Monetary Policy Shocks and Stock Returns Reactions: Evidence from Botswana

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Abstract

This paper applies standard vector autoregressions (VAR) technique to quarterly data for Botswana for the period 1993-2010 to investigate the impact of monetary policy shocks on stock returns. Monetary policy is measured by changes in the 91 day Bank of Botswana Certificates rate. Our results indicate that positive interest rate innovations are associated with increases, rather than decreases, in the aggregate stock returns of companies listed on the Botswana Stock Exchange (BSE). A possible explanation for this counter-intuitive result is that the market capitalization in BSE is dominated by commercial banks, which are also the main beneficiaries of the interest income from investment in risk-free Bank of Botswana Certificates. The observed positive reaction of aggregate stock returns to monetary policy tightening suggests that the increase in returns to bank stocks offsets the negative reactions of non-bank stock returns. Variance decomposition shows that monetary policy shocks explain a relatively small proportion of stock returns variability.

Keywords: Monetary policy; stock returns; vector autoregressions, Botswana

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1 Introduction

A review of the monetary policy literature reveals numerous attempts to describe and quantify the interactions between monetary policy and stock prices. These studies have been carried out from various viewpoints and using different techniques (see, e.g., Thorbecke, 1997; Patelis, 1997; Bernanke and Kuttner, 2005; Ioannidis and Kontonikas, 2008; Bjornland and Leitemo, 2009 and Nemaorani, 2012). Much of this empirical literature concludes that there is a relationship between monetary policy and stock prices and the strength of relationship depends on structural and institutional features of the economy.[27]

However, most of these studies have focused on industrial and to a lesser extent, emerging market economies. The absence of such studies in developing countries can be explained, at least in part, by lack of well-functioning capital markets and unavailability of good quality data. Nonetheless, the differences in the structural and institutional arrangements between developed and developing countries render the results from the former not directly applicable in the latter countries. Yet, with monetary policy increasingly becoming the policy of choice the world over,[28] understanding the link between monetary policy and stock prices in a developing country context is useful to both monetary authorities and investors. Monetary authorities need to understand the relationship between monetary policy and stock prices so that they can appreciate the role that stock prices should play in monetary policymaking. This would help them know if they should target stock prices or use stock price information as indicators of the monetary policy stance, i.e., respond with policy instruments to stock price movements. Investors on the other hand need to know how monetary policy affects the performance of stock markets in order to be able to accurately measure the intrinsic value of stocks. This study builds on the existing literature on the relationship between monetary policy and stock prices by considering the case of a small developing country. In particular, it investigates the direction and magnitude of the impact of monetary policy shocks on stock returns in Botswana.

The paper proceeds as follows. Section 2 presents an overview of the evolution of monetary policy and of the Botswana stock market. This is followed by a brief review of the literature.

[27] Sellin (2001) provides a detailed review of the early literature.
[28] See Mishkin (1996: 1)

Section 4 discusses the theoretical framework, while the modelling strategy and the data used in the study are explained in section 5. Section 6 presents the estimation and empirical results, while section 7 concludes and offers some policy suggestions.

2 Overview of Botswana's Monetary Policy and the Stock Market

2.1 Monetary Policy and its Operating Procedures

Broadly speaking, there have been two monetary policy regimes since 1976. This study focuses on the second of these. The first regime, which covered the period 1976 to 1989, was characterized by multiple monetary policy goals that included monetary stability and economic growth. The implementation of monetary policy was through direct controls, such as prescribing both lending and deposit interest rates, credit limits and reserve requirements. In addition, the exchange rate was adjusted alternately to mitigate imported inflation or to maintain domestic industry competitiveness. Little importance was attached to the interest rate as a tool for the control of inflation. Rather interest rates were kept low to encourage borrowing for domestic investment. On the other hand, the increase in financial flows associated with the growth of the economy, the large trade surplus and liquidity inflows generated by mining resulted in a rapid build-up of excess liquidity in the financial system.

These developments, combined with the regulated interest rates which were often set too low relative to inflation, encouraged excess borrowing for consumption and unproductive investment (Bank of Botswana, 2005). This, in turn, led to accelerated inflation, which was often in double digits. The use of the exchange rate for both inflation control and promotion of competitiveness also created a conflict. A depreciation of the exchange rate to promote exports resulted in imported inflation. In view of this conflict, and a realization that much of the inflation was domestically generated and as such outside the control of the exchange rate, a range of reforms were introduced at the beginning of 1990 following the recommendations of a joint study by the government of Botswana and the World Bank (World Bank, 1989).

Under the second regime, the use of the exchange rate as the main instrument of monetary policy was discontinued. Interest rates ceilings and credit controls were removed, allowing commercial

banks to set their deposit and lending rates. The Bank of Botswana (BoB) began issuing its own paper; Bank of Botswana Certificates (BoBCs) in May 1991 to mop up excess liquidity that had accumulated in the banking system. The exchange controls were completely removed from the current account transactions, with remaining controls on the capital account eliminated in 1999 (Masalila, 2001). In a way, direct controls gradually gave way to indirect instruments of monetary policy. The monetary policy focus also shifted to maintenance of price stability as the primary goal. However, until recently, the Bank had an implicit inflation objective that was derived internally on the basis of forecast trading partner inflation (Bank of Botswana, 2008).

In 2002, the Bank publicly announced its numeric inflation objective for the first time. The Bank announced an annual inflation objective range of 4 – 6 per cent[29]. The inflation objective was specified as an annual average of 12-month changes in the consumer price index (CPI). In 2006, the bank specified both the annual and medium term range (3-year horizon) as 4 – 7 and 3 – 6 per cent, respectively.[30] Although the operational objective has always been defined in terms of changes in the CPI, the Bank's focus is on the "underlying" or "core" inflation rate, which excludes the prices of the goods with more volatile behaviour, such as fuel and administered prices (Bank of Botswana, 2010).

In order to achieve its objective, the Bank uses three main instruments of monetary policy. These are open market operations (OMOs), the bank rate and the reserve requirements. However, because of the excess liquidity in the banking system, the last of these has been found to be less effective and has been used sparingly. The day-to-day management of monetary policy has since 1991 been based on short-term interest rates. The bank rate – the rate at which it lends to financial institutions to finance their overnight liquidity needs – is used to signal the desired direction and level of market interest rates. However, the main operational instrument of monetary policy is the auctioning of its own debt securities, BoBCs. In order to stabilize the bank rate around its target, the Bank auctions BoBCs to increase or decrease liquidity in the financial system. The amount of BoBCs auctioned at any point in time depends on the amount of funds identified as "excess" and this amount is specified relative to a particular level of real interest

[29] The inflation targets for other years were as follows: 2003 (4 – 6); 2004 (4 - 7); 2005 (3 – 6 per cent, but was revised to 4 – 7 in mid-year); 2006-2007 (4-7); 2008-present (3-6).
[30] The annual inflation target was abandoned in mid-2008.

rates, comparable to those prevailing in Organization for Economic Cooperation and Development (OECD) countries (Bank of Botswana, 2008).[31] That is, BoBCs would be auctioned until the effective yield on the Three-month BoBCs is comparable to those in the OECD countries. Since March 2006 trade in BoBCs has been restricted to commercial banks only.

In order to strengthen and fine-tune its OMOs, the Bank introduced repos (sale and repurchase agreements) and reverse repos in January 1999. The repurchase agreement is a form of a collateralised lending between two parties, which involves sale of securities with an agreement to reverse the transaction in the future at a specified price (Bank of Botswana, 1998). This entails buying BOBCs from a commercial bank when there is shortage of liquidity and the reverse applies when liquidity is withdrawn. The Bank also introduced the Secured Lending Facility (SLF), where commercial banks could borrow from the Bank of Botswana to meet unexpected adverse daily balances.

[31] Although the open market operations could also inject liquidity into the banking system, in Botswana the operations have mainly been aimed at mopping up excess liquidity.

Table 1 below summarises the monetary policy operations during this period. It is clear from the table that several attempts have been made to strengthen and fine-tune the monetary policy since 1991.

Table 1: Changes in monetary operations and objectives

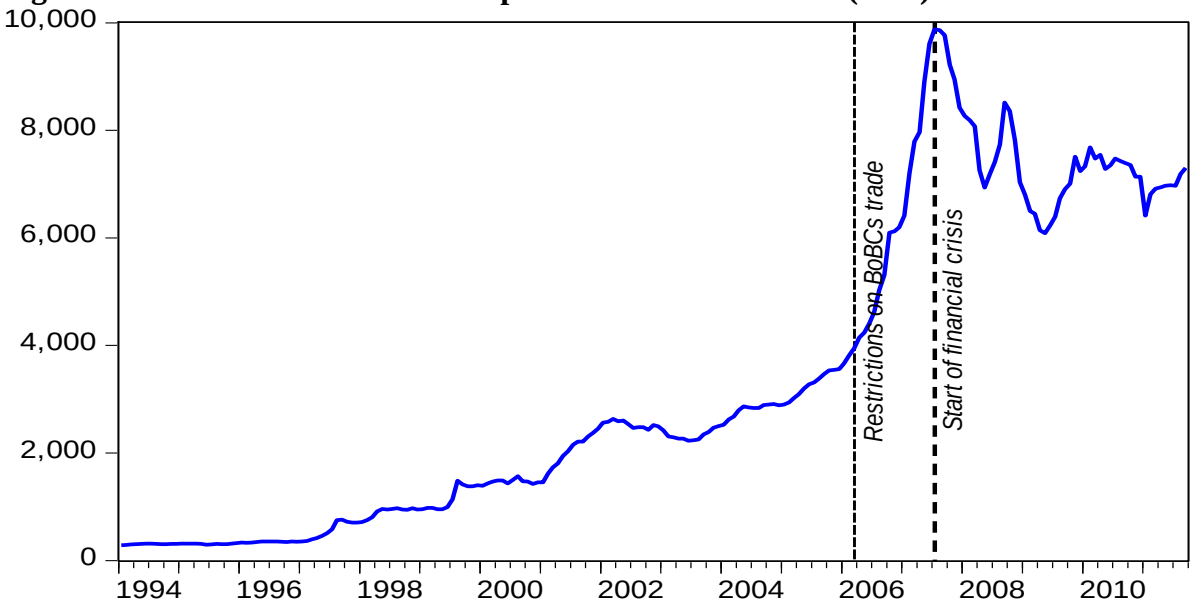
Year	Nature of changes	Objective
1991	• Introduction of BoBCs with varying maturities of up to 12 months	• Liquidity absorption measure
1994	• Change from multiple reserve requirements to a single reserve requirements based on total deposits of 3.25 percent	• Efficiency measure
1998	• Repos and Reverse Repos introduced • Secured Lending Facility (set at 6 percent above Bank rate)	• Short-term liquidity management • Bridging commercial banks' overnight liquidity shortages
2001	• 3-month BOBC (91-days) used as the primary instrument	• Effectiveness and development measure
2002	• Annual inflation objective introduced and set at 4-6 percent	• Anchoring inflation expectations
2004	• Annual inflation objective 4-7 percent • Outright purchase of BoBCs between Bank of Botswana and commercial banks discontinued • 14-day BoBCs introduced • BoBCs auction changed from fixed to uniform price auction	• Accommodation of inflationary effect of 7.5 percent pula devaluation • Secondary market development measure • Efficiency measure
2005	• Inflation objective of 3-6 percent and mid-term adjustment to 4-7 percent	• Accommodation of inflationary effects of 12 percent pula devaluation
2006	• Medium-term (3-year rolling horizon) inflation objective set at 3-6 percent • Participation of BoBCs auctions confined to commercial and merchant banks • Reserve requirement adjusted upward to 5 percent • Introduction of Intra-Day Lending Facility	• Price stability objective can reasonably be achieved in the medium-term • Efficiency and international best practice • Liquidity control measure • Promote efficient settlement
2008	• Annual inflation objective dropped	• Price stability objective can reasonably be achieved in the medium term

Source: Adapted from Bank of Botswana Annual Report 2010

2.2 Development of Botswana's Stock Market

Botswana stock market (BSE) is one of the youngest but fast growing exchanges in the world. Established in 1989 with only five listed companies, the BSE achieved remarkable growth, both in terms of market capitalization and number of participants. Figure 1 present the monthly movement of the Domestic Companies Index (DCI) between 1994 and 2011.

Figure 1: Botswana's Domestic Companies Index - 1994-2011 (Pula)



Source: Authors' calculation based on data from Botswana Stock Exchange Achieves

It is clear from Figure 1 above the BSE achieved some phenomenal growth over the 1994-2011 period, posting annual average growth of approximately 16 percent. Jefferis and Kenewendo (2010) indicate that annual returns (in Pula) on the domestic board averaged 24% a year (excluding dividends) between 1990 and 2009. The highest growth rate was recorded between March 2006 (start of restrictions on BoBCs trading) and July 2007 (the start of the financial crisis). The sharp drop in the index observed on the graph coincides with the start of the world financial crisis. As of 29th September 2011, the domestic board boasted a market capitalization of P31 469.61 million. Despite its phenomenal growth, the BSE is among the smallest and most illiquid exchanges in the world as shown in Table 2.

Table2 Stock Market Indicators: Botswana, Sub-Saharan Africa and by income group 2001-2010

	Botswana	SSA	RSA	lower middle income	Upper middle income	Middle income
Market capitalization(% of GDP)	**29.6**	107.5	215.1	47.9	59.4	57.1
Stocks traded, total value (% of GDP)	**0.8**	40.0	97.5	35.7	47.5	45.1
Stocks traded, turnover ratio (%)	**3.2**	44.4	48.0	88.4	79.7	80.9

Notes: SSA is Sub-Saharan Africa and RSA is the Republic of South Africa
Source: Author's calculations based on data from World Development Indicators

Two commonly-used measures of stock market activity are market capitalization and value of shares traded, both in relation to GDP. Stock market capitalization is the value of all domestic shares listed on the national stock market, while value of shares traded is limited to only those stocks that are traded. The latter may be interpreted as a measure of the liquidity of the stock market.

The ratio of market capitalization to GDP suggests that Botswana is not very far behind on the influence of stock market activity in the country. However, the effective capitalization is considered less relevant because the BSE is dominated by the value of the three largest commercial banks, which accounted for 60 percent and 53 percent of the Domestic Companies Index in 2000-2005 and September 2011, respectively. Moreover, these commercial banks, just like most of the listed companies, allow only a small proportion of their shares to be traded on the exchange. This unwillingness to offer stocks for sale is reflected in the value of stocks traded as a percentage of GDP and the stocks traded turnover ratio, which averaged 0.8 and 3.2 percent in 2001-2010 period, respectively. The relatively high illiquidity suggests a limited use of the stock market to finance economic activity in Botswana.

In an attempt to develop and improve the exchange's liquidity, the Central Securities Depository (CSD) was introduced in October 2007 (Nemaorani, 2012). The CSD is a computer-based system that facilitates holding of securities in electronic accounts in contrast to paper share certificates, which was used until September, 2007. This development is expected to ensure swift transfer of securities, hence improving liquidity in the exchange market.

3 Brief Review of the Literature

The relationship between monetary policy and stock returns has been a topic of intense research by both monetary and financial economists for the last two decades. While monetary economists are mostly concerned with whether monetary policy has any bearing on stock prices, financial economists are concerned with whether equity is a good hedge against inflation. A comprehensive review of the literature in this field was done by Sellin (2001) and Bordo and Wheelock (2004). Here we only provide a brief review of some of the recent empirical literature in the area. Empirical literature on the relationship between monetary policy and stock prices has followed two main approaches; vector autoregressions (VAR) and non-VAR analysis.

3. 1 Non-VAR Studies

Patelis (1997) investigated whether some portion of the observed changes in US stock returns could be attributed to shifts in the monetary policy stance. Using a simple two-equation system with one equation representing the monetary policy and the other the stock returns, he found that monetary policy variables are significant predictors of future returns, although they could not account fully for the observed stock return predictability. Rigobon and Sack (2004) estimated the response of asset prices to changes in monetary policy for the US using sample period running from Jan 3 1994 to Nov 26 2001. Using a technique called identification through heteroskedasticity in the "event-study" method that included 78 policy dates, they found that an unanticipated 25-basis point increase in the short-term interest rate results in a 1.7% decline in the Standard & Poor and the Wilshire 5000 indices. The response of the Nasdaq index was found to be larger at 2.4%.

Ioannidis and Kontonikas (2008) investigated the effect of the monetary policy on stock returns in thirteen OECD countries over the period 1972-2002. They regressed the stock market variable on the monetary policy variable and found that stock returns decrease when money supply decreases. Their findings indicate that monetary policy shifts have significant negative impact on both nominal and inflation-adjusted stock returns. This relationship was significantly different

from zero at the 5 percent level in 10 out of 13 countries. However, the strengths of the links differed from one country to another possibly because of their inherent structural differences.

In Africa, Daferighe and Aje (2009) examined the link between stock prices and monetary policy using Nigerian data for the period 1997-2006 and found evidence of a negative, albeit weak relationship. Nemaorani (2012) estimated single equation models by regressing real and nominal stock returns on changes in short-term interest rate using Botswana data. Using monthly data for the period 2001-2011, he found a positive and statistically significant relationship between interest rate changes and stock returns. His explanation for this counter-intuitive result was that the dominant players in the domestic stock market, who are the commercial banks, are also the main beneficiaries of interest rate increases through their exclusive participation in the Bank of Botswana Certificates. However, Nemaorani does not explain how he dealt with the simultaneity and omitted variables problems described earlier.

Structural equation studies indicate that monetary policy tightening has a negative impact on stock prices and that the strengths of the links depend on structural and institutional arrangements in the economy. However, this approach to estimating the interactions between monetary policy and asset prices suffers from the endogeneity problem - while asset prices are influenced by the short-term interest rate, the short-term interest rate is simultaneously affected by asset prices. In order to side step the endogeneity problem, many monetary policy-asset price studies have resorted to the use of VARs.

3.2 VAR Studies

Thorbecke (1997) used a standard VAR in which monetary policy innovations are identified by Cholesky decomposition to investigate the relationship between monetary policy and asset prices in the U.S. Using various measures of monetary policy stance, he found evidence indicating that expansionary monetary policy increases ex-post stock returns. Specifically, he found that a one-standard deviation positive innovation in the federal funds rate depressed stock returns by an average of -0.80 percent per month and a one-standard deviation positive innovation in

nonborrowed reserves increased stock returns by an average of 1.79 percent per month. In another U.S. study, Bernanke and Kuttner (2005) analysed the impact of changes in monetary on equity prices using VAR estimated over the period of 1973-2002. They found that an unanticipated 25-basis-point cut in the federal funds rate target leads to a one per cent increase in broad stock indexes. However, Laopodis (2006) divided the data for 1970-2004 into three monetary policy regimes and found the results to be inconclusive in the sense that the relationships differed across monetary policy regimes.

Bjornland and Lietemo (2009) employed a VAR methodology that used both short-run and long-run identification scheme to examine the relationship between monetary policy and asset prices and found that there is substantial simultaneous interaction between the interest rate setting and shocks to real stock returns in the US. This implies that just as monetary policy is important for the determination of stock prices, the stock market is an important source of information for the conduct of monetary policy.

Beyond the U.S., Neri (2004) employed a structural VAR model to evaluate the effects of exogenous monetary policy shocks on stock market indices in the G7 countries and Spain. He estimated a separate model for each country and found that a contractionary monetary policy has a negative and transitory effect on stock market prices. He also found evidence of significant cross-country heterogeneity in magnitude, persistence and the timing of the response.

VAR studies provide evidence in support of that found by structural equation models: that is, stock returns respond negatively to a tightening of monetary policy, but monetary policy account for only a small part of the variations in stock returns. Thus, evidence from both modelling strategies indicate that expansionary monetary policy increases stock returns, but the strength of the relationships depends on the state of financial and institutional developments in the countries under investigation.

4 Theoretical Framework

The present value or discounted cash flow model offers some theoretical explanation of the link between monetary policy actions and changes in stock returns. It states that stock price equals the expected present value of future net cash flows. Therefore, expansionary monetary policy is expected to increase future net cash flows or decrease the discount factors at which those cash flows are capitalized. The model can be derived by assuming that (i) investors are risk-neutral and (ii) have two alternative investment opportunities over a one period horizon: either a stock with the expected gross return$[E_t\,(S_{t+1} + D_{t+1})/S_t]$, or a risk-free bond with constant nominal gross return 1+R (see, e.g., Cuthbertson and Nitzsche, 2004). S_t is the stock price at time t, D_t is the dividends at time t, and E_t is the conditional expectations operator based on information available to market participants at time *t* and R is the rate of return used by market participants to discount future dividends. Arbitrage opportunities imply that, for investors to be indifferent between the two alternatives, they must yield the same expected return, i.e.,

$$E_t\,(S_{t+1} + D_{t+1})/S_t = 1 + R \qquad (1)$$

Re-arranging equation 1 yields the Euler equation that determines the stock price movement over time:

$$S_t = \delta(E_t S_{t+1} + E_t D_{t+1}) \qquad (2)$$

Where $\delta = 1/(1+R)$. Solving equation 2 by repeated forward substitution yields

$$S_t = \mathrm{E}_t\left[\sum_{j=1}^{K}\left(\frac{1}{1+R}\right)^j D_{t+j}\right] + \mathrm{E}_t\left[\left(\frac{1}{1+R}\right)^j S_{t+K}\right] \qquad (3)$$

Where, *K* is the investor's time horizon (stock holding period). The transversality condition implies that as the horizon *K* increases the second term on the right-hand side of equation 3 vanishes to zero, (i.e.,$\lim \mathrm{E}_t\left[\left(\frac{1}{1+R}\right)^j S_{t+K}\right] = 0, as\ K \to \infty$). This condition is equivalent to the no rational stock price bubbles assumption. Thus equation 3 reduces to the more familiar rational stock valuation formula for stock prices

$$S_t = \mathrm{E}_t\left[\sum_{j=1}^{K}\left(\frac{1}{1+R}\right)^j D_{t+j}\right] \qquad (4)$$

From the equation 4 it follows that a change in monetary policy can affect stock returns in two ways. First, there is a direct effect on stock returns by altering the discount rate, R, used by

market participants. Tighter monetary policy leads to an increase in the rate at which firms' future cash flows are capitalised causing stock prices to decline. Second, monetary policy changes exert an indirect effect on the firms' stock value by altering expected future cash flows, D_t. As highlighted by Ioannidis and Kontonikas (2008) the above model has two underlying assumptions; the discount factors used by market participants are generally linked to market rates of interest and secondly the central bank is able to influence market interest rates.

5 Modeling Strategy

This study follows much of the empirical literature on the relationship between monetary policy and stock prices by using Vector autoregressions methodology (VAR). One important characteristic of the VAR approach is that statistical, rather than economic criteria are taken as the starting point for constructing econometric models, imposing as little economic structure on the estimations as possible. Therefore, the approach has the advantage of avoiding the contentious issues about the underlying structure of the economy, which is appealing when working with developing economies that are often characterised by uncertainties regarding their structure. Another advantage of the VAR approach is its inherent ability to incorporate the endogeneity — the interdependence among the system's variables — which is a feature of the monetary transmission mechanism. In addition, a VAR approach allows researchers to separate the endogenous reaction of the monetary authorities to developments in the economy from exogenous monetary policy shocks.

The VAR approach involves a series of steps. First, the functional form of the monetary policy feedback rule, the variables in the rule and the policy instrument are specified. The feedback rule links monetary policy actions i_t to a set of information variables (Φ_t) that characterize the state of the economy:

$$i_t = f(\Phi_t) + \sigma_i \varepsilon_t^i \quad (5)$$

Where $f(.)$ is usually assumed to be a linear function. ε_t^i is the exogenous component of the monetary policy rule followed by the central bank and σ_i is the standard deviation of the monetary policy shock. Second, this policy rule is estimated in a reduced-form VAR model that includes other macroeconomic variables. Third, identification restrictions are placed on the

parameters of the estimated VAR to identify the monetary policy shocks. Fourth, impulse response functions are then constructed to trace out the dynamic responses of the system's variables to the monetary policy shocks. Finally, one can also determine the percentage of each variable's forecast error variance that is attributable to innovations in each of the endogenous variables.

5.1 VAR Specification

A VAR is a set of equations in which each variable in the system is determined by its own lagged values and the lags of all the other variables in the system. Specifically, we consider the following reduced-form VAR model (omitting constant and other deterministic terms):

$$x_t = \sum_{i=1}^{q} A_i x_{t-i} + u_t \quad (6)$$

where x_t is an $(n \times 1)$ vector of endogenous variables, including the instrument of the monetary authority and stock returns; A_i is an $(n \times n)$ matrix of parameters; x_{t-i} is a vector of lagged x variables; and u_t is an $(n \times 1)$ vector of serially uncorrelated reduced-form disturbances with $E[\varepsilon_t] = 0$ and $E[u_t u_t'] = \Sigma_u$.

Pre-multiplying equation (6) by B_0, yields the following associated structural VAR model:

$$B_0 x_t = \sum_{i=1}^{q} B_i x_{t-i} + \varepsilon_t \quad (7)$$

Where $B_i = B_0 A_i$ are $(n \times n)$ matrices of coefficients; B_0 is an $(n \times n)$ matrix of contemporaneous interactions among endogenous variables in the vector x_t; ε_t is an $(n \times 1)$ vector of mean zero serially uncorrelated structural disturbances, i.e., $E[\varepsilon_t] = 0$, $E[\varepsilon_t \varepsilon_t'] = \Sigma_\varepsilon$ and $[\varepsilon_t \varepsilon_s'] = 0$ for $t \neq s$. Σ_ε is the variance-covariance matrix for the structural shocks. Therefore, the reduced-form disturbances, u_t, are linear combinations of the structural shocks in the form of:

$$u_t = B_0^{-1} \varepsilon_t \quad (8)$$

And the covariance matrix for the residuals, Σ_u, is given as:

$$\Sigma_u = B_0^{-1} \Sigma_\varepsilon (B_0^{-1})' \quad (9)$$

An ordinary least squares (OLS) estimate of the VAR provides an estimate of Σ_u, that can be used with equation (9) to obtain estimates of B_0 and Σ_ε. However, there are n^2 elements in B_0 and $n(n+n)/2$ unique elements in Σ_ε, but only $n(n+n)/2$ unique elements in Σ_u. Thus, in order to identify structural shocks from the OLS estimates of the reduced-form model, at least n^2 restrictions need to be imposed on B_0 and Σ_ε.

5.2 VAR Identification

There are three commonly used methods of identification in the monetary VAR literature: *Recursive* VARs, which assumes that contemporaneous interactions between the exogenous shocks and endogenous variables are characterized by a Wold causal chain (or a recursive ordering); *Structural VARs with long-run restrictions*, which impose the restriction that changes in money supply have no long-run effects on the real variables (Blanchard and Quah, 1989); *Structural VARs with short-run restrictions*, which impose restrictions on the contemporaneous effects of the shocks based on economic theory (Bernanke, 1986) and information assumed available to particular economic agents (Sims, 1986).

This paper uses the first approach. This approach to identifying the VAR, originally proposed by Sims (1980), uses the so-called Choleski factorization of the variance-covariance matrix Σ_ε. The Choleski factorization imposes n normalization restrictions (diagonal elements of B_0 are equal to 1) and restricts additional $n(n-1)/2$ elements of B_0 to zero. Thus it imposes a total of $n(n+1)/2$ restrictions on the system, which just identifies the structural form. The Choleski factorization implies that the first variable in the VAR system is assumed to be contemporaneously exogenous to all the remaining variables, and the second variable is contemporaneously exogenous to all except the first variable, and so on (Sims, 1980). This implies that only one residual is included in the first equation (and *n-1* zero restrictions), two residuals in the second (and *n-2* zero restrictions) and so on. This is reflected in the composition of the reduced-form error terms:

$$u_t = B_0^{-1}\varepsilon_t = \begin{pmatrix} 1 & 0 & 0 & \cdots & 0 \\ b_{21} & 1 & 0 & \cdots & 0 \\ b_{31} & b_{32} & 1 & \cdots & \vdots \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ b_{n1} & b_{n2} & b_{n3} & \cdots & 1 \end{pmatrix}^{-1} \begin{pmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \\ \varepsilon_{3,t} \\ \vdots \\ \varepsilon_{n,t} \end{pmatrix} \quad (10)$$

The advantage of using the Choleski decomposition in identification is that it is simple and also reduces the investigator's discretion and the scope for *data-mining*. All that the modeller needs to do is to decide on the ordering of the variables in the model.

5.3 Data and Choice of Variables

5.3.1 Choice of Variables

Since VARs are data intensive, one has to decide on the minimal set of variables to model, which might be regarded as capturing the principal interactions in the monetary policy-asset price relationships. This paper estimates a six-variable VAR that includes world oil prices, real GDP growth, the inflation rate, a measure of monetary policy given by the first difference of the short-term interest rate, the (nominal) real exchange rate and (nominal) real stock returns.

The world oil price is included to capture additional information about the future course of inflation that might be available to the monetary authorities. This variable accounts for the forward-looking monetary policy and its omission is argued to often result in *price-puzzles* – positive interest rate innovations being associated with increases, rather than decreases, in the price level (see, e.g., Sims, 1992). The remaining variables are the standard variables of open economy business cycle models: output, inflation, an interest rate, the exchange rate and the stock price. Output is measured by real non-mineral private GDP. Inflation is proxied by CPI inflation. While most studies of the Botswana economy use the bank rate as a measure of monetary policy, this study uses the 91 day BoBCs rate as the short-term interest rate. This is because the former is an administrative rate which is infrequently changed, while the latter is a market rate of interest, determined by supply and demand. A discussion of the Bank's operating

procedures also suggests that 91 day BoBCs rate is the appropriate interest rate.[32] The Domestic Companies Index (DCI) is used as a proxy for stock prices and captures the movement of prices of domestic stocks listed on BSE. The exchange rate is represented by the bilateral rate between the Botswana *Pula* and the South African *Rand*. The exchange rate is included as a transmitter of external shocks on the economy's purchasing power. The choice of the Rand/Pula exchange rate is influenced by the importance of South Africa in Botswana's economic activity.

The order of orthogonalization is the same as the order in which the variables are listed above. The ordering of the domestic variables is based on the idea that exogenous technology shocks influence real economic activity, which in turn influences labour demand and the demand for money, and hence inflation dynamics. These variables influence the monetary policy actions of the Bank of Botswana. The exchange rate and stock returns are placed last because as forward-looking asset prices they react quickly to all available information. However, since Botswana operates a crawling-peg exchange rate system the response of the exchange rate is expected to be slower than that of the stock returns. Stock returns then react to all other variables, but do not contemporaneously affect them.[33] Ordering stock returns last is also consistent with the efficient market hypothesis suggested by Chen, Roll and Ross (1986), which show that the stock market reacts sensitively to shocks in macroeconomic variables. The world oil price is placed first because Botswana, as a small economy is not expected to influence world oil prices.

5.3.2 Data

This study employs quarterly data for the period 1993Q3-2010Q4. World oil price series (o*) was obtained from the International Monetary Fund's International Financial Statistics Database and was converted from US$ to Botswana pula using the exchange rates obtained from the same source. Real GDP, Inflation (π), the nominal rand/pula exchange rate (exch) and the 91day Bank of Botswana Certificates rate (BoBCsr) were obtained from Bank of Botswana Annual Bulletins. The Domestic Companies Index (DCI) series was obtained from Botswana Stock Exchange Archives. All series values were first de-seasonalized using the census X12 procedure with multiplicative adjustment. Then all series, except π and BOBCsr, were transformed to their

[32] The more variability in the BoBCs rate is also likely to assist the computational process of estimation.
[33] We experimented with placing the exchange rate last but the results were qualitatively similar.

natural logarithms. We then computed the growth of each series as the first difference of its log multiplied by 100 (e.g., real GDP growth is $g_t = \Delta lnGDPx100$; change in nominal exchange rate is $e_t = \Delta \ln exchx100$; the real exchange rate is defined as nominal exchange rate multiplied by the ratio of domestic consumer price index to foreign (South Africa) consumer price index[34] and nominal stock returns is $s_t = \Delta lnDCIx100$). Real stock returns is nominal stock returns *minus* inflation, i.e., $rs_t = s_t - \pi_t$. Change in the short-term interest rate is the first difference of the BoBCs (i.e., $r_t = \Delta BoBCsr_t$). The results of the unit root tests are presented in Table A1 in the Appendices and indicate that each of the domestic variables $(g_t, \pi_t, r_t, e_t, rs_t)$ is stationary while world oil price (o*) is not. However, the latter became stationary after being differenced once.

Another important issue in the estimation of VARs is the selection of the lag order. A long lag quickly exhausts degrees of freedom and reduces the precision with which effects can be estimated, while too few may not mop up serial correlation. Limited sample size suggests that parsimonious models should be preferred. Under these circumstances one may follow the Schwarz information criterion (SC), which selects one lag (see Table A2 in the Appendices). Moreover, Ivanov and Killan (2005) show that SC appears to be the most accurate lag selection criteria for quarterly data with less than 120 observations.

However, the choice of the preferred lag order relied on tests of serial correlation in the residuals. That is, the lag order has been determined by requiring that the resulting model has serially uncorrelated residuals, since the estimates could be severely biased if serial correlation remains (Favero, 2001). This approach leads to the use of two lags. Therefore we estimate the following reduced-form VAR.

$$x_t = C + \delta_1 D_{023} + \delta_2 D_{053} + \delta_3 D_{061} + \delta_4 D_{fc} + \sum_{j=1}^{2} \Lambda_j x_{t-j} + u_t \qquad (13)$$

Where, D_{023} is a dummy variable that takes the value 1 for 2002Q3 and 0 otherwise, D_{053} is a dummy variable equal to 1 for 2005Q3 and 0 otherwise, D_{061} takes the value 1 for 2006Q1-2007Q2, D_{fc} is a dummy variable included to control for the effect of the financial crisis and it takes a value of 1 for the period 2007Q3 to 2009Q2 and 0 otherwise and $x_t = (\Delta o_t, g_t, \pi_t, r_t, e_t, rs_t)'$ is a vector of endogenous variables as defined earlier. Botswana

[34] An increase in the exchange rate represents an appreciation of the domestic currency.

introduced value added tax (VAT) in July 2002 and the D_{023} variable is intended to capture the inflationary pressure of this tax, whereas D_{053} for the third quarter of 2005 is included to capture the possible effects of a 12 percent devaluation of the domestic currency in July, which also marked the switch from adjustable peg to crawling peg exchange rate system. D_{061} is included to control for the abnormal growth in the DCI associated with the introduction of restriction of BoBCs' trading to commercial banks only.

6 Estimation and Empirical results

6.1 Specification (diagnostic) Tests

As noted by Favero (2001) an important assumption of econometrics is that any model formulated to describe economic relationships should have constant parameters over time. Before using our model to investigate the impact of monetary policy shocks on stock returns, we perform some specification (diagnostic) tests on the reduced form VAR. The test for stability of the VAR is examined by considering its characteristic roots and the results are presented in Figure A1 in the Appendices. Since the results show that all the inverse roots of the AR Characteristic Polynomial lie inside the unit circle, the VAR passes the stability tests. As shown in Table A3 the VAR residual serial autocorrelation LM tests also indicate no autocorrelation in the residuals. A third test of the VAR adequacy is carried out by looking at the patterns of the impulse response functions presented in Figure A2 in the Appendices, which again shows that most of the impulse patterns accord with prior expectations and are consistent with available empirical literature. The VAR is therefore accepted as an adequate model from which reliable measures of monetary policy innovations can be derived.

6.2 Empirical Results

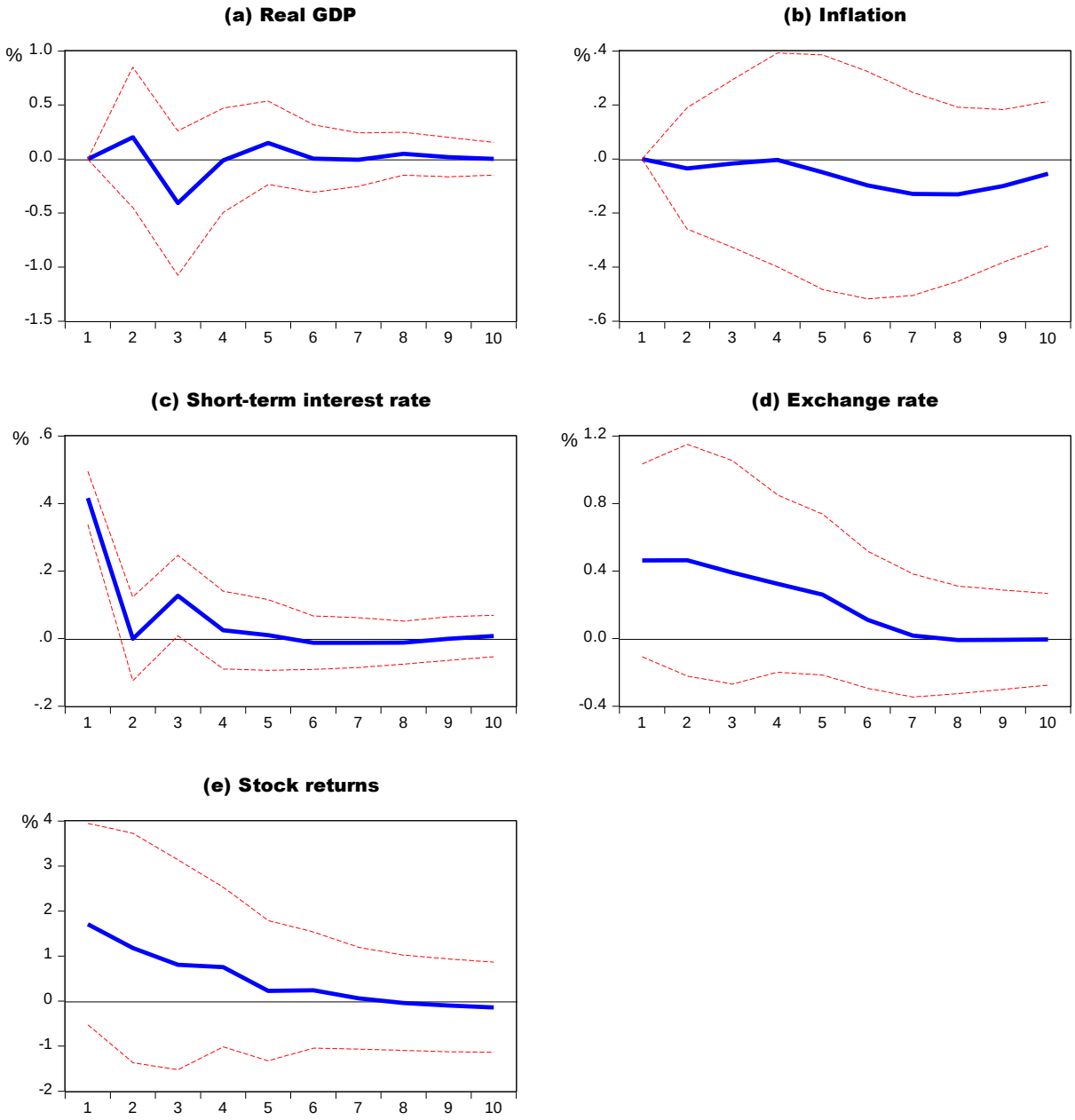
From the estimated reduced form VAR and the identification restrictions, we examine the relationships between the monetary policy variable; the bank rate, and stock returns. This section is divided into two subsections; section 5.2.1 presents impulse responses of stock returns to a positive one-standard-deviation shock to the bank rate. Section 5.2.2 presents results of the forecast error variance decomposition analysis to determine the contribution of monetary policy shocks to the variance of stock returns.

6.2.1 Impulse Response Functions

Figure 2 displays the impulse response functions – the dynamic responses of each domestic variable to a contractionary monetary policy shock. Each graph presents the impulse responses (solid lines) to a one standard-deviation positive shock to the short-term interest rate. The responding variables are named at the top of each graph. The vertical axes show the deviation of each variable's response from its baseline trajectory. The horizontal axes show the number of quarters since the shock took place. The upper and lower dashed lines in each graph are two-standard error bands. The error bands are included to show the uncertainty associated with the point estimates.[35] As is the case in many VAR studies, the impulse response functions are generally statistically insignificant. Therefore the interpretation that follows concentrates on the point estimates and will note significance only, with insignificance being the norm.

[35] The standard errors are computed from 1000 Monte Carlo repetitions.

Figure 2: Impulse responses to a contractionary monetary policy shock



An examination of the impulse response functions to an unexpected contractionary monetary policy shock indicates that the interest rate shock itself is transitory. After a contractionary monetary policy shock, the interest rate immediately jumps up by about 40 basis points, and takes about five quarters to return to its equilibrium trend. However, although the interest rate stays above the pre-shock level, the effect is not statistically significant beyond two quarters out. Following the same shock, the exchange rate appreciates on impact and then gradually depreciates, reaching its baseline value in seven quarters. The response of the exchange rate is

consistent with Dornbusch's prediction that, following a policy shock the exchange rate overshoots its long-run level on impact, and then gradually adjusts to its initial value. In response to the 0.4 percent unexpected increase in the interest rate, real output growth first increases, reaching a maximum of 0.2 percent in quarter two and then declines and bottoms out at -0.4 percent in quarter three and then recovers to its baseline trajectory. As expected inflation rate exhibits a delayed response. In response to the contractionary monetary policy shock, inflation rate only starts to fall in quarter four, reaches its minimum of -0.13 percent in quarter seven and then slows recovers to its pre-shock rate. The findings that the exchange rate responds to the policy shock immediately, while output responds with a lag and the inflation rate with an even longer lag are consistent with the theoretical predictions of the dynamic responses to a contractionary monetary policy shock.

Turning attention to the impact on asset returns, the response of stock returns appears counter-intuitive and at variance with findings from the studies reviewed in this paper. Stock returns increase immediately following a positive interest rate innovation and then gradually decline to reach its initial level in quarter seven. Our theoretical prediction was that monetary policy tightening should increase the rate at which firms' future cash flows are capitalized or lower their expected future cash flows and thus causing stock prices to fall. This was also the finding of almost all the studies reviewed, except for that of Nemaorani (2012). As Nemaorani noted, this effect is not entirely unexpected for Botswana and can be explained by considering the operation of monetary policy and the composition of the DCI.

First, monetary policy setting has since March 2006 been such that only commercial banks can trade in the BoBCs. Although this has been important to the Bank of Botswana as BOBCs are the main instruments through which the Bank can control liquidity and hence money supply, BoBCs have provided commercial banks with a risk-free investment opportunity. A joint World Bank and IMF Financial Sector Assessment Report (2008) indicates that commercial banks in Botswana have been overly reliant on BoBCs and as a result realized returns on equity as high as fifty percent. On the other hand the BSE's domestic board is dominated by the banking sector which accounted for over 60 percent and 53 percent of the market capitalisation in 2000-2005 and September 2011, respectively. The implication of this has been that a monetary policy

tightening that increases the interest rate also increases the banks' expected cash flow from their BoBCs holdings and hence returns to their stocks. The dominance of market capitalization by commercial banks implies that the response of the stock returns to monetary policy changes reflects mainly that of the bank stocks. That is, the positive response of bank stocks overwhelms the possibly negative response of the other companies.

6.2.2 Forecast Error Variance Decompositions

Another set of insights from the VAR analysis relates to the importance of monetary policy in the variance of the stock returns. Forecast error variance decompositions show the proportions of the variations in endogenous variables due to individual shocks at different forecast horizons. Table 3 presents the variance decompositions to show the share of fluctuations in the stock returns due to the interest rate innovations over a two-year time horizon.

Table 3: Forecast Error Variance Decomposition of Stock returns

		Innovation to:					
Period	S.E.	Oil	Output	Inflation	Int. rate	Exc. Rate	Stock returns
1	2.412515	0.023649	0.148354	1.302978	**3.630261**	0.519538	94.37522
2	2.600117	0.552118	0.352975	5.114561	**4.773818**	1.282453	87.92407
3	2.668157	1.234927	0.365256	5.007846	**5.375635**	1.330553	86.68578
4	2.730434	1.260663	0.363046	5.496100	**5.900272**	1.470842	85.50908
5	2.757600	1.426489	0.583859	6.026585	**5.893690**	1.455450	84.61393
6	2.764323	2.324478	0.682146	6.556546	**5.850115**	1.429560	83.15716
7	2.770264	2.961344	0.675947	6.694873	**5.799098**	1.439738	82.42900
8	2.775055	3.219051	0.675373	6.674414	**5.780725**	1.434914	82.21552

Cholesky Ordering: Oil Output Inflation Interest rate Exchange rate Stock returns

The results reported in Table 3 indicate that monetary policy shocks explain about 3.6 percent of stock returns fluctuations in quarter one, which is the largest non-own share. This share increases to about 6 percent in two years. Taken as a whole this indicates that unanticipated monetary policy shocks account for only a small part of the variations in stock returns. This can be attributed to the "washing out" effect of the positive response of bank stocks and the negative response of non-bank stocks.

6.2.3 Sensitivity Analysis

VARs can be quite sensitive to the assumptions used in their estimation (See Stock and Watson, 2001). In particular, changes in the number of lags, identification restrictions and model specification can have large effects on the results (Favero, 2001). It is important to consider these potential weaknesses when using VAR analysis. Alternative specifications were considered to examine the sensitivity of the results to different lag length specifications, choice of the monetary policy variable, alternative ordering of variables, variable selection and specification.

Table 4: Selected VAR exercises

VAR model	r-shock	Comments
{o*, **i***, g, π, r, e, sr}	√	-
{ o*, g, π, **br**, e, sr}	√	-
{o*, g, π, **br**, e, sr}	No effect	Oscillates around zero
{o*, g, π, r, **ne**, sr}	√	-
{o*, g, π, r, e, sr}lag=1	√	Price puzzle
{oy*, gy, π, r, ey, sry}	√	Positive output response

Table 4 summarizes the results from the robustness exercises that consider changes in the baseline model with different variables, introduced one at a time: a foreign monetary policy rate (i*), , interest rate in level (lr), bank rate (br) and the nominal effective exchange rate (ne). The check mark stands for qualitatively similar effects of monetary policy on stock returns as in the baseline VAR. In general, the results are qualitatively similar to those in the baseline VAR. The main results also hold if the VAR is specified in gaps (y) or when a lag of one is used as recommended by the SC.

7 Conclusions and Policy Suggestions

This paper examined the effect of monetary policy on stock returns of firms listed on the Botswana Stock Exchange. The existence of such a relationship has important implications for both stock market participants and central bankers. Central bankers are interested in whether monetary policy actions are propagated through the financial markets, while market participants use the information for stock price determination and portfolio formation. Theory postulates that stock prices equal the expected present value of future net cash flows. Thus an expansionary monetary policy increase future cash flows or decrease the discount factors at which those cash

flows are capitalized, hence is positively related to stock prices. This study used a six variable standard VAR model which included change in the policy interest rate and a set of domestic and foreign conditioning variables. The results suggest that an unexpected contractionary monetary policy, as measured by a shock to the change in the short-term interest rate, is associated with an increase, rather than a decrease, in stock returns. This is inconsistent with both theory and much of the available empirical studies conducted elsewhere.

A possible explanation for this counterintuitive result is that the DCI is dominated by commercial banks, which are also the main beneficiaries of the interest income from investment in risk-free BoBCs. The observed positive reaction of stock prices to monetary policy tightening suggests that the increase in returns to bank stocks offsets the negative reactions of non-bank stock prices. Moreover, the evidence from variance decompositions show that monetary policy shocks explain a very small proportion of stock returns variability, which can be taken as evidence in support of the "washing out" view.

The implication of our findings is that the monetary policy transmission through the stock market runs against the grain, possibly because of the restriction of BoBCs trade to commercial banks, who also dominate market capitalization of the Botswana Stock Exchange. While these findings may suggest that the Bank can continue to focus on inflation control without fear of destabilizing the stock market, it also points to a need for policy reform to reduce reliance of commercial banks on the BoBCs.

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Appendices

Table A1: Unit Root and Stationarity Tests: Levels of variables

	ADF(τ)				PP(τ)			
Series	Trend	lag	constant	lag	trend	lag	constant	lag
Oil price	-3.76**	1	-0.90	1	-2.86	2	-0.65	1
Output growth	-8.72***	1	-8.78***	1	-26.52***	-	-23.68***	-
Change in exchange rate	-6.19***	0	-5.92***	0	-6.32***	4	-6.06***	4
Inflation	-4.88***	1	-4.89***	1	-3.27*	1	-3.33**	1
Nominal stock returns	-5.39***	0	-5.28***	0	-5.38***	1	-5.31***	2
Real stock returns	-5.29***	0	-5.19***	0	-5.32***	2	-5.23***	2
Change in Nominal interest	-6.01***	0	-6.01***	0	-6.09***	3	-6.10***	3
Change in real interest	-5.30***	0	-5.20***	0	-5.32***	2	-5.23***	2

Notes: ADF stands for the Augmented Dickey-Fuller and PP the Phillips-Perron tests. All tests include a constant. Trend implies test with both trend and a constant. For both ADF and PP tests with a trend and constant, the critical values are: -4.156, -3.504 and -3.182 for the 1%, 5% and 10 % significance level, respectively. For the tests with just a constant the critical values are -3.571, -2.922 and -2.599, respectively.

Table A2: VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1011.453	NA	12383354	33.35911	33.56674	33.44048
1	-866.5186	256.6047	350223.6	29.78750	**31.24089***	30.35709
2	-836.5786	47.11868	441852.0	29.98619	32.68534	31.04401
3	-810.4937	35.92020	668268.4	30.31127	34.25618	31.85732
4	-766.6518	51.74792	617744.9	30.05416	35.24483	32.08843
5	-742.4687	23.78663	1251083.	30.44160	36.87803	32.96410
6	-675.7970	52.46293	783479.0	29.43597	37.11817	32.44669
7	-579.7930	56.65813	270075.9	27.46862	36.39658	30.96757
8	-447.4515	**52.06878***	**56202.76***	**24.30989***	34.48361	**28.29706***

* 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

Table A3: VAR Residual Serial Correlation LM Tests

Null Hypothesis: no serial correlation at lag order h

Lags	LM-Statistic	Probability
1	24.37442	0.9296
2	29.13931	0.7842
3	31.66995	0.6747
4	29.29102	0.7782
5	32.60733	0.6307
6	24.77946	0.9209

Probs from chi-square with 36 df.

Figure A1: Inverse Roots of AR Characteristic Polynomial

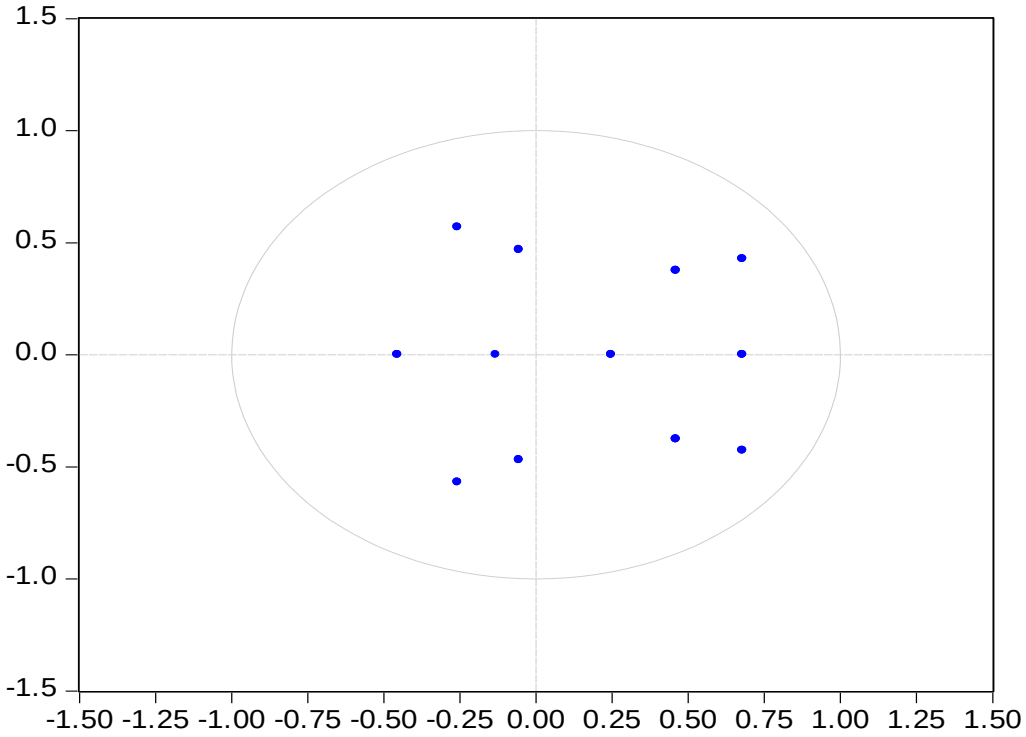

Figure A2: Response to Cholesky One S.D. Innovations ± 2 S.E.