EFFECTS OF SOUTH AFRICAN MONETARY POLICY IMPLEMENTATION ON THE CMA: A PANEL VECTOR AUTOREGRESSION APPROACH

Monaheng Seleteng (Ph.D)
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Abstract

The paper investigates the effects of South African monetary policy implementation on selected macroeconomic variables in the rest of the Common Monetary Area (CMA) looking specifically at the response of a shock to South African key interest rate (repo rate) on macroeconomic variables such as the regional lending rates, interest rate spread, private sector credit, money supply, inflation and economic growth in the rest of the CMA countries. The analysis is conducted using impulse-response functions derived from Panel Vector Autoregression (PVAR) methodology. The estimates are conducted using annual data for a panel of four CMA countries for the period 1980 – 2012. The results show that a positive shock to South African repo rate significantly affects lending rates, inflation and economic growth in the entire CMA countries. South African repo rate has more impact on lending rates in the entire CMA. This is then followed by the impact on inflation and then economic growth.

Keywords: Monetary Policy, Transmission Mechanism, Interest rates, Impulse-Response Functions, PVAR Model, Variance-Decomposition.

JEL Classification: C3, E43, E47, E52, E58, E61

1.1 Introduction

Monetary policy is regarded as a key element of macroeconomic policy and its effective conduct is critical to economic performance and prospects. It is therefore widely accepted among economists that the primary objective of monetary policy is to achieve and maintain price stability. However, there are different schools of thought as to how this objective can be achieved effectively. Therefore, different central banks have adopted various regimes in order to achieve and maintain price stability, namely; exchange rate targeting, monetary targeting, eclectic monetary targeting and inflation targeting. In recent years, a growing number of countries have adopted the inflation targeting (IT) as their monetary policy framework. The adoption of this framework has been a good development in the approach of various central banks around the globe to the conduct of monetary policy. New Zealand was the first country to implement this strategy in 1990 and this was then followed by other central banks in developed and emerging markets, and many more are considering adopting this new framework in the future.

Like other countries, South Africa (SA) through its central bank, the South African Reserve Bank (SARB), adopted the IT monetary policy framework in February 2000. The IT framework in SA is based on inflation expectations and hence it is forward looking in the sense that a specific target for inflation has to be met within a predetermined time. Over the past decades, the other countries in the CMA[1] have harmonised their monetary and exchange rate policies. Lesotho, Namibia and Swaziland (LNS) countries have pegged their respective national currencies to the South African rand, and as long as SA pursues a price stability objective, the impact will be transmitted to these countries and their economies will be affected. The CMA arrangement has therefore prevented the LNS countries from exercising discretionary monetary policies. This framework is in practice a *de facto* monetary policy framework for the CMA as a whole. Needless to say, the CMA arrangement resembles an asymmetric monetary union, with bigger country, SA, responsible for monetary policy formulation and implementation. The SA repo rate has direct effects on other variables in the South African economy, such as other interest rates, the exchange rate, money and credit, other assets prices and decision on spending and investment (Smal and Jager, 2001). Due to the close economic and financial linkages between SA and the LNS countries, the effects of monetary policy implementation in SA may have implications for the LNS countries. Therefore, the monetary policy stance in SA may have spill-over effects onto the rest of the CMA neighbouring economies such as Lesotho. This study therefore seeks to

[1] CMA: Lesotho, Namibia, South Africa and Swaziland

look at the effects of SA's monetary policy implementation on key macroeconomic variables in the rest of the CMA.

Economists are still uncertain about the effects of monetary policy on economic activity and prices. Therefore, the subject of monetary policy transmission mechanism has received growing interest among researchers, economists and central bankers, with the result that a large body of theoretical and empirical studies have emerged. This includes among others, Mishkin (1995), Taylor (1995), Peersman (2001), and Smal & Jager (2001). Recent empirical and theoretical studies mainly focused on the United States economy, and tend to converge on the view that contractionary monetary policy shocks lead to a temporary decrease in output and to a gradual decline in prices.

Closer economic linkages among countries warrant increased exposure to shocks, both positive and negative, in partner countries. Hence, developments in one economy can spill-over to other countries through several channels, depending on the depth of the underlying economic linkages (IMF, 2012). The IMF highlights these channels as: (i) trade in goods and services; (ii) financial sector interconnections; (iii) flow of capital; (iv) labour movements and remittance flows. Furthermore, institutional factors can also play a role: examples may include, as already indicated, the CMA arrangement. The paper focuses on the financial sector interconnections channel which is a premise of the institutional arrangement within the CMA agreement. We closely follow the framework of Mishkin (1995) which represents the interest rate channel as follows:

$$\uparrow repo \rightarrow \uparrow interest\ rates \rightarrow (\downarrow Investment, \downarrow Consumption) \rightarrow \downarrow Output$$

The above relationship is expected to hold even for the rest of the CMA countries. Given limited empirical evidence on the effects of South African monetary policy implications on macroeconomic variables in the LNS countries, the paper contributes to the body of knowledge by investigating the matter. The rest of the paper is organised as follows: section 1.2 discusses the stylized facts of key interest rates, interest rate spread, private sector credit extension, money supply, inflation and economic growth in the CMA. Section 1.3 deals with the literature review on the subject matter, while section 1.4 contains the empirical framework. Empirical results are discussed in section 1.5 and section 1.6 concludes.

1.2 Stylized Facts

The prime lending interest rates in the region move in line with the South African lending rates with Lesotho depicting the higher rates than the rest of the region from 1999 onwards. This trend is in line with expectations given the fact that SA conducts the monetary policy for the entire region under the CMA agreement. In terms of the spread between deposit rate and lending rate from 1980 to 2012, the narrowest margin has generally been observed in SA and widest in Lesotho. The interest rate spread for the rest of the other CMA countries has remained low and the trend followed that experienced in SA.

On the private sector lending front, SA has been the biggest lender to the private sector in the region followed by Namibia. Lesotho has been the smallest lender to the private sector since 2003. This proves the fact that the commercial banks in Lesotho although being highly liquid, tend to transfer their excess liquidity funds to their parent companies in SA, rather than lending these funds to the private sector. However, there has been some noticeable improvement since 2003. In terms of broad money supply, for most of the years, SA continuously registered the highest broad money supply as a share of GDP in the CMA followed by Namibia, then Lesotho. Swaziland continued to register the lowest money supply throughout the years. The money supply in Lesotho and Swaziland continued to be below the CMA average.

On the economic activity front, the real economic trends in the CMA follow each other closely, largely attrubutable to the close trade linkages between these countries. All these countries experienced recession between 2008 and 2009, largely due to global financial crisis. However, all the member countries recovered from global financial crisis after 2009 with an exception of Swaziland, which continued to experience recession afterwards. Refer to the appendix for graphical representation of these stylized facts.

1.3 Literature Review

There is limited empirical evidence or studies investigating any impact of a shock in one variable in one country on other variables in another country or region. Hence to the best of our knowledge, empirical literature has hardly given any attention to effects of a change in the SA repo rate to lending rates, private sector credit, money supply, inflation and economic growth in the CMA.

Peersman and Smets (2001) applied identified VAR methodology to synthetic Euro Area data from 1980 to 1998 to study the macroeconomic effects of an unexpected change in monetary policy in the Euro Area. The findings revealed that a temporary rise in the nominal and real short-term interest rate tends to be followed by a real appreciation of the exchange rate and a temporary fall in output. Prices were found to be more sluggish and only start to fall significantly below zero several quarters after GDP. The findings further revealed a slow negative response of broad money and an immediate and negative effect on credit to the private sector. In a similar token, Peersman and Mojon (2001) investigated the effects of monetary policy shock in 10 countries of the Euro Area for the pre-European Monetary Union (EMU) period using Vector Autoregressions (VARs) techniques over the same period 1980-1998. The findings depicted that a contractionary monetary policy shock leads to a temporary fall in GDP that peaks typically around four quarters after the shock and to a gradual decrease in the price level.

De Angelis *et al.* (2005) examined the influence of repo rate on the interbank lending rate and analysed the transmission channels of interest rates before and after the adoption of the repo system in SA in September 2001. The Granger-Causality tests were employed in the Error Correction Mechanism (ECM) framework and the results revealed that the influence of repo rate on the interbank rate was stronger before the adoption of the new system.

In literature, studies investigating the spill-over effects of a policy shock in one country to other countries are scarce. Beetsma *et al.* (2006) investigated the trade spill-overs of fiscal policy among 14 European Union (EU) countries for the period 1965 – 2004 using a Panel Vector Autoregression (PVAR) technique. In particular, the study estimates the overall effect of domestic fiscal impulses on exports by trading partners in Europe in two steps. Firstly, they estimated the link between domestic fiscal impulse and domestic output (referred to as fiscal block), and secondly they estimated the link between foreign exports and domestic output (referred to as trade block). By combining these two links, they were able to quantify the overall effect of a domestic fiscal impulse on foreign exports. Therefore, firstly for the fiscal block, their study used a PVAR model in which responses of output to the fiscal shocks were traced out. Secondly, for the trade block, they used a panel trade model based on the gravity approach and then estimated the dynamic responses of bilateral exports by the EU trading partners to domestic output.

Mirdala (2009) estimated structural VAR model for the countries from the Visegrad group[2] with the objective of analysing the impact of the central banks' monetary policy on selected macroeconomic variables, in particular on; the real GDP, inflation, M3, interest rates and real effective exchange rate during the period 1999-2008. The findings revealed that a positive

[2] Czech Republic, Hungary, Poland and Slovak Republic

monetary policy shock has high impact on the GDP variability implying that the real GDP is rather sensitive to changes in the monetary policy impulses. The findings on the impact on inflation developments are rather mixed. For some countries, the positive monetary policy shock caused the decrease in the inflation while for some countries the positive monetary policy shock caused an increase in the inflation.

Ikhide and Uanguta (2010) used the Vector Autoregression (VAR) framework to trace the impact of SARB's monetary policy on the LNS economies. In particular, the study examined how a change in the policy instrument of the SARB affects money, credit and level of prices in the LNS economies and consequently assessed the capability of these economies to undertake independent monetary policy. The findings showed that the lending rates, level of prices and money supply respond instantaneously to changes in the repo rate. Furthermore, the findings confirmed that the SA repo rate is indeed a relevant policy instrument for the LNS countries as opposed to these countries' respective central bank rates.

The focus of the paper is to investigate the SA monetary policy spill-overs to the rest of the CMA region for the period 1980 – 2012 using a PVAR model. In particular, the study focuses on the response of a shock to South African repo rate on the regional lending rates, interest rate spread, private sector credit, money supply, inflation and economic growth in the rest of the CMA region. As discussed in section 1.1, an advantage of focusing on CMA countries is that this helps to limit the potential heterogeneity as these economies share many similarities.

1.4 EMPIRICAL ANALYSIS

The analysis is based on annual data for five countries obtained from the World Bank Development Indicators (WDI) and IMF International Financial Statistics (IFS) for the period 1980 to 2012. This implies that N = 4 and T = 33 (N > T), hence we have N×T = 132 observations, therefore a use of panel time series is appropriate. The variables used in the model include; SA repo rate, lending rate, private sector credit extension as a share of GDP, broad money supply as a share of GDP, inflation and real economic growth rate.

Before estimating the model, the time series is tested for stationarity. We use Im, Pesaran and Shin (2003) (IPS) and the Levin, Lin and Chu (2002) (LLC) specifications to test for the presence of a unit root in the panel. The LLC test assumes a common ρ for all cross-sections as opposed to the IPS which assumes individual ρ_i's for cross-sections. Im, Pesaran and Shin (2003) used

Monte-Carlo simulation and compared IPS and LLC, under the assumption of no cross-sectional correlation in panels and their findings revealed that the IPS test is more powerful than the LLC test. Therefore, IPS generally would be the preferred test. Furthermore, as highlighted by Hoang and Mcnown (2006), even though the IPS test requires a balanced panel, it is the most often unit root test used in practice. Table 1 shows that all the variables are stationary in levels, with an exception of South African repo rate, private sector credit extension and broad money supply[3]. These variables are integrated of order one, I(1), hence they are used in their first differences in the PVAR estimation.

Table 1: Panel Unit Root Tests[4]

	SA_repo	*Lrate*	*Intspr*	*lpvtcrd*	*Lm2*	*Linfl*	*lgrowth*
IPS W-stat							
Levels	0.29	-1.28[a]	-1.57[a]	0.66	0.29	-1.58[b]	-3.29[a]
[P-value]	[0.61]	[0.09]	[0.05]	0.75	[0.62]	[0.06]	[0.00]
Differences	-5.04[a]	-7.87[a]	-5.22[a]	-4.15[a]	-5.57[a]	-5.68[a]	-8.12[a]
[P-value]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
LLC t*-stat							
Levels	1.17	-0.57	-1.49[b]	-0.48	0.06	-1.78[a]	0.39
[P-value]	[0.88]	[0.28]	[0.07]	[0.31[	[0.52]	[0.04]	[0.65]
Differences	-4.05[a]	-8.92[a]	-3.77[a]	-2.27[a]	-5.97[a]	-2.00[a]	-2.66[a]
[P-value]	[0.00]	[0.00]	[0.00]	[0.01]	[0.00]	[0.02]	[0.00]

[a]/[b]/[c] denotes significance at 1%, 5% and 10%, respectively. All variables are in logarithm form. [*p*-values] are in square brackets.

1.4.1 Panel Vector Autoregression Model

This section describes the model specification being used to assess the response of lending rate, interest rate spread, private sector credit, broad money supply, inflation and economic growth in other CMA countries due to a shock to South African repo rate. The paper adopts the PVAR approach which controls for heterogeneity and endogeneity in a panel framework. Vector autoregression models (VAR) introduced by Sims (1980) are considered the reference in econometric modelling of the monetary policy transmission mechanism. As argued by Fry and Pagan (2005), this class of models offers the ideal combination between the data-based approach and the coherent approach based on economic theory. A PVAR combines the VAR approach,

[3] For graphical inspection of the data, refer to the appendix
[4] Refer to appendix for variable description

which treats all variables in the system as endogenous, with a panel data approach, which allows for unobserved heterogeneity[5] (Love and Zicchino, 2006).

In this paper we use a Panel Vector Autoregression (PVAR) developed by Holtz-Eakin *et al.* (1988) to generate impulse-response functions that we then use to analyse the impact of shocks to the South African key interest rate (repo rate) on other variables in the other CMA countries. The PVAR technique allows for country-specific heterogeneity. Zuniga (2011) points out that the PVAR model offers advantages over other methods because it accounts for dynamics in the system and endogeneity problems. Therefore, the impulse-response functions derived from this technique show the response of (lending rate, interest rate spread, private sector credit extension, broad money supply, inflation and economic growth in other CMA countries) to an orthogonal shock from another variable of interest (South African repo rate), hence identifying the response of the impact of one shock at a time. Furthermore, impulse-response functions derived from PVAR estimations provide more understanding of the impact of monetary policy than the statistical results (Bernanke and Gertler, 1995).

Due to the limited time-span of data for countries in the CMA region, using a single VAR model will not be appropriate since this compromises the degree of freedom. A PVAR allows us to overcome this problem. In our analysis, a standard PVAR model is made up of seven equations for (*SA repo, lrate, intspr, pvtcrd, m2, infl* and *growth*) as follows:

$$SA\_repo_{it} = \beta_{1,0} + \sum_{i=1}^{s} \beta_{1,i}\, SA\_repo_{i,t-1} + \sum_{i=1}^{s} \theta_{1,i}\, lr_{i,t-1} + \sum_{i=1}^{s} \alpha_{1,i}\, intspr_{i,t-1} + \sum_{i=1}^{s} \rho_{1,i}\, pvtcrd_{i,t-1} + \sum_{i=1}^{s} \gamma_{1,i}\, m2_{i,t-1} + \sum_{i=1}^{s} \eta_{1,i}\, infl_{i,t-1} + \sum_{i=1}^{s} \varphi_{1,i}\, gr_{i,t-1} + \mu_{1,it} \quad (1.1)$$

$$lrate_{it} = \beta_{2,0} + \sum_{i=1}^{s} \beta_{2,i}\, SA\_repo_{i,t-1} + \sum_{i=1}^{s} \theta_{2,i}\, lr_{i,t-1} + \sum_{i=1}^{s} \alpha_{2,i}\, intspr_{i,t-1} + \sum_{i=1}^{s} \rho_{2,i}\, pvtcrd_{i,t-1} + \sum_{i=1}^{s} \gamma_{2,i}\, m2_{i,t-1} + \sum_{i=1}^{s} \eta_{2,i}\, infl_{i,t-1} + \sum_{i=1}^{s} \varphi_{2,i}\, gr_{i,t-1} + \mu_{2,it} \quad (1.2)$$

$$intspr_{it} = \beta_{3,0} + \sum_{i=1}^{s} \beta_{3,i}\, SA\_repo_{i,t-1} + \sum_{i=1}^{s} \theta_{3,i}\, lr_{i,t-1} + \sum_{i=1}^{s} \alpha_{3,i}\, intspr_{i,t-1} + \sum_{i=1}^{s} \rho_{3,i}\, pvtcrd_{i,t-1} + \sum_{i=1}^{s} \gamma_{3,i}\, m2_{i,t-1} + \sum_{i=1}^{s} \eta_{3,i}\, infl_{i,t-1} + \sum_{i=1}^{s} \varphi_{3,i}\, gr_{i,t-1} + \mu_{3,it} \quad (1.3)$$

$$pvtcrd_{it} = \beta_{4,0} + \sum_{i=1}^{s} \beta_{4,i}\, SA\_repo_{i,t-1} + \sum_{i=1}^{s} \theta_{4,i}\, lr_{i,t-1} + \sum_{i=1}^{s} \alpha_{4,i}\, intspr_{i,t-1} + \sum_{i=1}^{s} \rho_{4,i}\, pvtcrd_{i,t-1} + \sum_{i=1}^{s} \gamma_{4,i}\, m2_{i,t-1} + \sum_{i=1}^{s} \eta_{4,i}\, infl_{i,t-1} + \sum_{i=1}^{s} \varphi_{4,i}\, gr_{i,t-1} + \mu_{4,it} \quad (1.4)$$

[5] Thanks to Inessa Love for providing her STATA program for statistical calculations.

$$m2_{it} = \beta_{5,0} + \sum_{i=1}^{s} \beta_{5,i}\, SA\_repo_{i,t-1} + \sum_{i=1}^{s} \theta_{5,i}\, lr_{i,t-1} + \sum_{i=1}^{s} \alpha_{5,i}\, intspr_{i,t-1} + \sum_{i=1}^{s} \rho_{5,i}\, pvtcrd_{i,t-1} + \sum_{i=1}^{s} \gamma_{5,i}\, m2_{i,t-1} + \sum_{i=1}^{s} \eta_{5,i}\, infl_{i,t-1} + \sum_{i=1}^{s} \varphi_{5,i}\, gr_{i,t-1} + \mu_{5,it} \quad (1.5)$$

$$infl_{it} = \beta_{6,0} + \sum_{i=1}^{s} \beta_{6,i}\, SA\_repo_{i,t-1} + \sum_{i=1}^{s} \theta_{6,i}\, lr_{i,t-1} + \sum_{i=1}^{s} \alpha_{6,i}\, intspr_{i,t-1} + \sum_{i=1}^{s} \rho_{6,i}\, pvtcrd_{i,t-1} + \sum_{i=1}^{s} \gamma_{6,i}\, m2_{i,t-1} + \sum_{i=1}^{s} \eta_{6,i}\, infl_{i,t-1} + \sum_{i=1}^{s} \varphi_{6,i}\, gr_{i,t-1} + \mu_{6,it} \quad (1.6)$$

$$growth_{it} = \beta_{7,0} + \sum_{i=1}^{s} \beta_{7,i}\, SA\_repo_{i,t-1} + \sum_{i=1}^{s} \theta_{7,i}\, lr_{i,t-1} + \sum_{i=1}^{s} \alpha_{7,i}\, intspr_{i,t-1} + \sum_{i=1}^{s} \rho_{7,i}\, pvtcrd_{i,t-1} + \sum_{i=1}^{s} \gamma_{7,i}\, m2_{i,t-1} + \sum_{i=1}^{s} \eta_{7,i}\, infl_{i,t-1} + \sum_{i=1}^{s} \varphi_{7,i}\, gr_{i,t-1} + \mu_{7,it} \quad (1.7)$$

The standard PVAR model made up of equations (1.1 – 1.7) can be succinctly put in a matrix notation as follows:

$$Z_{it} = \Gamma_0 + \Gamma_1 \mathrm{Z}_{\mathrm{i,t-1}} + \Gamma_2 \mathrm{Z}_{\mathrm{i,t-2}} + \cdots + \Gamma_{\mathrm{s}} \mathrm{Z}_{\mathrm{i,t-s}} + \varepsilon_{\mathrm{it}} \quad (2)$$

where Z_{it} represents a (7×1) vector of system variables (*SA_repo, lrate, intspr, pvtcrd, m2, infl and growth*), Γ_0 is a (7×1) vector of constants, $\Gamma_{1,2,\ldots,s}$ is a (7×7) matrix of coefficient estimates, *E* is a (7×1) vector of system innovations, while *i* is a cross-sectional identifier and *s* is the optimal lag length of each variable selected in accordance with the Akaike Information Criterion (AIC) and Schwarz Bayesian Criterion (SBC). The lag length of 1 was adopted and shows a superior performance (see appendix for detailed results of lag length selection criteria).

The focus of the analysis is on the resulting impulse-response functions, which estimates the response of particular variables in the system to innovations in another variable in the system, while holding all other shocks at zero. However, the variance-covariance matrix of the errors is unlikely to be diagonal; therefore in order to isolate the shocks to one of the VAR errors it is necessary to decompose the residuals in such a way that they become orthogonal. In order to do this, PVAR uses a Cholesky decomposition of the variance-covariance matrix of residuals (Love and Zicchino 2006; Zuniga 2011). The convention is to adopt a particular ordering and allocate any correlation between the residuals of any two elements to the variable that comes first in the ordering. Therefore the assumption is that the variables at the beginning of the ordering contemporaneously affect variables that follow them, as well as with a lag, while the latter variables affect the former only with a lag.

The ordering of variables in a VAR has been a subject of much controversy in the literature since alternative orderings may influence the explanatory powers of our equations. It has been argued that the importance of a given variable in terms of extent to which its innovations influence other variables may depend critically on the arbitrary ordering that is chosen (Porter and Offenbacher, 1983). Our analysis assumes that the contemporaneous causal order runs from South African repo rate (*SA_repo*) to lending rates in the rest of CMA (*lrate*) to interest rate spread (*intspr*) to private sector credit extension (*pvtcrd)* to broad money supply (*m2*) to inflation (*infl*) and then to economic growth (*growth*). The fact that South African repo rate is placed first assumes that South African repo rate contemporaneously affect all variables in rest of the CMA region while the other variables affect South African repo rate only with a lag[5]. The choice of ordering is based on the premise that the announcement of the repo rate changes by the SARB evokes commercial banks movements in lending rates within 24 hours within the CMA. Therefore, putting the repo rate first means that it is assumed that this rate does not respond to any other variables within the current period, but that all other variables potentially respond to this rate contemporaneously (Ikhide and Uanguta, 2010).

The PVAR methodology imposes a restriction that there are common dynamics across cross-sectional units. However, this is likely to be violated in practice; therefore in order to overcome this, we have to allow for individual heterogeneity by means of fixed effects, denoted by $\mathcal{F}_{\mathrm{i}}$ in the model. Therefore the model in (2) becomes:

$$Z_{it} = \Gamma_0 + \Gamma_1 Z_{i,t-1} + \cdots + \Gamma_s Z_{i,t-s} + \mathcal{F}_i + \varepsilon_{it} \qquad (3)$$

The correlation between fixed effects and lagged regressors is avoided using a mean-differencing transformation referred to as Helmert transformation (Arellano and Bover, 1995). This Helmert tranformation removes the forward means and preserves the orthogonality, and therefore allows for the use of lagged regressors as instruments. The data series are time-demeaned before the Helmert transformation is carried out, since the model uses untransformed variables as instruments of the Helmert transformed variables. As a consequence, these allows for estimation of coefficients using System Generalized Method of Moments (SYS-GMM). Lagged values of *SA_repo, lrate, intspr, pvtcrd, m2, infl* and *growth* are used as instruments. Following Love and Zicchino (2006), the analysis uses the coefficient bands for the impulse-response functions as estimated by Monte Carlo simulation, with 1 000 being the number of repetitions used.

[5] As a robustness check, different orderings were used but the results remained more or less the same.

1.5 EMPIRICAL RESULTS

The coefficients of the PVAR estimation, which are used to construct the impulse response functions (IRFs) are depicted in Table 2 and the impulse-response graphs are presented in Figure 1. The continuous line represents the point estimate (response to a shock) of the impulse response and the broken lines represent the 90 per cent confidence bands.

Table 2: Dynamic Results

	GMM Estimates						
	Response of						
	SA_repo	*lrate*	*intspr*	*pvtcrd*	*M2*	*infl*	*Growth*
Response to:							
SA_repo (t-1)	1.06***	0.58**	0.12	-0.07	0.04	0.47**	1.35**
	[7.14]	[9.54]	[0.87]	[-0.77]	[0.64]	[1.89]	[1.91]
lrate(t-1)	-0.60***	-0.10	-0.09	0.01	-0.07	-0.38	-1.68
	[-2.47]	[-1.00]	[-0.45]	[0.04]	[-0.69]	[-0.95]	[-1.45]
intspr(t-1)	-0.28***	-0.04	-0.71***	-0.13*	-0.04	-0.31	1.68***
	[-2.17]	[-0.71]	[6.06]	[-1.68]	[-0.42]	[1.43]	[2.69]
pvtcrd(t-1)	-0.13	0.02	-0.02	0.79***	-0.01	-0.13	0.18
	[-1.36]	[0.61]	[-0.25]	[14.26]	[-0.36]	[-0.79]	[0.39]
m2(t-1)	-0.26*	-0.24***	-0.08	0.05	0.89***	0.40*	0.98
	[-1.73]	[-3.99]	[-0.59]	[0.61]	[15.06]	[1.65]	[1.39]
infl (t-1)	-0.01	-8.21	-0.06	-0.07**	0.0004	0.34***	-0.09
	[-0.09]	[-0.00]	[-1.21]	[-1.93]	[0.02]	[3.42]	[-0.34]
growth (t-1)	0.01	0.01***	0.01	0.02*	-0.01	0.01	-0.04
	[0.51]	[0.61]	[0.25]	[1.73]	[-1.03]	[0.27]	[-0.37]

Note: Seven-variable VAR model is estimated by GMM, country and time fixed effects are removed prior to estimation. Reported numbers show the coefficients of regressing the column variables on lags of the row variables. Heteroscedasticity adjusted t-statistics are in parentheses. ***/**/* denotes significance at 1%, 5% and 10%, respectively.

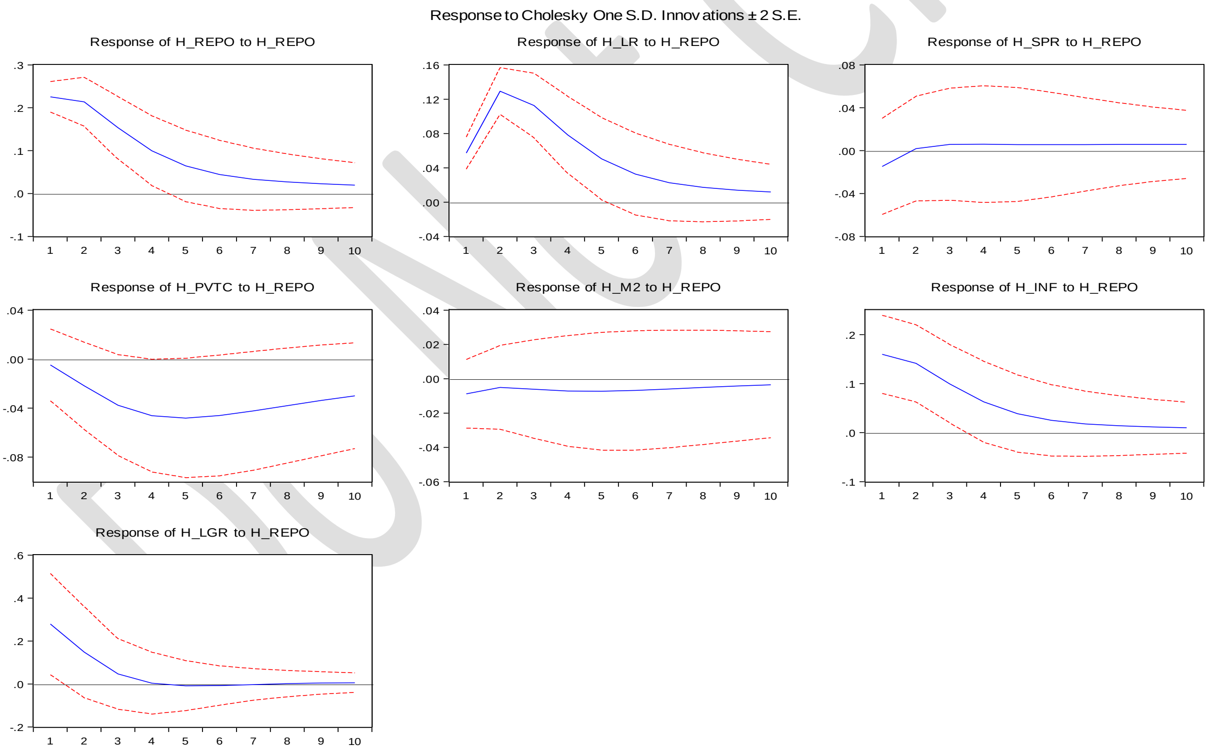
Dynamic results and impulse-responses are reported in Table 2 and Figure 1, respectively. Table 2 shows that a response of lending rate in the rest of the CMA region to a positive shock on the South African repo rate is positive and statistically significant. In particular, a 10 per cent increase in South African repo rate leads to about 0.6 per cent increase in the lending rates in the rest of the CMA region for up to five periods, after which it becomes statistically insignificant. Furthermore, the response of inflation in the CMA to a shock in SA repo rate is also positive and statistically significant for up to about four periods as depicted in Figure 1. This is in line with the findings by Smal and Jager (2001) that the lag varies between one and two periods[6], but

[6] Since our time series is on an annual basis, one period refers to one year.

with rapid financial market innovations and globalization, this lag may differ. It may be iterated that there are long lags in the transmission mechanism (i.e. between a change in the monetary policy stance and the rate of inflation) and it is important to note that these lags differ from country-to-country and also within the same country from time-to-time (Smal and Jager, 2001). The response of economic growth in the CMA region to a positive shock in SA repo rate is positive and statistically significant for one year only, after which it becomes insignificant. The interest rate spread, private sector credit extension and broad money supply seem not to respond to shock in the South African repo rate.

Figure 1 further shows that a one standard deviation shock to the South African repo rate results in an immediate and statistically significant increase in itself for up to about 4 periods after the shock, after which the impact becomes statistically insignificant.

Figure 1: Impulse Responses to South African Repo Rate Shock



In order to determine the ability of South African repo rate shocks to explain fluctuations in the variables of interest in the rest of the CMA, a standard variance decomposition exercise is conducted and the results are presented in Table 3

.

Table 3: Shocks and Variance Decomposition

Forecast Horizon (Years)	Fraction of Variance That Can Be Attributed to Shocks to:						
	SA_repo	lrate	intspr	pvtcrd	m2	infl	growth
A. SA repo							
10	70.04	5.39	15.75	5.69	1.92	1.09	0.11
20	69.29	5.31	15.90	6.20	1.97	1.22	0.11
B. lrate							
10	63.81	13.02	11.22	4.53	6.53	0.69	0.18
20	63.00	12.77	11.22	5.04	7.02	0.78	0.18
C. intspr							
10	0.55	5.99	87.48	0.74	3.38	1.77	0.08
20	0.69	5.80	85.38	0.95	5.34	1.72	0.10
D. pvtcrd							
10	17.25	3.97	1.96	69.79	2.78	3.09	1.14
20	18.74	3.57	1.86	67.19	4.44	3.16	1.04
E. m2							
10	1.02	0.37	8.30	3.15	85.81	0.28	1.07
20	0.96	0.34	9.65	2.79	84.69	0.41	1.15
F. infl							
10	24.54	2.69	16.34	2.24	4.81	49.14	0.23
20	23.84	2.60	17.06	2.32	6.19	47.69	0.29
G. growth							
10	7.59	0.15	9.99	1.05	2.05	0.38	78.77
20	7.60	0.17	9.99	1.09	2.06	0.39	78.72

Table 3 reports the results of variance decomposition and the estimates represent the percentage of variation in the row variable explained by the column variable. The first column shows the fraction of the 10 and 20 period-ahead forecast error that can be explained by South African repo rate shocks. South African repo rate has more impact on lending rates in the entire CMA region, accounting for about 63.8 per cent and 63.0 per cent of its short-run and long-run variance, respectively. This is then followed by the impact on inflation and private sector credit in the region, at about 24 per cent and 18 per cent, respectively both in the short-run and long-run. The table further illustrates that South African repo rate has a marginal impact on interest rate spread, broad money supply and economic growth in the CMA, accounting for about 0.6 per cent, 1.0 per cent and 7.6 per cent, respectively of its short-run and long-run variance. However, the decomposition of variance of South African repo rate indicates that this variable is most likely explained by its own variations at 70.0 per cent and 69.3 per cent of its short-run and long-run variance, respectively.

To test for stability of the PVAR model, a number of diagnostic tests were conducted. The results show no evidence of serial correlation and heteroscedasticity. Furthermore, the model also passes the normality test[7].

Box 1: Determination of policy rate in Lesotho

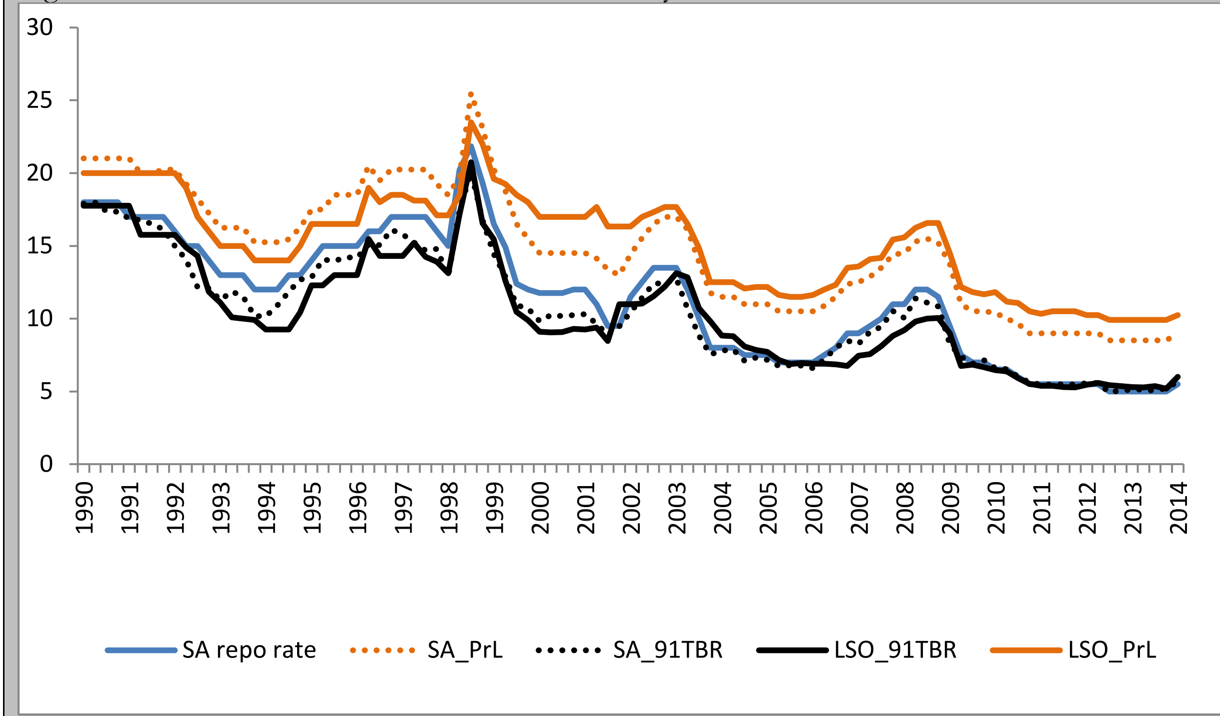
Background

Following the recommendations from the IMF Mission on Money and Capital Markets that visited Lesotho in November 2012, it was recommended that the Central Bank of Lesotho (CBL) needs to introduce a policy rate linked to the South African policy rate in order to provide market signals that would guide pricing in the credit market. Furthermore, the policy rate will ultimately assist in the management of the structural excess liquidity currently prevailing in the system. During that mission, the IMF recommended that the proposed policy rate should be linked to the South African monetary policy rate.

The focus of monetary policy in Lesotho is to ensure that domestic inflation remains in line with regional (particularly South African) inflation. This is achieved through the maintenance of the pegged exchange rate system. Therefore, monetary policy aims to ensure that the one-to-one peg is always backed by adequate level of foreign reserves. In the implementation of the monetary policy in Lesotho, the CBL takes reserve money as its operating target, 91-day Treasury bill rate as its intermediate target and net international reserves (NIR) as its ultimate target. The main instrument that is used to meet the reserve money target is the issuance of Government of Lesotho (GoL) 91-day Treasury bills. Considering the close relationship between monetary policy implementation in Lesotho and South Africa (SA), the CBL also closely monitors the Lesotho 91-day Treasury bill yields in comparison to its South African equivalent. Figure 1 shows that interest rates in the Lesotho move in line with the South African interest rates given the fact that SA conducts the monetary policy for the entire region under the CMA agreement.

[7] See appendix for detailed diagnostic tests results.

Figure 1: Lesotho and South African interest rates dynamics

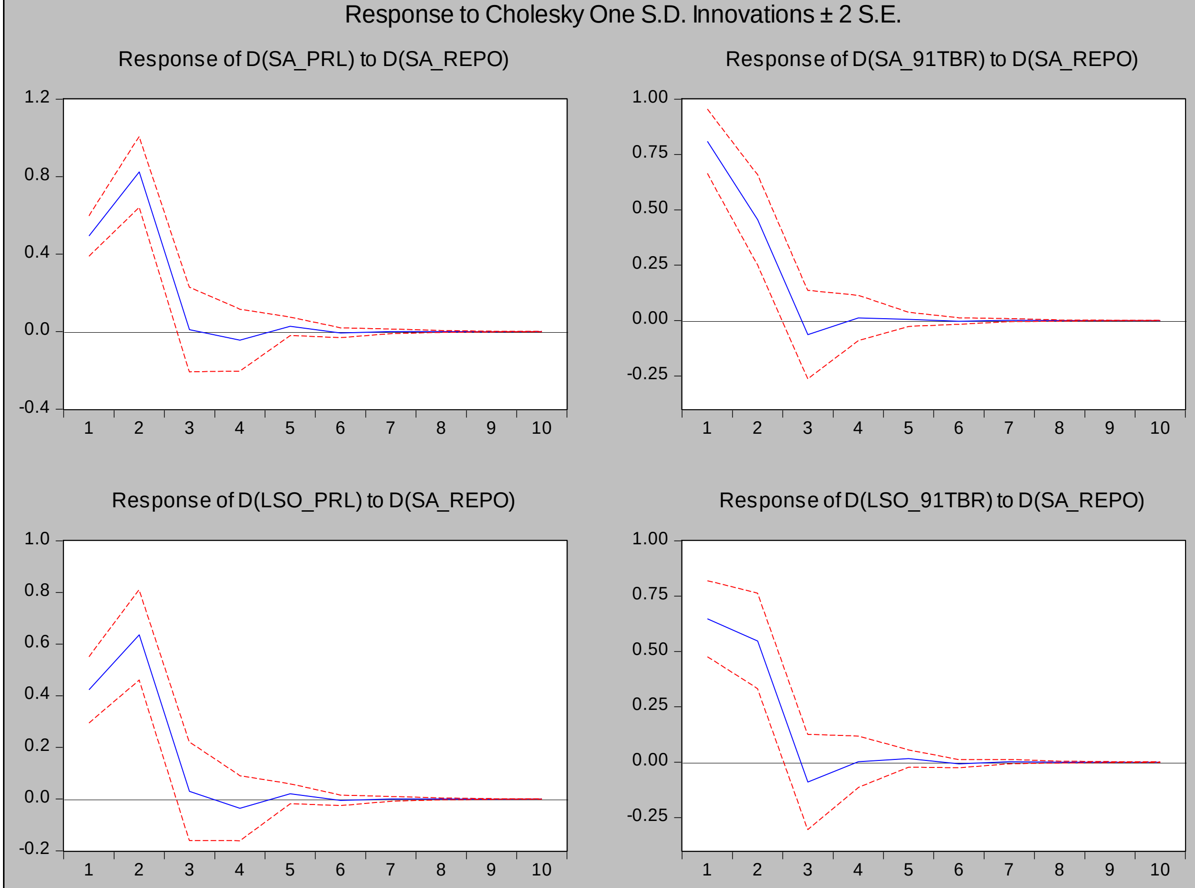


Source: South African Reserve Bank and Central Bank of Lesotho

Determining the Band

This brief analysis looks at the relationship between interest rates in Lesotho and South Africa and tries to determine a band/range for a policy rate in Lesotho. The proposed band depends largely on the transmission mechanism of South African monetary policy implementation into Lesotho. Quarterly data for the period 1990:QI – 2014:QI is used in the analysis and impulse-response functions are used to determine the magnitute of how the Lesotho interest rates react to a positive shock in the South African key interest rate (repo rate). This magnitute is then utilized to establish a band within which the Lesotho policy interest rate should be determined relative to the South African counterpart rate.

Figure 2: Impulse-Responses to South African Policy Rate Shock

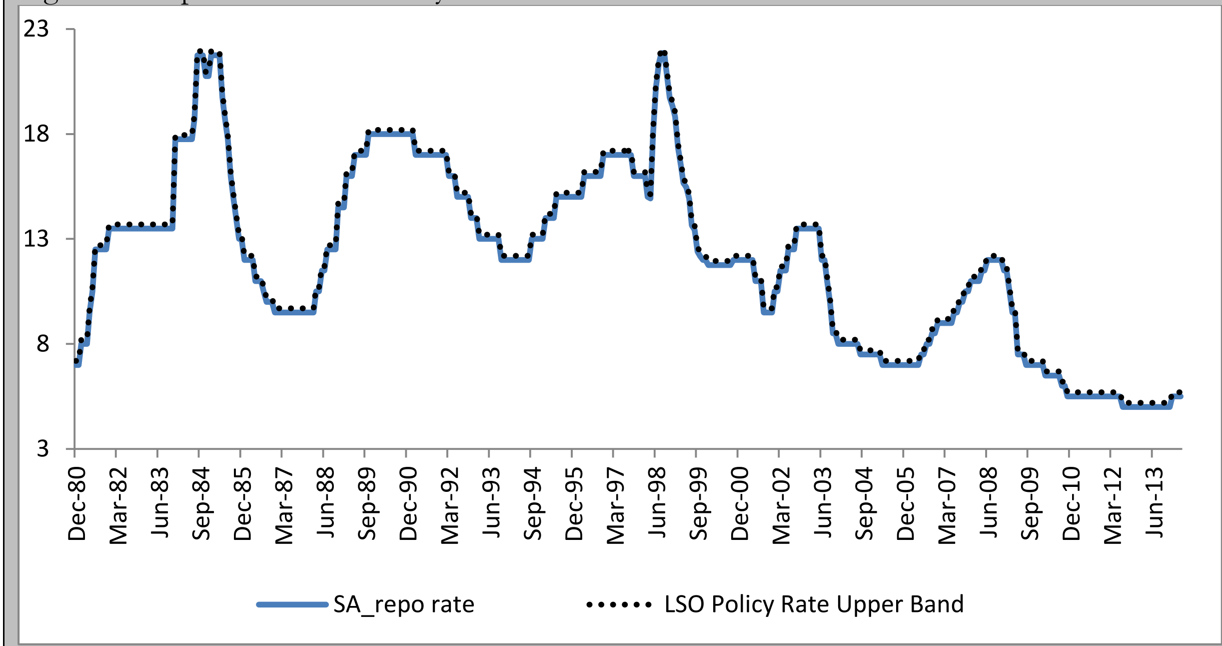


Looking at the impulse-responses of both SA and Lesotho prime lending rates to a positive shock in the SA repo rate, it can be observed that a positive shock to South African repo rate has an immediate and positive effect on prime lending rate in South Africa. A peak of 0.83 per cent is reached after two quarters following a shock. The impulse then drops rapidly and becomes insignificant after three quarters. Similarly, prime lending rate in Lesotho also reacts immediately and positively to a shock in the South African repo rate. In the case of Lesotho, a peak of 0.64 per cent is also reached after two quarters after which the effect drops quickly and becomes statistically insignificant. The differences in the peaks observed in both SA and Lesotho prime lending rates is 0.19 percentage points (19 basis points) which can be rounded up to 0.20 percentage points (20 basis points).

In a similar fashion, looking at the impulse-responses of both SA and Lesotho 91-day Treasury bill rates to a similar shock in the SA repo rate, it can be observed that a positive shock to South African repo rate also has an immediate and positive effect on 91-day Treasury bill rate in South Africa. A peak of 0.81 per cent is reached after one quarter following a shock. The impulse then drops rapidly and becomes insignificant after three quarters. In the same token, a peak of 0.65

per cent is also reached after one quarter after which the effect then drops quickly and becomes statistically insignificant. The differences in the peaks observed in both SA and Lesotho 91-day treasury bill rates is 0.16 percentage points (16 basis points) which can also be rounded up to 0.20 percentage points (20 basis points).

Figure 3: Proposed Lesotho Policy Interest Rate Band



Source: South African Reserve Bank and Author's calculations

Conclusion

A maximum of (+/- 0.20 percentage points) 20 basis points above the South African repo rate is proposed for the Lesotho policy rate. It is envisaged that this upper band is sufficient to give signals to the credit market in the country and also to address the structural excess liquidity currently prevalent in the country.

1.6 CONCLUSION

The purpose of the study was to assess the impact of SA monetary policy implementation on some selected macroeconomic variables in the rest of the CMA countries. More specifically, the study looked at the response of a positive shock to SA key interest rate (repo rate) on the lending rates, interest rate spread, private sector credit extension, money supply, inflation and economic growth in the LNS countries.

The impulse response results derived from estimating a seven-variable PVAR demonstrates that shocks to South Africa repo rate have statistically significant impact on lending rate, inflation and economic growth in the rest of the CMA region. The results further depict that South African repo rate has no significant impact on interest rate spread, private sector credit extension and broad money supply in the CMA. The findings are in line with the findings by Ikhide and Uanguta (2010), who also found that the lending rates and level of prices in the LNS countries respond instantaneously to changes in the SA repo rate. However, contrary to their findings, money supply was found not to respond instantaneously to a shock in the SA repo rate.

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APPENDIX

1. Variable Description

Abbreviation	Description	Source
SA_repo	South African Key Interest Rate (Repo Rate)	SARB
Lrate	Lending Rate	WDI
Intspr	Interest Rate Spread	WDI
Pvtcrd	Private Sector Credit Extension	IFS
M2	Broad Money Supply	IFS
Infl	Consumer price inflation	WDI
Growth	Real Economic Growth Rate	WDI

2. Graphical Inspection of Data

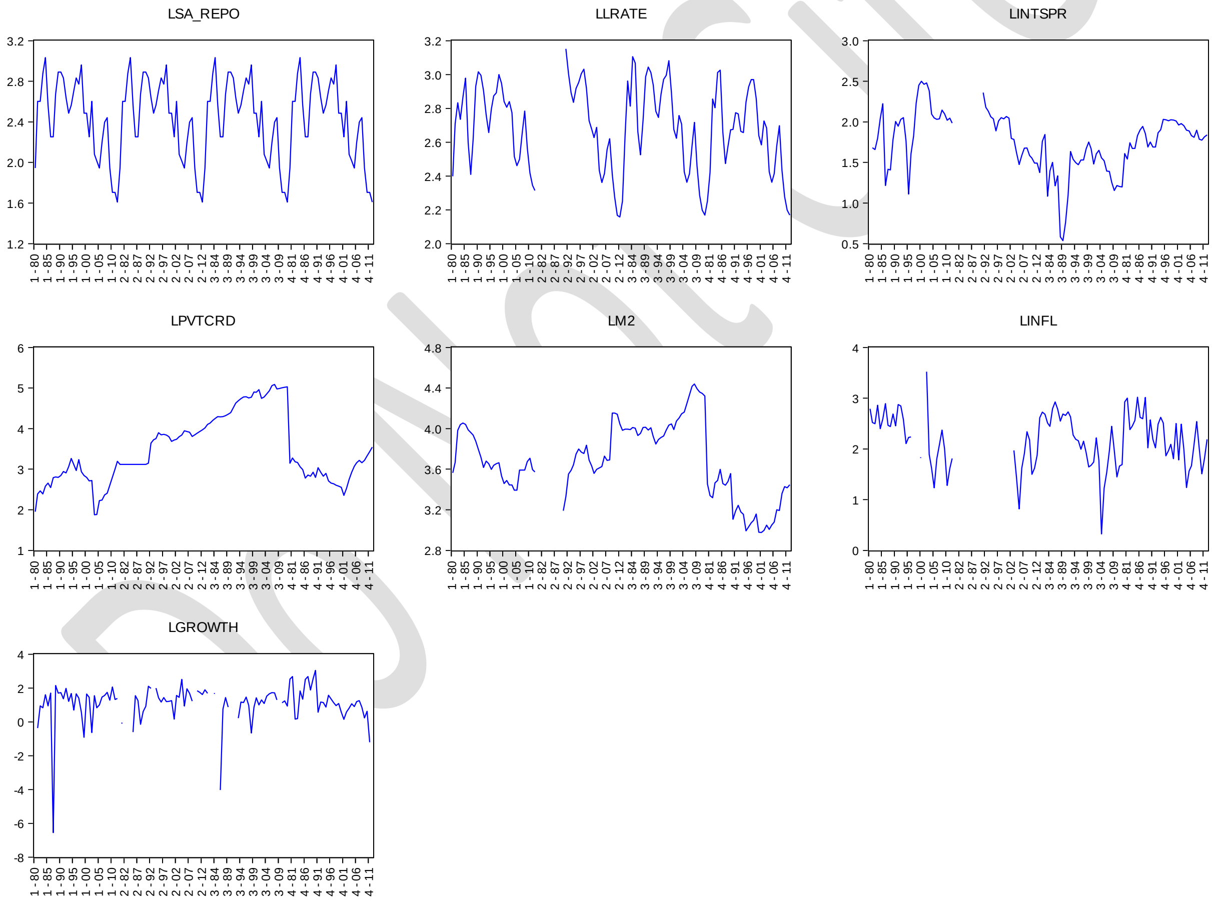


Figure 1: CMA Lending interest rates

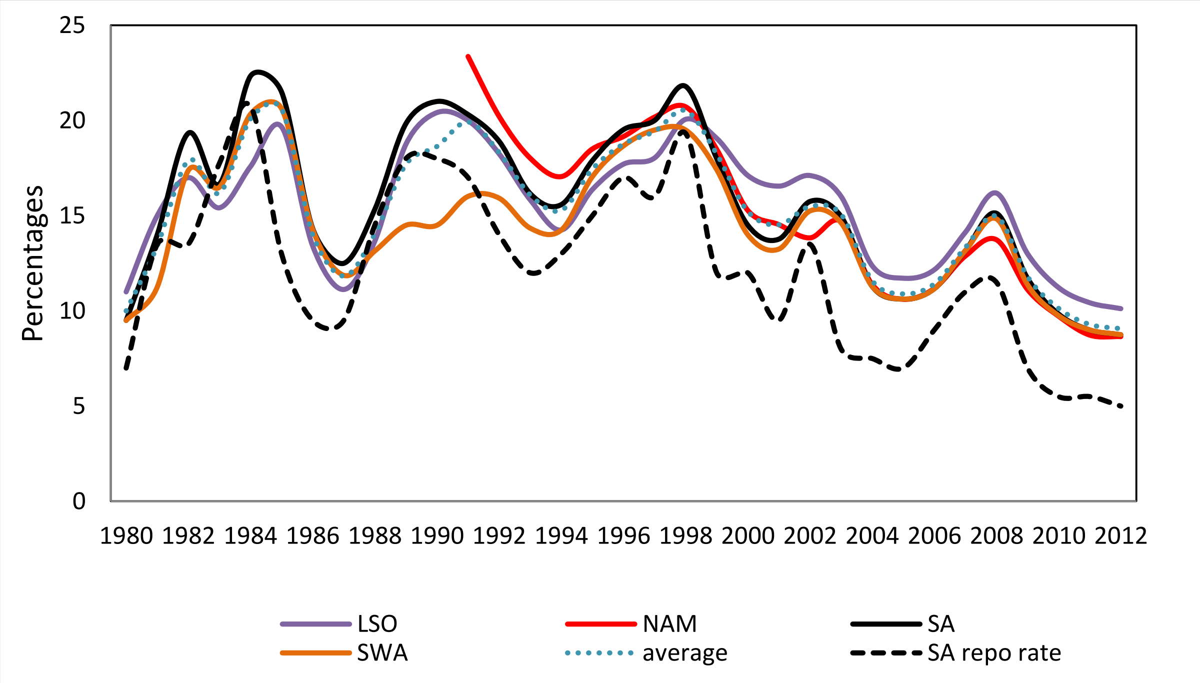


Figure 2: CMA Trends in Interest Rate Spread

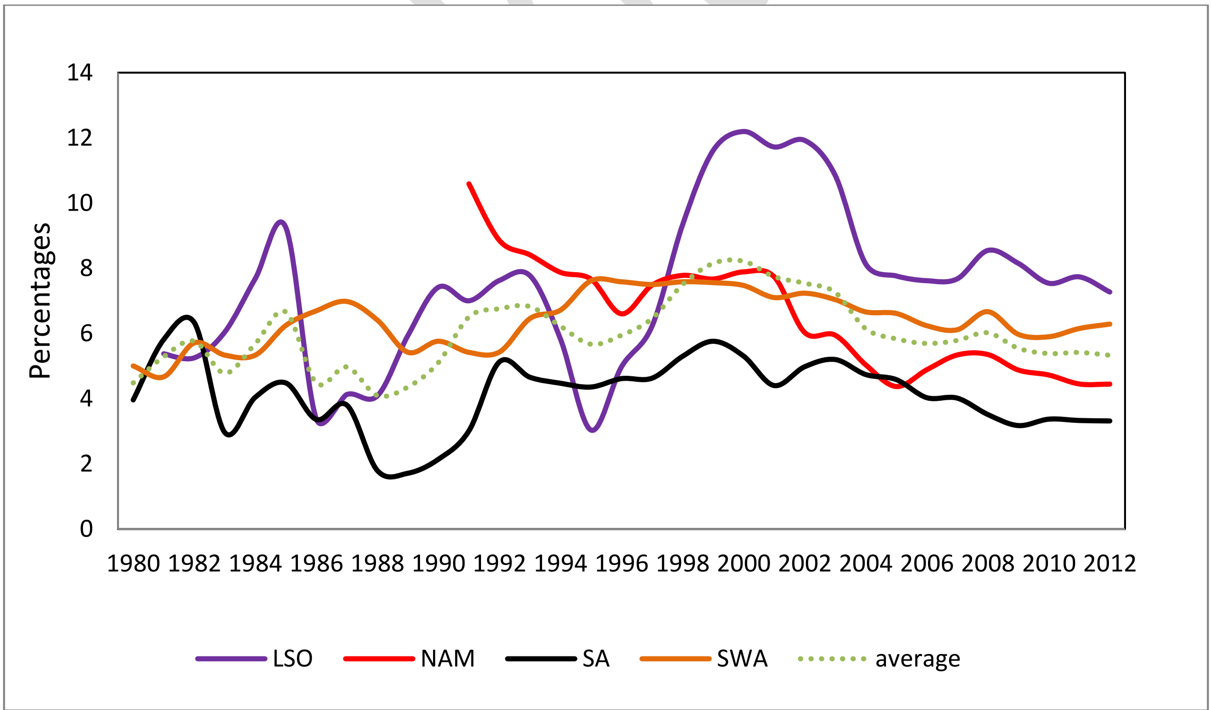


Figure 3: CMA Trends in Private Sector Credit Extension

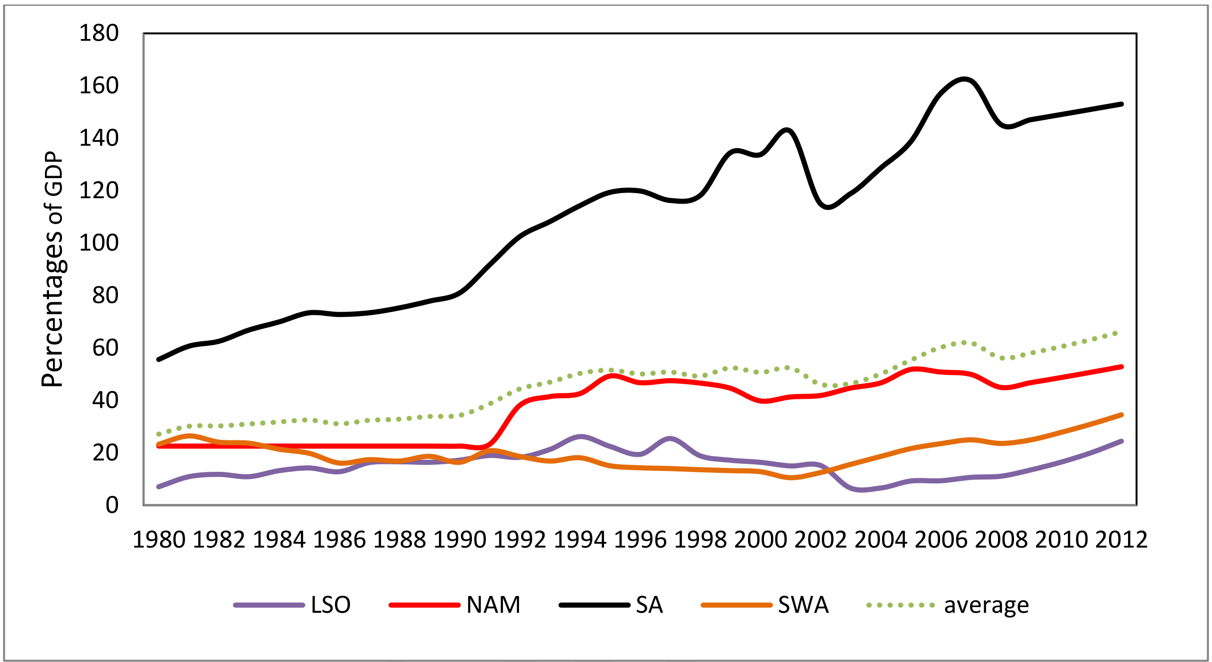


Figure 4: CMA Trends in Broad Money Supply

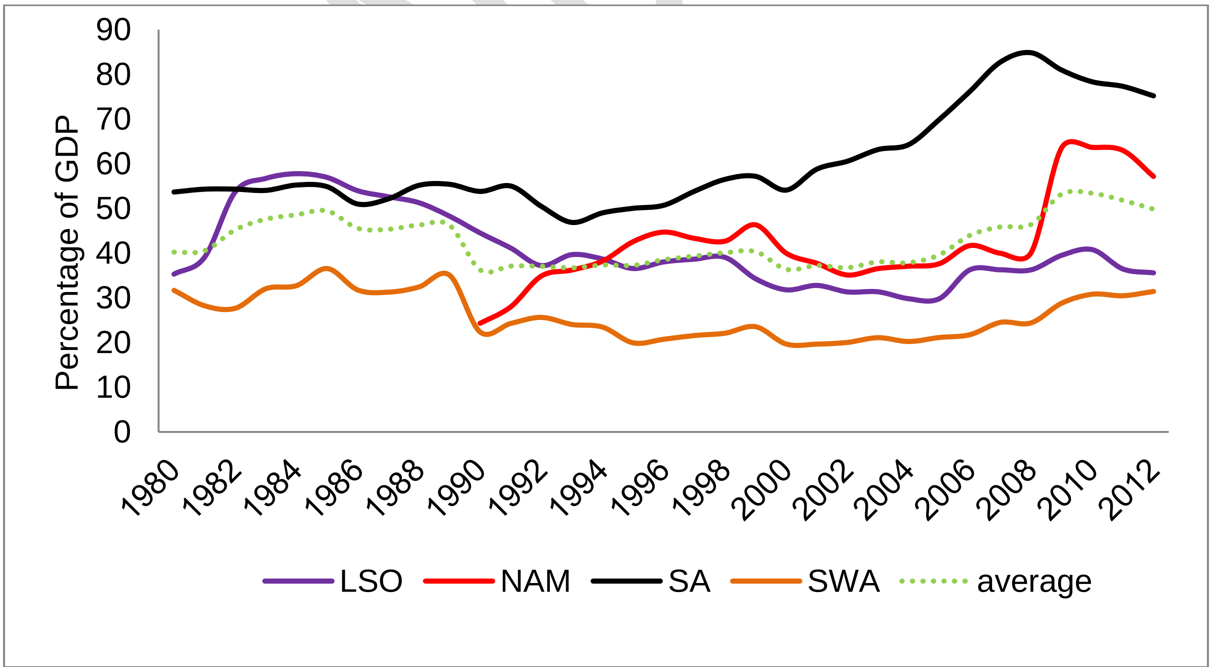
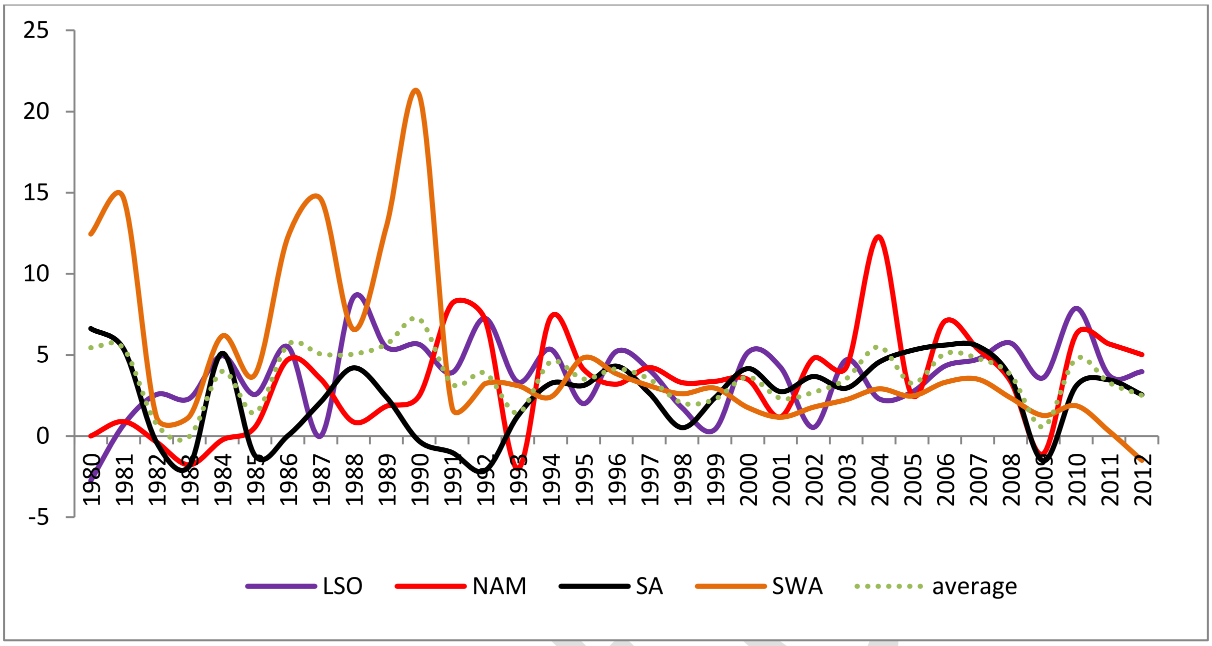


Figure 5: CMA Trends in Real Economic Growth



3. Descriptive Statistics

	SA_REPO	LRATE	INTSPR	PVTCRD	M2	INFL	GR
Mean	11.71	14.69	5.79	49.67	43.09	9.77	3.90
Median	12.00	14.50	5.42	23.67	39.50	8.93	3.33
Maximum	20.75	22.33	12.19	161.90	84.83	33.81	21.01
Minimum	5.00	8.65	1.70	6.53	19.63	-9.61	-2.13
Std. Dev.	4.31	3.54	1.95	46.16	16.39	5.38	3.61
Skewness	0.20	0.16	0.77	1.10	0.51	0.66	1.76
Kurtosis	2.06	2.11	4.41	2.80	2.56	6.63	8.17
Jarque-Bera	4.58	3.90	19.26	21.61	5.52	65.57	171.68
Probability	0.10	0.14	0.00	0.00	0.06	0.00	0.00
Sum	1229.64	1543.09	608.35	5215.74	4524.48	1026.42	409.54
Sum Sq. Dev.	1935.51	1309.94	399.02	221618.5	27947.46	3017.89	1357.32
Observations	105	105	105	105	105	105	105

4. Lag Length Selection Criteria

VAR Lag Order Selection Criteria
Endogenous variables: H_REPO H_LR H_SPR H_PVTC H_M2 H_INF H_LGR
Exogenous variables:
Sample: 1980 2012
Included observations: 59

Lag	LogL	LR	FPE	AIC	SC	HQ

1	129.5415	NA	1.55e-10*	-2.730221*	-1.004808*	-2.056690*
2	171.3614	63.79299	2.09e-10	-2.486826	0.963999	-1.139764
3	208.0717	47.28783	3.74e-10	-2.070226	3.106012	-0.049632
4	259.5498	54.09566	4.88e-10	-2.154230	4.747420	0.539895

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

5. Detailed VAR results

Vector Autoregression Estimates
Sample (adjusted): 1981 2011
Included observations: 80 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	H_REPO	H_LR	H_SPR	H_PVTC	H_M2	H_INF	H_LGR
H_REPO(-1)	1.059046	0.580792	0.115482	-0.066706	0.037526	0.465832	1.349207
	(0.14823)	(0.06090)	(0.13194)	(0.08613)	(0.05901)	(0.24579)	(0.70630)
	[7.14446]	[9.53736]	[0.87525]	[-0.77448]	[0.63591]	[1.89528]	[1.91025]
H_LR(-1)	-0.600105	-0.100123	-0.097398	0.006243	-0.066896	-0.382597	-1.676892
	(0.24252)	(0.09963)	(0.21586)	(0.14091)	(0.09655)	(0.40211)	(1.15553)
	[-2.47450]	[-1.00495]	[-0.45120]	[0.04430]	[-0.69289]	[-0.95146]	[-1.45119]
H_SPR(-1)	-0.284663	-0.037971	0.707038	-0.127966	-0.022020	-0.309849	1.679603
	(0.13107)	(0.05385)	(0.11667)	(0.07616)	(0.05218)	(0.21733)	(0.62454)
	[-2.17177]	[-0.70516]	[6.06025]	[-1.68024]	[-0.42200]	[-1.42569]	[2.68936]
H_PVTC(-1)	-0.130851	0.024402	-0.021090	0.794633	-0.013683	-0.126392	0.182608
	(0.09592)	(0.03941)	(0.08538)	(0.05574)	(0.03819)	(0.15905)	(0.45705)
	[-1.36413]	[0.61923]	[-0.24701]	[14.2573]	[-0.35832]	[-0.79467]	[0.39954]
H_M2(-1)	-0.256826	-0.242322	-0.077903	0.052761	0.886686	0.404245	0.982327
	(0.14785)	(0.06074)	(0.13160)	(0.08591)	(0.05886)	(0.24515)	(0.70447)
	[-1.73708]	[-3.98958]	[-0.59197]	[0.61417]	[15.0645]	[1.64898]	[1.39443]
H_INF(-1)	-0.005370	-8.21E-05	-0.064329	-0.066832	0.000431	0.337744	-0.096517
	(0.05952)	(0.02445)	(0.05298)	(0.03459)	(0.02370)	(0.09870)	(0.28362)
	[-0.09021]	[-0.00336]	[-1.21415]	[-1.93231]	[0.01821]	[3.42199]	[-0.34030]
H_LGR(-1)	0.010657	0.005264	0.004680	0.020952	-0.008518	0.009229	-0.037125
	(0.02081)	(0.00855)	(0.01853)	(0.01209)	(0.00829)	(0.03451)	(0.09917)
	[0.51202]	[0.61563]	[0.25262]	[1.73246]	[-1.02797]	[0.26742]	[-0.37435]

6. Variance Decomposition

				Variance Decomposition of H_REPO:				
Period	S.E.	H_REPO	H_LR	H_SPR	H_PVTC	H_M2	H_INF	H_LGR
1	0.225507	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.322422	92.85043	3.452708	2.570698	0.505993	0.501329	0.003425	0.115415
3	0.374398	85.60511	5.242272	6.534732	1.495400	0.983583	0.027991	0.110911

4	0.403196	79.90141	5.766159	10.11481	2.609611	1.348067	0.163982	0.095963
5	0.420030	75.96589	5.779140	12.60593	3.581935	1.588820	0.386790	0.091494
6	0.430237	73.45654	5.668542	14.10232	4.324770	1.735700	0.618357	0.093769
7	0.436573	71.91677	5.562212	14.93443	4.858274	1.822300	0.808242	0.097769
8	0.440599	70.97983	5.484120	15.38251	5.233968	1.873329	0.944917	0.101331
9	0.443227	70.40249	5.430415	15.62260	5.499367	1.904101	1.037007	0.104016
10	0.444987	70.03770	5.393717	15.75234	5.689338	1.923398	1.097561	0.105952
11	0.446194	69.80022	5.368323	15.82319	5.827398	1.936097	1.137424	0.107349
12	0.447036	69.64116	5.350455	15.86204	5.929051	1.944886	1.164039	0.108371
13	0.447632	69.53204	5.337690	15.88312	6.004620	1.951262	1.182133	0.109125
14	0.448058	69.45577	5.328459	15.89420	6.061162	1.956080	1.194644	0.109683
15	0.448366	69.40168	5.321722	15.89961	6.103644	1.959842	1.203411	0.110095
16	0.448590	69.36288	5.316771	15.90183	6.135649	1.962857	1.209617	0.110397
17	0.448755	69.33478	5.313110	15.90232	6.159808	1.965321	1.214043	0.110617
18	0.448876	69.31427	5.310391	15.90191	6.178070	1.967366	1.217217	0.110775
19	0.448966	69.29919	5.308363	15.90109	6.191891	1.969080	1.219503	0.110888
20	0.449033	69.28803	5.306845	15.90012	6.202361	1.970528	1.221155	0.110967

Variance Decomposition of H_LR:

Period	S.E.	H_REPO	H_LR	H_SPR	H_PVTC	H_M2	H_INF	H_LGR
1	0.092642	38.10696	61.89304	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.161143	76.96253	21.08129	0.086124	0.024212	1.733080	3.18E-05	0.112736
3	0.204952	77.74798	16.19745	2.249639	0.514971	3.062061	0.002682	0.225219
4	0.229111	73.89053	15.12264	5.263886	1.366031	4.110308	0.022646	0.223960
5	0.242605	70.20457	14.46108	7.817186	2.278641	4.909154	0.123540	0.205830
6	0.250466	67.56424	13.93431	9.489379	3.052915	5.485426	0.280518	0.193216
7	0.255194	65.87172	13.55393	10.42628	3.634053	5.891312	0.436337	0.186374
8	0.258111	64.83447	13.29910	10.90144	4.046120	6.177907	0.558337	0.182618
9	0.259962	64.20319	13.13215	11.12563	4.333167	6.383604	0.641919	0.180336
10	0.261174	63.81212	13.02170	11.22375	4.533842	6.534495	0.695272	0.178824
11	0.261992	63.56191	12.94697	11.26135	4.675939	6.647724	0.728328	0.177774
12	0.262559	63.39570	12.89517	11.27089	4.778016	6.734479	0.748715	0.177030
13	0.262960	63.28121	12.85845	11.26809	4.852236	6.802126	0.761395	0.176496
14	0.263248	63.19986	12.83193	11.26044	4.906671	6.855614	0.769379	0.176109
15	0.263458	63.14055	12.81248	11.25150	4.946818	6.898367	0.774458	0.175829
16	0.263614	63.09641	12.79803	11.24288	4.976528	6.932823	0.777707	0.175626
17	0.263731	63.06299	12.78715	11.23526	4.998556	6.960774	0.779786	0.175479
18	0.263819	63.03733	12.77890	11.22881	5.014906	6.983562	0.781109	0.175375
19	0.263886	63.01739	12.77258	11.22352	5.027048	7.002215	0.781942	0.175302
20	0.263938	63.00173	12.76770	11.21926	5.036067	7.017532	0.782457	0.175253

Variance Decomposition of H_SPR:

Period	S.E.	H_REPO	H_LR	H_SPR	H_PVTC	H_M2	H_INF	H_LGR
1	0.200722	0.540309	9.093655	90.36604	0.000000	0.000000	0.000000	0.000000
2	0.246061	0.365283	7.683920	91.12040	0.006182	0.050027	0.735970	0.038219
3	0.267118	0.358299	6.972922	91.03569	0.048688	0.235169	1.298858	0.050374
4	0.278133	0.376722	6.608573	90.65432	0.138160	0.570711	1.594109	0.057402
5	0.284527	0.398799	6.402287	90.14240	0.255655	1.015492	1.722984	0.062387
6	0.288620	0.424406	6.269489	89.57449	0.378557	1.515829	1.770556	0.066676
7	0.291461	0.454342	6.173621	88.99903	0.492300	2.027098	1.782844	0.070762
8	0.293556	0.487585	6.099134	88.44781	0.590579	2.519092	1.781034	0.074765
9	0.295167	0.521861	6.039187	87.93979	0.672172	2.974148	1.774188	0.078653
10	0.296439	0.554774	5.990325	87.48461	0.738248	3.383643	1.766055	0.082347
11	0.297461	0.584572	5.950376	87.08537	0.790850	3.744908	1.758147	0.085781
12	0.298290	0.610347	5.917714	86.74087	0.832178	4.058949	1.751030	0.088914
13	0.298968	0.631892	5.891019	86.44732	0.864288	4.328881	1.744868	0.091732
14	0.299523	0.649447	5.869203	86.19959	0.888994	4.558881	1.739650	0.094240
15	0.299980	0.663477	5.851371	85.99205	0.907832	4.753521	1.735295	0.096453
16	0.300354	0.674522	5.836789	85.81917	0.922079	4.917351	1.731698	0.098393

17	0.300663	0.683112	5.824858	85.67577	0.932771	5.054657	1.728748	0.100086
18	0.300916	0.689725	5.815090	85.55721	0.940735	5.169339	1.726345	0.101555
19	0.301125	0.694770	5.807087	85.45944	0.946624	5.264859	1.724398	0.102825
20	0.301297	0.698587	5.800526	85.37895	0.950947	5.344240	1.722827	0.103920

Variance Decomposition of H_PVTC:

Period	S.E.	H_REPO	H_LR	H_SPR	H_PVTC	H_M2	H_INF	H_LGR
1	0.131029	0.132422	5.048482	0.000236	94.81886	0.000000	0.000000	0.000000
2	0.176143	1.616702	6.517250	1.849787	86.88661	0.057001	1.577933	1.494719
3	0.205200	4.562890	6.446001	2.574163	82.19781	0.264071	2.394523	1.560542
4	0.226177	7.926695	5.884856	2.716136	78.68918	0.563460	2.733405	1.486271
5	0.242104	10.86744	5.316624	2.573854	76.04898	0.925153	2.871168	1.396777
6	0.254458	13.11704	4.865747	2.370637	74.06792	1.318187	2.940269	1.320206
7	0.264125	14.73461	4.531037	2.201384	72.56929	1.715749	2.988610	1.259321
8	0.271718	15.87371	4.285368	2.084718	71.41670	2.098273	3.029617	1.211611
9	0.277690	16.67710	4.103957	2.010916	70.51487	2.453794	3.065221	1.174138
10	0.282387	17.25018	3.968692	1.965603	69.79975	2.776431	3.094806	1.144540
11	0.286078	17.66437	3.866935	1.937432	69.22774	3.064427	3.118032	1.121062
12	0.288977	17.96697	3.789838	1.919034	68.76796	3.318504	3.135295	1.102398
13	0.291251	18.18964	3.731100	1.906062	68.39745	3.540723	3.147466	1.087553
14	0.293034	18.35410	3.686151	1.896108	68.09854	3.733776	3.155573	1.075754
15	0.294430	18.47568	3.651629	1.887908	67.85722	3.900579	3.160596	1.066388
16	0.295524	18.56547	3.625031	1.880840	67.66229	4.044035	3.163366	1.058965
17	0.296380	18.63162	3.604480	1.874618	67.50472	4.166921	3.164551	1.053093
18	0.297051	18.68016	3.588562	1.869122	67.37722	4.271813	3.164661	1.048455
19	0.297577	18.71560	3.576200	1.864306	67.27395	4.361065	3.164078	1.044799
20	0.297989	18.74130	3.566578	1.860140	67.19018	4.436792	3.163079	1.041923

Variance Decomposition of H_M2:

Period	S.E.	H_REPO	H_LR	H_SPR	H_PVTC	H_M2	H_INF	H_LGR
1	0.089775	0.967857	1.359116	1.470718	5.468955	90.73335	0.000000	0.000000
2	0.120596	0.715783	0.828521	2.097833	5.189669	90.64076	0.000412	0.527024
3	0.140648	0.714470	0.620465	3.389837	4.695410	89.87798	0.007986	0.693851
4	0.155274	0.798812	0.518141	4.626123	4.270652	88.94376	0.035415	0.807095
5	0.166421	0.890706	0.462316	5.648113	3.941603	88.09054	0.078402	0.888323
6	0.175099	0.957745	0.429438	6.451124	3.692735	87.39464	0.126425	0.947889
7	0.181941	0.996445	0.408098	7.078579	3.503431	86.84924	0.172099	0.992111
8	0.187385	1.014009	0.392840	7.575161	3.357097	86.42302	0.212381	1.025489
9	0.191750	1.018507	0.381178	7.974837	3.241997	86.08548	0.246827	1.051177
10	0.195270	1.015841	0.371950	8.301152	3.150133	85.81357	0.276029	1.071331
11	0.198123	1.009669	0.364535	8.570239	3.076020	85.59133	0.300800	1.087407
12	0.200442	1.002080	0.358540	8.793498	3.015787	85.40782	0.321878	1.100401
13	0.202333	0.994204	0.353677	8.979371	2.966598	85.25528	0.339861	1.111006
14	0.203879	0.986633	0.349724	9.134397	2.926305	85.12800	0.355226	1.119721
15	0.205143	0.979652	0.346502	9.263810	2.893236	85.02153	0.368355	1.126919
16	0.206179	0.973381	0.343871	9.371885	2.866063	84.93235	0.379569	1.132884
17	0.207028	0.967849	0.341719	9.462151	2.843722	84.85758	0.389135	1.137839
18	0.207725	0.963032	0.339956	9.537537	2.825347	84.79488	0.397287	1.141963
19	0.208297	0.958879	0.338508	9.600486	2.810235	84.74227	0.404224	1.145398
20	0.208768	0.955327	0.337320	9.653036	2.797807	84.69813	0.410119	1.148261

Variance Decomposition of H_INF:

Period	S.E.	H_REPO	H_LR	H_SPR	H_PVTC	H_M2	H_INF	H_LGR
1	0.373912	18.22155	3.002617	0.308444	1.422940	0.441024	76.60343	0.000000
2	0.422529	25.44511	2.505685	3.048292	1.427494	0.704362	66.81866	0.050402
3	0.448743	27.45434	2.760917	6.568225	1.517637	1.380023	60.27244	0.046417
4	0.466118	27.25718	2.905603	9.805799	1.681975	2.053642	56.23104	0.064760
5	0.478134	26.55975	2.905047	12.23039	1.853728	2.660721	53.69257	0.097799

6	0.486610	25.90729	2.853614	13.86526	1.993663	3.204240	52.04278	0.133157
7	0.492687	25.40267	2.799206	14.92087	2.094480	3.689775	50.92846	0.164545
8	0.497127	25.02921	2.754553	15.59929	2.163340	4.119072	50.14421	0.190325
9	0.500440	24.75222	2.720081	16.04280	2.209773	4.493245	49.57097	0.210915
10	0.502962	24.54317	2.693648	16.34044	2.241362	4.814857	49.13924	0.227281
11	0.504912	24.38226	2.673216	16.54577	2.263237	5.088116	48.80706	0.240342
12	0.506439	24.25633	2.657264	16.69093	2.278665	5.318249	48.54773	0.250827
13	0.507645	24.15661	2.644704	16.79566	2.289715	5.510798	48.34323	0.259284
14	0.508604	24.07698	2.634753	16.87248	2.297717	5.671121	48.18082	0.266127
15	0.509371	24.01305	2.626831	16.92961	2.303557	5.804126	48.05115	0.271674
16	0.509986	23.96155	2.620501	16.97259	2.307839	5.914158	47.94719	0.276173
17	0.510480	23.91994	2.615427	17.00525	2.310991	6.004983	47.86358	0.279825
18	0.510879	23.88626	2.611350	17.03031	2.313316	6.079820	47.79616	0.282789
19	0.511202	23.85895	2.608066	17.04968	2.315033	6.141397	47.74167	0.285197
20	0.511462	23.83678	2.605416	17.06477	2.316304	6.192003	47.69757	0.287152

				Variance Decomposition of H_LGR:				
Period	S.E.	H_REPO	H_LR	H_SPR	H_PVTC	H_M2	H_INF	H_LGR
1	1.074487	6.721172	0.044185	0.051755	0.901480	0.762629	0.012819	91.50596
2	1.134919	7.731498	0.079750	7.639620	1.018083	1.310805	0.086750	82.13349
3	1.148284	7.716686	0.081808	9.072236	0.997864	1.608581	0.283164	80.23966
4	1.153378	7.649654	0.086812	9.582614	0.993466	1.793381	0.359876	79.53420
5	1.155899	7.621930	0.105703	9.798168	1.001825	1.901022	0.380190	79.19116
6	1.157320	7.607679	0.126025	9.903805	1.013683	1.964364	0.384181	79.00026
7	1.158128	7.597793	0.140406	9.957577	1.025256	2.002019	0.384579	78.89237
8	1.158587	7.591864	0.148658	9.983515	1.035667	2.024447	0.384385	78.83146
9	1.158853	7.589506	0.152902	9.994445	1.044872	2.037746	0.384209	78.79632
10	1.159016	7.589532	0.154978	9.997909	1.052945	2.045581	0.384166	78.77489
11	1.159124	7.590781	0.155979	9.998144	1.059932	2.050170	0.384263	78.76073
12	1.159202	7.592484	0.156464	9.997294	1.065880	2.052844	0.384475	78.75056
13	1.159261	7.594233	0.156700	9.996303	1.070853	2.054394	0.384763	78.74275
14	1.159309	7.595843	0.156814	9.995505	1.074944	2.055288	0.385087	78.73652
15	1.159347	7.597248	0.156867	9.994966	1.078264	2.055797	0.385413	78.73144
16	1.159379	7.598434	0.156890	9.994649	1.080928	2.056083	0.385720	78.72729
17	1.159405	7.599417	0.156899	9.994496	1.083047	2.056239	0.385994	78.72391
18	1.159425	7.600218	0.156900	9.994449	1.084721	2.056321	0.386232	78.72116
19	1.159442	7.600864	0.156899	9.994467	1.086036	2.056360	0.386431	78.71894
20	1.159455	7.601379	0.156897	9.994518	1.087065	2.056375	0.386596	78.71717

Cholesky Ordering: H_REPO H_LR H_SPR H_PVTC H_M2 H_INF H_LGR

7. Diagnostic tests

7.1 Autocorrelation

VAR Residual Portmanteau Tests for Autocorrelations
Null Hypothesis: no residual autocorrelations up to lag h
Sample: 1980 2012
Included observations: 80

Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	45.15450	NA*	45.72608	NA*	NA*
2	73.87509	0.0123	75.18309	0.0095	49

*The test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for (approximate) chi-square distribution

7.2 Normality

VAR Residual Normality Tests
Orthogonalization: Cholesky (Lutkepohl)
Null Hypothesis: residuals are multivariate normal
Sample: 1980 2012
Included observations: 80

Component	Skewness	Chi-sq	df	Prob.
1	-0.246145	0.807834	1	0.3688
2	0.352114	1.653125	1	0.1985
3	-2.532700	85.52760	1	0.0000
4	-1.316710	23.11633	1	0.0000
5	-0.188934	0.475947	1	0.4903
6	-0.732054	7.145367	1	0.0075
7	-3.194519	136.0661	1	0.0000
Joint		254.7923	7	0.0000

Component	Kurtosis	Chi-sq	df	Prob.
1	2.402408	1.190389	1	0.2753
2	3.124475	0.051647	1	0.8202
3	11.73660	254.4274	1	0.0000
4	7.972049	82.40423	1	0.0000
5	6.053167	31.07276	1	0.0000
6	4.349223	6.068008	1	0.0138
7	21.93938	1195.668	1	0.0000
Joint		1570.882	7	0.0000

Component	Jarque-Bera	df	Prob.
1	1.998223	2	0.3682
2	1.704772	2	0.4264
3	339.9550	2	0.0000
4	105.5206	2	0.0000
5	31.54870	2	0.0000
6	13.21337	2	0.0014
7	1331.734	2	0.0000
Joint	1825.674	14	0.0000

7.3 Heteroscedasticity

VAR Residual Heteroskedasticity Tests: No Cross Terms (only levels and squares)
Sample: 1980 2012
Included observations: 80

Joint test:

Chi-sq	df	Prob.

515.0275	392	0.0000

Individual components:

Dependent	R-squared	F(14,65)	Prob.	Chi-sq(14)	Prob.
res1*res1	0.236629	1.439192	0.1610	18.93035	0.1676
res2*res2	0.152201	0.833511	0.6311	12.17612	0.5922
res3*res3	0.238251	1.452139	0.1555	19.06008	0.1627
res4*res4	0.601908	7.019913	0.0000	48.15263	0.0000
res5*res5	0.137519	0.740282	0.7266	11.00149	0.6859
res6*res6	0.156858	0.863755	0.5999	12.54863	0.5623
res7*res7	0.370195	2.729045	0.0032	29.61564	0.0086
res2*res1	0.156447	0.861075	0.6026	12.51578	0.5650
res3*res1	0.213284	1.258712	0.2574	17.06275	0.2528
res3*res2	0.321803	2.203028	0.0168	25.74426	0.0279
res4*res1	0.358573	2.595469	0.0049	28.68585	0.0115
res4*res2	0.134457	0.721243	0.7455	10.75660	0.7050
res4*res3	0.215644	1.276465	0.2463	17.25150	0.2430
res5*res1	0.123535	0.654396	0.8088	9.882794	0.7707
res5*res2	0.176322	0.993879	0.4699	14.10574	0.4419
res5*res3	0.340396	2.396000	0.0092	27.23169	0.0180
res5*res4	0.238768	1.456277	0.1537	19.10143	0.1611
res6*res1	0.182106	1.033746	0.4327	14.56851	0.4083
res6*res2	0.143577	0.778360	0.6880	11.48613	0.6475
res6*res3	0.274654	1.758028	0.0651	21.97232	0.0792
res6*res4	0.379978	2.845353	0.0022	30.39821	0.0067
res6*res5	0.097418	0.501114	0.9242	7.793424	0.8998
res7*res1	0.374512	2.779921	0.0027	29.96097	0.0077
res7*res2	0.297217	1.963528	0.0352	23.77733	0.0487
res7*res3	0.312159	2.107044	0.0226	24.97274	0.0348
res7*res4	0.430962	3.516279	0.0003	34.47697	0.0018
res7*res5	0.189424	1.084989	0.3874	15.15389	0.3677
res7*res6	0.357817	2.586945	0.0050	28.62535	0.0117