)

2 Cointegrating Equation(s):      Log likelihood      -430.9433

Normalized cointegrating coefficients (standard error in parentheses)

NPL	GAP	R1	LNI	CPI	IM
1.000000	0.000000	0.094496	22.23610	0.231262	-0.002510
		(0.07885)	(9.75980)	(0.05817)	(0.00109)
0.000000	1.000000	-0.025500	-2.334084	-0.026826	0.000300
		(0.00663)	(0.82035)	(0.00489)	(9.2E-05)

Adjustment coefficients (standard error in parentheses)

D(NPL)	-0.145237	-1.106823
	(0.18969)	(2.24612)

D(GAP)	0.005286 (0.00113)	0.051415 (0.01334)
D(R1)	2.028222 (0.55388)	24.94781 (6.55858)
D(LNI)	0.010923 (0.00473)	0.187462 (0.05601)
D(CPI)	1.284154 (0.76011)	16.18426 (9.00054)
D(IM)	233.2197 (171.399)	2294.503 (2029.55)

3 Cointegrating Equation(s):      Log likelihood      -418.4461

Normalized cointegrating coefficients (standard error in parentheses)

NPL	GAP	R1	LNI	CPI	IM
1.000000	0.000000	0.000000	1084.462 (228.150)	7.047341 (1.30803)	-0.083375 (0.02544)
0.000000	1.000000	0.000000	-288.9801 (60.1622)	-1.866173 (0.34492)	0.022122 (0.00671)
0.000000	0.000000	1.000000	-11240.91 (2334.37)	-72.13052 (13.3833)	0.855750 (0.26027)

Adjustment coefficients (standard error in parentheses)

D(NPL)	-0.176917 (0.17358)	0.431493 (2.14338)	-0.028582 (0.04058)
D(GAP)	0.005300 (0.00113)	0.050694 (0.01394)	-0.000791 (0.00026)
D(R1)	1.887886 (0.43561)	31.76225 (5.37886)	-0.635359 (0.10184)
D(LNI)	0.011413 (0.00459)	0.163666 (0.05665)	-0.003082 (0.00107)
D(CPI)	1.288407 (0.76215)	15.97775 (9.41099)	-0.285571 (0.17818)
D(IM)	244.2175 (169.740)	1760.473 (2095.95)	-21.51607 (39.6822)

4 Cointegrating Equation(s):      Log likelihood      -411.8327

Normalized cointegrating coefficients (standard error in parentheses)

NPL	GAP	R1	LNI	CPI	IM
1.000000	0.000000	0.000000	0.000000	0.007792 (0.03822)	0.001158 (0.00094)
0.000000	1.000000	0.000000	0.000000	0.009679 (0.00618)	-0.000404 (0.00015)
0.000000	0.000000	1.000000	0.000000	0.837375	-0.020472

				(0.21660)	(0.00535)
0.000000	0.000000	0.000000	1.000000	0.006491	-7.79E-05
				(0.00090)	(2.2E-05)

Adjustment coefficients (standard error in parentheses)

D(NPL)	-0.462923	-2.673720	-0.005458	6.701854
	(0.22341)	(2.61059)	(0.04028)	(2.66635)
D(GAP)	0.003213	0.028030	-0.000623	0.009374
	(0.00143)	(0.01672)	(0.00026)	(0.01708)
D(R1)	2.181278	34.94765	-0.659080	8.678598
	(0.58770)	(6.86747)	(0.10595)	(7.01413)
D(LNI)	0.007312	0.119141	-0.002750	-0.249648
	(0.00615)	(0.07184)	(0.00111)	(0.07337)
D(CPI)	0.467895	7.069303	-0.219233	-4.294899
	(1.01373)	(11.8457)	(0.18276)	(12.0987)
D(IM)	183.6680	1103.077	-16.62067	-1620.262
	(230.488)	(2693.32)	(41.5537)	(2750.84)

5 Cointegrating Equation(s):      Log likelihood      -406.5984

Normalized cointegrating coefficients (standard error in parentheses)

NPL	GAP	R1	LNI	CPI	IM
1.000000	0.000000	0.000000	0.000000	0.000000	0.001341
					(0.00029)
0.000000	1.000000	0.000000	0.000000	0.000000	-0.000176
					(4.3E-05)
0.000000	0.000000	1.000000	0.000000	0.000000	-0.000797
					(0.00174)
0.000000	0.000000	0.000000	1.000000	0.000000	7.46E-05
					(1.2E-05)
0.000000	0.000000	0.000000	0.000000	1.000000	-0.023496
					(0.00190)

Adjustment coefficients (standard error in parentheses)

D(NPL)	-0.427998	-2.245713	-0.020509	5.217092	0.008179
	(0.22229)	(2.60064)	(0.04226)	(2.99880)	(0.01817)
D(GAP)	0.003061	0.026169	-0.000557	0.015831	-0.000159
	(0.00144)	(0.01681)	(0.00027)	(0.01939)	(0.00012)
D(R1)	2.237517	35.63687	-0.683317	6.287682	-0.142350
	(0.59106)	(6.91497)	(0.11237)	(7.97365)	(0.04831)
D(LNI)	0.008449	0.133075	-0.003240	-0.297985	-0.002755
	(0.00607)	(0.07106)	(0.00115)	(0.08194)	(0.00050)
D(CPI)	0.668533	9.528145	-0.305699	-12.82465	-0.146672
	(0.99808)	(11.6767)	(0.18975)	(13.4644)	(0.08157)
D(IM)	268.4020	2141.501	-53.13701	-5222.569	-15.40278
	(210.575)	(2463.55)	(40.0327)	(2840.72)	(17.2098)

**Table 4: Estimated VAR Results**

Vector Autoregression Estimates  
Date: 08/23/06 Time: 15:47  
Sample (adjusted): 1996Q1 2004Q4  
Included observations: 36 after adjustments  
Standard errors in ( ) & t-statistics in [ ]

	NPL	GAP	R1	LNI	CPI	IM
NPL(-1)	-0.262083 (0.41250) [-0.63535]	0.004499 (0.00177) [ 2.54740]	1.410905 (1.04656) [ 1.34813]	0.000225 (0.01010) [ 0.02231]	4.472217 (0.95673) [ 4.67448]	1157.658 (303.851) [ 3.80995]
NPL(-2)	0.059429 (0.51853) [ 0.11461]	0.004372 (0.00222) [ 1.96926]	1.226177 (1.31556) [ 0.93205]	-0.017101 (0.01270) [-1.34645]	3.020497 (1.20264) [ 2.51155]	844.6625 (381.951) [ 2.21144]
NPL(-3)	0.013057 (0.43603) [ 0.02994]	0.001812 (0.00187) [ 0.97070]	0.235674 (1.10626) [ 0.21304]	-0.018170 (0.01068) [-1.70136]	-1.608479 (1.01131) [-1.59049]	-250.4759 (321.184) [-0.77985]
NPL(-4)	0.013274 (0.33564) [ 0.03955]	-0.000471 (0.00144) [-0.32806]	0.544080 (0.85155) [ 0.63893]	-0.005202 (0.00822) [-0.63278]	-0.765110 (0.77846) [-0.98285]	-11.92161 (247.234) [-0.04822]
GAP(-1)	58.02839 (91.1618) [ 0.63654]	2.066947 (0.39028) [ 5.29602]	-71.49814 (231.288) [-0.30913]	2.425371 (2.23287) [ 1.08621]	-765.9077 (211.435) [-3.62242]	-182697.9 (67150.4) [-2.72073]
GAP(-2)	-203.6123 (229.991) [-0.88530]	-1.404230 (0.98464) [-1.42613]	331.6196 (583.515) [ 0.56831]	-5.028216 (5.63330) [-0.89259]	2092.508 (533.429) [ 3.92275]	470132.1 (169413.) [ 2.77506]
GAP(-3)	186.1175 (194.745) [ 0.95570]	0.612482 (0.83374) [ 0.73462]	-280.9841 (494.089) [-0.56869]	2.186050 (4.76998) [ 0.45829]	-1851.666 (451.679) [-4.09951]	-365531.7 (143450.) [-2.54815]
GAP(-4)	-42.94292 (65.3552) [-0.65707]	-0.155738 (0.27980) [-0.55661]	104.9715 (165.814) [ 0.63307]	0.113638 (1.60078) [ 0.07099]	617.5390 (151.581) [ 4.07399]	104644.8 (48141.1) [ 2.17371]
R1(-1)	0.109735 (0.12048) [ 0.91084]	-0.000793 (0.00052) [-1.53842]	0.559264 (0.30566) [ 1.82968]	0.002264 (0.00295) [ 0.76721]	-0.615045 (0.27943) [-2.20110]	-166.2901 (88.7436) [-1.87383]
R1(-2)	-0.046258	-0.000658	-0.407465	0.001335	-0.284590	-41.29058

	(0.11146) [-0.41503]	(0.00048) [-1.37907]	(0.28278) [-1.44093]	(0.00273) [ 0.48891]	(0.25851) [-1.10090]	(82.0999) [-0.50293]
R1(-3)	0.003932 (0.12322) [ 0.03191]	-0.000252 (0.00053) [-0.47697]	-0.079036 (0.31261) [-0.25282]	-0.001466 (0.00302) [-0.48575]	-0.329981 (0.28578) [-1.15467]	-105.6680 (90.7619) [-1.16423]
R1(-4)	-0.124247 (0.12310) [-1.00933]	-0.000484 (0.00053) [-0.91930]	-0.550171 (0.31231) [-1.76160]	0.001315 (0.00302) [ 0.43617]	-0.392782 (0.28551) [-1.37574]	-143.9397 (90.6747) [-1.58743]
LNI(-1)	18.81391 (16.2471) [ 1.15799]	-0.072010 (0.06956) [-1.03526]	-74.48281 (41.2207) [-1.80693]	0.946369 (0.39795) [ 2.37812]	-157.6024 (37.6825) [-4.18237]	-32175.81 (11967.7) [-2.68855]
LNI(-2)	-9.247492 (18.2988) [-0.50536]	-0.102001 (0.07834) [-1.30201]	55.09312 (46.4261) [ 1.18668]	0.342891 (0.44820) [ 0.76504]	31.54329 (42.4411) [ 0.74322]	-799.0934 (13479.0) [-0.05928]
LNI(-3)	2.883541 (11.9287) [ 0.24173]	0.068266 (0.05107) [ 1.33673]	-5.632252 (30.2646) [-0.18610]	-0.197798 (0.29218) [-0.67698]	51.16138 (27.6668) [ 1.84920]	15855.97 (8786.79) [ 1.80452]
LNI(-4)	6.318507 (9.48394) [ 0.66623]	0.025018 (0.04060) [ 0.61617]	31.03968 (24.0619) [ 1.29000]	-0.187588 (0.23230) [-0.80754]	-47.17096 (21.9965) [-2.14448]	-13534.92 (6985.93) [-1.93745]
CPI(-1)	-0.218165 (0.12760) [-1.70980]	-0.000204 (0.00055) [-0.37350]	0.380732 (0.32373) [ 1.17609]	-0.009364 (0.00313) [-2.99626]	0.793998 (0.29594) [ 2.68297]	-199.2425 (93.9884) [-2.11986]
CPI(-2)	0.295350 (0.17762) [ 1.66282]	-4.04E-05 (0.00076) [-0.05319]	-1.443425 (0.45064) [-3.20304]	0.005865 (0.00435) [ 1.34806]	-1.751154 (0.41196) [-4.25077]	-66.27291 (130.836) [-0.50653]
CPI(-3)	-0.373062 (0.24329) [-1.53338]	-0.001472 (0.00104) [-1.41315]	0.825912 (0.61727) [ 1.33802]	-0.004925 (0.00596) [-0.82650]	-0.115401 (0.56428) [-0.20451]	-343.2638 (179.212) [-1.91541]
CPI(-4)	0.337393 (0.16992) [ 1.98564]	0.000516 (0.00073) [ 0.70972]	-0.204618 (0.43110) [-0.47465]	0.008159 (0.00416) [ 1.96039]	0.842159 (0.39409) [ 2.13695]	333.5952 (125.162) [ 2.66532]
IM(-1)	0.000229 (0.00046) [ 0.49439]	-9.13E-09 (2.0E-06) [-0.00460]	-0.000414 (0.00118) [-0.35238]	3.05E-05 (1.1E-05) [ 2.68770]	0.000567 (0.00108) [ 0.52758]	0.630640 (0.34143) [ 1.84708]

IM(-2)	-0.000695 (0.00055) [-1.25850]	3.24E-06 (2.4E-06) [ 1.37024]	0.005342 (0.00140) [ 3.81129]	4.93E-06 (1.4E-05) [ 0.36437]	0.007212 (0.00128) [ 5.62879]	1.193882 (0.40693) [ 2.93386]
IM(-3)	0.000739 (0.00105) [ 0.70230]	1.02E-05 (4.5E-06) [ 2.26531]	0.001741 (0.00267) [ 0.65244]	-7.00E-06 (2.6E-05) [-0.27156]	0.008989 (0.00244) [ 3.68531]	2.596540 (0.77466) [ 3.35186]
IM(-4)	0.000208 (0.00062) [ 0.33505]	4.99E-06 (2.7E-06) [ 1.87805]	-0.000727 (0.00158) [-0.46150]	-8.73E-06 (1.5E-05) [-0.57369]	0.002127 (0.00144) [ 1.47668]	0.497186 (0.45739) [ 1.08700]
C	-31.30283 (31.6259) [-0.98978]	0.071377 (0.13540) [ 0.52717]	-162.0533 (80.2387) [-2.01964]	1.898857 (0.77463) [ 2.45131]	364.3957 (73.3514) [ 4.96781]	72820.49 (23295.9) [ 3.12590]
R-squared	0.927940	0.999645	0.990975	0.994295	0.999488	0.977471
Adj. R-squared	0.770717	0.998870	0.971283	0.981849	0.998370	0.928316
Sum sq. resids	30.01619	0.000550	193.2129	0.018008	161.4676	16286464
S.E. equation	1.651891	0.007072	4.191040	0.040461	3.831302	1216.794
F-statistic	5.902066	1290.025	50.32382	79.88616	894.3236	19.88554
Log likelihood	-47.80971	148.5170	-81.32672	85.72677	-78.09593	-285.4837
Akaike AIC	4.044984	-6.862055	5.907040	-3.373709	5.727551	17.24909
Schwarz SC	5.144650	-5.762389	7.006706	-2.274043	6.827217	18.34876
Mean dependent	17.52000	3.814084	121.1825	3.404475	191.6031	3798.536
S.D. dependent	3.449811	0.210376	24.73141	0.300319	94.90226	4544.703
Determinant resid covariance (dof adj.)		5.070158				
Determinant resid covariance		0.004126				
Log likelihood		-207.6641				
Akaike information criterion		19.87023				
Schwarz criterion		26.46822				

**Table 5: Variance Decomposition**

Variance Decomposition of NPL:							
Period	S.E.	NPL	GAP	R1	LNI	CPI	IM
1	1.651891	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000
2	1.961812	77.80225	2.370426	2.148658	9.477751	7.296091	0.904822
3	2.069177	72.73671	2.172078	2.434753	14.22463	6.958303	1.473521
4	2.564341	47.35856	17.34826	1.585257	20.08766	5.577906	8.042361
5	2.844979	38.62945	17.20202	3.457258	26.13821	4.717789	9.855273
6	3.286110	29.00576	19.60245	2.681879	35.44115	4.953608	8.315156
7	3.573568	24.65986	17.73588	2.753507	42.09088	5.652366	7.107504

8	3.708467	22.94310	16.78183	2.884405	44.46057	6.296266	6.633823
9	3.800234	24.83915	16.08574	2.797090	43.55406	6.097729	6.626234
10	3.933700	25.39695	15.60267	2.617310	43.01736	6.378587	6.987128

Variance  
Decomposition  
of GAP:

Period	S.E.	NPL	GAP	R1	LNI	CPI	IM
1	0.007072	5.975084	94.02492	0.000000	0.000000	0.000000	0.000000
2	0.020957	18.28232	79.85245	0.371001	1.412923	0.081298	1.26E-05
3	0.040514	23.53720	73.12566	1.201525	1.511053	0.417669	0.206888
4	0.061978	27.39299	67.25011	2.556574	0.822564	0.950779	1.026983
5	0.082713	31.03563	59.64257	4.133500	0.652915	1.840456	2.694920
6	0.102254	34.20160	49.62890	5.325256	2.708337	3.166462	4.969453
7	0.122172	35.55956	38.26506	5.539333	8.367140	4.798536	7.470379
8	0.144198	34.58476	28.02612	4.892797	16.47558	6.261326	9.759416
9	0.168117	32.17911	20.61888	3.998920	24.16645	7.290941	11.74570
10	0.192298	29.39510	15.85673	3.271032	29.98728	7.925011	13.56486

Variance  
Decomposition  
of R1:

Period	S.E.	NPL	GAP	R1	LNI	CPI	IM
1	4.191040	31.70217	31.23794	37.05989	0.000000	0.000000	0.000000
2	5.626166	30.82529	17.47728	30.00225	18.67211	2.663310	0.359760
3	6.684707	32.88874	12.45449	22.05463	16.00827	1.929395	14.66448
4	9.449725	33.09189	6.926101	14.56075	9.833394	5.061459	30.52641
5	12.81526	34.04252	5.552512	11.23249	20.58225	7.978751	20.61148
6	16.45892	29.94386	4.201757	7.820857	35.22027	9.704378	13.10887
7	20.04864	27.12578	3.030962	5.361942	44.27465	10.94503	9.261644
8	22.92149	23.12898	2.346740	4.103082	50.60110	12.24254	7.577565
9	24.62879	20.03506	2.054915	3.573455	55.60253	11.81943	6.914610
10	25.07328	19.48564	2.305055	3.450445	56.38678	11.42855	6.943531

Variance  
Decomposition  
of LNI:

Period	S.E.	NPL	GAP	R1	LNI	CPI	IM
1	0.040461	7.394490	23.11876	3.382986	66.10377	0.000000	0.000000
2	0.071566	17.57246	12.60477	1.143736	53.16501	3.458575	12.05545
3	0.110615	14.82938	10.02723	0.479488	50.87446	6.856766	16.93269
4	0.138229	12.47685	8.531234	0.317487	47.85894	12.76154	18.05395
5	0.167008	8.678153	8.217464	0.217970	54.13736	11.57810	17.17096
6	0.173067	8.104313	8.716183	0.297241	54.96814	11.51904	16.39508
7	0.176782	7.832544	8.359965	0.322801	55.80303	11.61237	16.06929
8	0.182564	7.344763	9.372548	0.787051	53.81826	11.57575	17.10163

9	0.190172	6.857053	13.37458	1.175809	49.63951	10.68453	18.26851
10	0.199175	6.607584	16.15150	1.076691	47.22462	10.46978	18.46982

Variance  
Decomposition  
of CPI:

Period	S.E.	NPL	GAP	R1	LNI	CPI	IM
1	3.831302	32.93669	0.016916	7.155915	2.270450	57.62003	0.000000
2	6.693728	12.56122	1.692654	6.707499	44.96788	33.59465	0.476100
3	7.819701	9.313944	2.014984	7.649316	33.96093	24.77114	22.28969
4	10.34336	7.173129	2.463125	8.165815	27.62179	16.54527	38.03087
5	11.69806	7.320693	3.614652	9.524362	26.01870	13.03167	40.48992
6	12.13190	6.820407	5.716160	10.31006	25.39165	13.70679	38.05494
7	12.26920	6.673629	5.614671	10.09512	26.99298	13.41554	37.20806
8	12.54788	8.885592	6.564282	9.756211	25.91466	13.06255	35.81670
9	13.75429	11.27732	10.21536	8.268629	25.96752	13.89967	30.37151
10	17.59242	8.049117	9.743794	5.811158	37.53338	17.48889	21.37365

Variance  
Decomposition  
of IM:

Period	S.E.	NPL	GAP	R1	LNI	CPI	IM
1	1216.794	12.25923	5.611165	7.427466	15.84801	14.06423	44.78990
2	1960.185	31.77467	6.953901	3.799121	25.71548	7.633542	24.12328
3	2423.094	20.82640	4.661650	2.564404	37.75718	10.57305	23.61732
4	2596.054	18.21426	5.486950	2.386288	41.10705	10.27841	22.52704
5	2631.739	20.03593	5.400365	2.417972	40.06281	10.11787	21.96505
6	2682.980	21.10965	5.481989	2.358706	38.56390	9.783382	22.70237
7	2794.842	19.51869	9.796281	2.407410	35.69820	9.916874	22.66255
8	2859.214	19.36429	11.20193	2.319467	35.82019	9.498883	21.79524
9	2989.822	17.98248	11.90770	3.092444	35.92525	10.82910	20.26303
10	3074.863	17.21509	11.26545	3.756781	36.66917	11.92769	19.16582

Cholesky  
Ordering: NPL  
GAP R1 LNI  
CPI IM